

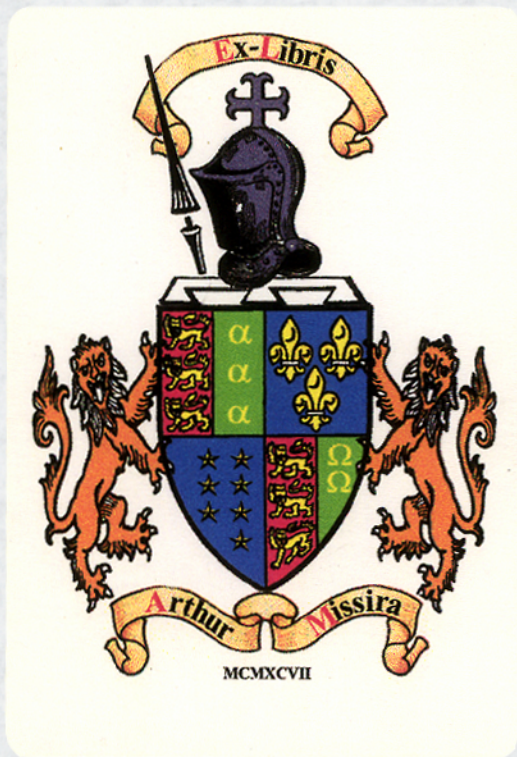
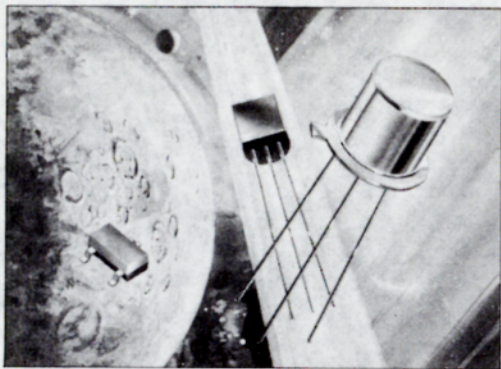


MOTOROLA Semiconductors

SMALL-SIGNAL TRANSISTOR DATA BOOK



**SMALL-SIGNAL
TRANSISTOR
DATA BOOK**



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MOTOROLA

SMALL-SIGNAL TRANSISTORS

This publication presents technical information for the several product families that comprise the Motorola small-signal transistor line. The families include both bipolar and field-effect transistors. These are available in a variety of packages; metal can, plastic, and microminiature. Complete device specifications and typical performance curves are given on individual data sheets, which are grouped by the various families.

A quick comparison of performance characteristics is presented in the easy-to-use selector guides in the first section. The tables will assist in the selection of the proper transistor for a specific application.

Separate sections are included to describe package outline drawings, and to clarify the mysteries of high reliability processing and testing.

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The following devices: 2N2405, BCV26, BCV27, BCY56, BCY57, BCY65, BCY66, BCY67, BCY77, BDT70, BDT71, BF178, BF410 Series, BFX29, BFX37, MMBV3700, PO17, PO7644, P2N1893, and more are available from Motorola although not represented in this book.

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2N5582JAN	4-25	-
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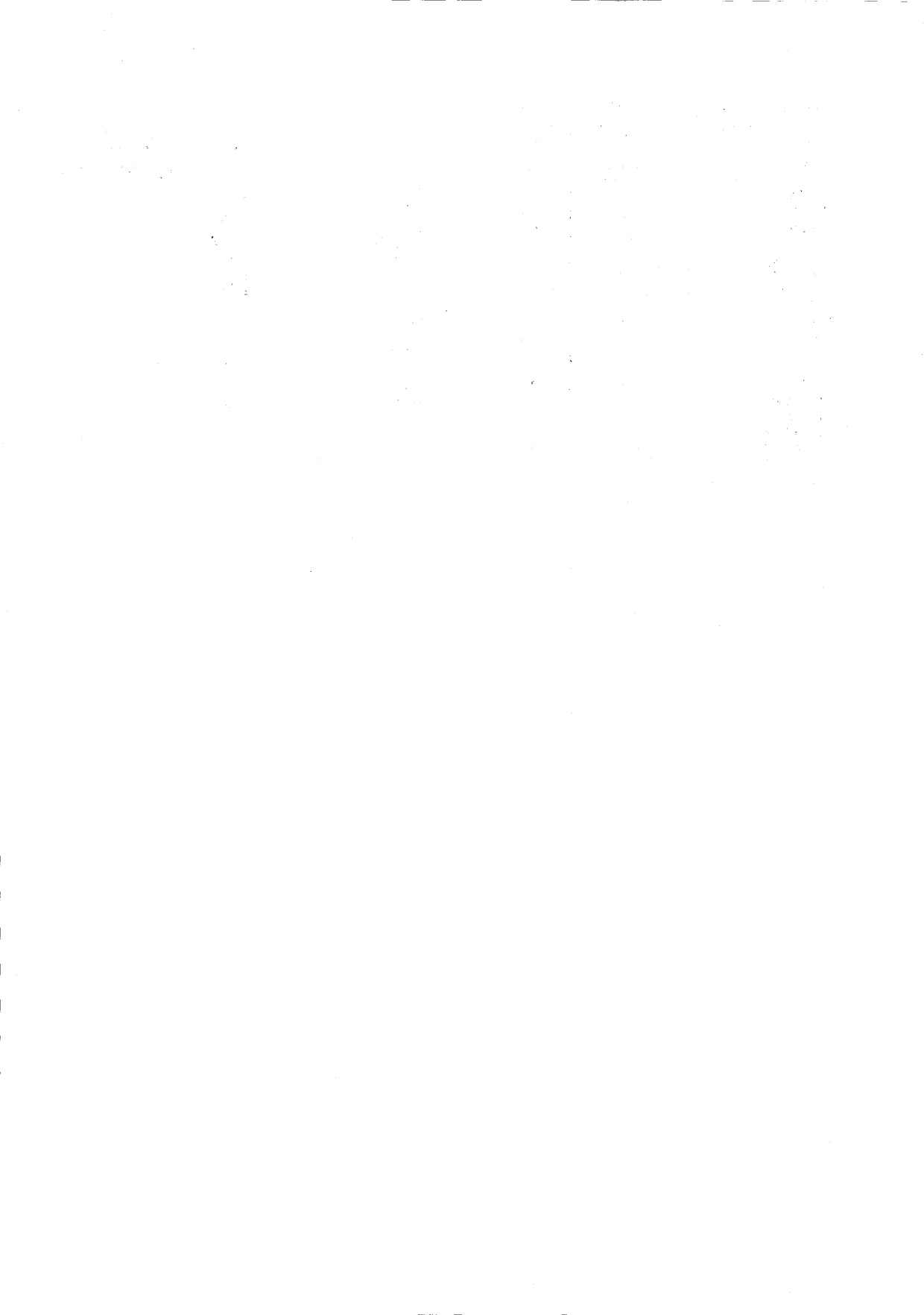
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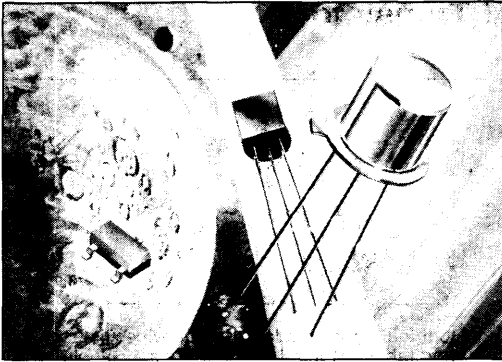
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The following selector guides highlight transistors that have emerged as the best values in their various categories. Semiconductors are manufactured by "batch" processes; therefore, each "batch" may yield devices with widely varying parameters, creating "families".

A large selection of plastic-encapsulated transistors is offered (TO-92, 1 Watt TO-92, SOT-23, SOT-89, Duals, and Quads).

For those applications where higher power dissipation and hermeticity are required, Motorola offers a full line of transistors in several metal-can packages.

FET's include devices developed for operation from dc to UHF in switching and amplifying applications.

A broad line of high frequency (RF) transistors with F_T 's up to 8 GHz are included for amplifiers, oscillators, mixers and switching applications.

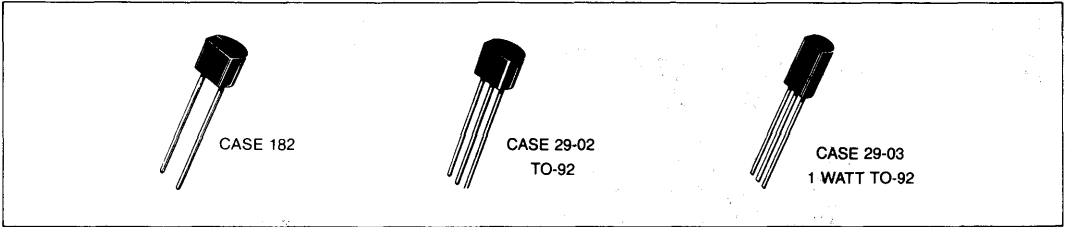
Devices which are qualified to JAN, JANTX, JANTXV, and JANS high reliability specifications are so noted in the applicable selector guide which includes also a list of CECC qualified types.

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Plastic-Encapsulated Small-Signal Transistors



Motorola's small-signal TO-92 plastic transistors encompass hundreds of devices with a wide variety of characteristics for general purpose, amplifier and switching applications. The popular high-volume TO-92 package combines proven reliability, performance, economy and convenience to provide the perfect solution for industrial and consumer design problems. All Motorola TO-92 devices are laser marked for ease of identification and shipped in antistatic containers, as part of Motorola's ongoing practice of maintaining the highest standards of quality and reliability.

In addition to the standard TO-92 devices listed in the following tables, Motorola also offers special electrical selections of these devices. Please contact your Motorola Sales Representative regarding any special requirements you may have.

In each of the following tables, the major specifications of the TO-92 transistor are given for easy comparison.

Motorola TO-92 transistors are available in the radial or axial tape and reel formats. Lead forming to fit TO-5 or TO-18 sockets is also available.

TABLE 1. General Purpose Amplifier Transistors (TO-92)

The general purpose Transistors are designed for small-signal amplification from D.C. to low radio frequencies. They are also useful as oscillators and general purpose switches.

NPN	PNP	BV _{CEO} (Volts)	P _d (mW)	I _C max. (mA) Cont.	H _{FE} @ I _C = 2.0 mA, V _{CE} = 5 V		F _T Typ. MHz	N _F Max. (dB)	Pin Out
					Min.	Max.			
BC182	BC212	50	625	100	120	460	200	10	CBE
BC237	BC307	45	625	100	120	460	200	10	CBE
BC238	BC308	25	625	100	120	800	200	10	CBE
BC239	BC309	45	625	100	180	800	240	4	CBE
BC546	BC556	65	625	100	120	450	300	10	CBE
BC546A	BC556A	65	625	100	120	220	300	10	CBE
BC546B	BC556B	65	625	100	180	450	300	10	CBE
BC547	BC557	45	625	100	120	450	300	10	CBE
BC547A	BC557A	45	625	100	120	220	300	10	CBE
BC547B	BC557B	45	625	100	180	450	300	10	CBE
BC547C	BC557C	45	625	100	380	800	300	10	CBE
BC548	BC558	30	625	100	120	800	300	10	CBE
BC548A	BC558A	30	625	100	120	220	300	10	CBE
BC548B	BC558B	30	625	100	180	450	300	10	CBE
BC548C	BC558C	30	625	100	380	800	300	10	CBE
BC317	BC320	45	625	150	110	450	250	6	EBC
BC318	BC321	30	625	150	110	800	250	6	EBC
BC319	BC322	20	625	150	200	800	250	4	EBC

TABLE 2. Low Noise and Good H_{FE} Linearity

These devices are designed to use on applications where good H_{FE} linearity and low noise characteristics are required: Instrumentation, Hi-Fi Preamplifier.

NPN	PNP	BV _{CEO} (Volts) Amb.	P _d mW 25°C Min.	H _{FE} @ I _C = 10 μA, V _{CE} = 5 V		H _{FE} @ I _C = 2 mA, V _{CE} = 5 V		V _T 120 Hz ¹ Typ.	mV Max.	N _F (dB) ² Typ.	Max.	F _T Typ. (MHz)	Pinning
				Min.	Typ.	Min.	Max.						
BC239	BC309	45	625	—	—	120	800	9.5	—	2	4	240	CBE
BC413	BC415	30	625	100	—	180	800	8	12	0.6	2.5	250	CBE
BC414	BC416	45	625	100	—	180	800	8	12	0.6	2.5	250	CBE
BC549	BC559	30	625	100	—	180	800	8	12	0.6	2.5	250	CBE
BC549B	BC559B	30	625	100	150	180	460	8	12	0.6	2.5	250	CBE
BC459C	BC559C	30	625	100	270	380	800	8	12	0.6	2.5	250	CBE
BC550	BC560	45	625	100	—	180	800	8	12	0.6	2.5	250	CBE
BC550B	BC560B	45	625	100	150	180	460	8	12	0.6	2.5	250	CBE
BC550C	BC560C	45	625	100	270	380	800	8	12	0.6	2.5	250	CBE
BC650	—	30	625	—	—	380	1400	—	—	—	1(\$)	300	EBC
BC651	—	45	625	—	—	380	1400	—	—	—	1(\$)	300	EBC
MPSA18	—	45	625	400	500	500	—	7	—	—	1.5	160	EBC
2N4123	2N4125	30	625	—	—	50	150 ³	—	—	—	6	300	EBC
2N4124	2N4126	25	625	—	—	120	360 ³	—	—	—	5	350	EBC
2N5088	—	30	625	300	900	350	—	—	—	—	3	150	EBC
2N5089	—	25	625	400	1200	450	—	—	—	—	2	150	EBC

¹ V_T: Total Input Noise Voltage (see Application Note, BC413/BC414 and BC415/BC416 Data Sheets) at R_S = 2 KΩ, I_C = 200 μA, V_{CE} = 5 Volts.

² N_F: Noise Figure at R_S = 2K, I_C = 200 μA, V_{CE} = 5 Volts. F = 30 Hz to 15 KHz.

³ At V_{CE} = 1 V.

* "S" version.

(\$) @ 1 KHz.

TABLE 3. High Current Amplifier Transistors (TO-92)

Useful in Low Power Audio Output Stages and Medium Current Switches.

NPN	PNP	BV _{CEO} (Volts)	P _D mW 25°C Amb.	I _C (mA) Cont.	H _{FE}		@ I _C (mA)	V _{CE} (Volts)	F _T Typical (MHz)	Pinning
					Min.	Max.				
BC337	BC327	45	625	800	100	600	100	1	210	CBE
BC338	BC328	25	625	800	100	600	100	1	210	CBE
BC445	BC446	60	625	300	70	—	10	5	250/200 ¹	CBE
BC447	BC448	80	625	300	70	—	10	5	250/200 ¹	CBE
BC449	BC450	100	625	300	70	—	10	5	250/200 ¹	CBE
BC485	BC486	45	625	1000	60	400	100	2	200/150 ¹	CBE
BC487	BC488	60	625	1000	60	400	100	2	200/150 ¹	CBE
BC489	BC490	80	625	1000	60	400	100	2	200/150 ¹	CBE
MPSA05	MPSA55	60	625	500	50	—	100	1	150/175 ¹	EBC
MPSA06	MPSA56	80	625	500	50	—	100	1	150/175 ¹	EBC
MPS8099	MPS8599	80	625	500	75	—	100	5	200	EBC
2N4409	—	50	625	250	60	400	10	1	200	EBC
2N4410	—	80	625	250	60	400	10	1	200	EBC
MPS650	MPS750	40	625	2000	75 40	—	1000 2000	2 2	100	EBC

¹ Relevant to PNP.

TABLE 4. High Voltage Amplifier Transistors (TO-92 - EBC)*

These high-voltage transistors are designed for driving neon bulbs and Nixie® indicator tubes, for direct line operation, and for other applications requiring high-voltage capability at relatively low collector current. These devices are listed in order of decreasing breakdown voltage (BV_{CEO}).

Device Type	BV _{CEO} Volts Min.	I _C Amp Cont.	h _{FE} @ I _C mA		V _{CE} (sat) Volts @ I _C mA		I _B mA	f _T MHz @ I _C mA		
			Min.	Max.	Min.	Max.		Min.	Max.	
NPN										
BF844	400	0.5	40	30	0.5	10	1	50	10	
MPSA44	400	0.3	40	100	0.75	50	5	20	10	
BF845	350	0.5	40	30	0.5	10	1	50	10	
MPSA45	350	0.3	50	100	0.75	50	5	20	10	
2N6517	350	0.5	30	30	0.3	10	1	40	10	
BF393	300	0.5	40	10	0.2	20	2	50	10	
MPS-A42	300	0.5	40	30	0.5	20	2	50	10	
2N6516	300	0.5	45	30	0.3	10	1	40	10	
BF392	250	0.5	40	10	0.2	20	2	50	10	
2N6515	250	0.5	50	30	0.3	10	1	40	10	
BF391	200	0.5	40	10	0.2	20	2	50	10	
MPS-A43	200	0.5	40	10	0.4	20	2	50	10	
2N5551	160	0.6	80	10	0.15	10	1	100	10	
2N5550	140	0.6	60	10	0.15	10	1	100	10	
MPS-L01	100	0.15	20	30	0.2	10	1	40	10	
PNP										
BF493S	350	0.5	40	10	2.0	20	2	50	10	
2N6520	350	0.5	30	30	0.3	10	1	40	10	
BF493	300	0.5	40	10	0.2	20	2	50	10	
MPS-A92	300	0.5	40	10	0.5	20	2	50	10	
2N6519	300	0.5	45	30	0.3	10	1	40	10	
BF492	250	0.5	40	10	0.2	20	2	50	10	
2N6518	250	0.5	50	30	0.3	10	1	40	10	
BF491	200	0.5	40	10	0.2	20	2	50	10	
MPS-A93	200	0.5	40	10	0.4	20	2	50	10	
2N5401	150	0.6	60	10	0.2	10	1	100	10	
2N5400	120	0.6	40	10	0.2	10	1	100	10	
MPS-L51	100	0.6	40	50	0.25	10	1	60	10	

* ECB PIN OUT (BF420/1/2/3): Table 10.
CBE PIN OUT (PBF259/493): Table 11.

TABLE 5. Industrial Transistors (TO-92)

These devices are special products ranges intended for use in applications which require well specified high performing devices like high quality amplifier differential input, driver stage.

NPN	PNP	BV _{CEO} (Volts)	P _D mW 25°C Amb.	I _C (mA) Cont.	H _{FE}		@ I _C (mA)	V _{CE} (Volts)	F _T Typ. (MHz)	Typ. (dB)	Pin Out	T _{ON} Typ. (nS)	T _{OFF} Typ. (nS)
					Min.	Max.							
BCX25	BCX26	60	625	200	70	400	10	5	250	2	CBE	70	1000/600
BCX27	BCX28	80	625	200	70	400	10	5	250	2	CBE	70	1000/600
BCX29	BCX30	100	625	200	70	400	10	5	250	2	CBE	70	1000/600
BCX45	BCX46	45	625	1000	50	—	100	2	150	2	CBE	30	380
BCX47	BCX48	60	625	1000	50	—	100	2	150	2	CBE	30	380
BCX49	BCX50	80	625	1000	50	—	100	2	150	2	CBE	30	380
BCX58	BCX78	32	625	200	120	630	2	5	250	2	CBE	75	600/350
BCX59	BCX79	45	625	200	120	630	2	5	250	2	CBE	75	600/350
MPS2222	—	30	625	600	75	—	10	10	250*	—	EBC	30	270
MPS2222A	—	40	625	600	75	—	10	10	300*	—	EBC	30	270
—	MPS2907	40	625	600	75	—	10	10	200*	—	EBC	45	100
—	MPS2907A	60	625	600	100	—	10	10	200*	—	EBC	45	100
MPS6531	MPS6534	40	625	600	90	270	100	1	250	—	EBC	30	250
MPS6532	MPS6535	30	625	600	30	—	100	1	250	—	EBC	30	250

* F_T Min.

TABLE 6. RF Transistors

The RF transistors are designed for Small Signal amplification from RF to VHF/UHF frequencies. They are also used as mixers and oscillators in the same frequency ranges. Several types are AGC characterised. The transistors are listed in order of decreasing f_T Min.

Device Type	Pin Out	BV_{CEO} min. Volts	P_d max. mW	I_C max. mA	h_{FE} Min.	@ I_C mA	V_{CE} Volts	f_T typ MHz	C_{RE} C_{RB} pF Max.	N_F typ dB	F MHz
NPN											
MPSH17	BEC	15	625	100	25	5	10	1600	0.9	6*	200
MPSH10	BEC	25	625	100	60	4	10	1500	0.7	—	—
BF374	BEC	25	625	100	70	1	10	800	0.6	4	100
BF375	BEC	25	625	100	35	1	10	800	0.6	4	100
BF959	CEB	20	625	100	40	20	10	800	0.65(\$)	3	200
MPS918	EBC	15	625	50	20	8	10	800	1.7	6*	60
MPS3563	EBC	12	625	50	20	8	10	800	1.7	6*	60
BF199	CEB	25	625	100	40	7	10	750	0.35	2.5	35
BF373	BEC	45	625	100	38	7	10	720	0.32	—	—
BF371	BEC	30	625	100	38	7	10	720	0.23(\$)	—	—
BF240	CEB	40	625	25	65	1	10	600	0.34	2.5	100
BF224	CEB	30	625	50	30	7	10	600	0.28(\$)	2.5	100
BF241	CEB	40	625	25	35	1	10	470	0.34	2.5	100
BF254	CEB	20	625	100	65	1	10	260	0.9(\$)	1.7	1
BF255	CEB	20	625	100	35	1	10	200	0.9(\$)	1.7	1
PNP											
BF509	CBE	35	625	50	20	3	10	850	0.25	2.5*	200
MPSH81	BEC	20	625	50	60	5	10	700	0.85	—	—
BF506	CBE	35	625	50	20	3	10	600	0.25	4*	200
MPSH54	EBC	80	625	100	30	1.5	10	130	1.6	2*	1

(\$) Typ.

* Max.

TABLE 7. High-Speed Saturated Switching Transistors

The transistors listed in this table are specially optimized for high-speed saturated switches. They are heavily gold doped and processed to provide very short switching times and low output capacitance (below 6 pF). The transistors are listed in order of decreasing turn-on time (t_{ON}).

Device Type	t_{on} ns Max.	t_{off} ns Max.	@ I_C mA	BV_{CEO} Volts Min.	h_{FE} Min.	@ I_C mA	$V_{CE(sat)}$ Volts @ I_C mA	& I_B mA	f_T MHz @ I_C mA		
NPN											
2N3904	70	250	10	40	100	10	0.2	10	1	300	10
2N3903	70	225	10	40	50	10	0.2	10	1	250	10
2N4400	35	255	150	40	50	150	0.4	150	15	200	20
MPS2369	12	18	10	15	40	10	0.25	10	1	500	10
PNP											
MPS404A	223*	835*	10	25'	30	12	0.2	24	1	—	—
2N3906	70	250	10	40	100	10	0.25	10	1	250	10
2N3905	70	225	10	40	100	10	0.25	10	1	200	10
2N4402	35	255	150	40	50	150	0.4	150	15	150	20
MPS3640	25	35	50	12	30	10	0.2	10	1	500	10

' BV_{EBO}

* Typ.

TABLE 8. Darlington Transistors (TO-92)

Darlington amplifiers are cascade transistors used in applications requiring very high gain and input impedance. These devices have monolithic construction.

Device Type	Pin Out	Absolute Max. Rating at 25°C		BVCEO (V)	HFE(1)				VCEsat			FT		Complementary Device Type
		Max PD Free Air at 25°C (mW)	Max IC (mA)		Bias		Min.	Max.	Bias		Max. V	IC (mA)	Min. (MHz)	
					VCE (V)	IC (mA)			IC (mA)	IB (mA)				

NPN

BC372	EBC	625	1000	100	5.0	100	25 K	160 K	250	0.25	1.0	100	100	
BC373	EBC	625	1000	80	5.0	100	25 K	160 K	250	0.25	1.0	100	100	
BC617	CBE	625	1000	40	5.0	200	20 K	70 K	200	0.20	1.1	500	150	
BC618	CBE	625	1000	55	5.0	200	10 K	50 K	200	0.20	1.1	500	150	
2N6426	EBC	625	500	40	5.0	100	30 K	300 K	500	0.50	1.5	10	125	
2N6427	EBC	625	500	40	5.0	100	20 K	200 K	500	0.50	1.5	10	125	
MPSA12	EBC	625	500	20(3)	5.0	10	20 K	—	10	0.01	1.0	10	125	MPSA62
MPSA13	EBC	625	500	30(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA63
MPSA14	EBC	625	500	30(3)	5.0	100	20 K	—	100	0.10	1.5	10	125	MPSA64
MPSA25	EBC	625	500	40(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA75
MPSA26	EBC	625	500	50(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA76
MPSA27	EBC	625	500	60(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA77
MPSA28	EBC	625	500	80(3)	5.0	100	10 K	—	100	0.10	1.4	10	125	
MPSA29	EBC	625	500	100(3)	5.0	100	10 K	—	100	0.10	1.4	10	125	
BC517	CBE	625	400	30(4)	2.0	20	30 K	—	100	0.10	1.0	10	125	

PNP

MPSA62	EBC	625	500	20(3)	5.0	10	5 K	—	10	0.01	1.0	100	125	MPSA12
MPSA63	EBC	625	500	30(3)	5.0	100	10 K	—	100	0.10	1.5	100	125	MPSA13
MPSA64	EBC	625	500	30(3)	5.0	100	20 K	—	100	0.10	1.5	100	125	MPSA14
MPSA75	EBC	625	500	40(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA25
MPSA76	EBC	625	500	50(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA26
MPSA77	EBC	625	500	60(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA27

(1) Pulse Test/Pulse Width ≤ 300 μs — Duty Cycle ≤ 2.0% (3) BVCEs @ IC = 100 μA (4) BVCEs @ IC = 2 mA.

(2) NF IC = 100 μA: VCE = 5 v, RS = 10 K, F = 10 Hz to 15.7 KHz.

TABLE 9. Dual Diodes

Dual diodes designed for use in low cost biasing, steering and voltage doubler applications including series, common cathode and common anode diodes.

Device Type	V(BR) Volts Min.	@ I(BR) μA	IR μA Max.	@ VR Volts	VF@ Volts Min./Max.	IF mA	CVR = 0 pF Max.	t _{rr} ns Max.	Description
MSD6100	100	100	0.1	50	0.67/0.82	10	1.5	4.0	Switching
MSD6102	70	100	0.1	50	0.76/1.0	10	3.0	100	Common Cathode
MSD6150	70	100	0.1	50	—/1.0	10	8.0	100	Common Anode

TABLE 10. Central Collector 800 MW TO-92

The transistors listed in this table have been designed to provide power dissipation. These devices are listed in order of decreasing breakdown voltage (BV_{CEO}).

Device Type	BV _{CEO} Volts Min.	I _C Amp Cont.	h _{FE} Min.	@ I _C mA	V _{CE(sat)} Volts Max.	@ I _C mA	@ I _B mA	f _T MHz Min.	@ I _C mA	PIN OUT
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NPN

BF420	300	0.1	40	25	2.0	20	2	60	10	ECB
BF422	250	0.1	50	25	2.0	20	2	60	10	ECB
BC639	80	1.0	40	150	0.5	500	50	60	10	ECB
BC637	60	1.0	40	150	0.5	500	50	60	10	ECB
BC635	45	1.0	40	150	0.5	500	50	60	10	ECB
BC368	20	1.0	60	1000	0.5	1000	100	65	10	ECB

PNP

BF421	300	0.1	40	25	2.0	20	2	60	10	ECB
BF423	250	0.1	50	25	2.0	20	2	60	10	ECB
BC640	80	1.0	40	150	0.5	500	50	60	10	ECB
BC639	60	1.0	40	150	0.5	500	50	60	10	ECB
BC636	45	1.0	40	150	0.5	500	50	60	10	ECB
BC369	20	1.0	60	1000	0.5	1000	100	65	10	ECB

TABLE 11. Telecom Transistors (TO92)

These devices are special product ranges intended for use in Telecom application which require an excellent long term reliability.

NPN DEVICES	PNP DEVICES	BV _{CEO} V	P _{DmW} 25°C Amb	I _C (mA) Cont	HFE				F _T Min MHz	PIN OUT
					min	max	I _C (mA)	V _{CE} (V)		
P2N2222	P2N2222A	30	625	600	75	—	10	10	250	CBE
		40	625	600	75	—	10	10	300	CBE
(1)PBF259,S (1)PBF259R,RS	P2N2907	40	625	600	75	—	10	10	200	CBE
		60	625	600	100	—	10	10	200	CBE
	(2)PBF493,S (2)PBF493R,RS	300	625	500	25	—	1	10	40	EBC
		300	625	500	25	—	1	10	40	CBE
		300	625	500	40	—	1	10	40	EBC
		300	625	500	40	—	1	10	40	CBE

(1) "S" version, HFE Min 60 @ I_C = 20 mA, V_{CE} = 10 V.

(2) "S" version, HFE Min 40 @ I_C = 0,1 mA, V_{CE} = 1 V.

TABLE 12. Voltage Reference Diodes (TO92)

These devices are highly reliable temperature compensated monolithic integrated circuit voltage stabiliser designed for use in television and FM radios that use variable capacitance diode tuners.

Device Type	P _D (mW)	V _Z (V)			I _{ZT} (mA)	Δ V _Z /Δ T (mV/°C)			
		Min	Max	@		Type	@ I _{ZT} (mA)	T/Min (°C)	T/Max (°C)
MVS240	625	23	25	5	—0.2	5	0	70	
MVS460	625	31	35	5	—2.3	5	0	70	
MVS460-1	625	31	32	5	—2.3	5	0	70	
MVS460-2	625	32	34	5	—2.3	5	0	70	
MVS460-3	625	34	35	5	—2.3	5	0	70	

TABLE 13. TO 92 - 1 Watt Package

High-Current

EUROPEAN VERSION		PNP/ NPN	BVCEO (V)	IC Max (A)	ICBO		HFE				VCEsat			FT	
PIN OUT					max (nA)	VCB	min	max	IC(mA)	VCE (V)	maxV	ICmA	IB (mA)	min MHz	IC (mA)
ECB	EBC														
BDC01A BDC02A	BDB01A BDB02A	N P	45	1.5	100	45	40	400	100	1	0.7	1000	100	50	200
BDC01B BDC02B	BDB01B BDB02B	N P	60	1.5	100	60	40	400	100	1	0.7	1000	100	50	200
BDC01C BDC02C	BDB01C BDB02C	N P	80	1.5	100	80	40	400	100	1	0.7	1000	100	50	200
BDC01D BDC02D	BDB01D BDB02D	N P	100	1.5	100	100	40	400	100	1	0.7	1000	100	50	200
	BDB03 BDB04	N P	45	1.0	100	45	100	300	150	10	1.1	150	15	150	15
BDC03 BDC04		N P	20 20	1.0 1.0	100 100	25 25	60 60	— —	1000 1000	1 1	0.5 0.7	1000 1000	100 100	50 50	50 50
US VERSION															
DEVICE	PIN OUT														
MPSW01	EBC	N	30	1.0	100	30	50	—	1000	1	0.5	1000	100	50	50
MPSW51	EBC	P	30	1.0	100	30	50	—	1000	1	0.7	1000	100	50	50
MPSW01A	EBC	N	40	1.0	100	40	50	—	1000	1	0.5	1000	100	50	50
MPSW51A	EBC	P	40	1.0	100	40	50	—	1000	1	0.7	1000	100	50	50
MPSW05	EBC	N	60	0.5	100	40	80	—	50	1	0.4	250	10	50	200
MPSW55	EBC	P	60	0.5	100	40	80	—	50	1	0.5	250	10	50	250
MPSW06	EBC	N	80	0.5	100	60	80	—	50	1	0.4	250	10	50	200
MPSW56	EBC	P	80	0.5	100	60	80	—	50	1	0.5	250	10	50	250

High-Voltage

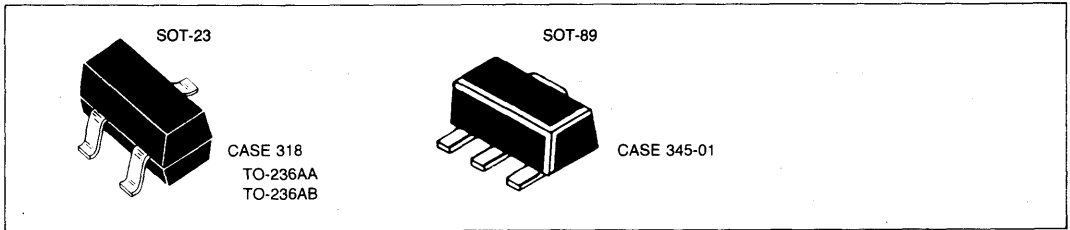
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EUROPEAN VERSION		POLA	BVCEO (V)	IC Max (A)	ICBO		HFE				VCEsat			F _T	
DEVICE	PIN OUT				max (nA)	VCB	min	max	VCE (V)	IC(mA)	max(V)	IC(mA)	IB (mA)	min MHz	IC (mA)
BDC05	ECB	N	300	0.5	10	200	40	—	20	25	2	20	2	60	10
BDC06	ECB	P	300	0.5	10	200	40	—	20	25	2	20	2	60	10
BDC07	ECB	N	250	0.5	10	200	50	—	20	25	2	20	2	60	10
BDC08	ECB	P	250	0.5	10	200	40	—	20	25	2	20	2	60	10
US VERSION		POLA	BVCEO (V)	IC Max (A)	max (nA)	VCB	min	max	VCE (V)	IC(mA)	max(V)	IC(mA)	IB (mA)	min MHz	IC (mA)
DEVICE	PIN OUT														
MPSW42	EBC	N	300	0.5	100	200	40	—	10	30	0.5	20	2	50	10
MPSW92	EBC	P	300	0.5	250	200	25	—	10	30	0.5	20	2	50	10
MPSW43	EBC	N	200	0.5	100	160	40	—	10	30	0.5	20	2	50	10
MPSW93	EBC	P	200	0.5	250	160	25	—	10	30	0.5	20	2	50	10
MPSW10	EBC	N	300	0.5	200	200	40	—	10	30	0.75	30	3	45	10
MPSW60	EBC	P	300	0.5	200	200	25	—	10	30	0.75	20	2	60	10

Darlington

US VERSION		POLA	BVCEO (V)	IC Max (A)	ICBO		HFE				VCEsat			F _T	
DEVICE	PIN OUT				max (nA)	VCB	min	max	IC(mA)	VCE (V)	max(V)	IC(mA)	IB (mA)	min MHz	IC (mA)
MPSW13	EBC	N	30	1	100	30	10K	—	100	5	1.5	100	0.1	125	10
MPSW63	EBC	P					20K	—	100	5	1.5	100	0.1	125	10
MPSW14	EBC	N	30	1	100	30	25K	150K	200	5	1.5	1000	2	100	200
MPSW64	EBC	P					15K	—	500	5	1.5	1000	2	100	200
MPSW45	EBC	N	40	1	100	30	25K	150K	200	5	1.5	1000	2	100	200
MPSW45A	EBC	N	50	1	100	30	15K	—	500	5	1.5	1000	2	100	200

Microminiature Products



Microminiature Space Saving Alternatives for Discrete Devices

A wide variety of discrete components from Motorola's repertoire of reliability-proven semiconductor processes and geometries are available in SOT (Small Outline Transistor) packages. Products include Bipolar and Field-Effect Transistors; Switching, Zener and Varactor Diodes; and Silicon Controlled Rectifiers. The surface-mounted SOT devices are currently being used by circuit designers on Printed Circuit Boards and Ceramic Substrate.

Some of the significant features of the SOT devices are:

- **Complete Pretest Capability** — all SOT's are 100% electrically tested.
- **Handling and Assembly Ease** — SOT's can be placed on substrates either manually or by using automated handling equipment.
- **Reliability** — SOT's are subjected to the same rigid reliability test performed on all Motorola plastic packages.
- **Small Size/Less Weight** — Considerable size reduction and weight-saving is achieved in circuit designs using SOT technology.
- **Broad Line** — Currently, Motorola offers over 250 standard discrete devices in the SOT packages. (Inquiries regarding customers' special requirements are invited.)
- **Marking Capability** — A multi-digit code is laser marked on every SOT device.

- **Multi-Sources** — Although Motorola was the first domestic supplier of SOT's, today there are several U.S. manufacturers, as well as many foreign sources for these devices.
- **Packaging** — Motorola standard shipping method for SOT's is in vials; additionally, in conjunction with the industry trend to use automatic placement equipment for microminiature components, Motorola offers the SOT-23 packaged in the 8mm tape and reel format.
- **Standard SOT-23 VS Low Profile SOT-23** — Motorola offers both the standard SOT-23 outline (TO-236AA) and the new "Low Profile" SOT-23 (TO-236AB). The only difference is the clearance from the bottom of the package to the surface of the substrate:

Device	Millimeters		Inches	
	Min	Max	Min	Max
Standard SOT-23	0.10	0.25	0.004	0.0098
Low Profile SOT-23	0.01	0.10	0.0005	0.0040

The "Low Profile" package is primarily designed for customers using two-sided printed circuit boards with the SOT-23's mounted on the "bottom side" of the board, and with the nonsurface mounted device on the "top side." Contact your Motorola representative for ordering instructions on "Low Profile" SOT-23's.

TABLE 1. General-Purpose SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending breakdown voltage.

NPN

Device Type	Marking	V _{BR} (CEO)	h _{FE}			f _T
			Min	Max	@ I _C (mA)	Min (MHz)
BCX70J	AJ	45	250	460	2	125
BCW72	K2	45	200	450	2	—
BCX70H	AH	45	180	310	2	125
BCX70G	AG	45	120	220	2	125
BCX19	U1	45	100	600	100	200
MMBT2222A	1P	40	100	300	150	200
MMBT3904	1A	40	100	300	10	200

MICROMINIATURE PRODUCTS (continued)

TABLE 1. General-Purpose SOT-23 Transistors (continued)

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending breakdown voltage.

NPN

Device Type	Marking	$V_{BR(CEO)}$	h_{FE}			f_T
			Min	Max	@ I_C (mA)	Min (MHz)
BCW60C	AC	32	250	460	2	125
BCW65C	EC	32	250	630	100	100
BCW60B	AB	32	180	310	2	125
BCW65B	EB	32	160	400	100	100
MMBT2222	1B	30	100	300	150	250
BCX20	U2	25	100	600	100	—
MMBT4124	ZC	25	60	—	50	300
BCW32	D2	20	200	450	2	—

PNP

Device Type	Marking	$V_{BR(CEO)}$	h_{FE}			f_T
			Min	Max	@ I_C (mA)	Min (MHz)
MMBT2907A	2F	60	100	300	150	200
BCX71J	BJ	45	250	460	2	—
BCW70	H2	45	215	500	2	—
BCX71H	BH	45	180	310	2	—
BCX17	T1	45	100	600	100	100
MMBT2907	2B	40	100	300	150	200
MMBT3906	2A	40	100	300	10	250
BCW61C	BC	32	250	460	2	—
BCW67C	EC	32	250	630	100	100
BCW61B	BB	32	180	310	2	—
BCW67B	DB	32	160	400	100	100
BCX18	T2	25	100	600	100	—
BCW30	C2	20	215	500	2	—
BCW29	C1	20	120	260	2	—

TABLE 2. SOT-23 Switching Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	Switching Time (ns)		$V_{BR(CEO)}$	h_{FE}			f_T Min (MHz)
		T_{ON}	T_{OFF}		Min	Max	@ I_C (mA)	
MMBT2369	1J	12	18	15	40	120	10	—
BSX39	02	12	18	14	40	200	10	—
BSV52	B2	12	18	12	40	120	10	400

PNP

MMBT3640	2J	25	35	12	30	120	10	500
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MICROMINIATURE PRODUCTS (continued)

TABLE 3. SOT-23 Transistors, VHF/UHF Amplifiers, Mixers, Oscillators

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	f _T		V _{BR} (CEO)	C _{ob} Max (pF)
		Min (GHz)	@ I _C (mA)		
MMBT3960A	1T	1.600	30	8	2.00
MMBT3960	1S	1.600	30	3	2.00
MMBT6543	3F	0.750	4	25	1.00
MMBTH10	3E	0.650	4	25	.70
MMBC1321Q2	Q2	0.600	2	25	1.80
MMBC1321Q3	Q3	0.600	2	25	1.80
MMBC1321Q4	Q4	0.600	2	25	1.80
MMBC1321Q5	Q5	0.600	2	25	1.80
MMBT918	3B	0.600	4	15	1.70
MMBTH24	3A	0.400	8	30	.36
MMBC1009F1	F1	0.150	1	25	3.50
MMBC1009F2	F2	0.150	1	25	3.50
MMBC1009F3	F3	0.150	1	25	3.50
MMBC1009F4	F4	0.150	1	25	3.50
MMBC1009F5	F5	0.150	1	25	3.50

PNP

MMBT4260	2R	2.000	10	10	2.50
MMBT4261	2S	2.000	10	10	2.50
MMBTH81	3D	0.600	5	20	.85

TABLE 4. Chopper Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

PNP

Device	Marking	V _{BR} (EBO)	V _{BR} (CEO)	HFE		
				Min	Max	@ I _C (mA)
MMBT404	2M	12	24	30	400	12
MMBT404A	2N	25	35	30	400	12

TABLE 5. SOT-23 Darlington Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	HFE			V _{BR} (CEO)	V _{CE(sat)} Max (V)
		Min	Max	@ I _C (mA)		
MMBTA14	1N	20 K	—	100	30	1.5
MMBT6427	1V	10 K	100 K	10	40	1.5
MMBTA13	1M	10 K	—	100	30	1.5

PNP

MMBTA64	2V	10 K		10	30	1.5
MMBTA63	2U	5.0 K		10	30	1.5

MICROMINIATURE PRODUCTS (continued)

TABLE 6. Low-Noise SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	NF dB (Typ)	V _{BR} (CEO)	hFE			f _T Min (MHz)
				Min	Max	@ I _C (mA)	
MMBT5088	1Q	1.0	30	300	900	1.0	50
MMBT5089	1R	1.0	25	400	1200	1.0	50
MMBT2484	1U	3.0	60	100	600	0.01	15
MMBT6428	1K	3.0	50	250	650	1.0	100
MMBT6429	1L	3.0	45	500	1250	1.0	100

PNP

MMBT5087	2Q	1.0	50	250	800	1.0	40
MMBT5086	2P	1.5	50	150	500	1.0	40

TABLE 7. High-Voltage SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	V _{BR} (CEO)	hFE			f _T Min (MHz)
			Min	Max	@ I _C (mA)	
MMBTA42	1D	300	40	—	10	50
MMBTA43	1E	200	40	—	10	50
MMBC1654N5	N5	160	150	330	15	120
MMBC1654N6	N6	160	100	220	15	120
MMBC1654N7	N7	160	50	130	15	120
MMBT5550	1F	150	60	250	10	100
MMBC1653N2	N2	130	150	330	15	120
MMBC1653N3	N3	130	100	220	15	120
MMBC1653N4	N4	130	50	130	15	120

PNP

MMBTA92	2D	300	40	—	10	50
MMBTA93	2E	200	40	—	10	50
MMBT5401	2L	150	60	240	10	100

TABLE 8. SOT-23 Driver Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	V _{BR} (CEO)	hFE			f _T Min (MHz)
			Min	Max	@ I _C (mA)	
MMBTA06	1G	80	50	—	10	100
BSS64	AM	80	20	80	4.0	50
MMBTA05	1H	60	50	—	10	100

PNP

BSS63	BM	100	30	—	10	50
MMBTA56	2G	80	50	—	10	100
MMBTA55	2H	60	50	—	10	100

MICROMINIATURE PRODUCTS (continued)

TABLE 9. RF SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	f_T			NF			Mag			f (MHz)
		Typ (GHz)	I_C (mA)	V_{CE} (V)	Typ (dB)	@ I_C (mA)	V_{CE} (V)	Typ (dB)	@ I_C (mA)	V_{CE} (V)	
MMBR930	7C	5.5	30	5.0	1.9	2.0	5.0	15.5	30	5.0	500
BFR92	P1	4.5	14	10	3.0	3.0	1.5	—	—	—	—
BFR93	R1	4.5	30	5.0	3.0	2.0	5.0	—	—	—	—
MMBR931	7D	3.5	1.0	1.0	2.7	0.5	1.0	18	1.0	1.0	500
MMBR2060	7E	2.5	20	10	2.0	1.5	10	13	20	10	500
MMBR5179	7H	1.5	5.0	6.0	4.0	1.5	6.0	11.0	5.0	6.0	450
MMBR920	7B	5.0	14	10	2.4	2.0	10	17	14	10	1000
MMBR901	7A	4.0	15	10	2.3	5.0	6.0	10.5	15	10	1000
MMBR5031	7G	2.0	5.0	6.0	1.9	1.0	6.0	13.5	5.0	6.0	450
MMBR2857	7K	1.0	4.0	10	—	—	—	—	—	—	—
BFS17	E1	1.0	2.0	5.0	5.0	2.0	5.0	—	—	—	30

PNP

MMBR4957	7F	2.0	2.0	10	2.5	2.0	10	14.5	2.0	10	450
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TABLE 10. RF Junction Field-Effect SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

N-CHANNEL

Device	Marking	NF		Y_{fs}			$V_{(BR)GSS}$
		Typ (dB)	f (MHz)	Min (mmhos)	Max (mmhos)	V_{DS} (V)	
MMBFU310	6C	1.5	100	10	18	10	-25
MMBF5484	6B	2.0	100	3.0	6.0	15	-25
MMBF5486	6H	2.0	100	4.0	8.0	15	-25
MMBF4416	6A	2.0	100	4.5	7.5	15	-30
MMBFJ310	6T	4.0	450	8.0	18	10	-25

TABLE 11. General-Purpose Field-Effect SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

N-CHANNEL

Device	Marking	$V_{(BR)GSS}$	Y_{fs}			I_{DSS}	
			Min (mmhos)	Max (mmhos)	V_{DS} (V)	Min (mA)	Max (mA)
MMBF5457	6D	-25	1.0	5.0	15	1.0	5.0
BFR30	M1	-25	1.0	4.0	10	4.0	10
BFR31	M2	-25	1.5	4.5	10	1.0	5.0
MMBF5459	6L	-25	2.0	6.0	15	4.0	16

P-CHANNEL

MMBF5460	6E	40	1.0	4.0	15	1.0	5.0
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TABLE 12. Chopper/Switches, Junction Field-Effect SOT-23 Transistors

N-CHANNEL

Device	Marking	$r_{DS(on)}$ Max (Ohms)	t_{off} Max (ns)	$V_{(BR)GSS}$	$V_{(GS)} \text{ off}$		I_{DSS}	
					Min (V)	Max (V)	Min (mA)	Max (mA)
MMBF4391	6J	30	20	-30	-4.0	-10	50	150
MMBF4860	6F	40	50	-30	-2.0	-6.0	20	100
MMBF4392	6K	60	35	-30	-2.0	-5.0	25	75
MMBF4393	6G	100	55	-30	-0.5	-3.0	5.0	30

MICROMINIATURE PRODUCTS (continued)



TABLE 13. SOT-23 Switching Diodes
(Dual Unless Otherwise Noted)

Diode Pinout: Noted Below

Device	Marking	Description	t _{rr} Max (ns)	V _{BR} Min (V)	I _R Max (μA)	V _F			C _{Vr} Max (pF)
						Min (V)	Max (V)	@ I _F (mA)	
MMBD2836	A2	Common Anode	(5) 6(1)	75	0.1	—	1.0	10	4.0
BAW56	A1	Common Anode	(5) 6(1)	70	2.5	—	1.1	50	1.5
MMBD2835	A3	Common Anode	(5) 6(1)	35	0.1	—	1.0	10	4.0
BAV74	JA	Common Cathode	(3) 2(2)	50	0.1	—	1.0	100	2.0
MMBD2838	A6	Common Cathode	(3) 6(1)	75	0.1	—	1.0	10	4.0
BAV70	A4	Common Cathode	(3) 6(1)	70	2.5	—	1.1	50	1.5
MMBD2837	A5	Common Cathode	(3) 6(1)	35	0.1	—	1.0	10	4.0
MMBD6100	5B	Common Cathode	(3) 15(1)	70	0.1	0.85	1.1	100	2.5
MMBD914	5D	Single	(6) 4(2)	100	0.05	—	1.0	10	4.0
BAS16	A6	Single	(6) 6(1)	75	1.0	—	0.715	1.0	2.0
BAL99	TF	Single	(7) 6(1)	70	2.5	—	1.1	50	1.5
MMBD6050	5A	Single	(6) 10(1)	70	0.1	0.85	1.1	100	2.5
BAV99	A7	Series	(4) 6(1)	70	2.5	—	1.1	50	1.5
MMBD7000	5C	Series	(4) 15(1)	100	0.3	0.75	1.1	100	1.5

- NOTES: (1) I_F = I_R = 10 mA, V_R = 5.0 V, I_{RR} = 1.0 mA
 (2) I_F = I_R = 10 mA, V_R = 6.0 V, I_{RR} = 1.0 mA
 (3) Pinout: 1-Anode, 2-Anode, 3-Cathode
 (4) Pinout: 1-Anode, 2-Cathode, 3-Cathode and Anode
 (5) Pinout: 1-Cathode, 2-Cathode, 3-Anode
 (6) Pinout: 1-Anode, 2-N.C., 3-Cathode
 (7) Pinout: 1-N.C., 2-Anode, 3-Cathode

TABLE 14. SOT-23 Tuning Diodes

Tuning Diode Pinouts: 1-Anode, 2-N.C., 3-Cathode

Device	Marking	B _{VR}		C _T			Capacitance Ratio		Q			R _S	V _F		I _R	
		Min (V)	@ I _R (μA)	Min (pF)	Max (pF)	@ V _R (V)	Min	Max	Min	@ V _R (V)	& f (MHz)	Max (ohms)	Max (V)	@ I _F (mA)	Max (μA)	@ V _R (V)
MMBV2097	4K	30	10	.8	1.2	4	2	2.6	325	4	100	—	—	—	.02	25
MMBV2098	4L			1.8	2.7			2.8								
MMBV105G	4E	30	10	1.8	2.8	2.5	4	6	150	(1)	100	—	—	—	.05	28
MMBV2101	4G			6.1	7.5			2.5								
MMBV2103	4H			9.0	11	4	2.6	400	4	50	—	—	—	.02	25	
MMBV3102	4C			30	10											20
MMBV2108	4X	30	10	24.3	29.7	4	2.7	3.3	300	4	50	—	—	—	.02	25
MMBV109	4A	30	10	26	32	.3	5	6.5	280	3	50	—	—	—	.02	25
MMBV2109	4J	30	10	29.7	36.3	4	2.7	3.3	200	4	50	—	—	—	.02	25

"PIN" CHANNEL SWITCH

MMBV3401	4D	35	10	—	1	20	—	—	—	—	—	.7	—	—	.1	25
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HOT CARRIER DIODES

MMBD101	4M	4	10	—	1	0	—	—	—	—	—	—	.6	10	.25	3	
MMBD352 (Dual)	5G	4	.25	—		—	—	—	—	—	—	—	.50		1.2	.2	25
MMBD501	5F	50	10	—		20	—	—	—	—	—	—	—				

Notes: (1) Voltage such that C_T = 9.0 pF.

MICROMINIATURE PRODUCTS (continued)

TABLE 15. SOT-23 Zener Diodes

Pinout 1-Anode, 2-N.C., 3-Cathode (Tolerance \pm 5%)

VZ (Nom) Volts	U.S. Standards	Device Marking	Pro-Electron Equivalent	Device Marking
3.3	MMBZ5226	8A		
3.6	MMBZ5227	8B		
3.9	MMBZ5228	8C		
4.3	MMBZ5229	8D		
4.7	MMBZ5230	8E	BZX84C4V7	Z1
5.1	MMBZ5231	8F	BZX84C5V1	Z2
5.6	MMBZ5232	8G	BZX84C5V6	Z3
6.0	MMBZ5233	8H		
6.2	MMBZ5234	8J	BZX84C6V2	Z4
6.8	MMBZ5235	8K	BZX84C6V8	Z5
7.5	MMBZ5236	8L	BZX84C7V5	Z6
8.2	MMBZ5237	8M	BZX84C8V2	Z7
8.7	MMBZ5238	8N		
9.1	MMBZ5239	8P	BZX84C9V1	Z8
10.0	MMBZ5240	8Q	BZX84C10	Z9
11.0	MMBZ5241	8R	BZX84C11	Y1
12.0	MMBZ5242	8S	BZX84C12	Y2
13.0	MMBZ5243	8T	BZX84C13	Y3
14.0	MMBZ5244	8U		
15.0	MMBZ5245	8V	BZX84C15	Y4
16.0	MMBZ5246	8W	BZX84C16	Y5
17.0	MMBZ5247	8X		
18.0	MMBZ5248	8Y	BZX84C18	Y6
19.0	MMBZ5249	8Z		
20.0	MMBZ5250	81A	BZX84C20	Y7
22.0	MMBZ5251	81B	BZX84C22	Y8
24.0	MMBZ5252	81C	BZX84C24	Y9
25.0	MMBZ5253	81D		
27.0	MMBZ5254	81E	BZX84C27	Y10
28.0	MMBZ5255	81F		
30.0	MMBZ5256	81G	BZX84C30	Y11
33.0	MMBZ5257	81H	BZX84C33	Y12

TABLE 16. SOT-23 Silicon Controlled Rectifier

Rectifier Pinouts: 1-Cathode, 2-Gate, 3-Anode

Device	Marking	I_F (mA)	V_{FXM} (mA)	I_{GT} (μ A)	V_{GT} (V)	I_H (mA)
MMBS5062	5T	500	100	200	.8	5
MMBS5061	5S	500	50	200	.8	5
MMBS5060	5R	500	25	200	.8	5

MICROMINIATURE PRODUCTS (continued)

TABLE 17. SOT-23 Silicon Programmable Unijunction Transistors

Transistor Pinouts: 1-Cathode, 2-Gate, 3-Anode

Device	Marking	I_{TRM} (Amp) (1)	I_{TSM} (Amp) (2)	Max (μA) I_p (3)	Min (V) V_T	Max (V)	Max (μA) I_V (3)	Max (V) V_F
MMBPU131	5Z	1	1	2	.2	.7	50	1.5

NOTES:

1. Repetitive Peak Forward Current
100 μs Pulse Width
1.0% Duty Cycle
2. Non-Repetitive Peak Forward Current
10 μs Pulse Width
3. $V_S = 10$ Vdc, $R_G = 1.0$ m Ω

TABLE 18. SOT-89 Transistors

Pinout: 1-Base, 2-Collector, 3-Emitter

General Purpose

NPN

Device	$V_{BR}(CEO)$	hFE			f_T Min (MHz)
		Min	Max	@ I_C (mA)	
BCX56	80	40	160	150	50
BCX55	60	40	160	150	50
BCX54	45	40	250	150	50
MXT3904	40	100	300	10	300
BCX68	20	85	375	500	65

PNP

BCX53	80	40	160	150	50
BCX52	60	40	160	150	50
BCX51	45	40	250	150	50
MXT3906	40	100	300	10	250
BCX69	20	85	375	500	65

High Voltage

NPN

MXTA44	400	50	200	10	—
MXTA42	300	40	—	10	50
MXTA43	200	50	200	30	—

PNP

MXTA92	300	40	—	10	50
MXTA93	200	30	150	30	50

Darlingtons

Device	hFE			$V_{BR}(CBO)$	$V_{CE(sat)}$ Max (V)
	Min	Max	@ I_C (mA)		

NPN

MXTA27	10 K	—	10	60	1.5
MXTA14	10 K	—	10	30	1.5

PNP

MXTA77	10 K	—	10	60	1.5
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MICROMINIATURE PRODUCTS (continued)

TABLE 18. SOT-89 Transistors (continued)

Pinout: 1-Base, 2-Collector, 3-Emitter

RF

NPN

Device	t_T		$V_{BR}(CEO)$	h_{FE}		
	Min (MHz)	I_C (mA)		Min	Max	I_C (mA)
BFQ19	4000	50	15	25	—	50
BFQ18A	3200*	—	15	25	—	50
MXR5943	1200	50	30	25	300	50
BFQ17	1200	150	25	25	—	50
MR3866	500	50	30	10	200	50

PNP

MXR583	1000	40	30	25	100	100
MXR5160	500	50	40	10	—	50

*Typ

Micro-T Transistors

Micro-T devices combine high performance with extremely small physical size. The devices shown in these tables are available from stock; all other Motorola small-signal transistors may be obtained in Micro-T packages on special order.

GENERAL-PURPOSE AND SWITCHING TRANSISTORS

For general-purpose applications and for designs requiring fast switching. Complete data sheets are available for prime devices; equivalent data sheets may be obtained when the same die is used in other 2N—standard devices. For devices not listed, contact your nearest Motorola representative or distributor. Ceramic packages with a cold sealing process are also available on demand.



Case 28

Package	NPN Types		PNP Type	
Plastic	MMT2222	MMT3904	MMT2369	MMT2907
Ceramic	MMCM2222	MMCM3904	MMCM2369	MMCM2907
Design Parameters				
BV _{CEO}	To 60 V	To 40 V	To 15 V	To 60 V
Operating h _{FE} Range	100 μ A to 500 mA	100 μ A to 100 mA	10 mA to 100 mA	100 μ A to 500 mA
f _T (Typ)	300 MHz 20 mA	300 MHz 10 mA	650 MHz 10 mA	350 MHz 50 mA
t _{on} (Typ)	25 ns	40 ns	2.0 ns	30 ns
	150 mA	10 mA	10 mA	150 mA
t _{off} (Typ)	250 ns	140 ns	15 ns	100 ns

RF AMPLIFIER

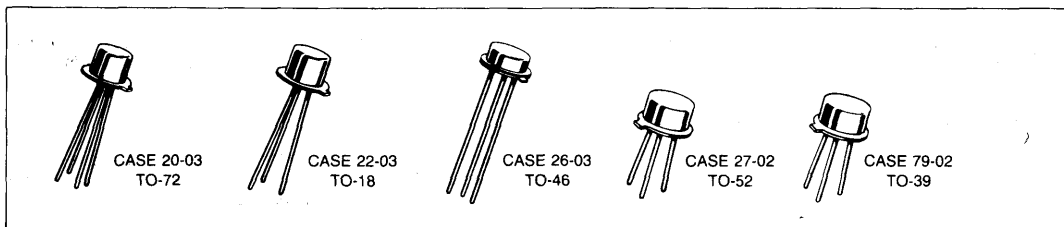
Standard RF devices in Micro-T packages are designed for applications where limited space is critical. This package is particularly attractive from a pre-testing and cost point of view as the RF parameters can be 100% tested for high performance. For complete design data, consult the prime device data sheet. For other devices not listed, contact your nearest Motorola sales representative or distributor. Ceramic packages with a cold sealing process are also available on demand.



Case 28

Package	NPN Type
Plastic	MMT918
Ceramic	MMCM918
BV _{CEO}	15 V
Operating h _{FE} Range	3.0 mA
f _T (Typ)	600 MHz 4.0 mA
NF (Typ)	6.0 dB 1.0 mA
G _{pe} (Typ)	15 dB 200 MHz
t _{on} (Typ)	

Metal Small-Signal Transistors



Motorola Small-Signal Metal Can Transistors are designed for use as General-Purpose Amplifiers, High-Speed Switches, High-Voltage Amplifiers, Low-Level/Low-Noise Amplifiers, High-Frequency Oscillators, Choppers, and Darlingtons. These devices are manufactured in a variety of packages, i.e., TO-18, TO-39, TO-46, TO-52, and TO-72.

The following selector guide tables also indicate those Motorola small-signal metal can transistors which are qualified under CECC 50000, and MIL-19500 high-rel requirements. Devices are available to CECC Levels L, F and E (see qualified products Table page 26). JAN, JANTX, JANTXV and JANS versions as specified.

TABLE 1. Switching Transistors

The following devices are intended for use in general-purpose switching and amplifier applications. Within each package group shown, the devices are listed in order of decreasing turn-on time (t_{ON}).

Package	Device Type	t_{on} ns Max	t_{off} ns Max	@ I_C mA	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	@ I_C mA	@ I_B mA	f_T MHz Min	I_C mA	Comments
TO-18	2N4014	35	60	500	50	1000	35	500	0.52	500	50	300	50	Exists under CECC Exists under CECC
	2N2369	12	18	100	15	500	20	100	0.25	10	1.0	500	10	
	2N2369A†	12	18	10	15	200	40	10	0.2	10	1.0	500	10	
	2N3227	12	18	100	20	50	30	100	0.25	10	1.0	500	10	
	BSX20	7	18	100	15	500	20	10	0.25	10	1.0	400	10	
TO-39	2N3735#	48	60	1000	50	1500	20	1000	0.5	500	50	250	50	
	2N3506#	45	90	1500	40	3000	40	1500	1.0	1500	150	60	100	
	BSX60	40	70	500	30	1000	30	500	0.5	500	50	—	—	
	2N3725	35	60	500	50	2000	35	500	0.52	500	50	300	50	
	BSX59	35	60	500	45	1000	25	500	0.5	500	50	—	—	
	2N3724	35	60	500	30	2000	35	500	0.42	500	50	300	50	
2N3303	15	25	1000	—	1000	20	10	0.7	1000	100	450	100		
TO-46	2N3737#	48	60	1000	50	1500	20	1000	0.5	500	50	250	50	
	2N3647	20	25	150	10	500	25	150	0.4	150	15	350	15	
	2N3509	12	18	10	20	500	100	10	0.25	10	1.0	500	10	

PNP

TO-18	2N2894	60	90	30	12	200	40	30	0.2	30	3.0	400	30	
	2N3546	40	30	50	12	200	25	50	0.25	50	5.0	700	10	
	2N4208	15	20	10	12	200	30	10	0.15	10	1.0	700	10	
	2N4209	15	20	10	15	50	40	50	0.6	50	5.0	850	10	
TO-39	2N3635#	400	600	50	140	1000	100	50	0.5	50	5.0	200	30	
	2N3636#	400	600	50	175	1000	50	50	0.5	50	5.0	150	30	
	2N4036	110	700	150	65	1000	40	150	0.65	150	15	60	50	
	2N4033#	100	240	500	80	1000	25	1000	0.5	500	50	150	50	
			(typ)											
	2N4407	75	225	1000	80	1500	30	1000	0.7	1000	100	150	50	
	2N3244	50	185	500	40	1000	50	500	0.5	500	50	175	50	
	2N3467#	40	90	500	40	100	40	500	0.5	500	50	175	50	
	2N3762#	43	115	1000	40	1500	30	1000	0.9	1000	100	180	50	
	2N4405**	40	210	500	80	1000	50	500	0.5	500	50	200	50	

*JAN available

**JAN/JANTX available

†JAN/JANTX/JANTXV/JANS available

#JAN/JANTX/JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 2. Darlington Transistors

These transistors are characterized for very high gain and input impedance applications. Devices are of monolithic construction.

Package	Device Type	V _{(BR)CEO} Volts Min	I _C mA Max	h _{FE}		I _C mA	V _{CE(sat)} Volts Max	I _C mA	I _B mA
				Min	Max				
NPN									
TO-18	MM6427	40	300	5000		10	1.5	100	0.1
TO-39	BSS52	80	1000	2000	—	500	1.6	1000	4.0
	BSS51	60	1000	2000	—	500	1.6	1000	1.0
	BSS50	45	1000	2000	—	500	1.6	1000	4.0
PNP									
TO-39	BSS62	80	1000	2000	—	500	1.8	1000	4.0
	BSS61	60	1000	2000	—	500	1.8	1000	1.0
	BSS60	45	1000	2000	—	500	1.8	1000	4.0

TABLE 3. High-Frequency Amplifiers/Oscillators

The transistors shown are designed for use as both oscillators and amplifiers at UHF and VHF frequencies. Devices are listed in decreasing order of V_{(BR)CEO} with each line.

Package	Device Type	V _{(BR)CEO} Volts Min	h _{FE} Min	I _C mA	G _{pe} dB Min	NF dB Max	f MHz	f _T MHz Min	I _C mA	C _{obo} pF Max
NPN										
TO-72	2N918†	15	20	3.0	15	6.0	60	600	4.0	1.7
PNP										
TO-72	2N4261#	15	30	10	—	—	—	1600	10	2.5

*JAN available

**JAN/JANTX available

†JAN/JANTX/JANTXV/JANS available

#JAN/JANTX/JANTXV available

TABLE 4. High-Voltage/High-Current Amplifiers

The following table lists Motorola standard devices that have high Collector-Emitter Breakdown Voltage. Devices are listed in decreasing order of V_{(BR)CEO} within each package type.

Package	Device Type	V _{(BR)CEO} Volts Min	I _C mA Max	h _{FE}		V _{CE(sat)} Volts Max	I _C mA	I _B mA	f _T MHz Min	I _C mA	Comments
				Min	@ I _C mA						
NPN											
TO-18	BSS73	300	500	40	30	0.5	50	5	100	20	
	BSS72	250	500	40	30	0.5	50	5	100	20	
	BSS71	200	500	40	30	0.5	50	5	100	20	
	BC394	180	500	30	10	0.3	10	1.0	50	20	
TO-39	2N3439#	350	1000	40	20	0.5	50	4	15	10	Exists under CECC
	MM421	325	1000	25	30	5.0	30	3	15	10	
	BF259	300	100	25	30	1.0	30	6	110	30	
	BF258	250	100	25	30	1.0	30	6	110	30	
	2N3440#	250	1000	40	20	0.5	50	4	15	10	Exists under CECC
	BSS78	250	500	40	30	0.4	30	3	70	20	
	BF337	200	200	20	30	—	—	—	80	30	
	BSS77	200	500	40	30	0.4	30	3	70	20	

JAN JANTX, JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 4. High-Voltage/High-Current Amplifiers (continued)

The following table lists Motorola standard devices that have high Collector-Emitter Breakdown Voltage. Devices are listed in decreasing order of $V_{(BR)CEO}$ within each package type.

Package	Device Type	$V_{(BR)CEO}$		I_C mA	h_{FE} @ I_C		$V_{CE(sat)}$			f_T		Comments
		Volts	Min		Min	@ I_C mA	Volts	@ I_C mA	& I_B mA	MHz	@ I_C mA	
TO-39	BUY49S	200		3000	40	500	0.2	500	50	—	—	
	BF257	160		100	25	30	1.0	30	6	110	30	
	BSW68A	150		2000	30	500	1.0	500	150	—	—	
	2N3114	150		200	30	30	1.0	50	5.0	40	30	
	2N3501#	150		300	100	150	0.4	150	15	150	20	
	BSW67A	120		2000	30	500	1.0	500	150	—	—	
	2N5682	120		1000	40	250	0.6	250	25	30	100	
	2N4924	100		200	40	150	0.4	50	5.0	100	20	
	MM3007	100		2500	50	250	0.35	150	15	50	50	
	2N5681	100		1000	40	250	0.6	250	25	30	100	
	2N4239	80		3000	30	250	0.3	500	50	2	100	
	MM3005	60		2500	50	150	0.35	150	15	50	50	
	2N4237	40		3000	30	250	0.3	500	50	2	100	

PNP

TO-18	BSS76	300		500	35	30	0.5	50	5.0	100	20	
	BSS75	250		500	35	30	0.5	50	5.0	100	20	
	BSS74	200		500	35	30	0.5	50	5.0	100	20	
	BC393	180		500	50	10	0.3	10	1.0	50	20	
	2N3497	120		100	40	10	0.35	10	1.0	150	20	
TO-39	2N5416#	300		1000	30	50	2.5	50	5	15	10	Exists under CECC
	MM4003	250		500	20	10	5.0	10	1.0	—	—	
	2N5415#	200		1000	30	50	2.5	50	5	15	10	Exists under CECC
	2N3637#	175		1000	100	50	0.5	50	5.0	200	30	
	2N3636#	175		1000	50	50	0.5	50	5.0	150	30	
	MM4001	150		500	20	10	0.6	10	1.0	—	—	
	2N3635#	140		1000	100	50	0.5	50	5.0	200	30	
	2N3634#	140		1000	50	50	0.5	50	5.0	150	30	
	2N3495	120		100	40	10	0.35	10	1.0	150	20	
	2N5680	120		1000	40	250	0.6	250	15	30	100	
	MM4000	100		100	20	10	0.6	10	1.0	—	—	
	MM5007	100		2000	50	250	0.5	150	15	30	50	
	2N5679	100		1000	40	250	0.6	250	25	30	100	
	2N5679	100		1000	40	250	0.6	250	25	30	100	
	2N4236	80		3000	30	250	0.6	1000	125	3	100	
	2N4036	65		1000	40	150	0.65	150	15	60	50	
	MM5005	60		2000	50	150	0.5	150	15	30	50	
2N4235	60		3000	30	250	0.6	1000	125	3	100		
2N4234	40		3000	30	250	0.6	1000	125	3	100		

JAN, JANTX, JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 5. General-Purpose Amplifiers

These transistors are designed for dc to VHF amplifier applications, general-purpose switching applications, and complementary circuitry. Devices are listed in decreasing order of $V_{(BR)CEO}$ within each package group.

Package	Device Type	$V_{(BR)CEO}$ Volts Min	f_T MHz @	I_C mA	I_C mA Max	h_{FE}		I_C mA	Comments	
						Min	Max			
TO-18	2N2896	90	120	50	1000	60	200	150	Exists under CECC HFE groups Exists under CECC A, B, C, HFE groups Exists under CECC A, B, C, HFE groups Exists under CECC B, C, HFE groups	
	2N3700#	80	80	1.0	1000	50	500	500		
	2N2484#	60	15	0.05	50	100	500	0.01		
	2N930	45	30	0.5	30	100	300	0.01		
	BCY59	45	125	10	200	120	630	2		
	BC107	45	150	10	100	110	800	2		
	2N2222A#	40	300	20	800	100	300	150		
	BCY58	32	125	10	200	120	630	2		
	2N2222#	30	250	20	800	100	300	150		
	BSX51	25	150	10	200	75	225	2		
	BSX52	25	150	10	200	180	540	2		
	BC108	20	150	10	100	110	800	2		
	BC109	20	150	10	100	200	800	2		
	TO-39	BSX47	80	50	50	1000	40	400		150
		2N1711	80	70	50	1000	100	300		150
2N3019#		80	100	50	1000	100	300	150		
BSX46		60	50	50	1000	40	250	100		
BC141		60	50	50	1000	40	400	100		
2N1613#		50	60	50	500	40	120	150		
BSX45		40	50	50	1000	40	250	100		
BC140		40	50	50	1000	40	400	100		
2N2219A#		40	300	20	800	100	300	150		
2N3053		40	100	50	700	50	250	150		
BFY50		35	60	50	1000	30	—	150		
BFY51		30	50	50	1000	40	—	150		
2N2219#		30	250	20	800	100	300	150		
BFY52		20	50	50	1000	50	—	150		

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 5. General-Purpose Amplifiers (continued)

Package	Device Type	V _{(BR)CEO} Volts Min	f _T MHz Min	@ I _C mA	I _C mA Max	h _{FE}		@ I _C mA	Comments
						Min	Max		
PNP									
TO-18	2N3963	80	40	0.5	200	100	450	0.01	Exists under CECC Exists under CECC Exists in A, B, C HFE groups Exists in VII, VIII, IX, X HFE groups Exists under CECC Exists under CECC Exists in VII, VIII, IX, X HFE groups Exists in A, B, C HFE groups Exists in A, B, C HFE groups
	2N4026	80	100	50	1000	15	—	100	
	2N4029	80	150	50	1000	25	—	100	
	2N3799	60	30	0.5	50	300	900	0.5	
	2N2906A#	60	200	50	600	40	120	150	
	2N2907A†	60	200	50	600	100	300	150	
	2N3964	45	50	0.5	200	250	600	0.01	
	BC177	45	130	10	100	70	500	2	
	BCY79	45	180*	10	200	120	630	2	
	BCY71	45	200	10	200	100	600	10	
	2N2906#	40	200	50	600	40	120	150	
	2N2907#	40	200	50	600	100	300	150	
	BCY70	40	250	10	200	50	—	10	
	2N3251	40	300	10	200	100	300	10	
	BCY78	32	180*	10	200	120	630	2	
	BC178	30	130	10	100	70	800	2	
	BCY72	25	200	10	200	50	—	10	
BC179	20	130	10	100	120	800	2		
TO-39	MM5007	100	30	50	2000	50	250	250	Exist en -6, -10 HFE groups Exists in -6, -10, -16 HFE groups Exists in -6, -10, -16 HFE groups Exists under CECC Exists under CECC Exists in -6, -10, -16 HFE groups Exists in -6, -10, -16 HFE groups Exists under CECC Exists under CECC
	BSV17	80	50	50	1000	40	160	100	
	2N4033#	80	150	50	1000	25	—	100	
	2N4405**	80	200	50	1000	100	300	150	
	BFX41	75	100	50	1000	40	—	100	
	BFX40	75	100	50	1000	85	—	100	
	2N4036	65	60	50	1000	40	140	150	
	BSV16	60	50	50	1000	40	250	100	
	BC161	60	50	50	1000	40	400	100	
	2N2904A#	60	200	50	600	40	120	150	
	2N2905A†	60	200	50	600	100	300	150	
	BC160	40	50	50	1000	40	400	100	
	BSV15	40	50	50	1000	40	250	100	
	2N2904#	40	200	50	600	40	120	150	
2N2905#	40	200	50	600	100	300	150		
TO-46	2N2605#	45	30	0.5	30	100	300	0.01	
	2N3486	40	200	50	600	100	300	150	

* JAN available

** JAN/JANTX available

JAN/JANTX/JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 6. Choppers

Devices are listed in decreasing $V_{(BR)EBO}$.

Package	Device	$V_{(BR)EBO}$ Min	$V_{(BR)ECO}$	Min $h_{FE(inv)}$	Offset Voltage $V_{EC(ofs)}$ Max (mV)	On-State Resistance $r_{ec(on)}$ Max (Ω)
TO-46	2N2946	40	35	3.0	2.0	45
	2N2946A	40	35	20	2.0	8.0
	2N5230	30	20	15	0.5	8.0
	2N5231	30	20	15	0.8	10
	2N2945A	25	20	30	1.0	6.0
	2N2945	25	20	4.0	1.0	35
	2N5229	15	10	15	0.5	6.0

JAN/JANTX available

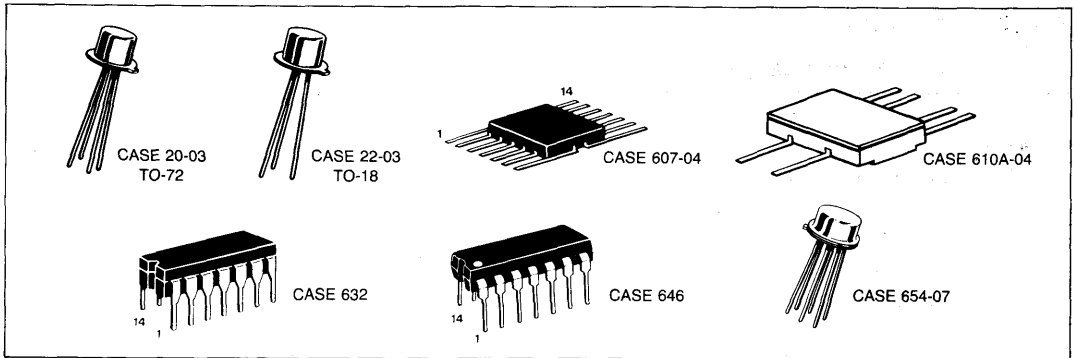
TABLE 7. CECC Qualified Types

Qualified products to CECC 50000

All CECC types are available to assessment levels E, F, L

2N1613 (CECC)	2N2369 (CECC)	2N3440 (CECC)
2N1711 (CECC)	2N2369A (CECC)	2N5415 (CECC)
2N1893 (CECC)	2N2484 (CECC)	2N5416 (CECC)
2N2218 (CECC)	2N2904 (CECC)	BC107-108-109 (CECC)
2N2218A (CECC)	2N2904A (CECC)	CV8616 (CECC)
2N2219 (CECC)	2N2905 (CECC)	CV9507 (CECC)
2N2219A (CECC)	2N2905A (CECC)	CV9543 (CECC)
2N2221 (CECC)	2N2906 (CECC)	PO7726 (CECC)
2N2221A (CECC)	2N2906A (CECC)	
2N2222 (CECC)	2N2907 (CECC)	
2N2222A (CECC)	2N2907A (CECC)	
2N2368 (UTE)	2N3439 (CECC)	

Multiple Small-Signal Transistors



The trend in electronic system design is toward the use of integrated circuits — to reduce component cost, assembly cost, and equipment cost. But ICs still aren't all things to all people, and for those circuit designs where ICs are not available, there is a noticeable swing towards the use of multiple devices.*

Motorola is reacting to this expanding market requirement by making available a large selection of Quad, Dual, and Darlington transistors for off-the-shelf delivery. The chips used in the Quad and Dual transistors are those that have emerged as the most popular ones for discrete transistor applications. But even be-

yond that, Motorola offers its entire vast repertoire of discrete small-signal transistors for multiple-device packaging. For special applications where the devices in this brochure might not quite fit the design requirements, special configurations can be supplied with quick turnaround time and at low premiums.

*Multiple devices, as described here, encompass two or more transistor chips in a single package. Included in this definition are the Darlington transistors which consist of two interconnected devices functioning as a single-stage amplifier.

Specification Tables

The following short form specifications include Quad and Dual transistors listed in alphanumeric order. Some columns denote two different types of data indicated by either **bold** or *italic* typeface. See key and headings for proper identification.

KEY	TYPE NO	ID	P _D Watts One Die Only	V _{CE} Volts Subscript Ref Point	I _C Amp Max	hFE @ I _C		f _T MHz Min	C _{ob} pF Max	hFE1	V _{BE}	G _p	NF	@ f	PACKAGE TO Case No. No.
						Min	Max			mV Max	dB Min	dB Max	Unit		
Alphanumeric listing type numbers						Common-emitter DC Current Gain						G _p - Power Gain NF - Noise Figure f - Test Frequency AUD - 10-15k Hz Frequency Units: H - Hertz K - kHz M - MHz G - GHz V _{CE(sat)} - Collector-Emitter Saturation Voltage I _C - Test Current Current Units: u - μA m - mA A - Amp			JEDEC Outline/ Motorola Package Outline
Identification Code 1st Letter: Polarity C - both types in multiple device N - NPN P - PNP 2nd Letter: Use A - General Purpose Amplifier E - Low Noise Audio Amplifier F - Low Noise RF Amplifier G - General Purpose Amplifier and Switch H - Tuned RF IF Amplifier M - Differential Amplifier S - High Speed Switch						Units for test current: A - ampere m - mA u - μA						hFE1/hFE2 - Current Gain Ratio V _{BE} - Differential Base Voltage VBE1 - VBE2 Differential Amplifiers t _{on} - turn-on time t _{off} - turn-off time			
Power Dissipation specified at 25°C Single die rating. Ref. Point: A - Ambient temperature C - Case temperature						Current Gain Bandwidth Product						Output Capacitance, common-base Shown without distinction. C _{cb} - Collector-Base Capacitance C _{ce} - Common-Emitter Reverse Transfer Capacitance			
						Continuous (DC) Collector Current						Rated maximum Collector-Emitter Voltage Subscript letter identifies base termination listed below in order of preference SUBSCRIPT O - V _{CEQ} , open			

MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

TABLE 1. Quad Transistors

TYPE NO.	ID	P _D Watts One Die Only	Ref. Point	V _{CE} Volts	Subscript	I _C Amp Max	h _{FE} Min	@ I _C Unit	f _T MHz Min	C _{ob} pF Max Typ*	t _{on} ns Max Typ*	t _{off} ns Max Typ*	ΔV _{BE} mV Max	G _p dB Min	NF dB Max Typ*	@ f Unit	PACKAGE			
																	TO- No.	Case No.		
MHQ918	NF	0.65 A	15	○	0.05	20	3.0 m	600	2.0						6.0	60 M	116	632		
MHQ2222	NG	0.65 A	40	○	0.5	100	150 m	200	8.0	25*	250*	.4	10	10 m	116	632	116	632		
MHQ2369	NS	0.5 A	15	○	0.5	40	10 m	450	4.0	9.0*	15*	.25	10	10 m	116	632	116	632		
MHQ2484	NA	0.6 A	40	○	0.05	300	1.0 m	50						2*	AUD	116	632	116	632	
MHQ2907	PG	0.65 A	40	○	0.6	100	150 m	200	8.0	30*	100*	.4	10	150 m	116	632	116	632		
MHQ3467	PS	0.9 A	40	○	1.0	20	500 m	125	25	40	90	.5	10	500 m	116	632	116	632		
MHQ3546	PS	0.5 A	12	○	0.2	30	10 m	600	6.0	15*	25*	.25	10	10 m	116	632	116	632		
MHQ3799	PA	0.5 A	60	○	0.05	300	0.1 m	60	4.0					2*	AUD	116	632	116	632	
MHQ4014	NS	0.75 A	45	○	1.5	35	500 m	200	10	35	60	.52	10	500 m	116	632	116	632		
MHQ6001	CA	0.65 A	30	○	0.5	40	150 m	200	8.0	30*	225*	.4	10	150 m	116	632	116	632		
MHQ6002	CA	0.65 A	30	○	0.5	100	150 m	200	8.0	30*	225*	.4	10	150 m	116	632	116	632		
MHQ6100	CA	0.5 A	40	○	0.05	75	1.0 m	175*	4.5*			.25			1.0 m	116	632	116	632	
MPQ918	NA	0.625 A	15	○	0.05	20	3.0 m	600	1.7					6.0	60 M		646		646	
MPQ2222	NA	0.65 A	30	○	0.5	100	150 m	200	8.0	25*	250*	.4	10	150 m		646		646		
MPQ2369	NS	0.5 A	15	○	0.5	40	10 m	450	4.0	9.0*	15*	.25	10	10 m		646		646		
MPQ2484	NA	0.625 A	40	○	0.05	300	1.0 m	50						2*	AUD		646		646	
MPQ2907	PA	0.65 A	40	○	0.6	100	150 m	200	8.0	30*	100*	.4	10	150 m		646		646		
MPQ3467	PS	0.75 A	40	○	1.0	20	500 m	125	25	40	90	0.5	10	500 m		646		646		
MPQ3546	PA	0.5 A	12	○	0.2	30	10 m	600	6.0	15*	25*	.25	10	10 m		646		646		
MPQ3725	NS	1.0 A	40	○	1.0	25	500 m	250	10	35	60	.45	10	500 m		646		646		
MPQ3762	PS	0.75 A	40	○	1.5	35	150 m	150	15	50	120	.55	10	500 m		646		646		
MPQ3799	PA	0.625 A	60	○	0.05	300	0.1 m	60	4.0					2*	AUD		646		646	
MPQ3904	NG	0.50 A	40	○	0.2	75	10 m	250	4.0	37*	136*	0.2	10	10 m		646		646		
MPQ3906	PG	0.50 A	40	○	0.2	75	10 m	200	4.5	43*	155*	.25	10	10 m		646		646		
MPQ6001	CG	0.65 A	30	○	0.5	40	150 m	200	8.0	30*	225*	0.4	10	150 m		646		646		
MPQ6002	CG	0.65 A	30	○	0.5	100	150 m	200	8.0	30*	225*	0.4	10	150 m		646		646		
MPQ6100	CA	0.5 A	40	○	0.05	75	1.0 m	50	4.0					4*	AUD		646		646	
MPQ6501	CG	0.65 A	30	○	0.5	40	150 m	200	8.0	30*	225*	0.4	10	150 m		646		646		
MPQ6502	CG	0.65 A	30	○	0.5	100	150 m	200	8.0	30*	225*	0.4	10	150 m		646		646		
MPQ6600	CA	0.5 A	40	○	0.05	75	1.0 m	50	4.0					4*	AUD		646		646	
MPQ6842	CA	0.75 A	40	○	0.5	70	10 m	300	4.5	45	150	0.15	10	0.5 m		646		646		
MPQ7042	NA	0.75 A	200	○	0.5	25	1.0 m	50	5.0			0.5	10	20 m		646		646		
MPQ7043	NA	0.75 A	250	○	0.5	25	1.0 m	50	5.0			0.5	10	20 m		646		646		
MPQ7052	CA	0.75 A	200	○	0.5	25	1.0 m	50	5.0			0.7	10	20 m		646		646		
MPQ7053	CA	0.75 A	250	○	0.5	25	1.0 m	50	5.0			0.7	10	20 m		646		646		
MPQ7092	PA	0.75 A	200	○	0.5	25	1.0 m	50	5.0			0.5	10	20 m		646		646		
MPQ7093	PA	0.75 A	250	○	0.5	35	10 m	50	5.0			0.5	10	20 m		646		646		
MQ918	NA	0.55 A	15	○	0.05	50	3.0 m	600	1.7					6.0	60 M		607		607	
MQ2219	NA	0.6 A	30	○	0.5	100	150 m	200	8.0					0.3	10	150 m		607		607
MQ2369	NS	0.40 A	15	○	0.5	40	10 m	500	4.0	15	20	.25	10	10 m		607		607		
MQ2484	NE	0.4 A	60	○	0.03	100	10 u	260*	6.0					3.0	AUD		607		607	
MQ2905A	PG	0.4 A	60	○	0.6	100	150 m	300	8.0	42	130	.4	10	150 m		607		607		
MQ3251	PA	0.40 A	40	○	0.05	100	10 m	300	6.0			.25	10	10 m		607		607		
MQ3467	PS	0.40 A	40	○	1.0	20	500 m	150	20	40	110	0.5	10	500 m		607		607		
MQ3725	NS	0.40 A	40	○	1.0	50	100 m	200	10	45	75	.26	10	100 m		607		607		
MQ3762	PS	0.40 A	40	○	1.5	20	1.0 A	150	20	40	110	1.0	10	1.0 A		607		607		
MQ3799	PA	0.40 A	60	○	0.05	300	100 u	450*	4.0			0.2	10	1.0 m		607		607		
MQ6001	CG	0.40 A	30	○	0.5	40	150 m	200	8.0	60	350	0.4	10	150 m		607		607		
MQ6002	CG	0.40 A	30	○	0.5	100	150 m	200	8.0	60	350	0.4	10	150 m		607		607		
MQ7001	PA	0.4 A	30	○	0.6	70	1.0 m	200	8.0			0.4	10	150 m		607		607		
MQ7003	NA	0.40 A	40	○	0.05	50	10 m	200	6.0			.35	10	1.0 m		607		607		
MQ7021	CG	0.40 A	40	○	0.05	50	10 m	200	6.0	28*	72*	.35	10	10 m		607		607		
2N5146	PA	0.4 A	40	○	1.5	20	1.0 A	150	20	40	110	1.0	10	1.0 A		607		607		
2N6501	NS	0.6 A	40	○	1.0	50	100 m	250	10	35	60	0.3	10	1.0 m		607		607		

Some columns show 2 different types of data indicated by either bold or italic typefaces. See key and headings.

MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

TABLE 2. Quad TMOS Fets (N Channel)

Device	$r_{ds(on)}$		$V_{GS(th)}$				I_{DSS}		$V_{(BR)DSS}$		I_{GSS}		C_{iss}		C_{rss}		t_{on}	t_{off}
	(Ω) Max	@ I_D (A)	(V)		V_{DS} (V)	I_D (mA)	(μA) Max	V_{DS} (V)	(V) Min	I_D (μA)	(nA) Max	V_{GS} (V)	(pF) Max	V_{DS} (V)	(pF) Max	V_{DS} (V)	(ns) Max	(ns) Max
			Min	Max														
MFQ930C	1.4	1.0	1.0	3.5	V_{GS}	1.0	10	35	35	10	50	15	70	25	18	25	15	15
MFQ960C	1.7	1.0	1.0	3.5	V_{GS}	1.0	10	60	60	10	50	15	70	25	18	25	15	15
MFQ990C	2.0	1.0	1.0	3.5	V_{GS}	1.0	10	90	90	10	50	15	70	25	18	25	15	15
MFQ107	14	0.2	1.0	4.0	V_{GS}	1.0	10	200	200	10	50	15	90	25	3.5	25	15	15
MFQ170	5	0.2	0.8	3.0	V_{GS}	1.0	0.5	25	60	10	10	15	70	25	18	25	10	10

TABLE 3. Dual Transistors

TYPE NO.	ID	P_D Watts One Die Only	Ref. Point	V_{CE} Volts	Subscript	I_C Amp Max	h_{FE} Min	@ I_C Unit	f_T MHz Min	C_{ob} pF Max	t_{on} ns Max	t_{off} ns Max	$V_{CE(sat)}$ Volts Max	I_C @ I_B	f & I_C Unit	PACKAGE	
																TO- No.	Case No.
BFX11	PM	0.4 A	45	○	0.05	80	50 m	130	8.0	0.8	5.0	0.25	20	50 m	78	654	
BFX15	NM	0.5 A	40	○	0.5	60	100 μ	50	15	0.9	5.0	1.0	10	1.0 m	78	654	
BFX36	PM	0.4 A	60	○	0.05	100	10 μ	40	6.0	0.9	3.0	0.25	20	10 m	78	654	
BFY81	NM	0.4 A	45	○	0.03	100	100 μ	60	6.0	0.8	10	0.35	10	1.0 m	78	654	
MD918	NF	0.55 A	15	○	0.05	50	3.0 m	600	1.7				6.0	60 M		654	
MD918A	NM	0.55 A	15	○	0.05	50	3.0 m	600	1.7	0.9	5.0		6.0	60 M		654	
MD918AF	NM	0.35 A	15	○	0.05	50	3.0 m	600	1.7	0.9	5.0		6.0	60 M		610A	
MD2219	NG	0.575 A	30	○	0.5	100	150 m	200	8.0	60	350	0.4	10	150 m		654	
MD2369	NS	0.55 A	15	○	0.5	40	10 m	500	4.0	15	20	.25	10	10 m		654	
MD2369A	NM	0.55 A	15	○	0.5	40	10 m	500	4.0	0.9	5.0	.25	10	10 m		654	
MD2905	PG	0.575 A	40	○	0.6	100	150 m	200	8.0	45	130	0.4	10	150 m		654	
MD2905A	PG	0.575 A	60	○	0.6	100	150 m	200	8.0	45	130	0.4	10	150 m		654	
MD2905AF	PG	0.35 A	60	○	0.6	100	150 m	200	8.0	45	130	0.4	10	150 m		610A	
MD3251	PA	0.575 A	40	○	0.20	100	1.0 m	250	6.0			.25	10	10 m		654	
MD3251A	PM	0.575 A	40	○	0.20	100	1.0 m	250	6.0	0.9	5.0	.25	10	10 m		654	
MD3251AF	PM	0.35 A	40	○	0.20	100	1.0 m	250	6.0	0.9	5.0	.25	10	10 m		610A	
MD3467	PS	0.60 A	40	○	1.5	20	500 m	150	20	40	110	0.5	10	500 m		654	
MD3467F	PS	0.35 A	40	○	1.5	20	500 m	150	20	40	110	0.5	10	500 m		610A	
MD3725	NS	0.60 A	40	○	1.0	50	100 m	200	10	45	75	.26	10	100 m		654	
MD3725F	NS	0.35 A	40	○	1.0	50	100 m	200	10	45	75	.26	10	100 m		610A	
MD3762	PS	0.60 A	40	○	1.5	20	1.0 A	150	20	40	110	1.0	10	1.0 A		654	
MD5000	PH	0.3 A	15	○	0.05	20	3.0 m	600	1.7			15		200 M		654	
MD5000A	PM	0.3 A	15	○	0.05	20	3.0 m	600	1.7	0.9	5.0	15		200 M		654	
MD6001	CG	.575 A	30	○	0.5	40	150 m	200	8.0	60	350	0.4	10	150 m		654	
MD6001F	CG	0.35 A	30	○	0.5	40	150 m	200	8.0	60	350	0.4	10	150 m		610A	
MD6002	CG	.575 A	30	○	0.5	100	150 m	200	8.0	60	350	0.4	10	150 m		654	
MD6002F	CG	0.35 A	30	○	0.5	100	150 m	200	8.0	60	350	0.4	10	150 m		610A	
MD6003	CA	.575 A	30	○	0.5	70	150 m	200	8.0			0.4	10	150 m		654	
MD6003F	CA	0.35 A	30	○	0.5	70	150 m	200	8.0			0.4	10	150 m		610A	
MD6100	CA	0.5 A	45	○	0.05	100	0.1 m	30	4.0			.25	10	1.0 m		654	
MD6100F	CA	0.35 A	45	○	0.05	100	0.1 m	30	4.0			.25	10	10 m		610A	
MD7000	NA	0.575 A	30	○	0.5	70	150 m	200	8.0			0.4	10	150 m		654	
MD7001	PA	0.6 A	30	○	0.6	70	150 m	200	8.0			0.4	10	150 m		654	
MD7001F	PA	0.350 A	30	○	0.6	70	150 m	200	8.0			0.4	10	150 m		610A	
MD7002	NA	0.575 A	40	○	0.03	40	100 μ	200	6.0			.35	10	10 m		654	
MD7002A	NM	0.575 A	40	○	0.03	40	100 μ	200	6.0	0.75	25	.35	10	10 m		654	
MD7003	NA	0.55 A	40	○	0.05	50	10 m	200	6.0			.35	10	1.0 m		654	
MD7003A	NM	0.55 A	40	○	0.05	50	10 m	200	6.0	0.75	25	.35	10	1.0 m		654	

Some columns show 2 different types of data indicated by either bold or italic typefaces. See key and headings.

MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

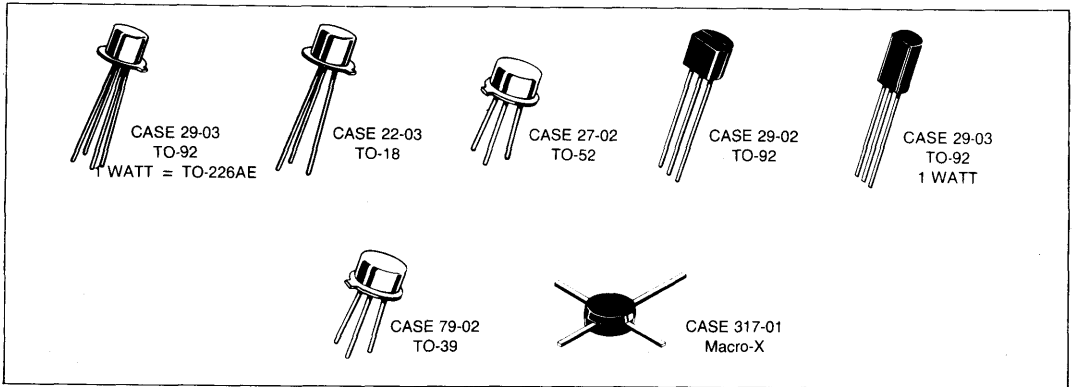
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TABLE 3. Dual Transistors (continued)

TYPE NO.	ID	P _D Watts One Die Only	Ref. Point	V _{CE} Volts	Subscript	I _C Amp Max	h _{FE} Min	@	I _C Unit	f _T MHz	C _{ob} pF	h _{FE1}	ΔV _{BE}	G _p	NF	@	f	Unit	PACKAGE
												h _{FE2}	mV Max	dB Min	dB Max				
MD7021	CG	0.55 A	40	○	0.05	50	10 m	200	6.0	28*	72*	.35	10	10 m				654	
MD7021F	CG	0.35 A	40	○	0.05	50	10 m	200	6.0	28*	72*	.35	10	10 m				610A	
MD8001	NM	0.575 A	40	○	0.03	100	1.0 m	260*	2.6*		15							654	
MD8002	NM	0.575 A	40	○	0.03	100	1.0 m	260*	2.6*		15							654	
MD8003	NM	0.575 A	40	○	0.03	100	1.0 m	260*	2.6*		15							654	
2N2060	NM	0.5 A	60	○	0.5	30	100 u	60	15	0.9	5.0			8.0	1000 H	78		654	
2N2223	NM	0.5 A	60	○	0.5	25	100 u	50	15	0.8	15	1.2	10	50 m				654	
2N2453	NM	0.5 A	30	○	0.05	80	10 u	60	8.0	0.9	3.0			7.0	1000 H	78		654	
2N2639	NM	0.3 A	45	○	0.03	50	10 u	80	8.0	0.9	5.0			4.0	AUD	78		654	
2N2641	NE	0.3 A	45	○	0.03	50	10 u	80	8.0					4.0	AUD	78		654	
2N2642	NM	0.3 A	45	○	0.03	100	10 u	80	8.0	0.9	5.0			4.0	AUD	78		654	
2N2644	NE	0.3 A	45	○	0.03	100	10 u	80	8.0					4.0	AUD	78		654	
2N2652	NM	0.3 A	60	○	0.5	50	1.0 m	60	15	0.85	3.0	1.2	10	50 m				654	
2N2722	NM	0.3 A	45	○	0.04	50	1.0 u	100	6.0	0.9	5.0	1.0	20	10 m				654	
2N2903	NM	0.6 C	30	○	0.05	125	1.0 m	60	8.0	0.8	10			7.0	1000 H	78		654	
2N2903A	NM	0.6 C	30	○	0.05	125	1.0 m	60	8.0	0.9	5.0			7.0	1000 H	78		654	
2N2913	NE	0.3 A	45	○	0.03	60	10 u	60	6.0					4.0	AUD			654	
2N2914	NE	0.3 A	45	○	0.03	150	10 u	60	6.0					3.0	AUD			654	
2N2915	NM	0.3 A	45	○	0.03	60	10 u	60	6.0	0.9	5.0			4.0	AUD			654	
2N2916	NM	0.3 A	45	○	0.03	150	10 u	60	6.0	0.9	5.0			3.0	AUD			654	
2N2917	NM	0.3 A	45	○	0.03	60	10 u	60	6.0	0.8	10			4.0	AUD			654	
2N2918	NM	0.3 A	45	○	0.03	150	10 u	60	6.0	0.8	10			3.0	AUD			654	
2N2919	NM	0.3 A	60	○	0.03	60	10 u	60	6.0	0.9	5.0			4.0	AUD			654	
2N2920	NM	0.3 A	60	○	0.03	150	10 u	60	6.0	0.9	5.0			3.0	AUD			654	
2N3043	NM	0.25 A	45	○	0.03	100	10 u	30	8.0	0.9	5.0			5.0	AUD			610A	
2N3045	NE	0.25 A	45	○	0.03	100	10 u	30	8.0					5.0	AUD			610A	
2N3046	NM	0.25 A	45	○	0.03	50	10 u	30	8.0	0.9	5.0			5.0	AUD			610A	
2N3048	NE	0.25 A	45	○	0.03	50	10 u	30	8.0					5.0	AUD			610A	
2N3726	PE	0.4 A	45	○	0.3	135	1.0 m	200	8.0	0.9	5.0			4.0	1000 H			654	
2N3806	PE	0.5 A	60	○	0.05	150	0.1 m	100	4.0					7.0	100 H			654	
2N3807	PE	0.5 A	60	○	0.05	300	0.1 m	100	4.0					4.0	100 H			654	
2N3808	PM	0.5 A	60	○	0.05	150	0.1 m	100	4.0	0.8	5.0			7.0	100 H			654	
2N3809	PM	0.5 A	60	○	0.05	300	0.1 m	100	4.0	0.8	5.0			4.0	100 H			654	
2N3810	PM	0.5 A	60	○	0.05	150	0.1 m	100	4.0	0.9	3.0			7.0	100 H			654	
2N3810A	PM	0.5 A	60	○	0.05	150	0.1 m	100	4.0	0.95	1.5			3.0	100 H			654	
2N3811	PM	0.5 A	60	○	0.05	300	0.1 m	100	4.0	0.9	3.0			4.0	100 H			654	
2N3811A	PM	0.5 A	60	○	0.05	300	0.1 m	100	4.0	0.95	1.5			1.5	100 H			654	
2N3813	PA	0.5 A	60	○	0.05	300	0.1 m	100	4.0					2.5	AUD			610A	
2N3816	PM	0.5 A	60	○	0.05	150	0.1 m	100	4.0	0.9	3.0			7.0	100 H			610A	
2N3817	PM	0.5 A	60	○	0.05	300	0.1 m	100	4.0	0.9	3.0			4.0	100 H			610A	
2N3838	CE	0.25 A	40	○	0.6	100	150 m	200	8.0	50	340			8.0	1000 H			610A	
2N4015	PM	0.4 A	60	○	0.3	135	1.0 m	200	8.0	0.9	5.0			4.0	1000 H			654	
2N4016	PM	0.4 A	60	○	0.3	135	1.0 m	200	8.0	0.9	2.5			4.0	1000 H			654	
2N4854	CE	0.3 A	40	○	0.6	100	150 m	200	8.0	60	350			8.0	1000 H			654	
2N4937	PM	0.6 A	40	○	0.05	50	1.0 m	300	5.0	0.9	3.0			4.0	AUD			654	
2N4939	PE	0.6 A	40	○	0.05	50	1.0 m	300	5.0					4.0	AUD			654	
2N4941	PM	0.6 A	40	○	0.05	50	1.0 m	300	5.0	0.9	3.0			4.0	AUD			610A	
2N4942	PE	0.6 A	40	○	0.05	50	1.0 m	300	5.0					4.0	AUD			610A	
2N5794	NG	0.5 A	40	○	0.6	100	150 m	200	8.0	45	310	0.3	10	150 m				654	
2N5796	NG	0.5 A	60	○	0.6	100	150 m	200	8.0	47	140	0.4	10	150 m				654	

Some columns show 2 different types of data indicated by either bold or italic typefaces. See key and headings.

Field-Effect Transistors



Motorola offers a line of field-effect transistors that encompasses the latest technology and covers the full range of FET applications. Included here is a wide variety of junction FETs, MOSFETs (with P- or N-channel polarity with both single and dual gates) and TMOS FETs. These FETs include devices developed for operation across the frequency range from dc to UHF in switching and amplifying applications. Package options

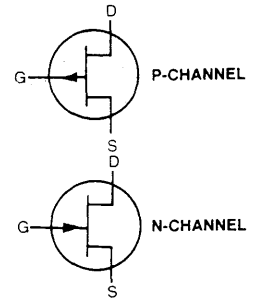
from low cost plastic to metal TO-72 packages are available. The selector guides on the following pages are designed to emphasize those FET families and device types that, by virtue of widespread industry use, ease of manufacture and, consequently, low relative cost, merit first consideration for new equipment design.

JFETs

TABLE 1. Switches and Choppers

JFETs operate in the depletion mode. They are available in both P- and N-channel and are offered in both metal and plastic packages. Applications include general-purpose amplifiers, switches and choppers, and RF amplifiers and mixers. These devices are economical and very rugged. The drain and source are interchangeable on many typical FETs.

JFETs



P-Channel JFETs

Package TO-	Device	$r_{ds(on)}$		$V_{GS(off)}$		I_{DSS}		$V_{(BR)GSS}$	C_{iss}	C_{rss}	t_{on}	t_{off}
		(Ω) MAX	@ I_D (μA)	(V)		(mA)		$V_{(BR)GDO}$				
92	MPF970	100	1.0	5.0	12	15	100	30	12	5.0	8.0	25
92	MPF971	250	1.0	1.0	7.0	2.0	80	30	12	5.0	10	120
72	2N3993	150	—	4.0	9.5	10	—	25	16	4.5	—	—
72	2N3994	300	—	1.0	5.5	2.0	—	25	16	4.5	—	—

N-Channel JFETs

18	2N4859A	25	—	2.0	6.0	50	—	30	10	4.0	8.0	20
18	2N4856A	25	—	4.0	10	50	—	40	10	4.0	8.0	20
18	2N4856	26	—	4.0	10	50	—	40	10	8.0	9.0	25
18	2N4859	25	—	4.0	10	50	—	30	18	8.0	9.0	25
18	2N4391	30	1.0	4.0	10	50	150	40	14	3.5	15	20
92	MPF4391	30	1.0	4.0	10	60	130	20	10	3.5	15	20
18	2N4091	30	1.0	5.0	10	30	—	40	16	5.0	25	40
92	MPF4091	30	1.0	5.0	10	30	—	40	16	5.0	25	40
92	J111	30	1.0	3.0	10	20	—	35	10 ^t	5.0 ^t	13	35
18	2N4857A	40	—	2.0	6.0	20	100	40	10	3.5	10	40

FIELD-EFFECT TRANSISTORS (continued)

TABLE 1. Switches and Choppers (continued)

N-Channel JFETs

Package TO —	Device	$r_{ds(on)}$		$V_{GS(off)}$		I_{DSS}		$V_{(BR)GSS}$ $V_{(BR)GDO}$	C_{iss}	C_{rss}	t_{on}	t_{off}
		(Ω) MAX	@ I_D (μA)	(V)		(mA)						
18	2N860A	40	—	2.0	6.0	20	100	30	10	3.5	10	40
18	2N4857	40	—	2.0	6.0	20	100	40	18	8.0	10	50
18	2N4860	40	—	2.0	6.0	20	100	30	18	8.0	10	50
18	2N4092	50	1.0	2.0	7.0	15	—	40	16	5.0	35	60
92	MPF4092	50	1.0	2.0	7.0	15	—	40	16	5.0	35	60
92	J112	50	1.0	1.0	5.0	5.0	—	35	10 ^t	5.0 ^t	13 ^t	35 ^t
18	2N4392	60	1.0	2.0	5.0	25	75	40	14	3.5	15	35
92	MPF4392	60	1.0	2.0	5.0	25	75	20	10	3.5	15	35
18	2N4858A	60	1.0	0.8	4.0	8.0	80	40	10	3.5	16	80
18	2N4861A	60	—	0.8	4.0	8.0	80	30	10	3.5	16	80
92	2N5639	60	1.0	—	(8.0) ^t	25	—	30	10	4.0	14	30
18	2N3971	60	1.0	2.0	5.0	25	75	40	25	6.0	30	60
18	2N4858	60	—	0.8	4.0	8.0	80	40	18	8.0	20	100
18	2N4861	60	—	0.8	4.0	8.0	80	30	18	8.0	20	100
18	2N4093	80	1.0	1.0	5.0	80	—	40	16	5.0	60	80
92	MPF4093	80	1.0	1.0	5.0	80	—	40	16	5.0	60	80
72	MPF3002	100	10 V	—	3.0	—	10	15	5.0	1.5	—	—
18	2N4393	100	1.0	0.5	3.0	5.0	30	40	14	3.5	15	50
92	MPF4393	100	1.0	0.5	3.0	5.0	30	20	10	3.5	15	55
92	2N5640	100	1.0	—	(6.0)	5.0	—	30	10	4.0	18	45
18	2N3972	100	1.0	0.5	3.0	5.0	30	40	25	6.0	80	100
92	J113	100	1.0	0.5	3.0	2.0	—	35	10 ^t	5.0 ^t	13 ^t	35 ^t
92	BF246A/247A	35 ^t	1.0	1.5	4.0	30	80	25	—	—	—	—
92	BF246B/247B	50 ^t	1.0	3.0	7.0	60	140	25	—	—	—	—
92	BF246C/247C	65 ^t	1.0	5.5	12.0	110	250	25	—	—	—	—
92	J107	8	—	0.5	4.5	100	—	25	—	—	—	—
92	J108	8	—	3.0	10.0	80	—	25	—	—	—	—
92	J109	12	—	2.0	6.0	40	—	25	—	—	—	—
92	J110	18	—	0.5	4.0	10	—	25	—	—	—	—

t = typical

TABLE 2. Low-Frequency/Low-Noise

P-Channel JFETs

Package TO —	Device	$R_{\theta} Y_{fs}$	$R_{\theta} Y_{os}$	C_{iss}	C_{rss}	$V_{(BR)GSS}$ $V_{(BR)GDO}$	$V_{GS(off)}$		I_{DSS}	
		(mmho) MIN	(μmho) MAX	(pF) (MAX)	(pF) MAX		(V) MIN	MIN	MAX	MIN
72	2N3909	1.0	100	32	16	20	0.3	7.9	0.3	15
18	2N2608	1.0	17	—	—	30	1.0	4.0	0.9	4.5
92	2N5460	1.0	50	7.0	2.0	40	0.75	6.0	1.0	5.0
92	2N5463	1.0	75	7.0	2.0	60	0.5	4.0	1.0	5.0
92	2N5461	1.5	50	7.0	2.0	40	1.0	7.5	2.0	9.0
92	2N5464	1.5	75	7.0	2.0	60	0.8	4.5	2.0	9.0

FIELD-EFFECT TRANSISTORS (continued)

TABLE 2. Low-Frequency/Low-Noise (continued)

P-Channel JFETs

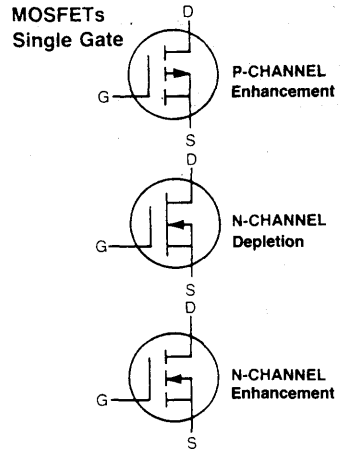
Package TO—	Device	$R_e Y_{fs}$	$R_e Y_{os}$	C_{iss}	C_{rss}	$V_{(BR)GSS}$ $V_{(BR)GDO}$	$V_{GS(off)}$		I_{DSS}	
		(mmho) MIN	(μ mho) MAX	(pF) (MAX)	(pF) MAX	(V) MIN	MIN	MAX	MIN	MAX
92	2N4360	2.0	100	20	5.0	20	0.4	9.0	3.0	30
92	2N5462	2.0	50	7.0	2.0	40	1.8	9.0	4.0	16
92	2N5465	2.0	75	7.0	2.0	60	1.5	6.0	4.0	16
18	2N2609	2.5	—	30	—	30	1.0	4.0	2.0	10
72	2N5270	2.5	75	7.0	2.0	60	2.0	6.0	7.0	14

N-Channel JFETs

Package TO—	Device	$R_e Y_{fs}$		$R_e Y_{os}$		C_{iss}	C_{rss}	$V_{(BR)GSS}$ $V_{(BR)GDO}$	$V_{GS(off)}$		I_{DSS}	
		(mmho) MIN	@ VDS (V)	(μ mho) MAX	@ VDS (V)	(pF) (MAX)	(pF) MAX	(V) MIN	MIN	MAX	MIN	MAX
92	MPF111	0.5	10	200	10	—	—	20	0.5	10	0.5	20
92	J201	0.5	20	1.0 ^t	20	5.0 ^t	2.0 ^t	40	0.3	1.5	0.2	1.0
92	MPF109	0.8	15	75	15	7.0	3.0	25	0.2	8.0	0.5	24
72	2N4220	1.0	15	10	15	6.0	2.0	30	—	4.0	0.5	3.0
72	2N5360	1.4	15	20	15	6.0	2.0	40	0.8	4.0	0.5	2.5
94	2N5458	1.5	15	50	15	7.0	3.0	25	1.0	7.0	2.0	9.0
72	2N5361	1.5	15	20	15	6.0	2.0	40	1.0	6.0	2.5	5.0
92	J203	1.5	20	10 ^t	20	5.0 ^t	2.0 ^t	40	2.0	10	4.0	20
72	2N3821	1.5	15	10	15	6.0	3.0	50	—	4.0	0.5	2.5
92	MPF3821	1.5	15	10	15	6.0	3.0	50	—	4.0	0.5	2.5
92	2N5457	2.0	15	50	15	7.0	3.0	25	0.5	6.0	1.0	5.0
92	2N5459	2.0	15	50	15	7.0	3.0	25	2.0	8.0	4.0	16
72	2N4221	2.0	15	20	15	6.0	2.0	30	—	6.0	2.0	6.0
92	BC264A	2.5	15	40 ^t	15	3 ^t	0.7 ^t	30	0.5	8.0	2.0	4.5
92	BC264B	3.0	15	40 ^t	15	3 ^t	0.7 ^t	30	0.5	8.0	3.5	6.5
92	BC264C	3.5	15	40 ^t	15	3 ^t	0.7 ^t	30	0.5	8.0	5.0	8.0
92	BC264D	4.0	15	40 ^t	15	3 ^t	0.7 ^t	30	0.5	8.0	7.0	12.0
92	BF244A/45A	3.0	15	40 ^t	15	3 ^t	0.7 ^t	30	0.4	2.2	2.0	6.5
92	BF244B/45B	3.0	15	40 ^t	15	3 ^t	0.7 ^t	30	1.6	3.8	6.0	15.0
92	BF244C/45C	3.0	15	40 ^t	15	3 ^t	0.7 ^t	30	3.2	7.5	12.0	25.0
92	BF256A	4.5	15	—	—	—	0.7 ^t	30	0.5	7.5	3.0	7.0
92	BF256B	4.5	15	—	—	—	0.7 ^t	30	0.5	7.5	6.0	13.0
92	BF256C	4.5	15	—	—	—	0.7 ^t	30	0.5	7.5	11.0	18.0
72	2N4221A	2.0	15	20	15	6.0	2.0	30	—	6.0	2.0	6.0
72	2N5362	2.0	15	40	15	6.0	2.0	40	2.0	7.0	4.0	8.0
72	2N3822	2.0	15	20	15	6.0	3.0	50	—	6.0	2.0	10
18	2N4341	2.0	15	60	15	7.0	3.0	50	2.0	6.0	3.0	9.0
72	2N4222	2.5	15	40	15	6.0	2.0	30	—	8.0	5.0	15
72	2N4222A	2.5	15	40	15	6.0	2.0	30	—	8.0	5.0	15
72	2N5363	2.5	15	40	15	6.0	2.0	40	2.5	8.0	7.0	14
72	2N4117	20	0.001	3.0	10	3.0	1.5	40	0.6	1.8	30	90
72	2N4117A	70	0.001	3.0	10	3.0	1.5	40	0.6	1.8	30	90
72	2N4118	80	0.001	5.0	10	3.0	1.5	40	1.0	3.0	80	240
72	2N4118A	80	0.001	5.0	10	3.0	1.5	40	1.0	3.0	80	240

t = typical.

FIELD-EFFECT TRANSISTORS (continued)



MOSFETS

MOSFETs are available in either depletion/enhancement or enhancement mode (in general, depletion/enhancement devices are operated in the depletion mode and are referred to as depletion devices). They are available in both N- and P-channel, and both single gate and dual gate construction. Some MOSFETs are also offered with input diode protection which reduces the chance of damage from static charge in handling.

TABLE 2. Low-Frequency/Low-Noise (continued)

P-Channel MOSFETs

Package TO—	Device	$R_{\theta l} Y_{fs}$		C_{iss}	C_{rss}	$V_{(BR)DDS}$	$V_{GS(TH)}$		I_{DSS}	
		(mmho) MIN	(μ mho) MAX	(pF) (MAX)	(pF) MAX	(V) MIN	(V) MIN	(V) MAX	(mA) MIN	(mA) MAX
72	3N155A	1.0	60	5.0	1.3	-35	-1.5	-3.2	—	-0.25
18	MFE823	1.0	—	6.0	1.5	-50	-3.0	-5.0	—	-0.25
72	MFE3003	—	—	5.0	1.0	-15	—	-4.0	—	10

N-Channel MOSFETs

18	2N3796	0.4	1.8	7.0	0.8	25	—	-7.0	2.0	6.0
18	MFE825	0.5	—	4.0	0.7	20	—	—	1.0	25
72	2N4351	1.0	—	5.0	1.3	25	1.0	5.0	—	10
72	3N169	1.0	—	5.0	1.3	25	0.5	1.5	—	10
72	3N170	1.0	—	5.0	1.3	25	1.0	2.0	—	10
72	3N171	1.0	—	5.0	1.3	25	1.5	3.0	—	10
72	MFE3002	—	—	5.0	1.0	15	—	3.0	—	10
18	2N3797	1.5	—	8.0	0.8	25	—	-7.0	2.0	6.0

TABLE 3.

N-Channel JFETs

Package TO—	Device	$R_{\theta l} Y_{fs}$		$R_{\theta l} Y_{os}$		C_{iss}	C_{rss}	NF		$V_{(BR)DSS}$	$V_{(BR)GDO}$	$V_{GS(off)}$		I_{DSS}	
		(mmho) MIN	@ f (MHz)	(μ mho) MAX	@ f (MHz)	(pF) (MAX)	(pF) MAX	(dB) MAX	RG = 1K f (MHz)	(V) MIN	(V) MIN	(V) MAX	(mA) MIN	(mA) MAX	
92	2N5484	2.5	100	75	100	5.0	1.0	3.0	100	25	0.3	3.0	1.0	5.0	
92	2N5485	3.0	400	100	400	5.0	1.0	4.0	400	25	1.0	4.0	4.0	10	
92	J305	3.0 ^t	400	80 ^t	100	3.0 ^t	0.8 ^t	4.0 ^t	400	30	0.5	3.0	1.0	8.0	
72	2N3823	3.2	200	200	200	6.0	2.0	2.5	100	30	—	8.0	4.0	20	
92	2N5486	3.5	400	100	400	5.0	1.0	4.0	400	25	2.0	6.0	8.0	20	
72	2N4416	4.0	400	100	400	4.0	0.8	4.0	400	30	2.0	6.0	5.0	15	
72	2N4416A	4.0	400	100	400	4.0	0.8	4.0	400	30	2.0	6.0	5.0	15	
92	2N5245	4.0	400	100	400	4.5	1.0	4.0	400	30	1.0	6.0	5.0	15	
92	J304	4.2 ^t	400	80 ^t	100	3.0 ^t	0.8 ^t	4.0 ^t	400	30	2.0	6.0	5.0	15	
52	U310	10	0.001	150	100	5.0	2.5	3 ^t	450	25	2.5	6.0	24	60	
92	J308	12 ^t	100	250 ^t	100	7.5	2.5	1.5 ^t	100	25	1.0	6.5	12	60	
92	J309	12 ^t	100	250 ^t	100	7.5	2.5	1.5 ^t	100	25	1.0	4.0	12	30	
92	J310	12 ^t	100	250 ^t	100	7.5	2.5	1.5 ^t	100	25	2.0	6.5	24	60	
72	3N128*	5.0	0.001	500	200	7.0	0.28	5.0	200	-50	-0.5	-8.0	5.0	25	

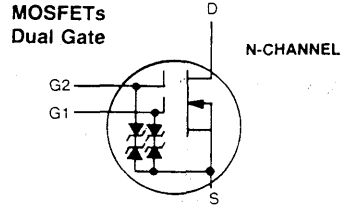
^t = typical

*N-Channel MOSFET

FIELD-EFFECT TRANSISTORS (continued)

MOSFETs Dual Gate MOSFETs

These devices are especially suited for RF amplifier and mixer applications in TV tuners, radio, etc. The Dual Gate construction also allows easy AGC control with very low power.



Dual Gate MOSFETs

Package TO —	Device	$R_{\theta} Y_{fsl}$		$R_{\theta} Y_{osl}$		C_{iss}	C_{rss}	NF		$V_{(BR)GSS}$ $V_{(BR)GDO}$	$V_{GS(off)}$		I_{DSS}	
		(mmho) MIN	@ f (MHz)	(μ mho) MAX	@ f (MHz)			(dB) MAX	@ RG = 1K f (MHz)		(V) MIN	MIN	MAX	MIN
72	3N211	17	0.001			—	0.05	3.5	200	± 6.0	-0.2	-5.5	6.0	40
72	3N213	15	0.001			—	0.05	4.0	45	± 6.0	-0.2	-5.5	6.0	40
72	3N212	17	0.001			—	0.05	4.0	45	± 6.0	-0.2	-4.0	6.0	40
72	3N203	7.0	0.001			4.3 ^t	0.03	4.5	200	± 6.0	-0.2	-5.0	3.0	11
72	3N201	8.0	0.001			4.5 ^t	0.03	4.5	200	± 6.0	-0.2	-5.0	6.0	30
72	3N202	8.0	0.001			4.3 ^t	0.03	4.5	200	± 6.0	-0.2	-5.0	6.0	30
72	3N204	10	0.001			—	0.03	5.0	400	25	-0.2	-4.0	6.0	30
72	3N205	10	0.001			—	0.03	5.0	400	25	-0.2	-4.0	6.0	30

^t = typical

FIELD-EFFECT TRANSISTORS (continued)

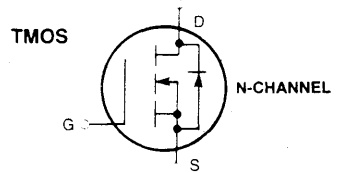
Small-Signal TMOS

TABLE 4. TMOS Power MOSFETs

Power MOSFETs, Motorola trademark TMOS, are FET transistors with an oxide insulated gate which controls vertical current flow.

This basic description fits a number of structures and process titles including Vertical DMOS, HEXMOS, TMOS, UMOS, Vertical MOS, and VMOS.

There are subtle parametric tradeoffs with these different products but they all exhibit higher input impedance, faster switching, enhanced thermal stability, and easier paralleling than bipolar transistors. In addition, they have lower "on" resistance and higher power handling capability than conventional horizontal MOSFETs or JFETs.



N-Channel

Package TO -	Device	r _{ds(on)}		V _{GS(t/h)}		I _{DSS}	V _{(BR)DSS}	I _{GSS}	C _{iss}	C _{rss}	t _{on}	t _{off}
		(Ω) MAX	@ I _D (A)	MIN	MAX							
39	MFE930	1.4	1.0	1.0	3.5	10	35	50	70	18	15	15
226AE	MPF930	1.4	1.0	1.0	3.5	10	35	50	70	18	15	15
39	MFE960	1.7	1.0	1.0	3.5	10	60	50	70	18	15	15
226AE	MPF960	1.7	1.0	1.0	3.5	10	60	50	70	18	15	15
39	MFE990	2.0	1.0	1.0	3.5	10	90	50	70	18	15	15
226AE	MPF990	2.0	1.0	1.0	3.5	10	90	50	70	18	15	15
18	MFE9200	6.4	.250	1.0	4.0	10	200	50	90	3.5	15	15
92	MPF9200	6.4	.250	1.0	4.0	10	200	50	90	3.5	15	15
92	BS107	14	0.20	1.0	2.6	0.03	200	10	90	3.5	15	15
92	BS170	5.0	0.20	0.8	3.0	0.5	60	10	38 ^t	4.5 ^t	10	10
226AE	MPF910	5.0	0.50	0.8	2.5	10	60	10	38 ^t	4.5 ^t	5.0 ^t	5.0 ^t
226AE	MPF6659	1.8	1.0	0.8	2.0	500	35	100	50	10	5.0	5.0
226AE	MPF6660	3.0	1.0	0.8	2.0	500	60	100	50	10	5.0	5.0
226AE	MPF6661	4.0	1.0	0.8	2.0	500	90	100	50	10	5.0	5.0
39	2N6659	1.8	1.0	0.8	2.0	10	35	100	50	10	5.0	5.0
39	2N6660	3.0	1.0	0.8	2.0	10	60	100	50	10	5.0	5.0
39	2N6661	4.0	1.0	0.8	2.0	10	90	100	50	10	5.0	5.0
226AE	MPF1010	—	—	0.3	2.5	10	100	10	35 ^t	6 ^t	5.0 ^t	5.0 ^t
39	MFE910	5.0	0.5	0.3	2.5	10	60	10	—	—	5.0 ^t	5.0 ^t

t = typical

GaAs FETs

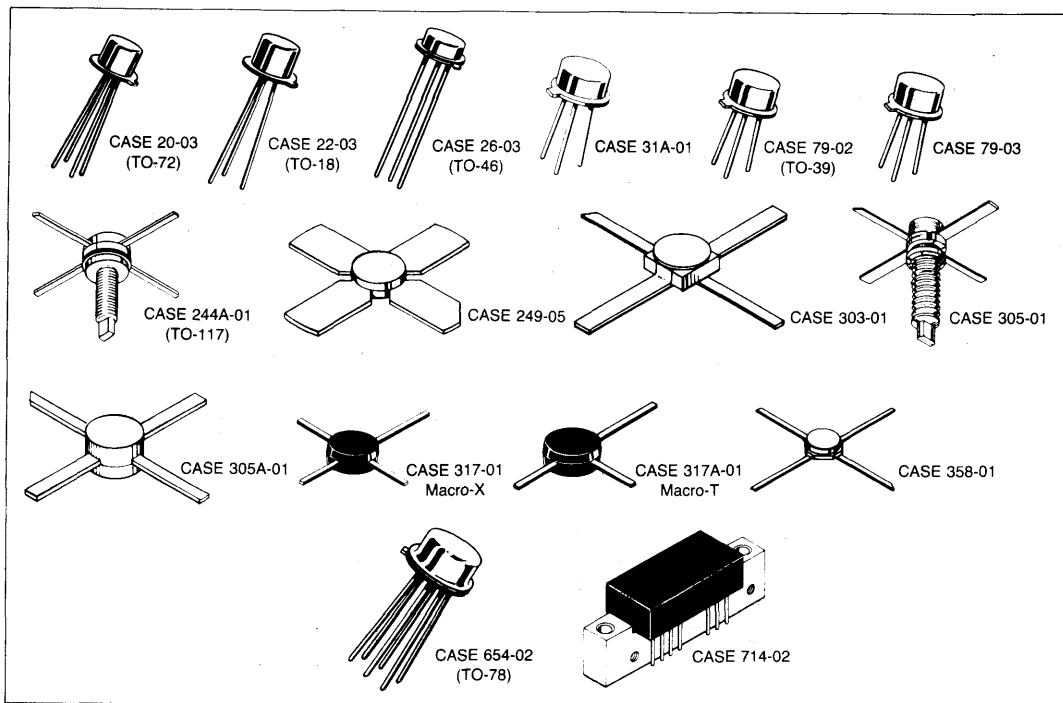
TABLE 5. GaAs Dual Gate Field-Effect Transistors

The GaAs Dual Gate FETs listed here are for low noise and high gain receiver amplifier and mixer applications.

Device Type	I _{DSS} Typ		Noise Figure			Gain		I _{nd3}	MdB	V _{(BR)DSX}	I _D mA	P _T mW	Package
	I _{DSS} (mA)	V _{ds}	NF dB	f MHz	I _D mA	dB Min	f MHz						
MRF966	50	5.0	1.2*	1000	10	15	1000	-65*	10*	10	60	350	317-1
MRF967	50	5.0	1.2*	1000	10	13	1000	-65*	10*	10	60	350	358-1

*Typ

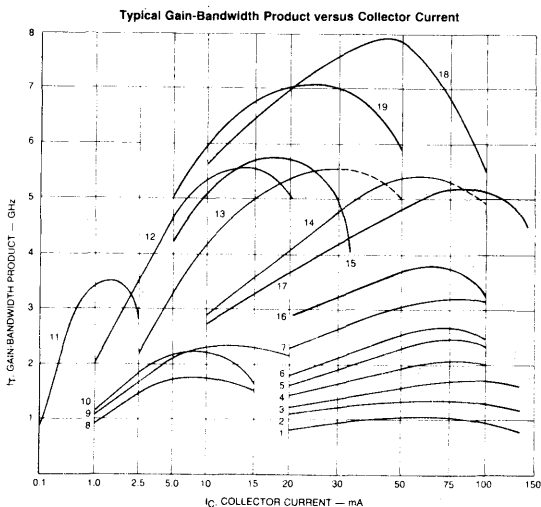
RF Small-Signal Transistors



Motorola's small-signal, low power RF transistor product range includes transistors with gain-bandwidths of 1.0 GHz to 8.0 GHz operating at currents of 0.25 mA to over 140 mA.

These devices are available in a wide variety of package types; metal can, plastic Macro-X and Macro-T, hermetic ceramic and microminiature. Most of these transistors are fully

characterized with y or s parameters; and in addition, there are non-saturated switching characteristics, low power driver specifications, and noise figure limits. QPL types with JAN, JTX and JTXV processing levels are available as well as Hi Rel processing to meet unique customer requirements.



RF Small-Signal Transistors

Motorola small-signal and medium power RF transistors with gain-bandwidth products from 1.0 GHz to 8.0 GHz operate with currents from 0.25 mA to over 140 mA. The following chart, combined with the tables of package options, enables the circuit designer to select the optimum device from Motorola's wide range of transistor/package combinations.

- | | |
|--|-----------------------------------|
| 1 2N3866, 2N3866A, MM8000 | 10 2N4957, 2N4958, 2N4959, PNP |
| 2 2N5160, MM4018, PNP | 11 MRF931 |
| 3 2N3948, 2N4427, MRF207 | 12 2N6603, BFR90, MRF901, MRF904 |
| 4 2N5109, 2N5943, MM8001, MM8002 | 13 2N6604, BFR91, MRF911, MRF914 |
| 5 2N5583, PNP | 14 BFR96, MRF961, MRF962, MRF965 |
| 6 2N5836, 2N5837 | 15 BFW92A |
| 7 MRF511, MRF517, MRF525 | 16 MRF559 |
| 8 2N2857, 2N3839, 2N5179, MRF501, MRF502 | 17 MRF580, MRF581, MRF586, MRF587 |
| 9 2N6304, 2N6305, BFX89, BFY90 | 18 MRF571, MRF572, MRF573 |
| | 19 MRF536, MRF534, MM4049, PNP |

RF SMALL-SIGNAL TRANSISTORS (continued)

1

TABLE 1. UHF and Microwave Oscillators

The transistors listed below are for UHF and microwave oscillator applications as initial signal sources or as output stages of limited range transmitters. Devices are listed in order of increasing output power.

Device Type	Test Conditions		P _{out} mW Min	f _T MHz Typ	Package
	f MHz	V _{CC} Volts			
2N5179	500	10	20	1800	TO-72
2N2857	500	10	30	1800	TO-72
2N3839	500	6.0	30	1800	TO-72
MM8009	1680	20	200	1400	TO-39
2N5108	1680	20	300	1400	TO-39
MRF905	1680	20	500*	2200	TO-46
2N3866	400	15	1000	1000	TO-39

*Typical

TABLE 2. GaAs Dual Gate Field-Effect Transistors

The GaAs Dual Gate N-Channel FET's listed here are for low noise and high gain receiver amplifier and mixer applications.

Device Type	I _{DSS} Typ		Noise Figure			Gain		IMD ₃	P _{1dB}	V _(BR) DSX	I _D mA	P _T mW	Package
	I _{DSS} (mA)	V _{ds}	NF dB	f MHz	I _D mA	dB Min	f MHz	dB	dBm				
MRF966	50	5.0	1.2*	1000	10	15	1000	-65*	10*	10	60	350	317-1
MRF967	50	5.0	1.2*	1000	10	13	1000	-65*	10*	10	60	350	358-1

*Typical

TABLE 3. Low-Noise Transistors

The low-noise devices listed are produced with carefully controlled r_b' and f_T to optimize device noise performance. Devices listed in the matrix are classified according to noise figure performance versus frequency.

NF dB	Frequency MHz						Polarity
	60	100	200	450	1000	2000	
1.5	2N5829	2N5829	MRF904	MRF571	MRF572		PNP NPN
	2N5031	2N5031					
2.0	2N4957	2N4957	2N5829	MRF904	MRF901		PNP NPN
	2N5032	2N5032	2N5031				
2.5	2N4958	2N4958	2N4957	2N5829	MRF901	MRF572 MRF573	PNP NPN NPN
	2N5032	2N5032	2N5032	2N5031			
3.0	2N4959	2N4959	2N4958	2N4957	2N5829	2N6603	PNP NPN NPN
	2N2857	2N2857	2N5032	2N5032	MRF901 2N6604		
3.5	2N4959	2N4959	2N4959	2N4958	2N4957	MRF901	PNP NPN
	2N5179	2N5179	2N2857	2N5032	2N5031		
4.0	2N4959	2N4959	2N4959	2N4959	2N4958	2N6604	PNP NPN
	2N5179	2N5179	2N5179	2N2857	2N5031		
4.5	2N4959	2N4959	2N4959	2N4959	2N4959		PNP NPN
	2N5179	2N5179	2N5179	2N2857	2N5032		

RF SMALL-SIGNAL TRANSISTORS (continued)

TABLE 4. CATV, MATV, and Class A Linear Transistors

The devices listed below are excellent for Class A linear CATV/MATV applications and are listed according to increasing gain-bandwidth (f_T). More information concerning the device for your specific linear design needs can be obtained through your local Motorola Sales Office or Motorola distributor.

Device Type	Nominal Test Conditions V_{CE}/I_C Volts/mA	f_T MHz Min	Noise Figure	Distortion Specifications				Package
			Max/Freq. dB/MHz	2nd Order IMD	3rd Order IMD	12 Ch. Cross- Mod.	Output Level dBmV	
MRF501	6/5	600	4.5*/200					TO-72
MRF502	6/5	800	4.0*/200					TO-72
2N5179	6/5	900	4.5/200					TO-72
BFY90	5/2	1000	5.0/500					TO-72
2N6305	5/10	1200	5.5/450					TO-72
BFX89	5/25	1200	6.5/500					TO-72
2N5109	15/50	1200	3.0*/200					TO-39
2N5943	15/50	1200	3.4/200	-50		-42	+50	TO-39
2N6304	5/10	1400	4.5/450					TO-72
MRF511	20/80	1500	7.3*/200	-50	-65	-57	+50	244A-01
2N5947	20/75	1500*	3.8/200		-55	-60	+50	244A-01
MRF517	15/60	2200	7.5/300	-60	-72	-57	+45	TO-39
BFW92A	5/2	4500*	3.0*/500					317A-01
MRF586	14/70	4500*	3.0/500	-50	-72		+50	TO-39
BFR90	10/14	5000*	2.4*/500					317A-01
BFR91	5/35	5000*	1.9*/500					317A-01
BFR96	10/50	5000*	3.0*/500					317A-01
MRF961	10/50	5000*	2.0*/500					317-01
MRF962	10/50	5000*	2.0*/500					303-01
MRF965	10/50	5000*	2.0*/500					TO-46
MRF581	10/75	5000*	3.0/500		-65		+50	317-01
MRF587	14/70	5500*	3.0/500	-52	-72		+50	244A-01

*Typ

TABLE 5. High-Speed Switches

The transistors listed below are for use as high-frequency current-mode switches. They are also suitable for RF amplifier and oscillator applications. The devices are listed in ascending order of collector current.

Device Type	Test Conditions I_C/V_{CE} mA/Volts	f_T MHz Min	$r_b' C_C$ Max	Package
2N3959	10/10	1300	25	TO-18
2N3960	10/10	1600	40	TO-18
2N5835	10/6.0	2500	5.0**	TO-72
MM4049*	20/5.0	4000	15	TO-72
MRF914	20/10	4500**	—	TO-72
2N5842	25/4.0	1700	40	TO-72
2N5841	25/4.0	2200	25	TO-72
2N5943	50/15	1200	5.5**	TO-39
2N5583*	50/10	1000	8.0**	TO-39
2N5836	50/6.0	2000	6.0**	TO-46
2N5837	100/3.0	1700	6.0**	TO-46

*PNP **Typ

RF SMALL-SIGNAL TRANSISTORS (continued)

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Class C Amplifiers

The transistors listed in these tables are specified for operation in Class C RF power amplifier circuits. The tables are arranged by increasing frequency of operation first, then by increasing output power. The first table contains those devices specified at 12.5 Vdc, while the following table contains devices specified at 28 Vdc.

TABLE 6. Low-Voltage Class C Amplifiers

Device Type	Frequency (MHz)	P _{in} (w)	P _{out} (w)	G _{pe} dB	Voltage (V)	Case Outline
MRF8003	27	0.05	0.5	10.0	12.5	TO-39
MRF8004	27	0.35	3.5	10.0	12.5	TO-39
MRF402	50	0.1	1.0	10.0	12.5	TO-39
MRF229	90	0.15	1.5	10.0	12.5	TO-39
MRF230	90	0.15	1.5	10.0	12.5	TO-39
MRF604	175	0.1	1.0	10.0	12.5	TO-46
2N4427	175	0.1	1.0	10.0	12.0	TO-39
MRF607	175	0.12	1.75	11.5	12.5	TO-39
2N6255	175	0.5	3.0	7.8	12.5	TO-39
MRF237*	175	0.25	4.0	12.0	12.5	TO-39
MRF207	220	0.15	1.0	8.2	12.5	TO-39
MRF225	225	0.18	1.5	9.0	12.5	TO-39
MRF227*	225	0.13	3.0	13.5	12.5	TO-39
2N3948	400	0.25	1.0	6.0	13.6	TO-39
2N6256	470	0.1	0.5	7.0	12.5	249-5
MRF515	470	0.12	0.75	8.0	12.5	TO-39
MRF581	470	0.05	1.2	13.8	12.5	317-1
MRF629*	470	0.32	2.0	8.0	12.5	TO-39
MRF626	470	0.05	0.5	10.0	12.5	305-1
MRF627	470	0.05	0.5	10.0	12.5	305A-1
MRF628	470	0.05	0.5	10.0	12.5	249-5
MRF630	470	0.25	3.0	10.8	12.5	TO-39
MRF559	870	0.063	0.5	9.0	12.5	317-1
MRF581	870	0.12	1.0	9.2	12.5	317-1

TABLE 7. High-Voltage Class C Amplifiers

Device Type	Frequency (MHz)	P _{in} (w)	P _{out} (w)	G _{pe} dB	Voltage (V)	Case Outline
2N3553	175	0.25	2.5	10.0	28.0	TO-39
MRF525*	400	0.001	0.02	13.0	26.0	TO-39
2N3866	400	0.1	1.0	10.0	28.0	TO-39
2N5160†	400	0.16	1.0	8.0	28.0	TO-39
MRF313	400	0.03	1.0	15.0	28.0	305A-1
MRF313A	400	0.03	1.0	15.0	28.0	305-1

*Grounded Emitter TO-39

†PNP

1

RF SMALL-SIGNAL TRANSISTORS (continued)

Small-Signal Amplifier Transistor Selection by Package

In small-signal RF applications the package style is often determined by the end application, or circuit construction technique. To aid the circuit designer in device selection, below are listed the Motorola broad range of RF small-signal amplifier transistors organized by package. Devices for other applications such as oscillators or switches are shown in the appropriate preceding tables.

TABLE 8. TO-39 METAL CAN

Device Type	Gain — BW		Noise Figure			Gain		Maximum Ratings		
	f _T GHz	I _C mA	NF dB	f MHz	I _C mA	dB Min	f MHz	V _{(BR)CEO} V	I _C mA	P _T mW
MM8000	0.7	50	2.7	200	10	11.4*	200	30	0.4	3.50
MM8001	0.9	50	2.7	200	10	11.4*	200	30	0.4	3.50
2N5109	1.2	50	3.0	200	10	11	216	20	400	2.50
2N5943	1.2	50	3.4	200	30	11.4*	200	30	400	3.50
MRF525†	2.5	50	4.0	400	—	13	400	35**	150	2.50
MRF517	2.7	60	7.5	300	50	10*	300	35**	150	2.50
MRF586	4.5	70	3.0	500	70	14*	500	17	200	2.50

†Grounded Emitter TO-39

*Typ

**V_{(BR)CBO}

TABLE 9. Plastic — SOE — Case 317-01/317A-01

Device Type	Gain — BW		Noise Figure			Gain		Maximum Ratings		
	f _T GHz	I _C mA	NF dB	f MHz	I _C mA	dB Min	f MHz	V _{(BR)CEO} V	I _C mA	P _T mW
MRF931	3.0	1.0	3.8	500	0.25	16*	500	5.0	5.0	50
MRF559	3.0	100	—	—	—	13.0*	512	18	150	2000
BFW92A	4.0	25	2.5	500	2.0	16*	500	5.0	50	190
MRF901	4.5	15	2.0	1000	5.0	10	1000	15	30	375
BFR96	4.5	50	2.0*	500	10	12	500	15	100	500
MRF961	4.5	50	2.0*	500	10	13.5	500	15	100	500
MRF911	5.0	30	2.5	1000	5.0	12.5*	1000	12	40	400
BFR90	5.0	14	2.4	500	2.0	18*	500	15	30	180
BFR91	5.0	30	1.9	500	2.0	16*	500	12	35	180
MRF571	8.0	5.0	1.0*	500	5.0	13.5	500	10	70	2500
MRF580	5.0	75	2.0*	500	50.0	11.0	500	18	200	2500
MRF581	5.0	75	2.0*	500	50.0	13.0	500	18	200	2500
MRF536**	5.0	20	4.5*	1000	3.0	8.5	1000	10	30	300

*Typ

**PNP

TABLE 10. Ceramic — SOE — Case 244A-01, 303-01, 358-01

Device Type	Gain — BW		Noise Figure			Gain		Maximum Ratings		
	f _T GHz	I _C mA	NF dB	f MHz	I _C mA	dB Min	f MHz	V _{(BR)CEO} V	I _C mA	P _T mW
2N5947	1.5	75	3.8	200	50	10	250	30	400	5000
MRF511	2.1	80	7.3	200	50	10	250	25	250	5000
2N6603	4.5	15	2.0	1000	5.0	13*	1000	15	30	400
MRF962	4.5	50	2.0*	500	10	15	500	15	100	750
2N6604	5.0	30	2.5	1000	5.0	14	1000	12	50	500
MRF587	5.5	70	3.0	500	70	15*	500	17	200	5800
MRF572	8.0	50	2.0	1000	5.0	10	1000	10	70	2500
MRF573	8.0	50	2.0	1000	5.0	10	1000	10	70	2500

*Typ

RF SMALL-SIGNAL TRANSISTORS (continued)

1

TABLE 11. TO-72 METAL CAN

Device Type	Gain — BW		Noise Figure			Gain		Maximum Ratings		
	f _T GHz	I _C mA	NF dB	f MHz	I _C mA	dB Min	f MHz	V(BR) _{CEO} V	I _C mA	P _T mW
2N5031	1.0	5.0	2.5	450	1.0	14	450	10	20	200
2N5032	1.0	5.0	3.0	450	1.0	14	450	10	20	200
2N4958*	1.0	2.0	3.3	450	2.0	16	450	30	30	200
2N4959*	1.0	2.0	3.8	450	2.0	15	450	30	30	200
2N5829*	1.2	2.0	2.5	450	2.0	17	450	30	30	200
2N4957*	1.2	2.0	3.0	450	2.0	17	450	30	30	200
MRF501	1.2	5.0	4.0	200	1.5	15**	200	15	50	200
MRF502	1.2	5.0	4.0	200	1.5	15**	200	15	50	200
2N6305	1.2	10	5.5	450	2.0	12	450	15	50	200
BFX89	1.2	25	6.5	500	2.0	19	200	15	50	200
BFY90	1.4	25	5.0	500	2.0	21	200	15	50	200
2N5179	1.4	10	4.5	200	1.5	15	200	12	50	200
2N6304	1.4	10	4.5	450	2.0	15	450	15	50	200
2N3839	1.6	8.0	3.9	450	1.5	12.5	450	15	40	200
2N2857	1.6	8.0	4.1	450	1.5	12.5	450	15	40	200
MRF904	4.0	15	1.5	450	5.0	16	450	15	30	200
MRF914	4.5	20	2.0	500	5.0	15	500	12	40	200

*PNP

**Typ

RF Amplifier Modules

The devices listed below are general purpose RF hybrid amplifiers, which feature input and output impedance matching and dc biasing networks for simplified RF amplifier design.

TABLE 12. General-Purpose 50 Ω — 100 Ω Wideband Modules

Device Type	Frequency Range MHz	Gain dB Min/Typ	Supply Voltage Vdc	Output Level 1 dB Compression mW/f (MHz)	Noise Figure @ 250 MHz dB
MHW590	10-400	32.5/34	24	800/200	5.0
MHW591	1.0-250	35/36.5	13.6	700/100	5.0
MHW592	1.0-250	34.5/36	24	900/100	5.0
MHW593	10-400	34/35.5	13.6	600/200	4.5

TABLE 13. TO-39 Wideband, 50 Ω Modules

The MWA Series features excellent gain versus frequency flatness, temperature stability and are cascadable for high gain lineups. Construction techniques include thin film gold metal circuitry and hermetic TO-39 package. MWA devices processed for military applications are available to special order.

Device Type	Frequency Range MHz	Gain dB Min/Typ	Supply Voltage Vdc	Output Level 1 dB Compression dBm Typ	Noise Figure (400 MHz) dB Typ
MWA110	0.1-400	13/14	2.9	-2.5	4.0
MWA120	0.1-400	13/14	5.0	+8.2	5.5
MWA130	0.1-400	13/14	5.5	+18	7.0
MWA210	0.1-600	9/10	1.75	+1.5	6.0
MWA220	0.1-600	9/10	3.2	+10.5	6.5
MWA230	0.1-600	9/10	4.4	+18.5	7.5
MWA310	0.1-1000	7/8	1.60	+3.5	6.5
MWA320	0.1-1000	7/8	2.9	+11.5	6.7
MWA330	0.1-1000	-6/2	4.0	+15.2	9.0

RF SMALL-SIGNAL TRANSISTORS (continued)

High Reliability RF Transistors

The listed devices are active per QPL-19500 (Qualified Products List). Check with your local Motorola Sales Office or franchised Distributor for current qualification status and additions.

2N2857JAN	2N4957JAN
2N2857JTX	2N4957JTX
2N2857JTXV	2N4957JTXV
2N3553JAN	2N5109JAN
2N3553JTX	2N5109JTX
2N3553JTXV	2N5109JTXV
2N3866JAN	2N6603JAN
2N3866JTX	2N6603JTX
2N3866JTXV	2N6603JTXV
2N3866AJAN	2N6604JAN
2N3866AJTX	2N6604JTX
2N3866AJTXV	2N6604JTXV
2N3960JAN	
2N3960JTX	
2N3960JTXV	

Transistor Complements

The transistor complements listed are suitable for most applications requiring NPN and PNP devices of similar RF characteristics. If your application demands special matching of complementary transistors, please contact your local Motorola Sales Office or Motorola distributors.

NPN	PNP
2N2857	2N4958
2N3553	MM4019
2N3866	2N5160
2N3959, 2N3960	2N4260, 2N4261
2N3906JAN	MM4261H
2N5943	2N5583
MRF531	MRF532
MRF904	MM4049
MRF571	MRF536

Devices for Hi-Rel Applications

In addition to CECC 50 000 Qualified Devices listed on page 1-25, Motorola offers over 650 devices listed in QPL-19500, and is certified to supply small-signal bipolar devices to ALL FOUR quality levels of MIL-S-19500: JAN, JANTX, JANTXV, and JANS.

Refer also to section 9 for Quality Assurance Processing Information.

Switching and High-Frequency Transistors

		MIL-S-19500	
2N703 JAN	153	2N3253 JAN	/347
2N706 JAN	120	2N3444 JAN	/347
2N708 JAN,JTX	312	2N3467 JAN,JTX,JTXV	/348
2N718A JAN,JTX,JTXV	181	2N3468 JAN,JTX,JTXV	/348
2N869A JAN,JTX	283	2N3485A JAN,JTX	/392
2N914 JAN,JTX	373	2N3486A JAN,JTX	/392
2N916 JAN	271	2N3498 JAN,JTX,JTXV	/366
2N918 JAN,JTX,JTXV,JANS	301	2N3499 JAN,JTX,JTXV	/366
2N929 JAN,JTX	253	2N3500 JAN,JTX,JTXV	/366
2N930 JAN,JTX	253	2N3501 JAN,JTX,JTXV	/366
2N1132 JAN	177	2N3506 JAN,JTX,JTXV	/349
2N1613 JAN,JTX,JTXV	181	2N3507 JAN,JTX,JTXV	/349
2N2218 JAN,JTX,JTXV	251	2N3634 JAN,JTX,JTXV	/357
2N2218A JAN,JTX,JTXV	251	2N3635 JAN,JTX,JTXV	/357
2N2219 JAN,JTX,JTXV	251	2N3636 JAN,JTX,JTXV	/357
2N2219A JAN,JTX,JTXV	251	2N3637 JAN,JTX,JTXV	/357
2N22219AL JANS	/	2N3700 JAN,JTX,JTXV	/391
2N2221 JAN,JTX,JTXV	255	2N3735 JAN,JTX,JTXV	/395
2N2221A JAN,JTX,JTXV	255	2N3737 JAN,JTX,JTXV	/395
2N2222 JAN,JTX,JTXV	255	2N3743 JAN,JTX,JTXV	/397
2N2222A JAN,JTX,JTXV,JANS	225	2N3762 JAN,JTX,JTXV	/396
2N2369A JAN,JTX,JTXV,JANS	/317	2N3763 JAN,JTX,JTXV	/396
2N2481 JAN,JTX	268	2N3764 JAN,JTX,JTXV	/396
2N2904 JAN,JTX,JTXV	290	2N3765 JAN,JTX,JTXV	/396
2N2905 JAN,JTX,JTXV	290	2N4033 JAN,JTX,JTXV	/511
2N2905A JAN,JTX,JTXV	290	2N4261 JAN,JTX	/511
2N2905AL JANS	/	2N4405 JAN,JTX	/488
2N2906 JAN,JTX,JTXV	291	2N4449 JAN,JTX,JTXV	/317
2N2906A JAN,JTX,JTXV	291	2N4453 JAN,JTX	/283
2N2907 JAN,JTX,JTXV	291	2N4930 JAN,JTX,JTXV	/397
2N2907A JAN,JTX,JTXV,JANS	291	2N4931 JAN,JTX,JTXV	/397
2N2944A JAN,JTX,JTXV	/	2N5581 JAN,JTX	/423
2N2945A JAN,JTX,JTXV	/	2N5582 JAN,JTX	/423
2N2946A JAN,JTX,JTXV	/		
2N3013 JAN,JTX	/287		
2N3019,S JAN,JTX,JTXV	/391		
2N3250A JAN,JTX,JTXV	/323		
2N3251A JAN,JTX,JTXV	/323		

RF Transistors

		MIL-S-19500	
2N918 JAN,JTX,JTXV,JANS	/301	2N3959 JAN,JTX,JTXV	/399
2N2857 JAN,JTX,JTXV	/343	2N3960 JAN,JTX,JTXV	/399
2N3375 JAN,JTX,JTXV	/341	2N4957 JAN,JTX,JTXV	/426
2N3553 JAN,JTX,JTXV	/341	2N5109 JAN,JTX,JTXV	/453
2N3866 JAN,JTX,JTXV	/398	2N6603 JAN,JTXV	/522
2N3866A JAN,JTX,JTXV	/398	2N6604 JAN,JTXV	/522

Multiple Devices

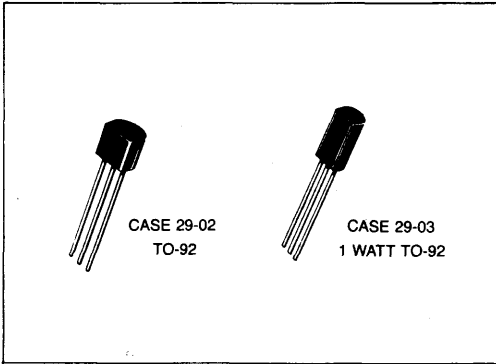
MIL-S-19500	
2N2060 JAN,JTX,JTXV	/270
2N2919 JAN,JTX,JTXV	/355
2N2920 JAN,JTX,JTXV	/355
2N3810 JAN,JTX,JTXV	/336
2N3811 JAN,JTX,JTXV	/336
2N4854 JAN,JTX,JTXV	/421
2N5793 JAN,JTX,JTXV	/495
2N5794 JAN,JTX,JTXV	/495
2N5795 JAN,JTX,JTXV	/496
2N5796 JAN,JTX,JTXV	/496

Field-Effect Transistors

MIL-S-19500	
2N2608 JAN	/295
2N2609 JAN	/296
2N3330 JAN,JTX	/378
2N3821 JAN,JTX,JTXV	/375
2N3822 JAN,JTX,JTXV	/375
2N3823 JAN,JTX,JTXV	/375
2N4856 JAN,JTX,JTXV	/385
2N4857 JAN,JTX,JTXV	/385
2N4858 JAN,JTX,JTXV	/385
2N4859 JAN,JTX,JTXV	/385
2N4860 JAN,JTX,JTXV	/385
2N4861 JAN,JTX,JTXV	/385
2N4091 JAN,JTX,JTXV	/431
2N4092 JAN,JTX,JTXV	/431
2N4093 JAN,JTX,JTXV	/431

Plastic-Encapsulated Small-Signal Transistors

2



Motorola's small-signal TO-92 plastic transistors encompass hundreds of devices spanning the gamut from general-purpose amplifiers and switches with a wide variety of characteristics to dedicated special-purpose devices for the most demanding applications. The popular high-volume TO-92 package combines proven reliability, performance, economy and convenience to provide the perfect solution for industrial and consumer design problems.

As an additional service to our customers Motorola will, upon request, supply the following:

- Radial tape and reel
- Axial tape and reel
- TO-5 lead forming
- TO-18 lead forming

Contact your Motorola representative for ordering information.

2N3903
2N3904

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current — Continuous	I _C	200	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
*Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

***THERMAL CHARACTERISTICS**

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

*Indicates Data in addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	Vdc
Base Cutoff Current (V _{CE} = 30 Vdc, V _{EB} = 3.0 Vdc)	I _{BL}	—	50	nAdc
Collector Cutoff Current (V _{CE} = 30 Vdc, V _{EB} = 3.0 Vdc)	I _{CEX}	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc)	2N3903 2N3904	h _{FE}	20	—	—
			40	—	
(I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc)	2N3903 2N3904		35 70	— —	
(I _C = 10 mAdc, V _{CE} = 1.0 Vdc)	2N3903 2N3904		50 100	150 300	
(I _C = 50 mAdc, V _{CE} = 1.0 Vdc)	2N3903 2N3904		30 60	— —	
(I _C = 100 mAdc, V _{CE} = 1.0 Vdc)	2N3903 2N3904		15 30	— —	
Collector-Emitter Saturation Voltage(1) (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)		V _{CE(sat)}	— —	0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)		V _{BE(sat)}	0.65 —	0.85 0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	2N3903 2N3904	f _T	250 300	— —	MHz
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2N3903, 2N3904

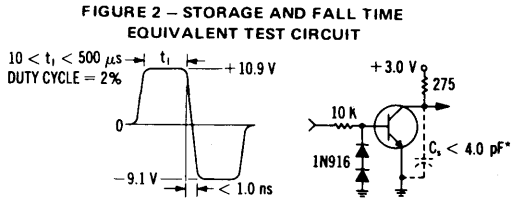
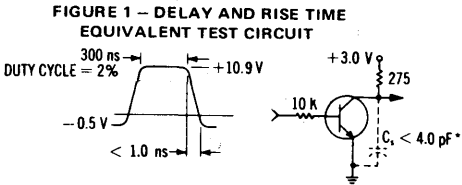
ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	8.0	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	2N3903 1.0 2N3904 1.0	8.0 10	k ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	2N3903 0.1 2N3904 0.5	5.0 8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	2N3903 50 2N3904 100	200 400	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	1.0	40	μmos
Noise Figure ($I_C = 100\ \mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 1.0\text{ k ohms}$, $f = 10\text{ Hz to }15.7\text{ kHz}$)	NF	2N3903 — 2N3904 —	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Delay Time	($V_{CC} = 3.0\text{ Vdc}$, $V_{BE} = 0.5\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 1.0\text{ mAdc}$)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = I_{B2} = 1.0\text{ mAdc}$)	t_s	—	175	ns
Fall Time		t_f	—	200	ns
			—	50	ns

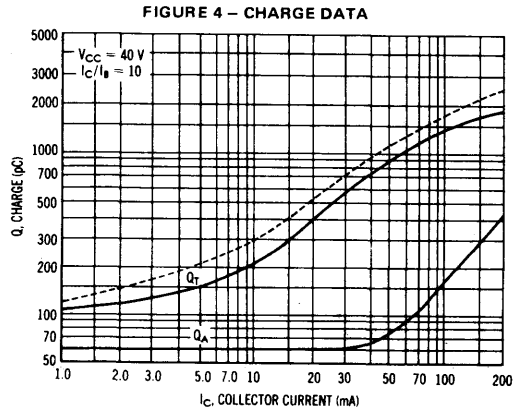
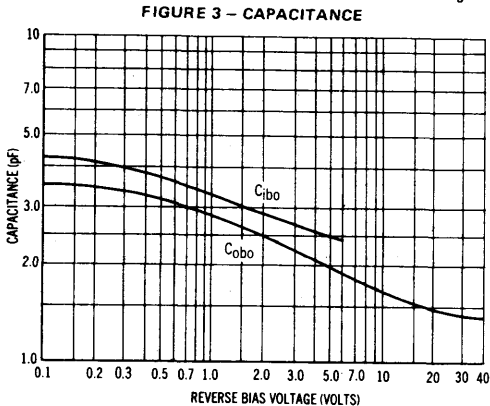
(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.



*Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

— $T_J = 25^\circ\text{C}$ --- $T_J = 125^\circ\text{C}$



2

FIGURE 5 - TURN-ON TIME

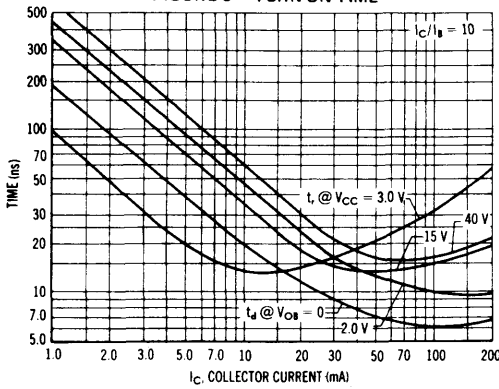


FIGURE 6 - RISE TIME

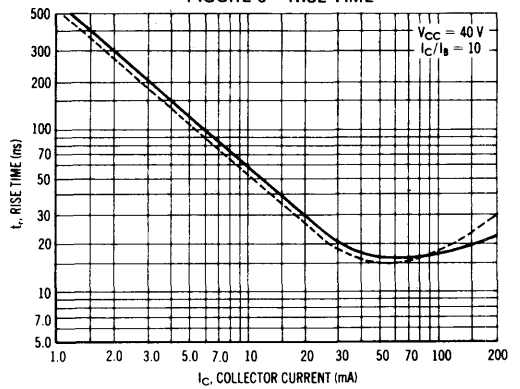


FIGURE 7 - STORAGE TIME

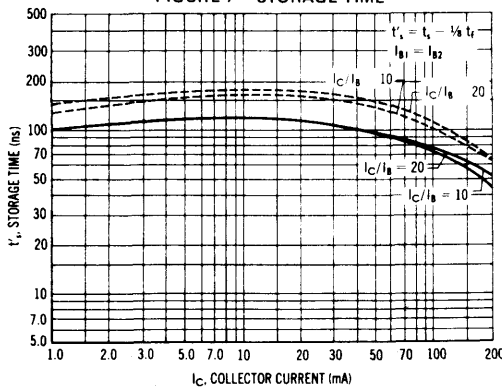
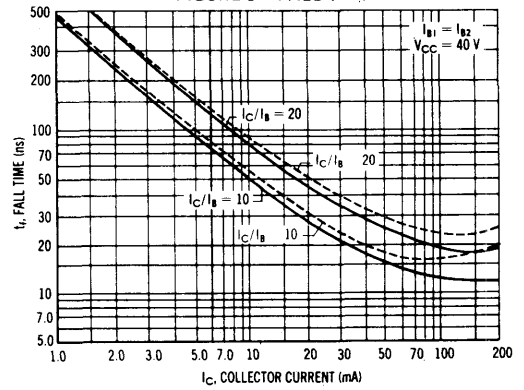


FIGURE 8 - FALL TIME



TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

$V_{CE} = 5.0$ Vdc, $T_A = 25^\circ\text{C}$,
Bandwidth = 1.0 Hz

FIGURE 9

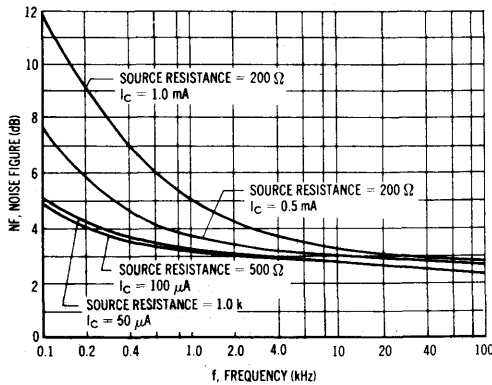
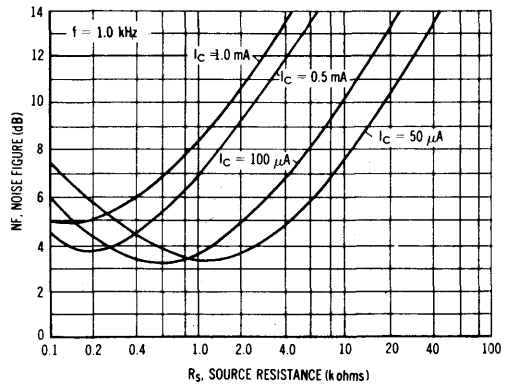


FIGURE 10



h PARAMETERS

($V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$)

FIGURE 11 – CURRENT GAIN

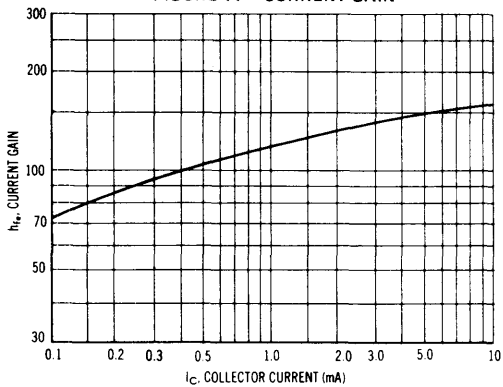


FIGURE 12 – OUTPUT ADMITTANCE

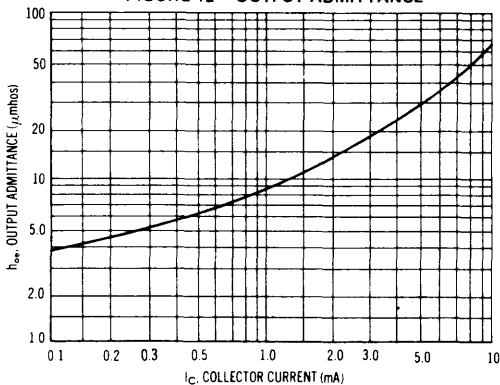


FIGURE 13 – INPUT IMPEDANCE

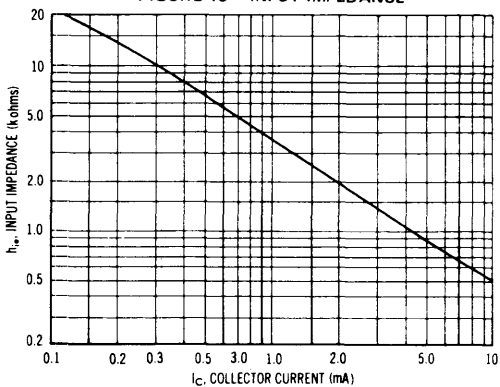
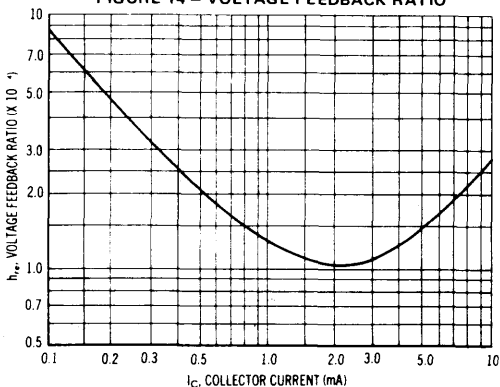
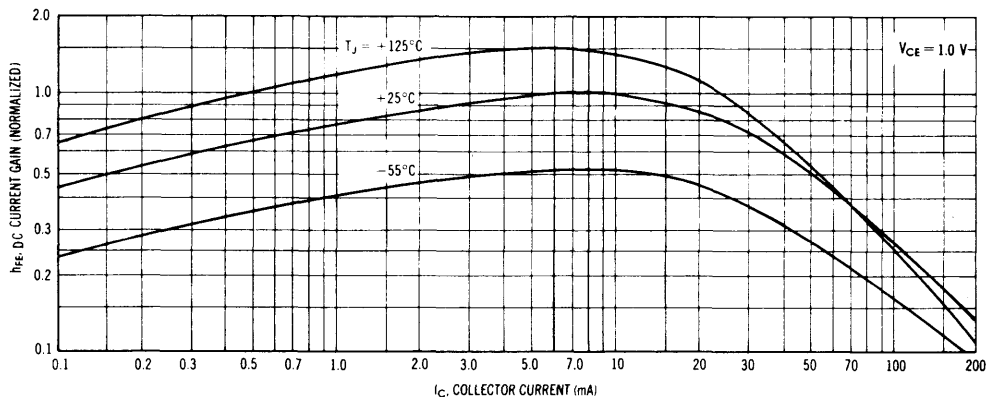


FIGURE 14 – VOLTAGE FEEDBACK RATIO



TYPICAL STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN



2

FIGURE 16 - COLLECTOR SATURATION REGION

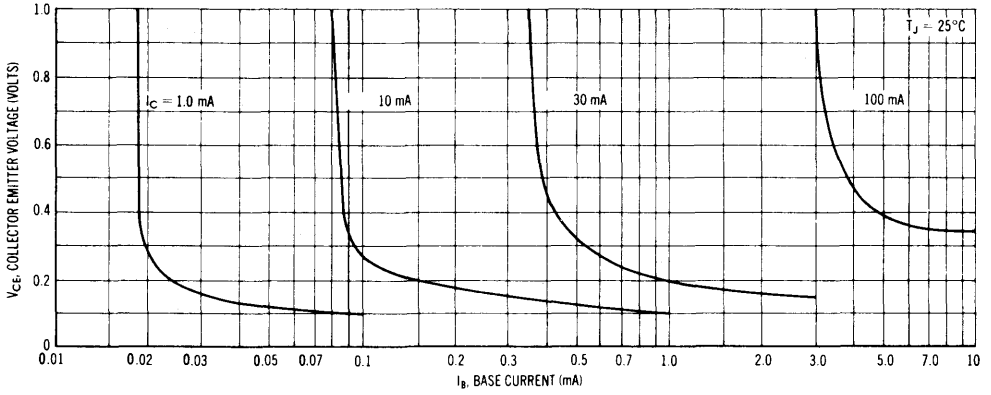


FIGURE 17 - "ON" VOLTAGES

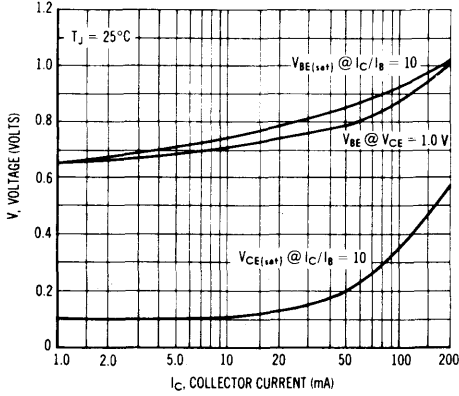
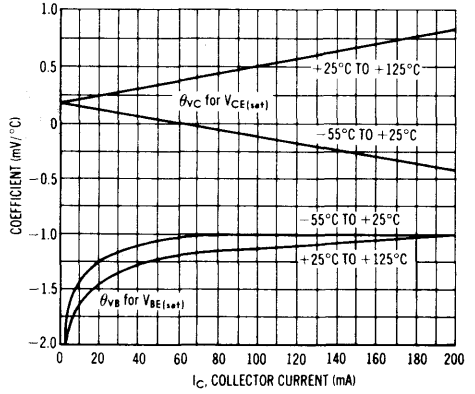


FIGURE 18 - TEMPERATURE COEFFICIENTS



2N3905
2N3906

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE
TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	200	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Total Power Dissipation @ T _A = 60°C	P _D	250	mW
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

***THERMAL CHARACTERISTICS**

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Base Cutoff Current (V _{CE} = 30 Vdc, V _{BE} = 3.0 Vdc)	I _{BL}	—	50	nAdc
Collector Cutoff Current (V _{CE} = 30 Vdc, V _{BE} = 3.0 Vdc)	I _{CEX}	—	50	nAdc

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	2N3905 2N3906	30 60	— —	—
(I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc)		2N3905 2N3906	40 80	— —	
(I _C = 10 mAdc, V _{CE} = 1.0 Vdc)		2N3905 2N3906	50 100	150 300	
(I _C = 50 mAdc, V _{CE} = 1.0 Vdc)		2N3905 2N3906	30 60	— —	
(I _C = 100 mAdc, V _{CE} = 1.0 Vdc)		2N3905 2N3906	15 30	— —	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)	V _{CE(sat)}		— —	0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)	V _{BE(sat)}		0.65 —	0.85 0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	2N3905 2N3906	200 250	— —	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 100 kHz)	C _{obo}		—	4.5	pF

2N3905, 2N3906

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ibo}	—	10.0	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	0.5 2.0	8.0 12	k ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	0.1 0.1	5.0 10	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	50 100	200 400	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	1.0 3.0	40 60	μmhos
Noise Figure ($I_C = 100\ \mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 1.0\text{ k ohm}$, $f = 10\text{ Hz to }15.7\text{ kHz}$)	NF	— —	5.0 4.0	dB

SWITCHING CHARACTERISTICS

Parameter	Conditions	Symbol	Min	Max	Unit
Delay Time	$(V_{CC} = 3.0\text{ Vdc}$, $V_{BE} = 0.5\text{ Vdc}$ $I_C = 10\text{ mAdc}$, $I_{B1} = 1.0\text{ mAdc}$)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time		t_s	—	200 225	ns
Fall Time	$(V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = I_{B2} = 1.0\text{ mAdc}$)	t_f	—	60 75	ns

(1) Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

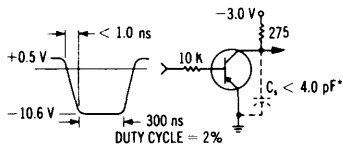
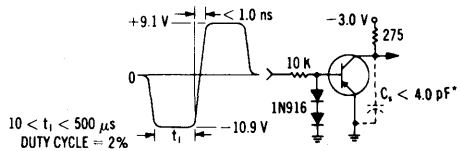


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

— $T_J = 25^\circ\text{C}$ --- $T_J = 125^\circ\text{C}$

FIGURE 3 – CAPACITANCE

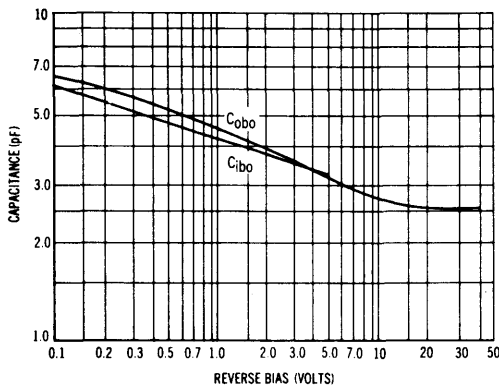


FIGURE 4 – CHARGE DATA

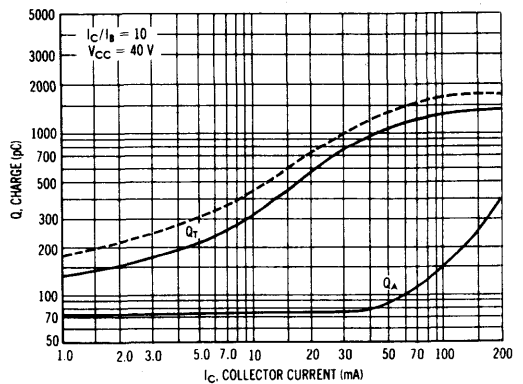


FIGURE 5 — TURN-ON TIME

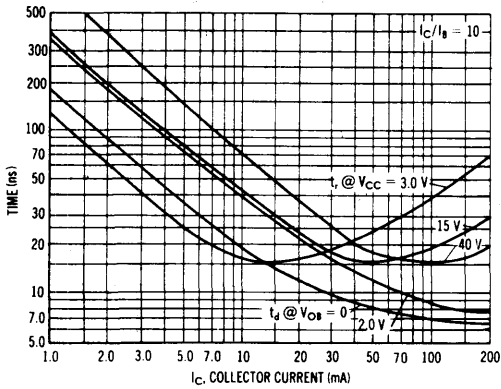
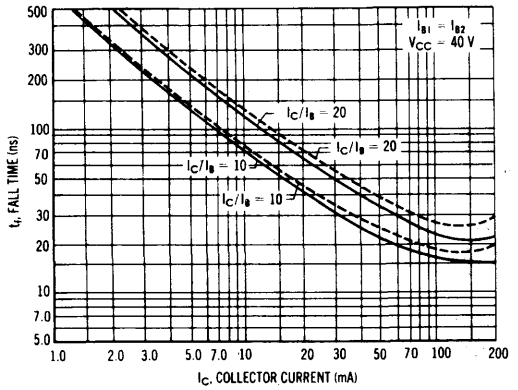


FIGURE 6 — FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

$V_{CE} = 5.0 \text{ Vdc}$, $T_A = 25^\circ\text{C}$,

Bandwidth = 1.0 Hz

FIGURE 7 —

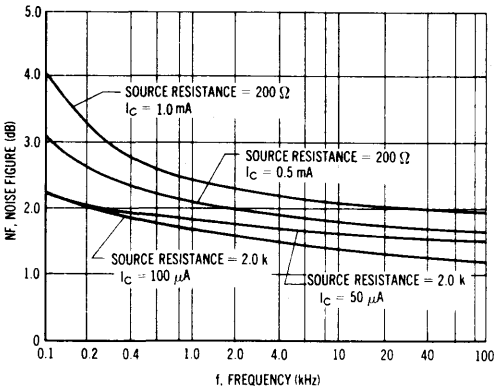
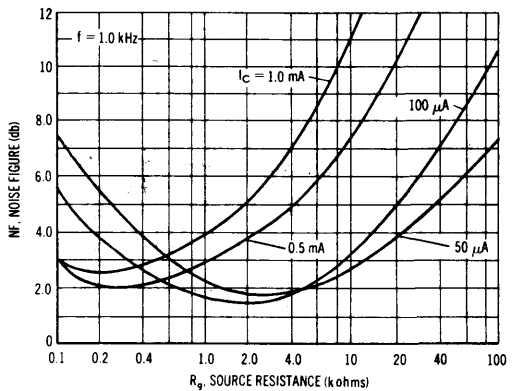


FIGURE 8 —



h PARAMETERS

($V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$)

FIGURE 9 — CURRENT GAIN

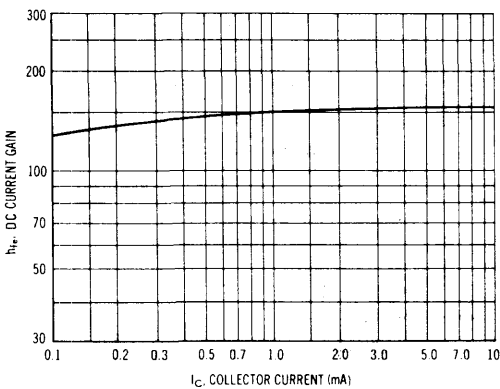


FIGURE 10 — OUTPUT ADMITTANCE

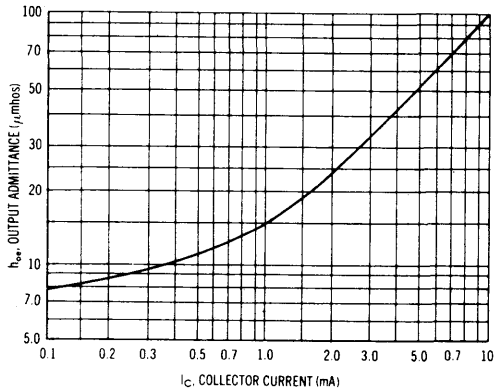


FIGURE 11 — INPUT IMPEDANCE

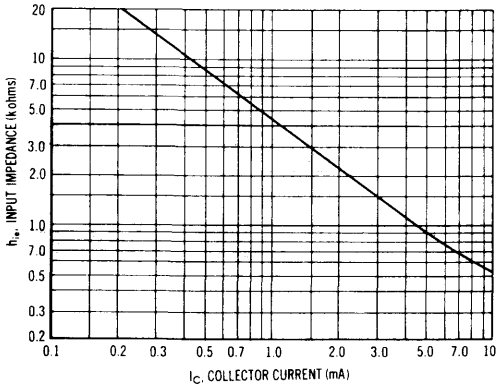
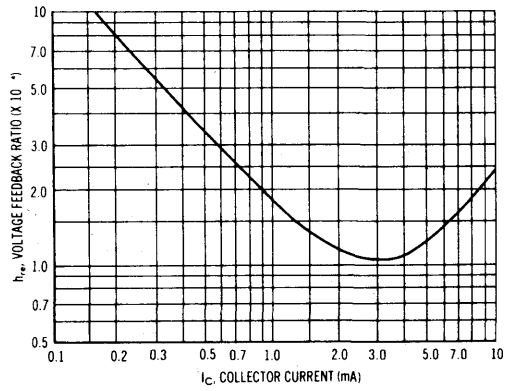


FIGURE 12 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 13 — DC CURRENT GAIN

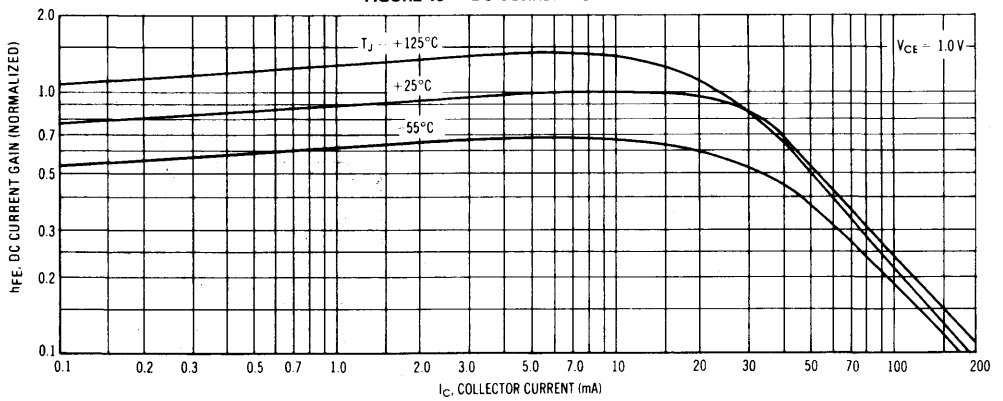


FIGURE 14 — COLLECTOR SATURATION REGION

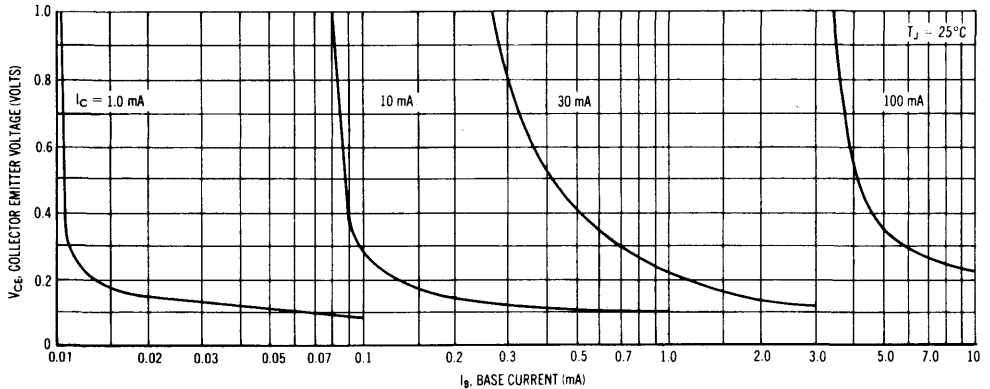


FIGURE 15 — "ON" VOLTAGES

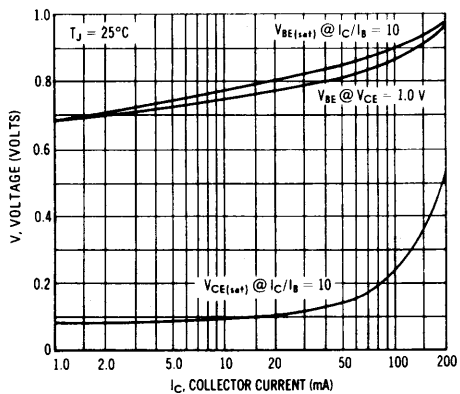
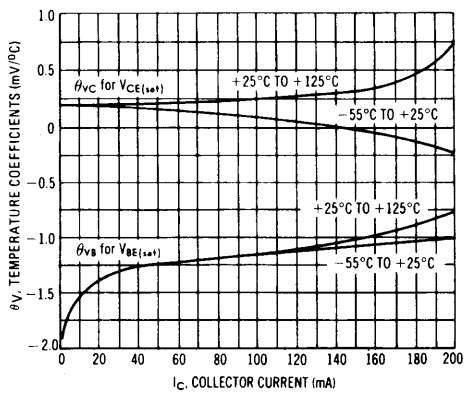


FIGURE 16 — TEMPERATURE COEFFICIENTS



2N4123 2N4124

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4123	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350	2.8	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	8.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_E = 0$)	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	40 30	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 2.0$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	50 120	150 360	—
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)		25 60	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, $f = 100$ MHz)	f_T	250 300	— —	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, $f = 100$ MHz)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 100$ kHz)	C_{ibo}	—	8.0	pF
Collector-Base Capacitance ($I_E = 0$, $V_{CB} = 5.0$ V, $f = 100$ kHz)	C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{fe}	50 120	200 480	—

2N4123, 2N4124

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Current Gain — High Frequency ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	$ h_{fe} $	2.5	—	—
		3.0	—	
	2N4123	50	200	
		2N4124	120	
Noise Figure ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 1.0 \text{ kohm}$, Noise Bandwidth = 10 Hz to 15.7 kHz)	NF	—	6.0	dB
		—	5.0	
	2N4123	—	—	
	2N4124	—	—	

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2.0%.

FIGURE 1 — CAPACITANCE

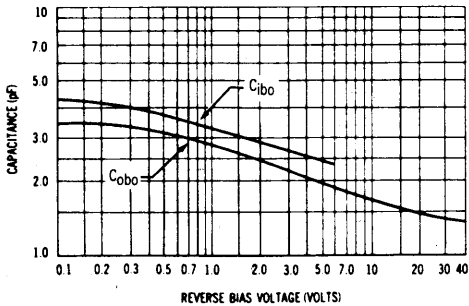
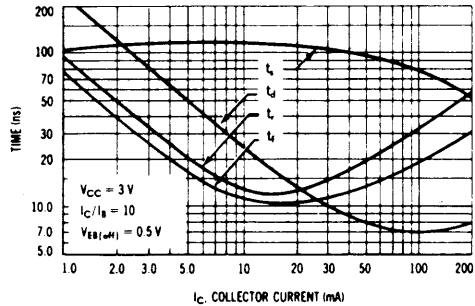


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

($V_{CE} = 5 \text{ Vdc}$, $T_A = 25^\circ\text{C}$)
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

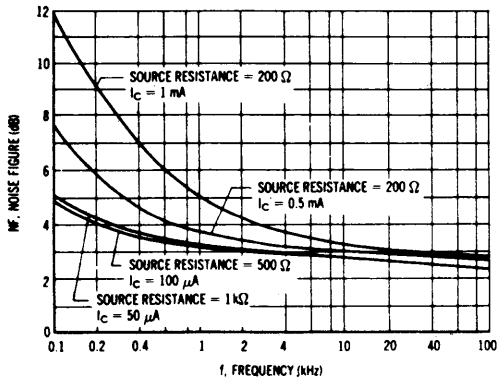
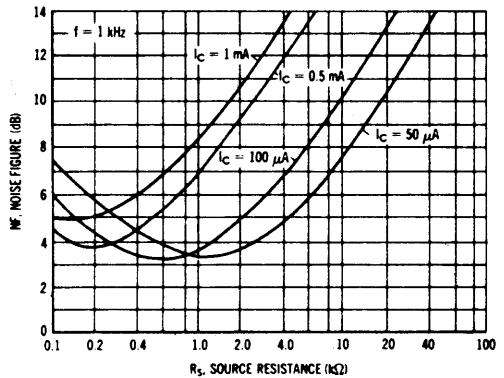


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

$V_{CE} = 10 \text{ V}$, $f = 1 \text{ kHz}$, $T_A = 25^\circ\text{C}$

FIGURE 5 — CURRENT GAIN

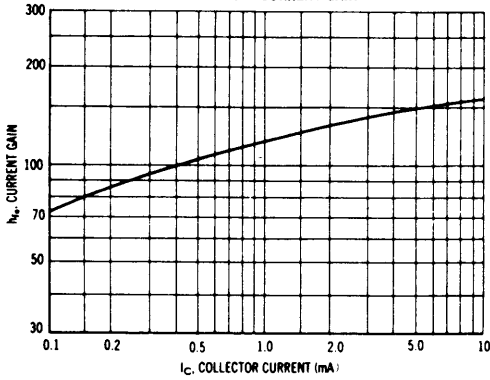


FIGURE 6 — OUTPUT ADMITTANCE

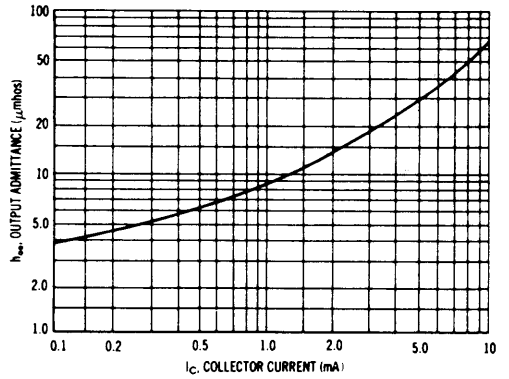


FIGURE 7 — INPUT IMPEDANCE

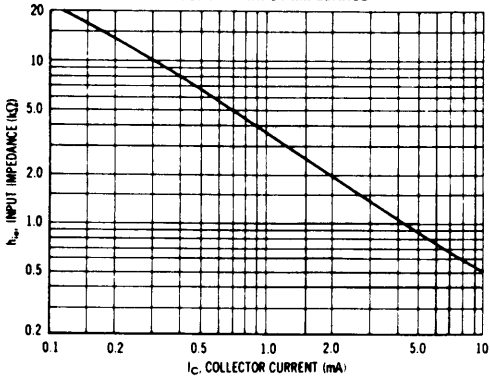
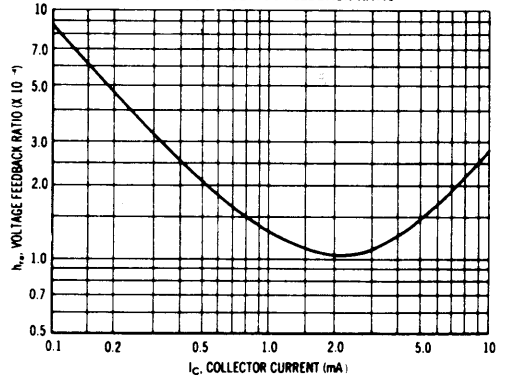


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — DC CURRENT GAIN

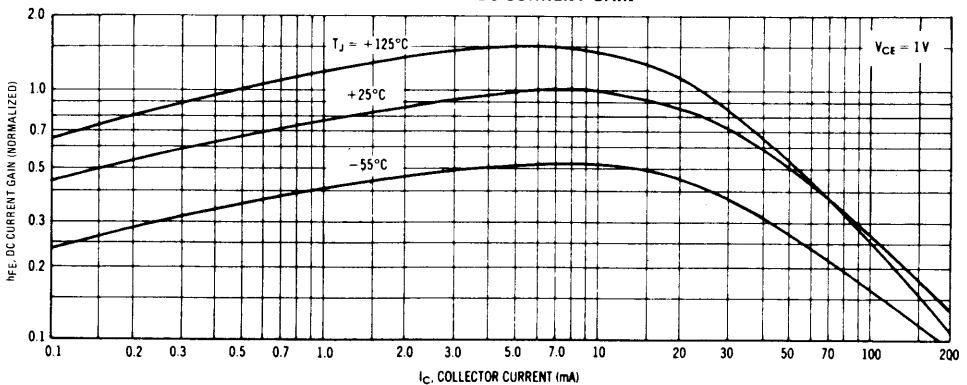


FIGURE 10 — COLLECTOR SATURATION REGION

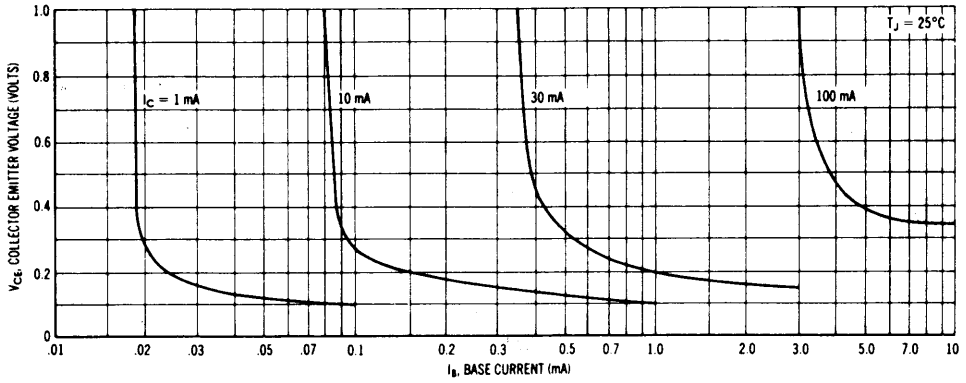


FIGURE 11 — "ON" VOLTAGES

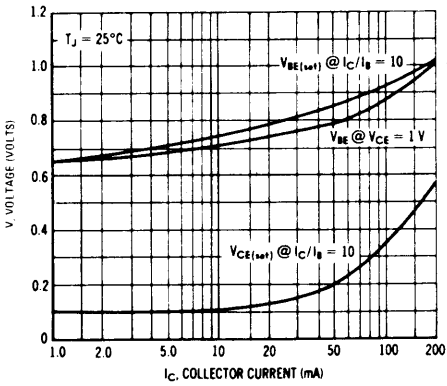
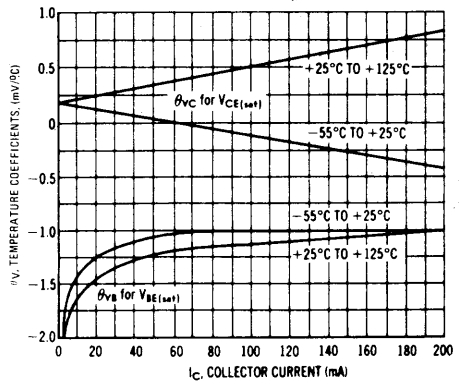


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4125 2N4126

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CE0}	30	25	Vdc
Collector-Base Voltage	V_{CB0}	30	25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}, I_E = 0$)	2N4125 2N4126	$V_{(BR)CEO}$	30 25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	2N4125 2N4126	$V_{(BR)CBO}$	30 25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}, I_E = 0$)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}, I_C = 0$)		I_{EBO}	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 2.0 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	2N4125 2N4126	h_{FE}	50 120	150 360	—
($I_C = 50 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	2N4125 2N4126		25 60	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$)		$V_{BE(sat)}$	—	0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	2N4125 2N4126	f_T	200 250	— —	MHz
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$)		C_{ibo}	—	10	pF
Collector-Base Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)		C_{cb}	—	4.5	pF
Small-Signal Current Gain ($I_C = 2.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	2N4125 2N4126	h_{fe}	50 120	200 480	—
Current Gain — High Frequency ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	2N4125 2N4126	$ h_{fe} $	2.0 2.5	— —	—
Noise Figure ($I_C = 100 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}, R_G = 1.0 \text{ k ohm}$, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4125 2N4126	NF	— —	5.0 4.0	dB

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{sec}$, Duty Cycle = 2.0%.

FIGURE 1 — CAPACITANCE

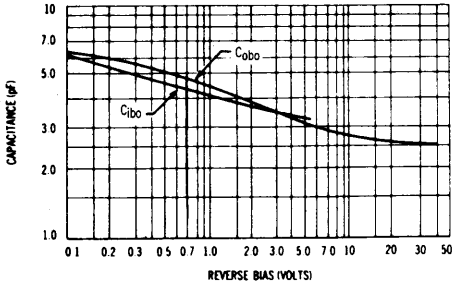
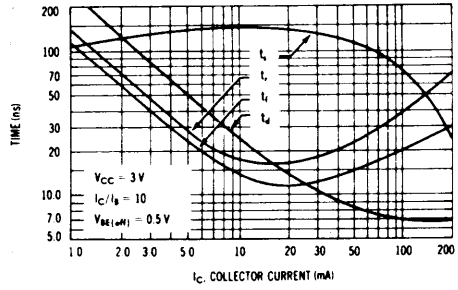


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 5.0 \text{ Vdc}$, $T_A = 25^\circ\text{C}$,
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

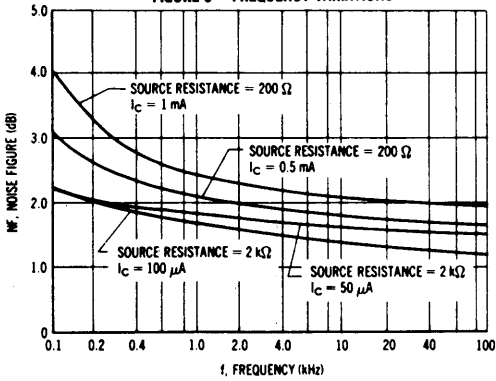
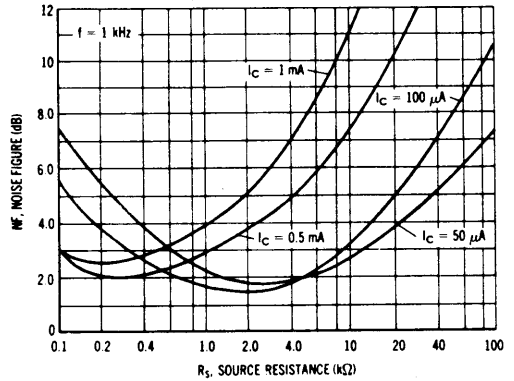


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

$V_{CE} = 10 \text{ V}$, $f = 1 \text{ kHz}$, $T_A = 25^\circ\text{C}$

FIGURE 5 — CURRENT GAIN

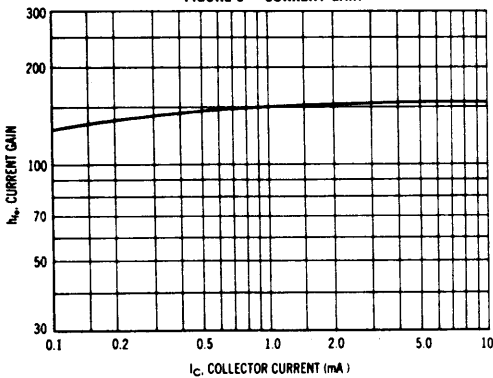
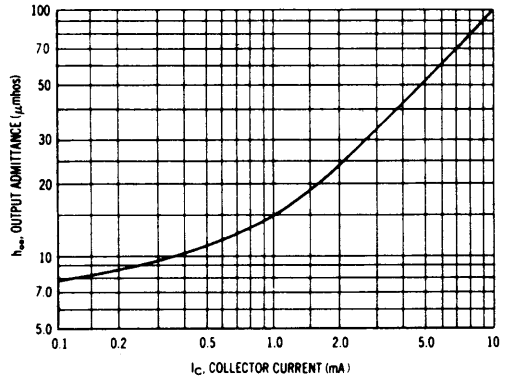


FIGURE 6 — OUTPUT ADMITTANCE



2

FIGURE 7 — INPUT IMPEDANCE

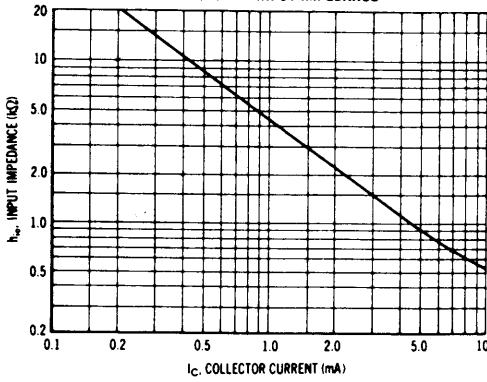
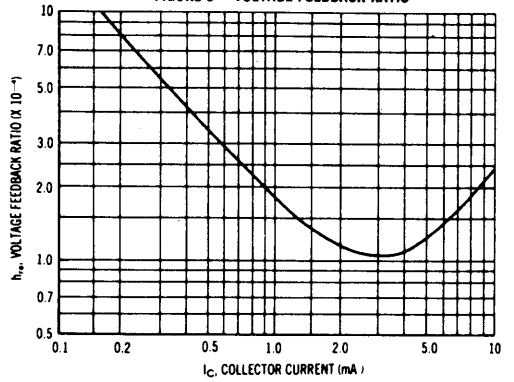


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — DC CURRENT GAIN

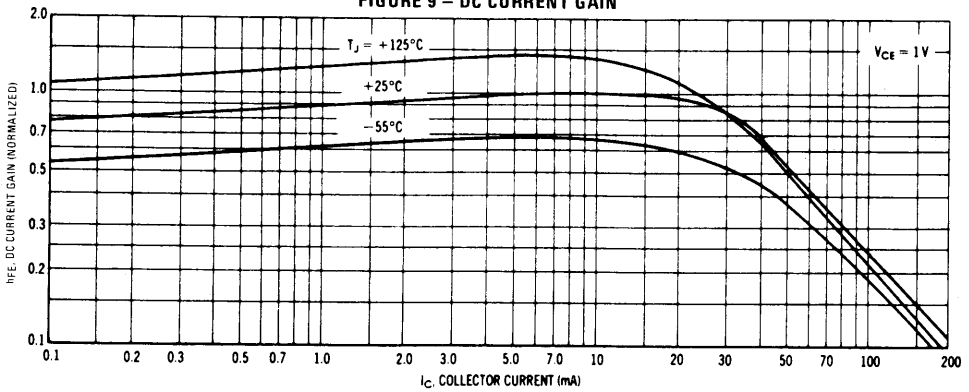


FIGURE 10 — COLLECTOR SATURATION REGION

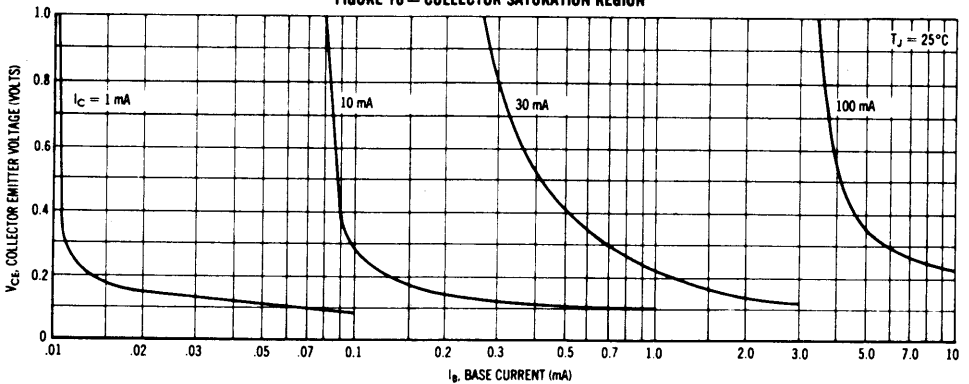


FIGURE 11 — "ON" VOLTAGES

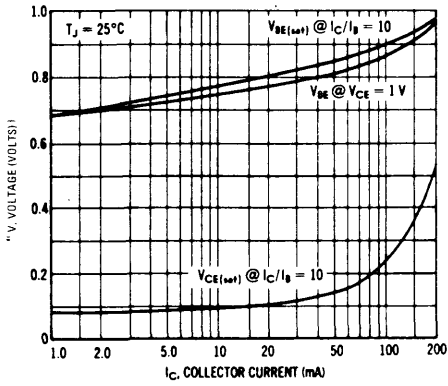
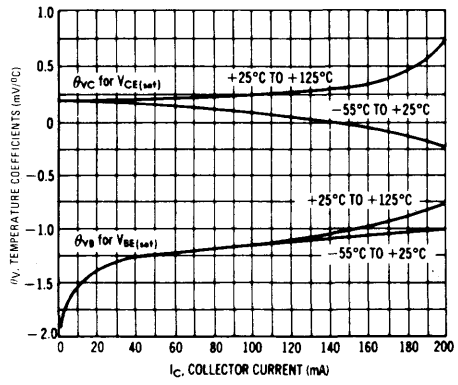


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4264 2N4265

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N4264	2N4265	Unit
Collector-Emitter Voltage	V_{CE0}	15	12	Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mAdc}, I_E = 0$)	$V_{(BR)CEO}$	15 12	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 12 \text{ Vdc}, V_{EB(off)} = 0.25 \text{ Vdc}$) ($V_{CE} = 12 \text{ Vdc}, V_{EB(off)} = 0.25 \text{ Vdc}, T_A = 100^\circ\text{C}$)	I_{BEV}	— —	0.1 10	μAdc
Collector Cutoff Current ($V_{CE} = 12 \text{ Vdc}, V_{EB(off)} = 0.25 \text{ Vdc}$)	I_{CEX}	—	100	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	Symbol	Min	Max	Unit
2N4264	h_{FE}	25	—	—
2N4265		30	—	
($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	40	160	—
2N4265		100	400	
($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$)	h_{FE}	20	—	—
2N4265		45	—	
($I_C = 30 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	40	—	—
2N4265		90	—	
($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)(1)	h_{FE}	30	—	—
2N4265		55	—	
($I_C = 200 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)(1)	h_{FE}	20	—	—
2N4265		35	—	
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)(1)	$V_{CE(sat)}$	— —	0.22 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)(1)	$V_{BE(sat)}$	0.65 0.75	0.80 0.95	Vdc

2N4264, 2N4265

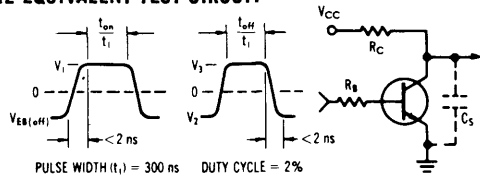
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mA, V _{CE} = 10 V, f = 100 MHz)	f _T	350	—	MHz
Input Capacitance (V _{BE} = 0.5 V, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	8.0	pF
Collector-Base Capacitance (V _{CB} = 5.0 V, I _E = 0, f = 1.0 MHz)	C _{cb}	—	4.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V _{CC} = 10 V, V _{EB(off)} = 2.0 V, I _C = 100 mA, I _{B1} = 10 mA) (Fig. 1, Test Condition C)	t _d	—	8.0	ns
Rise Time (I _C = 100 mA, I _{B1} = 10 mA) (Fig. 1, Test Condition C)	t _r	—	15	ns
Storage Time (V _{CC} = 10 V, I _C = 10 mA, for t _s) (I _C = 100 mA for t _f)	t _s	—	20	ns
Fall Time (I _{B1} = I _{B2} = 10 mA) (Fig. 1, Test Condition C)	t _f	—	15	ns
Turn-On Time (V _{CC} = 3.0 V, V _{EB(off)} = 1.5 V, I _C = 10 mA, I _{B1} = 3.0 mA) (Fig. 1, Test Condition A)	t _{on}	—	25	ns
Turn-Off Time (V _{CC} = 3.0 V, I _C = 10 mA, I _{B1} = 3.0 mA, I _{B2} = 1.5 mA) (Fig. 1, Test Condition A)	t _{off}	—	35	ns
Storage Time (V _{CC} = 10 V, I _C = 10 mA, I _{B1} = I _{B2} = 10 mA) (Fig. 1, Test Condition A)	t _s	—	20	ns
Total Control Charge (V _{CC} = 3.0 V, I _C = 10 mA, I _B = mA) (Fig. 1, Test Condition B)	Q _T	—	80	pC

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — SWITCHING TIME EQUIVALENT TEST CIRCUIT

TEST CONDITION	I _C	V _{CC}	R _B	R _C	C _{S(max)}	V _{EB(off)}	V ₁	V ₂	V ₃
	mA	V	Ω	Ω	pF	V	V	V	V
A	10	3	3300	270	4	-1.5	10.55	-4.15	10.70
B	10	10	560	960	4	—	—	-4.65	6.55
C	100	10	560	96	12	-2.0	6.35	-4.65	6.55



CURRENT GAIN CHARACTERISTICS

FIGURE 2 — MINIMUM CURRENT GAIN

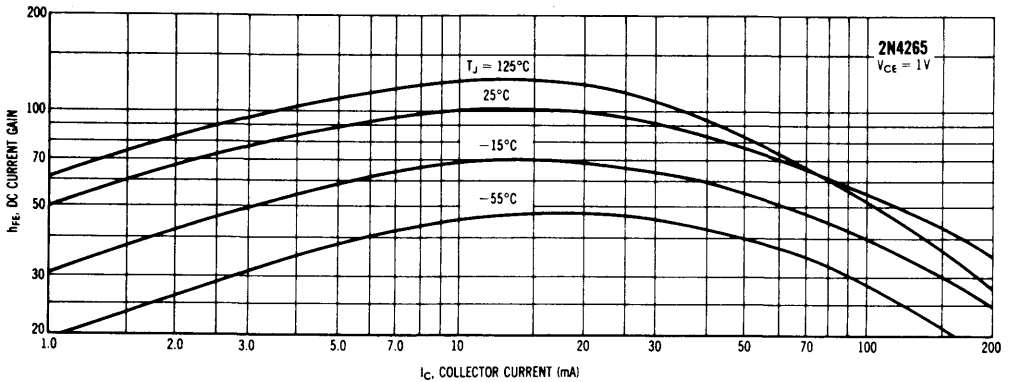
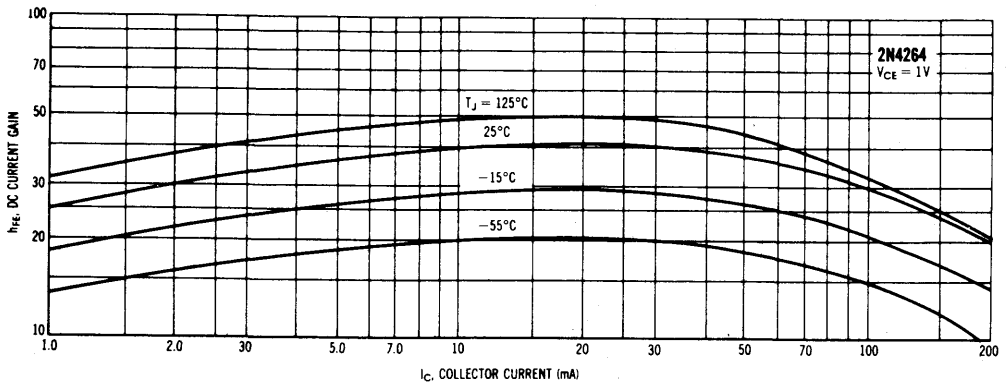


FIGURE 3 — Q_T TEST CIRCUIT

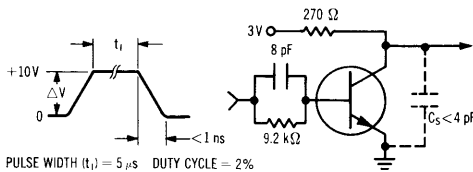
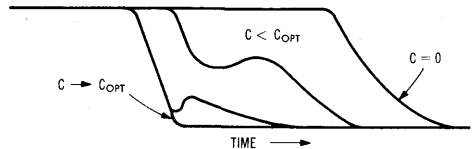


FIGURE 4 — TURN-OFF WAVEFORM



NOTE 1

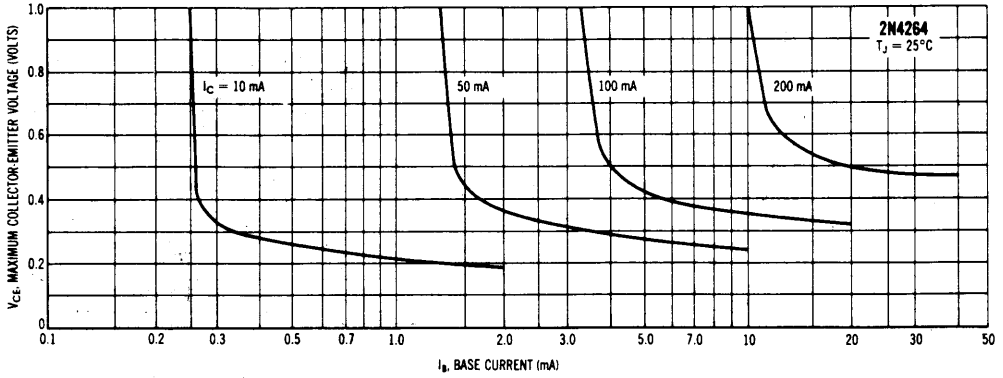
If I_B were suddenly removed, the transistor would continue to conduct until Q_3 is removed from the active regions through an external path or through internal recombination. Since the internal recombination time is long compared to the ultimate capability of a transistor, a charge, Q_1 , of opposite polarity, equal in magnitude, can be stored on an external capacitor, C , to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 3 shows the test circuit and Figure 4 the turn-off waveform. Given Q_1 from Figure 13, the external C for worst-case turn-off in any circuit is: $C = Q_1/\Delta V$, where ΔV is defined in Figure 3.

Q_2 is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_3 is the charge required to charge the collector-base feedback capacity. Q_4 is excess charge resulting from overdrive, i.e., operation in saturation.

The charge required to turn a transistor "on" to the edge of saturation is the sum of Q_1 and Q_2 , which is defined as the active region charge, Q_A . $Q_A = I_{B1}t$, when the transistor is driven by a constant current step (t_{B1}) and $I_{B1} \ll \frac{I_C}{h_{FE}}$.

“ON” CONDITION CHARACTERISTICS

FIGURE 5 — COLLECTOR SATURATION REGION



2

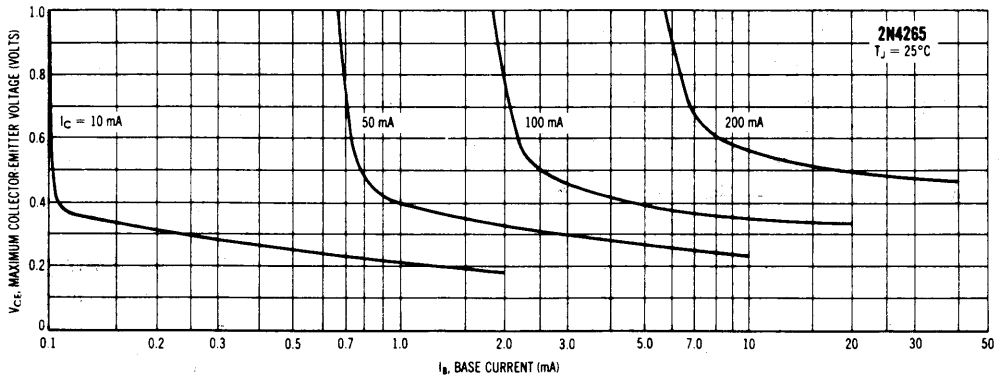


FIGURE 6 — SATURATION VOLTAGE LIMITS

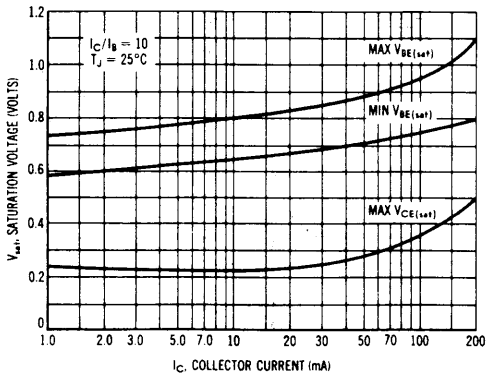
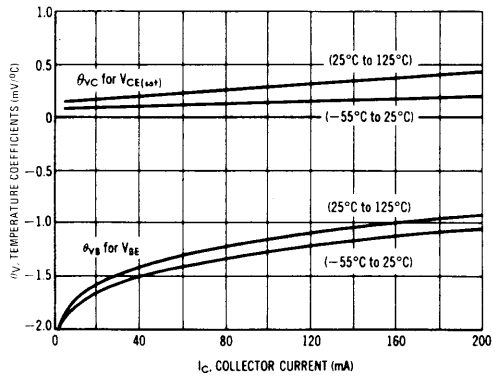


FIGURE 7 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 8 — DELAY TIME

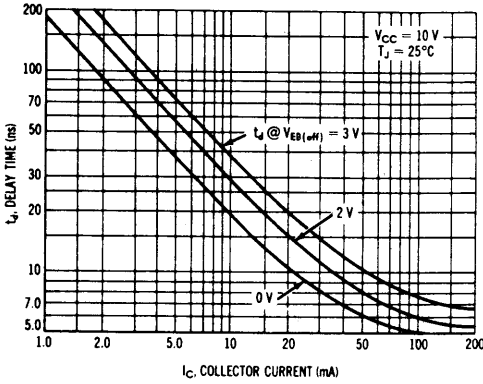


FIGURE 9 — RISE TIME

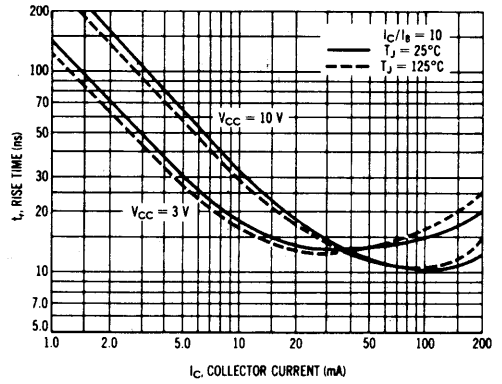


FIGURE 10 — STORAGE TIME

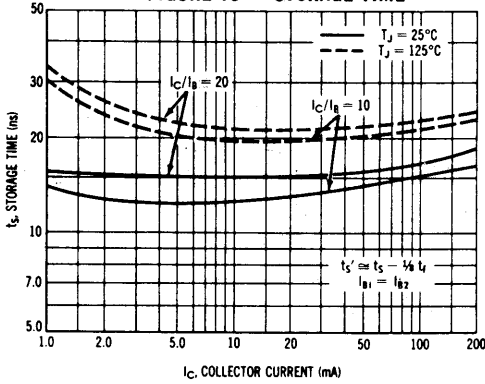


FIGURE 11 — FALL TIME

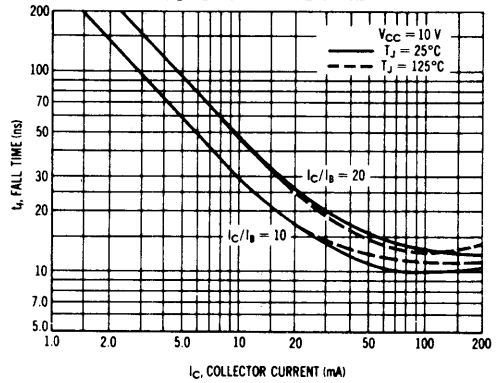


FIGURE 12 — JUNCTION CAPACITANCE

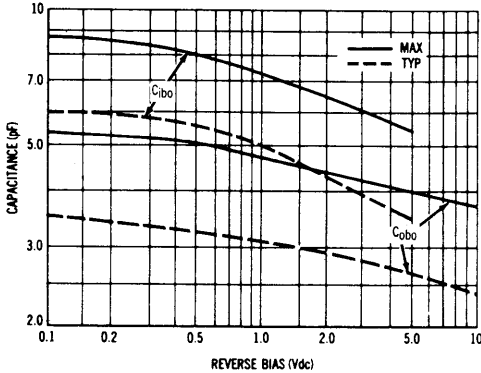
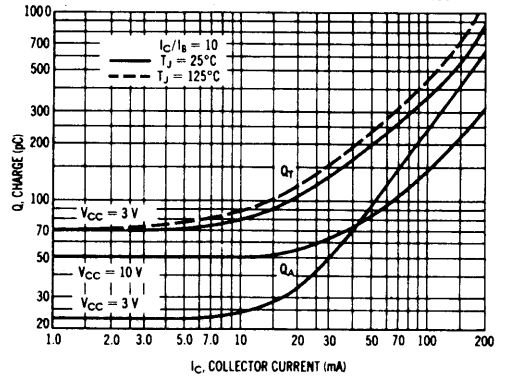


FIGURE 13 — MAXIMUM CHARGE DATA



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current — Continuous	I _C	600	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

2N4400
2N4401

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	Vdc
Base Cutoff Current (V _{CE} = 35 Vdc, V _{EB} = 0.4 Vdc)	I _{BEV}	—	0.1	μAdc
Collector Cutoff Current (V _{CE} = 35 Vdc, V _{EB} = 0.4 Vdc)	I _{CEX}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	20	—	—
(I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc)				
(I _C = 10 mAdc, V _{CE} = 1.0 Vdc)				
(I _C = 150 mAdc, V _{CE} = 1.0 Vdc)				
(I _C = 500 mAdc, V _{CE} = 2.0 Vdc)				
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)				
Base-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{BE(sat)}	0.75	0.95 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	200 250	—	MHz
Collector-Base Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 100 kHz)	C _{cb}	—	6.5	pF

2N4400, 2N4401

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Emitter-Base Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{eb}	—	30	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	0.5 1.0	7.5 15	k ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	0.1	8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	20 40	250 500	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	1.0	30	μmhos

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30\text{ Vdc}$, $V_{EB} = 2.0\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = 15\text{ mAdc}$)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	$(V_{CC} = 30\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = I_{B2} = 15\text{ mAdc}$)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

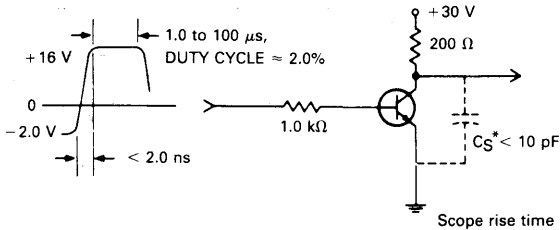
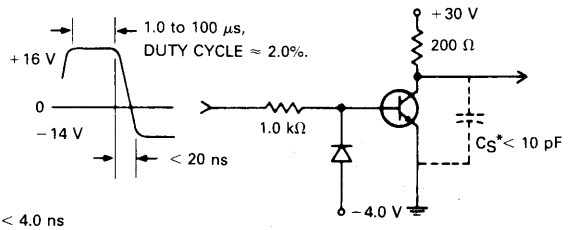


FIGURE 2 — TURN-OFF TIME



*Total shunt capacitance of test jig connectors, and oscilloscope

TRANSIENT CHARACTERISTICS

— 25°C - - - 100°C

FIGURE 3 — CAPACITANCES

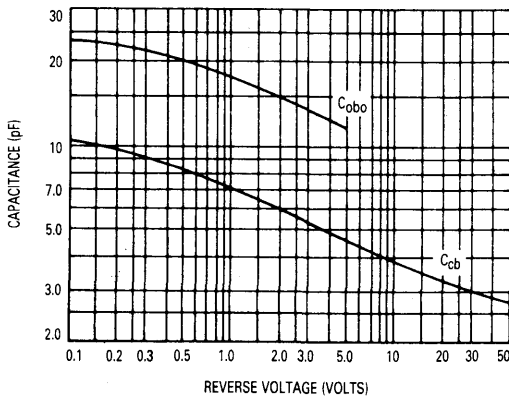


FIGURE 4 — CHARGE DATA

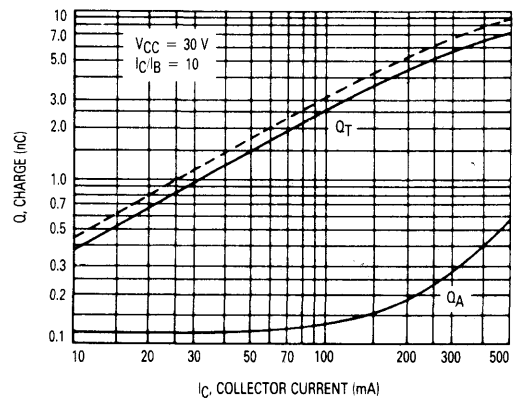


FIGURE 5 — TURN-ON TIME

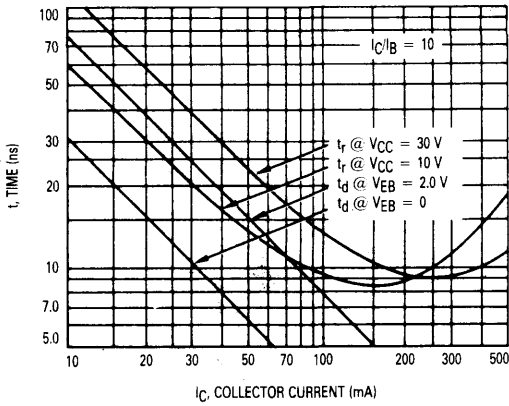


FIGURE 6 — RISE AND FALL TIMES

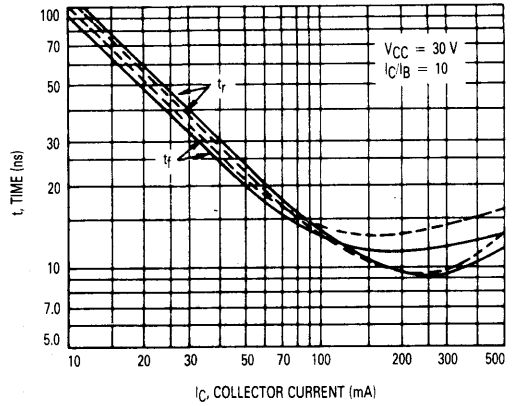


FIGURE 7 — STORAGE TIME

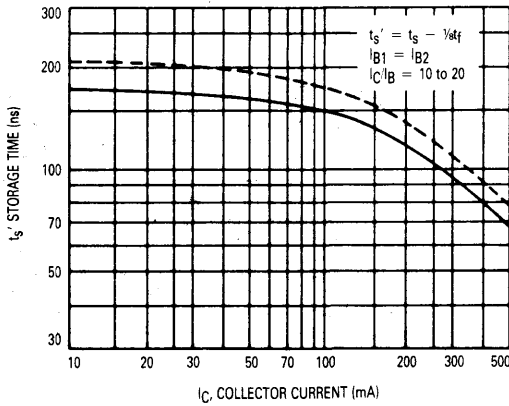
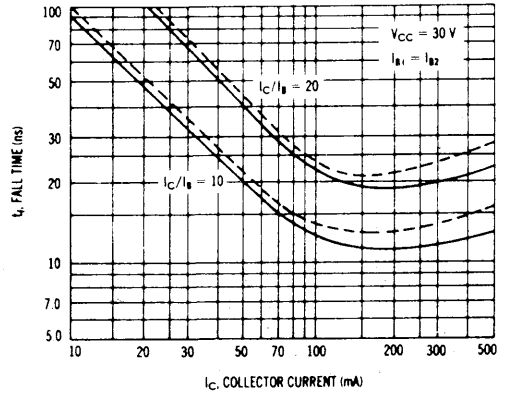


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10$ Vdc, $T_A = 25^\circ\text{C}$
Bandwidth = 1.0 Hz

FIGURE 9 — FREQUENCY EFFECTS

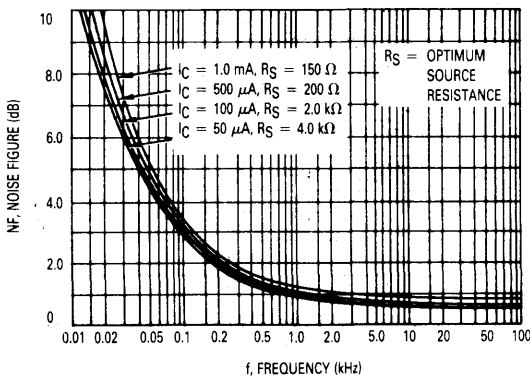
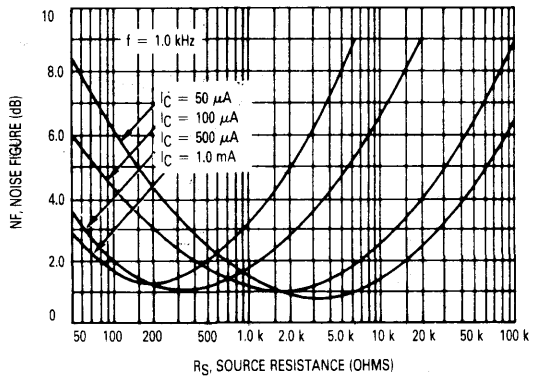


FIGURE 10 — SOURCE RESISTANCE EFFECTS



2N4400, 2N4401

h PARAMETERS

$V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were

selected from both the 2N4400 and 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

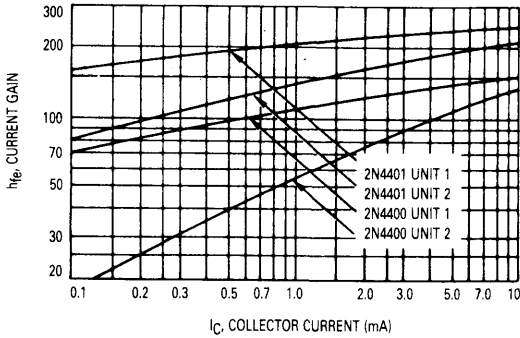


FIGURE 12 — INPUT IMPEDANCE

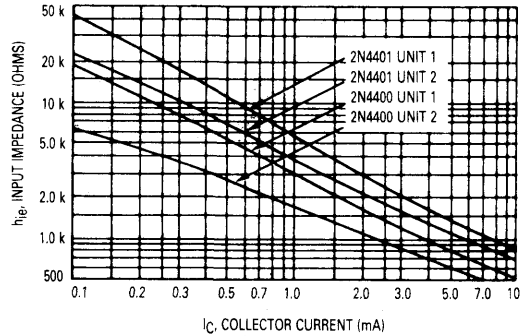


FIGURE 13 — VOLTAGE FEEDBACK RATIO

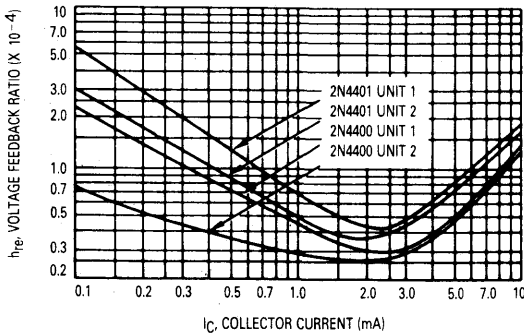
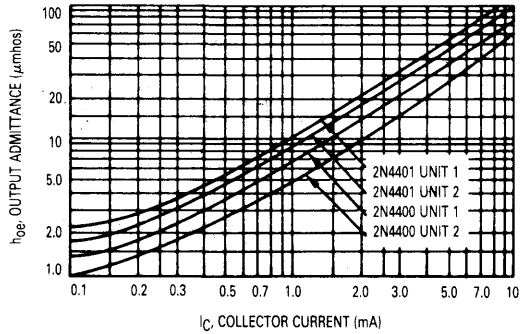


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

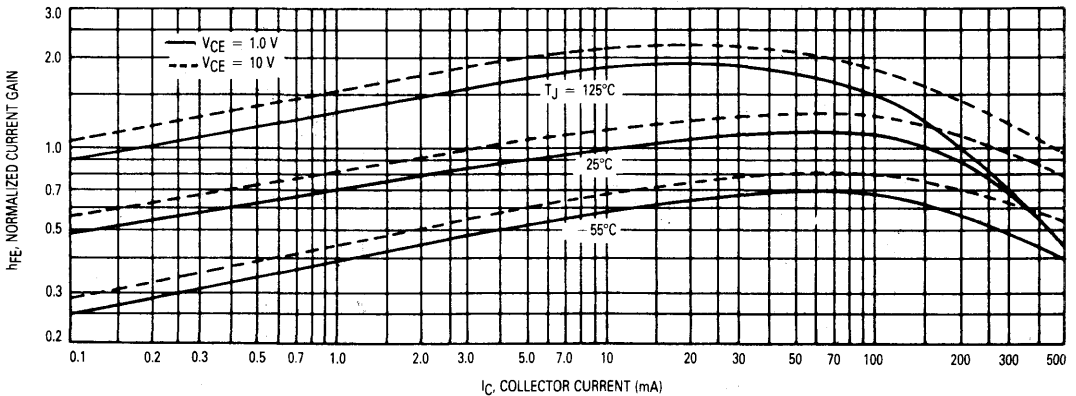


FIGURE 16 — COLLECTOR SATURATION REGION

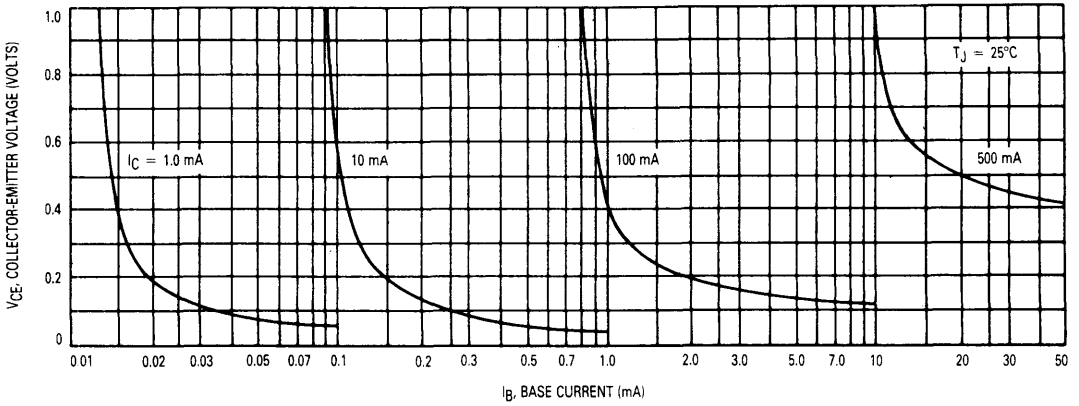


FIGURE 17 — "ON" VOLTAGES

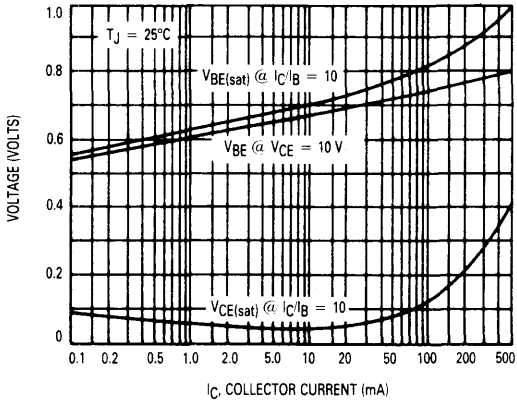
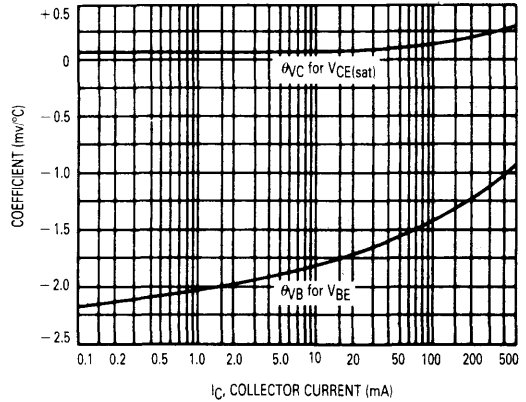


FIGURE 18 — TEMPERATURE COEFFICIENTS



2N4402 2N4403

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE
TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current ($V_{CE} = 35$ Vdc, $V_{BE} = 0.4$ Vdc)	I_{BEV}	—	0.1	μAdc
Collector Cutoff Current ($V_{CE} = 35$ Vdc, $V_{BE} = 0.4$ Vdc)	I_{CEX}	—	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4403	h_{FE}	30	—	—
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4402 2N4403		30 60	—	—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4402 2N4403		50 100	—	—
($I_C = 150$ mAdc, $V_{CE} = 2.0$ Vdc)(1)	2N4402 2N4403		50 100	150 300	—
($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)(1)	Both		20	—	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	—	0.4 0.75	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	0.75 —	0.95 1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	2N4402 2N4403	f_T	150 200	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 140$ kHz)		C_{cb}	—	8.5	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 140$ kHz)		C_{eb}	—	30	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	2N4402 2N4403	h_{ie}	750 1.5k	7.5k 15k	ohms

2N4402, 2N4403

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{re}	0.1	8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	30 60	250 500	—
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	1.0	100	μmhos

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30 \text{ Vdc}$, $V_{BE} = 2.0 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = 15 \text{ mAdc}$)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	$(V_{CC} = 30 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = I_{B2} = 15 \text{ mAdc}$)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

SWITCHING TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 — TURN-ON TIME

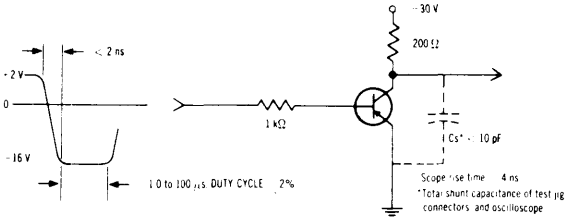
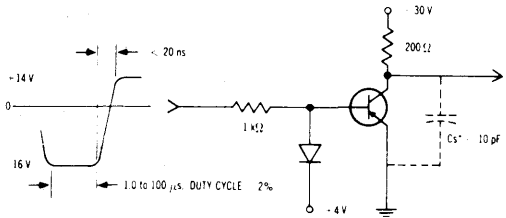


FIGURE 2 — TURN-OFF TIME



TRANSIENT CHARACTERISTICS

— 25°C - - - 100°C

FIGURE 3 — CAPACITANCES

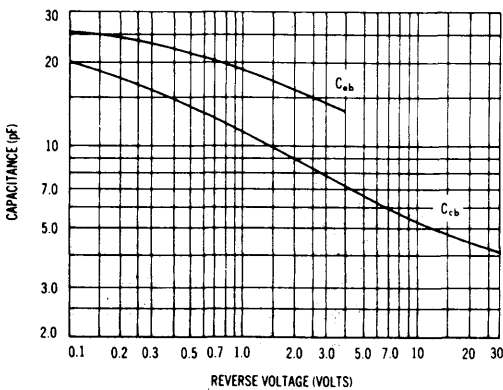
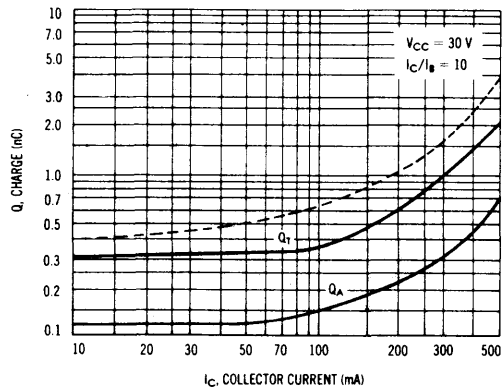


FIGURE 4 — CHARGE DATA



2

FIGURE 5 — TURN-ON TIME

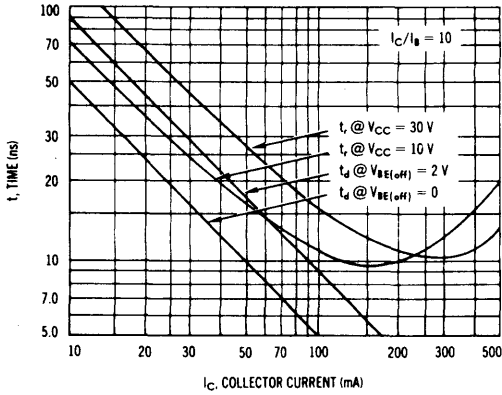


FIGURE 6 — RISE TIME

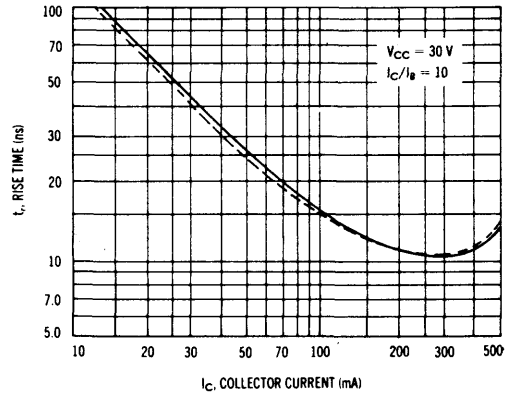
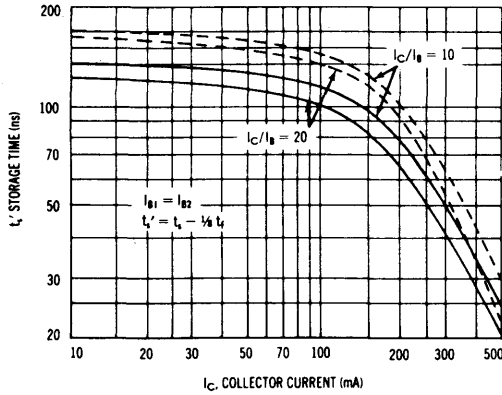


FIGURE 7 — STORAGE TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10$ Vdc, $T_A = 25^\circ\text{C}$
Bandwidth = 1.0 Hz

FIGURE 8 — FREQUENCY EFFECTS

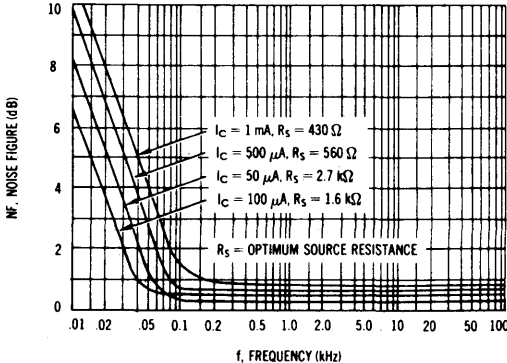
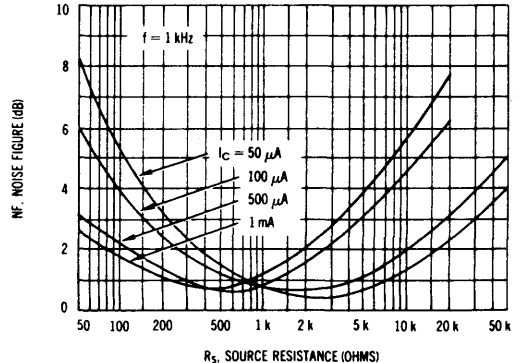


FIGURE 9 — SOURCE RESISTANCE EFFECTS



2N4402, 2N4403

h PARAMETERS

$V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$, $T_A = 25^\circ\text{C}$

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the

2N4402 and 2N4403 lines, and the same units were used to develop the correspondingly-numbered curves on each graph.

FIGURE 10 — CURRENT GAIN

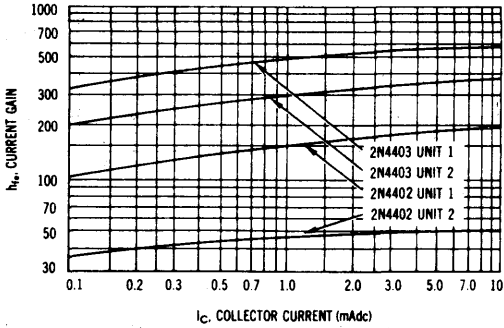


FIGURE 11 — INPUT IMPEDANCE

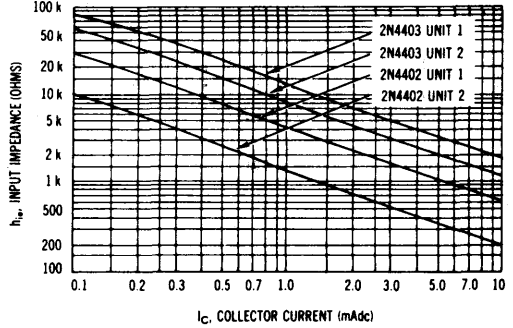


FIGURE 12 — VOLTAGE FEEDBACK RATIO

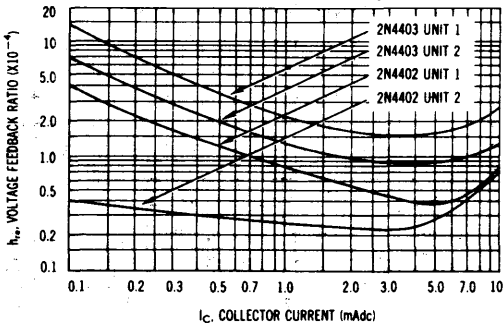
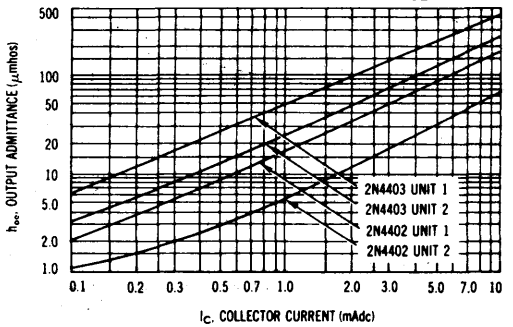
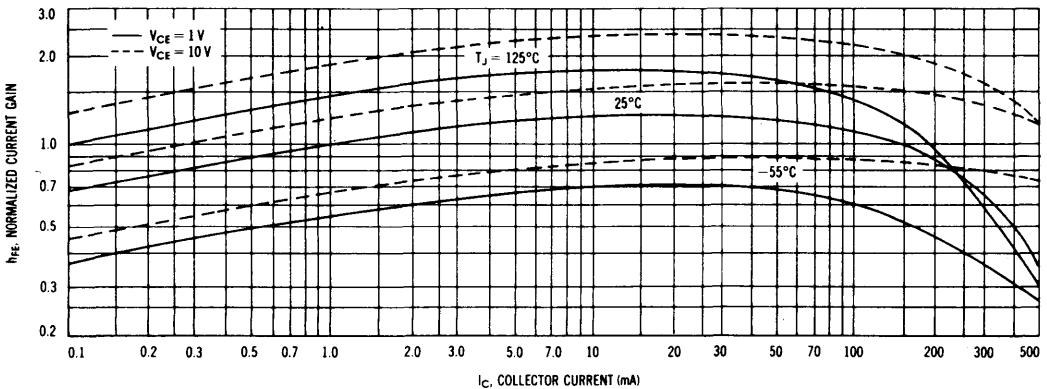


FIGURE 13 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 14 — DC CURRENT GAIN



2

FIGURE 15 — COLLECTOR SATURATION REGION

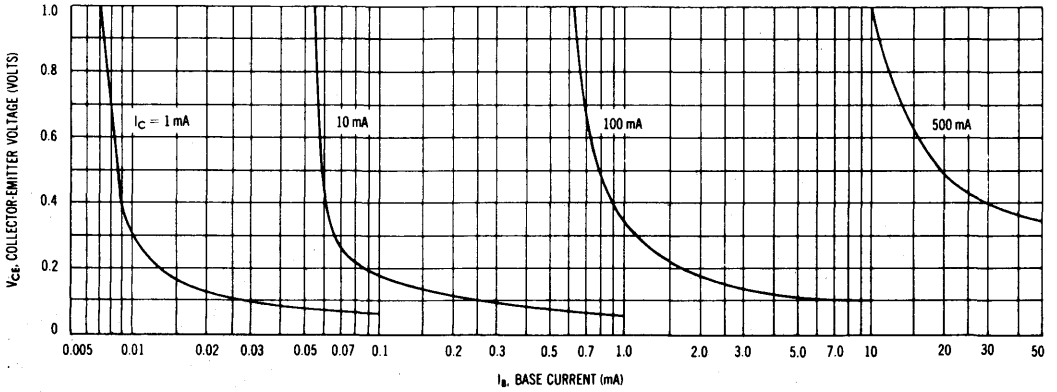


FIGURE 16 — "ON" VOLTAGES

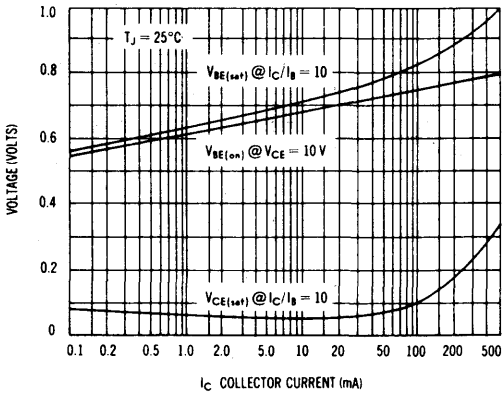
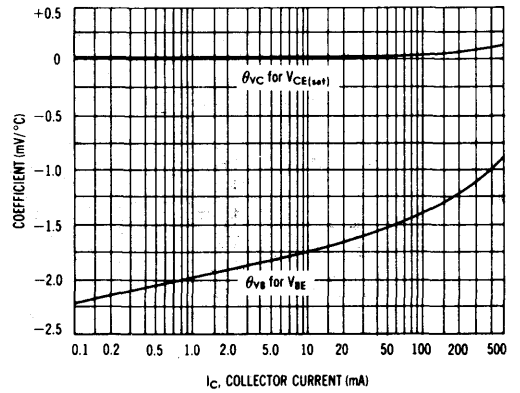


FIGURE 17 — TEMPERATURE COEFFICIENTS



MAXIMUM RATINGS

Rating	Symbol	2N4409	2N4410	Unit
Collector-Emitter Voltage	V_{CEO}	50	80	Vdc
Collector-Base Voltage	V_{CBO}	80	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	250		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

2N4409
2N4410

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	50 80	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 500$ μ Adc, $V_{BE} = 5.0$ Vdc, $R_{BE} = 8.2$ kohms)	$V_{(BR)CEX}$	80 120	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	80 120	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 100^\circ\text{C}$) ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	— — — —	0.01 1.0 0.01 1.0	μ Adc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μ Adc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	60 60	— 400	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	—	0.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)	$V_{BE(sat)}$	—	0.8	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 30$ MHz)	f_T	60	300	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 140$ kHz, emitter guarded)	C_{cb}	—	12	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 140$ kHz, collector guarded)	C_{eb}	—	50	pF

(1) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

(2) $f_T = |h_{fe}| \cdot f_{test}$.

2N5086 2N5087

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$) ($V_{CB} = 35$ Vdc, $I_E = 0$)	I_{CBO}	—	10 50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 100$ μ Adc, $V_{CE} = 5.0$ Vdc)	2N5086 2N5087	h_{FE}	150 250	500 800	—
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N5086 2N5087		150 250	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)(2)	2N5086 2N5087		150 250	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	0.85	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 500$ μ Adc, $V_{CE} = 5.0$ Vdc, $f = 20$ MHz)		f_T	40	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, $f = 100$ kHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz)	2N5086 2N5087	h_{fe}	150 250	600 900	—
Noise Figure ($I_C = 20$ μ Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ k ohms, $f = 10$ Hz to 15.7 kHz)	2N5086 2N5087	NF	— —	3.0 2.0	dB
($I_C = 100$ μ Adc, $V_{CE} = 5.0$ Vdc, $R_S = 3.0$ k ohms, $f = 1.0$ kHz)	2N5086 2N5087		— —	3.0 2.0	

(2) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

2N5088 2N5089

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)
AMPLIFIER TRANSISTOR
NPN SILICON**

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N5088	2N5089	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	35	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350	2.8	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	2N5088 2N5089	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	2N5088 2N5089	$V_{(BR)CBO}$	35 30	— —	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}, I_E = 0$) ($V_{CB} = 15 \text{ Vdc}, I_E = 0$)	2N5088 2N5089	I_{CBO}	— —	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)} = 3.0 \text{ Vdc}, I_C = 0$) ($V_{EB(off)} = 4.5 \text{ Vdc}, I_C = 0$)		I_{EBO}	— —	50 100	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 100 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)	2N5088 2N5089	h_{FE}	300 400	900 1200	—
($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	2N5088 2N5089		350 450	— —	
($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)(2)	2N5088 2N5089		300 400	— —	
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)(2)		$V_{BE(on)}$	—	0.8	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 500 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}, f = 20 \text{ MHz}$)		f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)		C_{cb}	—	4.0	pF
Emitter-Base Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)		C_{eb}	—	10	pF
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$)	2N5088 2N5089	h_{fe}	350 450	1400 1800	—
Noise Figure ($I_C = 100 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}, R_S = 10 \text{ kohms}, f = 10 \text{ Hz to } 15.7 \text{ kHz}$)	2N5088 2N5089	NF	— —	3.0 2.0	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
 (2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N5208

**CASE 29-02, STYLE 2
TO-92 (TO-226AA)**

**GENERAL PURPOSE
TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	25	Vdc
Collector-Base Voltage	V_{CB0}	30	Vdc
Emitter-Base Voltage	V_{EB0}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

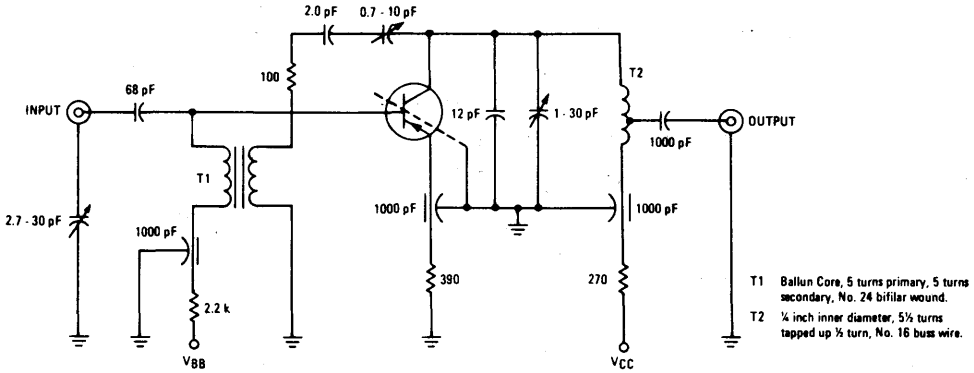
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$	357	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	10	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	120	—
Base-Emitter On Voltage ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc)	$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	300	1200	MHz
Input Capacitance ($V_{BE} = 2.0$ Vdc, $I_C = 0$, $f = 1.0$ MHz)	C_{ibo}	—	4.0	pF
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	1.0	pF
Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 10$ Vdc, $f = 31.8$ MHz)	$rb'C_C$	—	10	ps
Noise Figure ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 75$ ohms, $f = 100$ MHz, BW = 1.0 MHz)	NF	—	3.0	dB
FUNCTIONAL TEST				
Amplifier Power Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	G_{pe}	22	—	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

FIGURE 1 - 100 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



COMMON-EMITTER Y PARAMETERS (Polar Plots)

$V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$

FIGURE 2 - INPUT ADMITTANCE

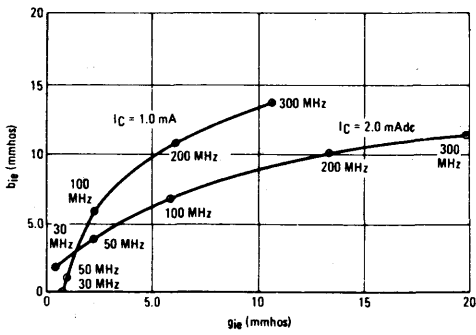


FIGURE 3 - OUTPUT ADMITTANCE

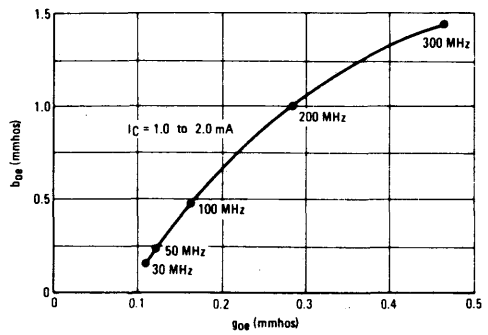


FIGURE 4 - FORWARD TRANSFER ADMITTANCE

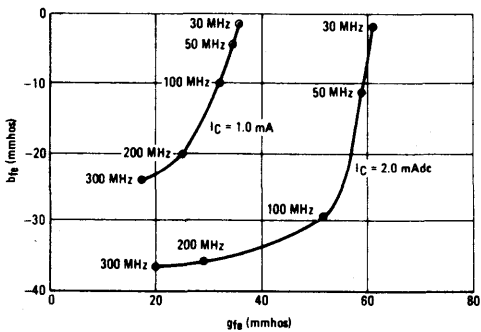
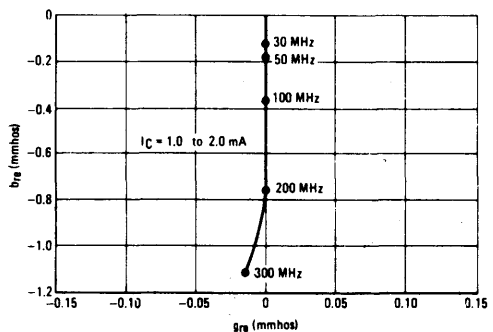
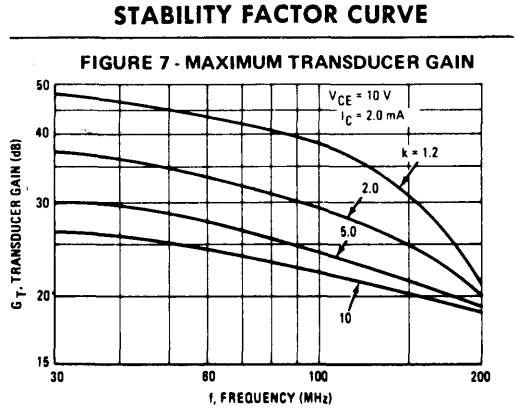
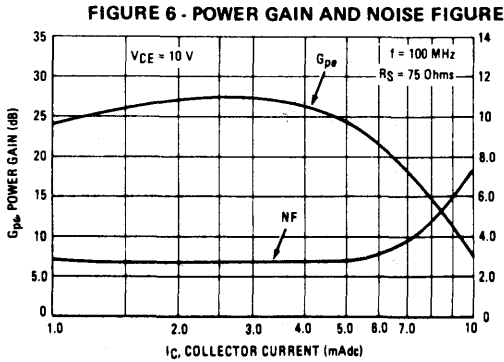


FIGURE 5 - REVERSE TRANSFER ADMITTANCE





COMMON-EMITTER Y PARAMETERS vs FREQUENCY
 $V_{CE} = 10 \text{ Vdc}, T_A = 25^\circ\text{C}$

FIGURE 8 - INPUT ADMITTANCE

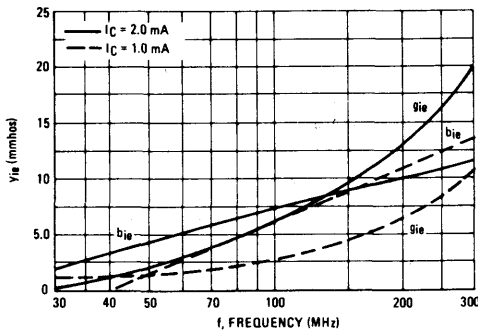


FIGURE 9 - OUTPUT ADMITTANCE

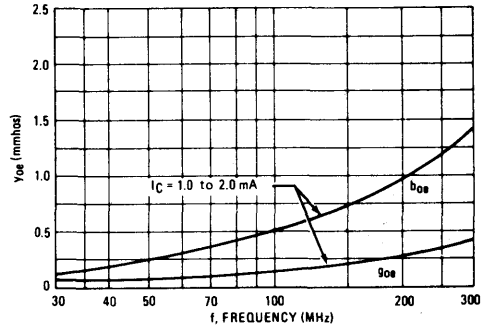


FIGURE 10 - FORWARD TRANSFER ADMITTANCE

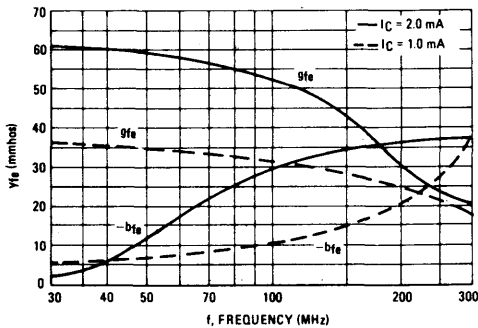
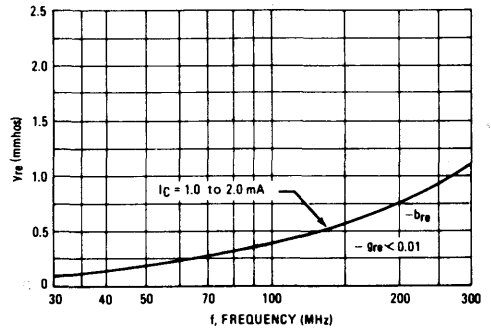


FIGURE 11 - REVERSE TRANSFER ADMITTANCE



STABILITY FACTOR CURVES

FIGURE 12 - OPTIMUM SOURCE ADMITTANCE

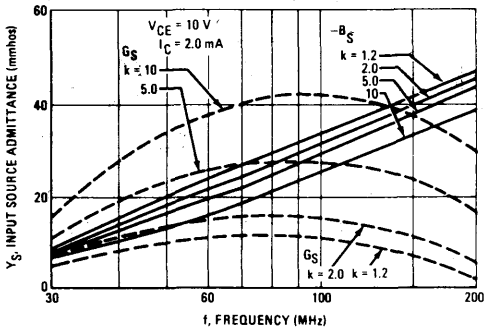
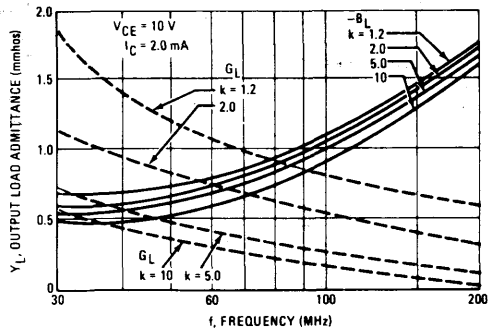


FIGURE 13 - OPTIMUM LOAD ADMITTANCE



When a potentially unstable device is operated without feedback, there is an infinite number of combinations of source and load admittance associated with any given circuit stability factor (k). Equations have been developed for determining the optimum source and load admittance for maximum gain. Figures 7, 12 and 13 provide a solution to the equations for the 2N5208.

NOISE FIGURE

FIGURE 14 - FREQUENCY EFFECTS

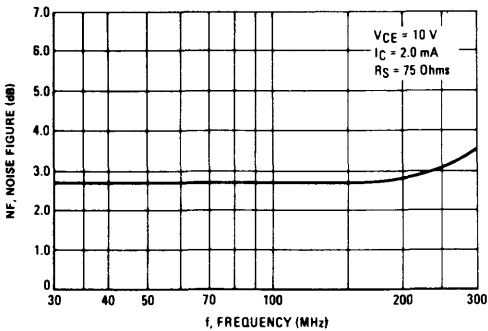


FIGURE 15 - SOURCE RESISTANCE EFFECTS

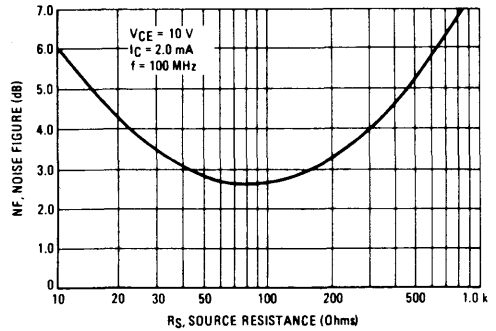


FIGURE 16 - CURRENT-GAIN — BANDWIDTH PRODUCT

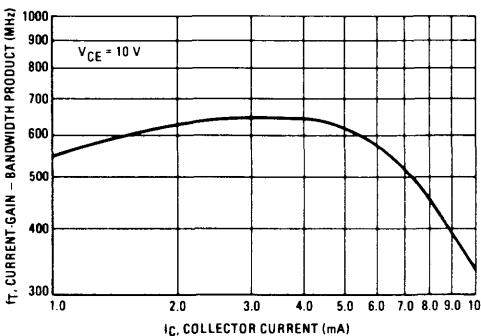
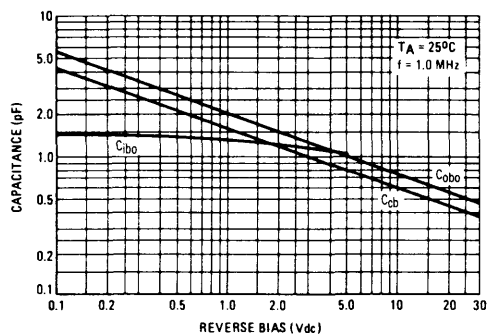
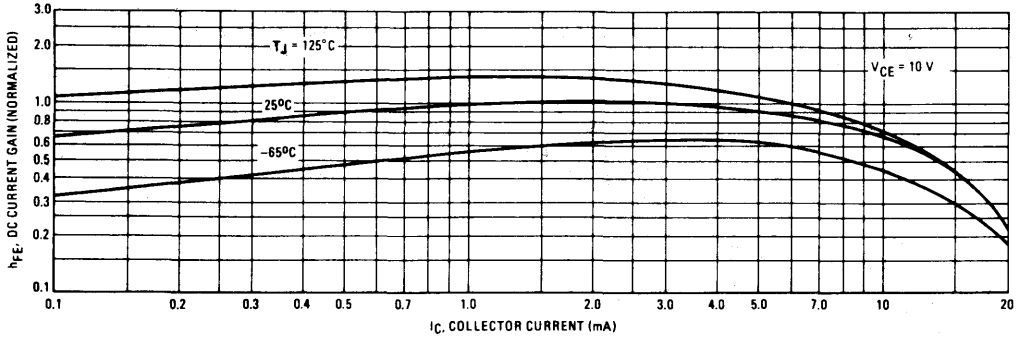


FIGURE 17 - CAPACITANCES



2

FIGURE 18 - DC CURRENT GAIN



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	357	°C/W

2N5209
2N5210

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	Vdc
Collector Cutoff Current ($V_{CB} = 35$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 100$ μ Adc, $V_{CE} = 5.0$ Vdc)	h_{FE}	100 200	300 600	—
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)		150 250	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)(2)		150 250	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 500$ μ Adc, $V_{CE} = 5.0$ Vdc, $f = 20$ MHz)	f_T	30	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz)	h_{fe}	150 250	600 900	—
Noise Figure ($I_C = 20$ μ Adc, $V_{CE} = 5.0$ Vdc, $R_S = 22$ k ohms, $f = 10$ Hz to 15.7 kHz)	NF	—	3.0 2.0	dB
($I_C = 20$ μ Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ k ohms, $f = 1.0$ kHz)		—	4.0 3.0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

(2) Pulse Test: Pulse Width = 300 μ s, Duty Cycle = 2.0%.

2N5400 2N5401

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5400	2N5401	Unit
Collector-Emitter Voltage	V_{CE0}	120	150	Vdc
Collector-Base Voltage	V_{CBO}	130	160	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	120 150	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	130 160	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 100^\circ\text{C}$) ($V_{CB} = 120$ Vdc, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	— — — —	100 50 100 50	nAdc μ Adc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	30 50	—	—
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)		40 60	180 240	
($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)		40 50	—	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	— —	0.20 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	— —	1.0 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ Mhz)	f_T	100 100	400 300	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	6.0	pF

2N5400, 2N5401

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	30	200	—
		40	200	
Noise Figure ($I_C = 250\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 1.0\text{ kohm}$, $f = 10\text{ Hz to }15.7\text{ kHz}$)	NF	—	8.0	dB

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2.0%.

FIGURE 1 – DC CURRENT GAIN

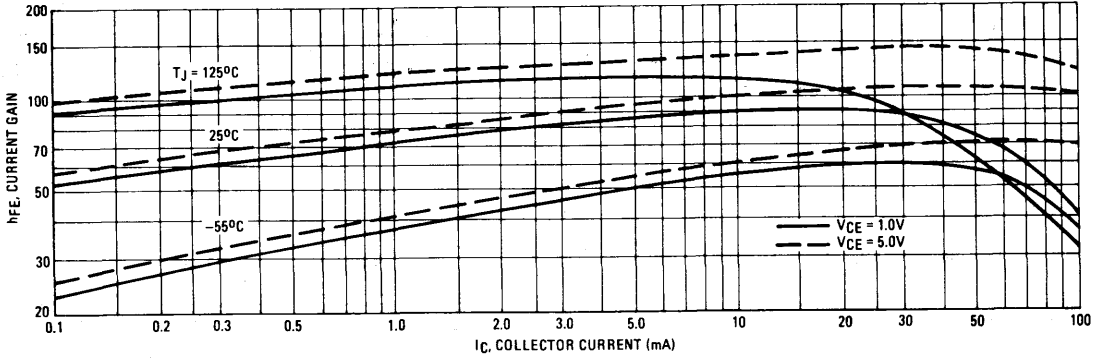


FIGURE 2 – COLLECTOR SATURATION REGION

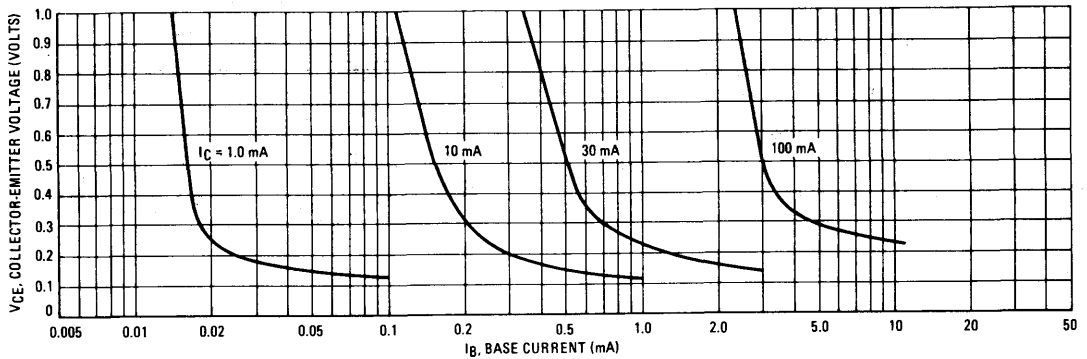
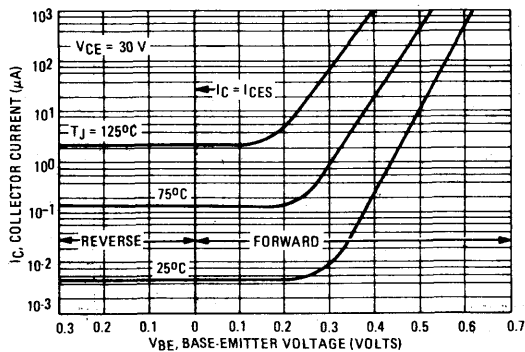


FIGURE 3 – COLLECTOR CUT-OFF REGION



2N5400, 2N5401

FIGURE 4 - "ON" VOLTAGES

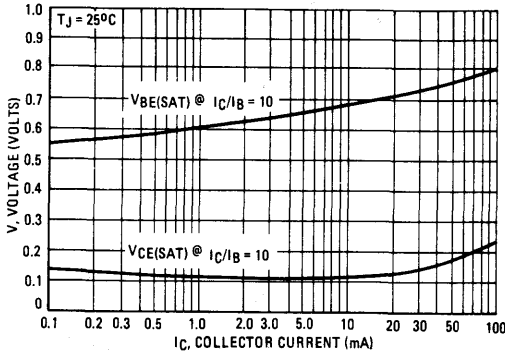


FIGURE 5 - TEMPERATURE COEFFICIENTS

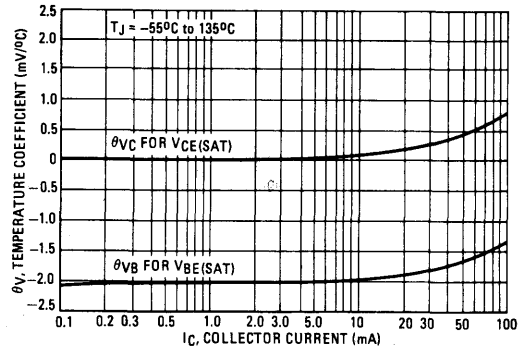


FIGURE 6 - SWITCHING TIME TEST CIRCUIT

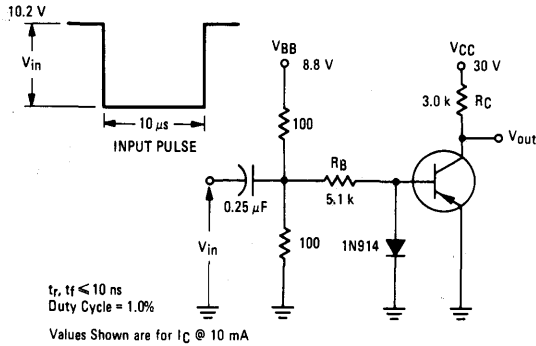


FIGURE 7 - CAPACITANCES

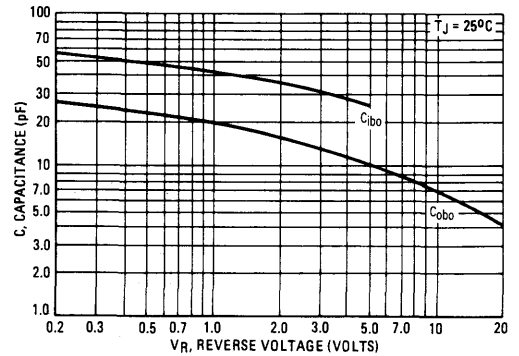


FIGURE 8 - TURN-ON TIME

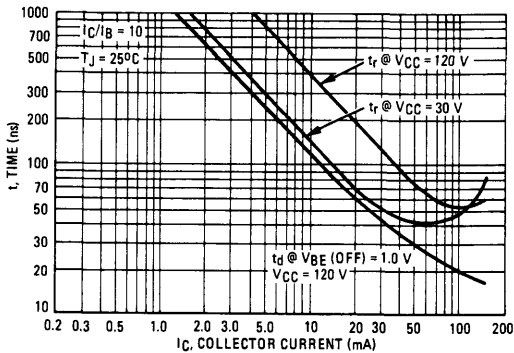
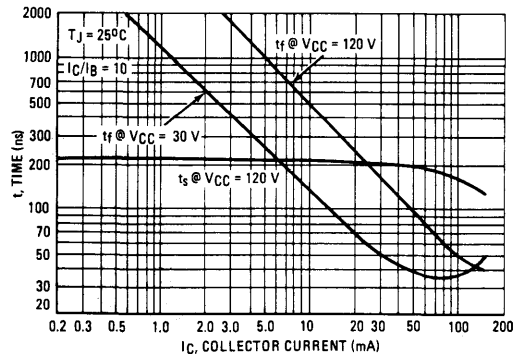


FIGURE 9 - TURN-OFF TIME



2N5550
2N5551

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5550	2N5551	Unit
Collector-Emitter Voltage	V _{CEO}	140	160	V _{dc}
Collector-Base Voltage	V _{CBO}	160	180	V _{dc}
Emitter-Base Voltage	V _{EBO}	6.0		V _{dc}
Collector Current — Continuous	I _C	600		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350	2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0	8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to + 150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	357	°C/W

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	140 160	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	160 180	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 100 Vdc, I _E = 0) (V _{CB} = 120 Vdc, I _E = 0) (V _{CB} = 100 Vdc, I _E = 0, T _A = 100°C) (V _{CB} = 120 Vdc, I _E = 0, T _A = 100°C)	I _{CBO}	— — — —	100 50 100 50	nAdc μAdc
Emitter Cutoff Current (V _{EB} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	50	nAdc
ON CHARACTERISTICS(2)				
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	60 80	— —	—
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)		60 80	250 250	
(I _C = 50 mAdc, V _{CE} = 5.0 Vdc)		20 30	— —	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	0.15	V _{dc}
(I _C = 50 mAdc, I _B = 5.0 mAdc)		— —	0.25 0.20	
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	—	1.0	V _{dc}
(I _C = 50 mAdc, I _B = 5.0 mAdc)		— —	1.2 1.0	

2N5550, 2N5551

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	100	300	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	30	pF
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	50	200	—
Noise Figure ($I_C = 250\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 1.0\text{ kohm}$, $f = 10\text{ Hz to }15.7\text{ kHz}$)	NF	—	10	dB
			8.0	

(2) Pulse Test: Pulse Width = $300\text{ }\mu\text{s}$, Duty Cycle = 2.0%.

FIGURE 1 — DC CURRENT GAIN

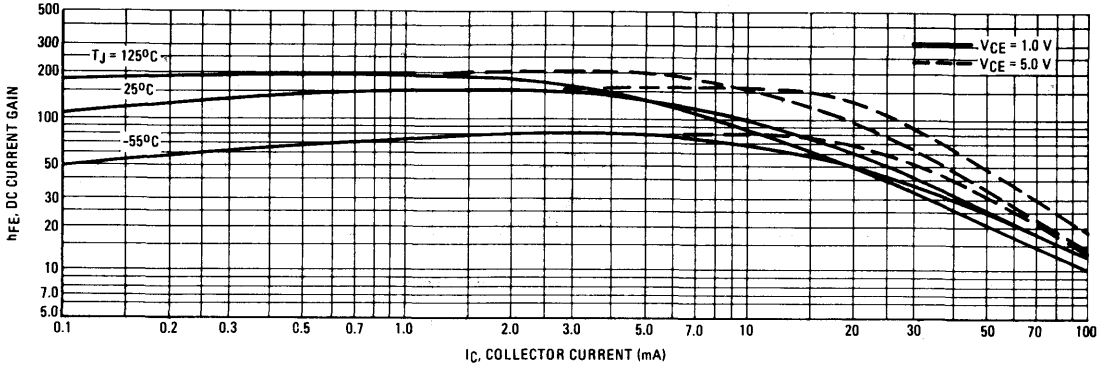


FIGURE 2 — COLLECTOR SATURATION REGION

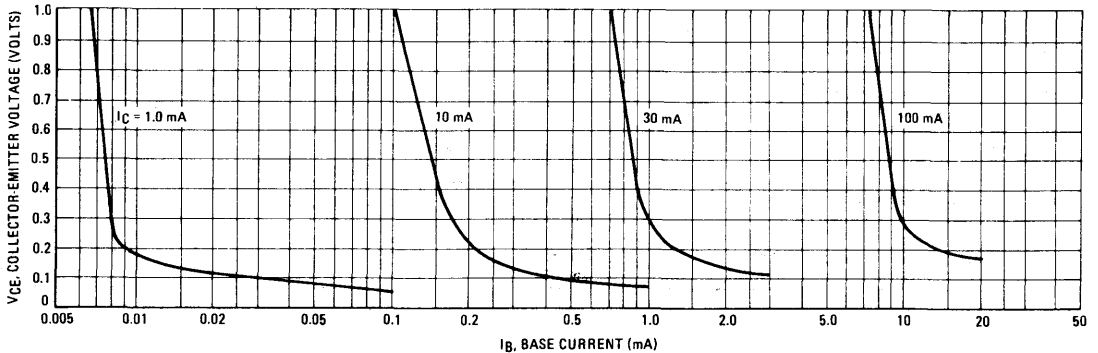


FIGURE 3 – COLLECTOR CUT-OFF REGION

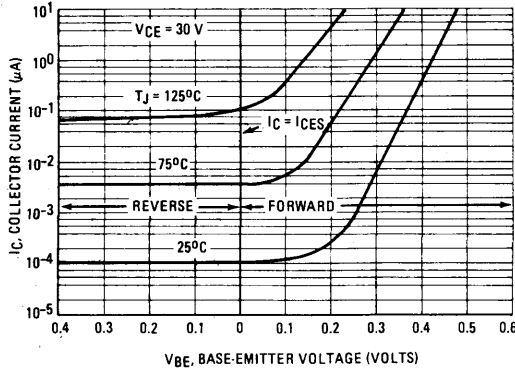


FIGURE 4 – "ON" VOLTAGES

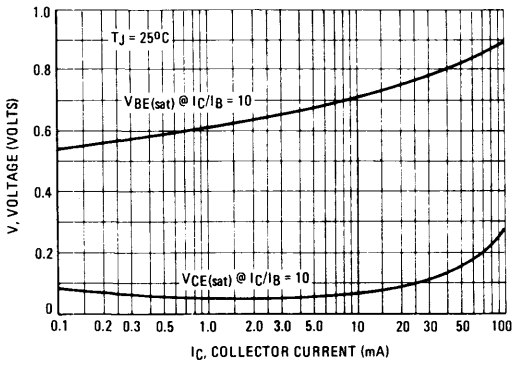


FIGURE 5 – TEMPERATURE COEFFICIENTS

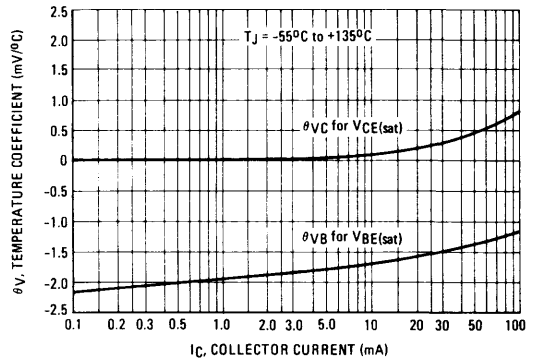


FIGURE 6 – SWITCHING TIME TEST CIRCUIT

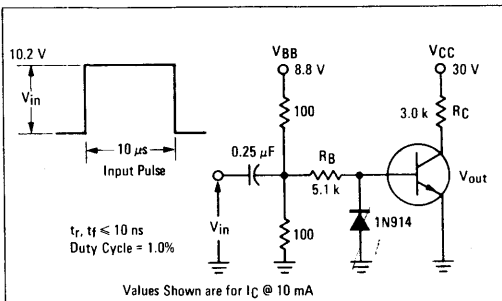
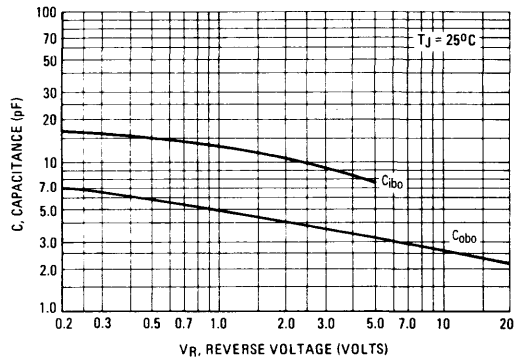


FIGURE 7 – CAPACITANCES



2N5550, 2N5551

2

FIGURE 8 - TURN-ON TIME

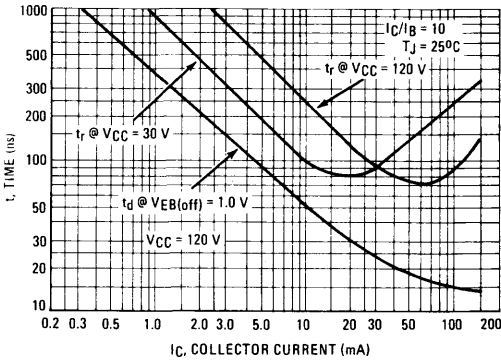
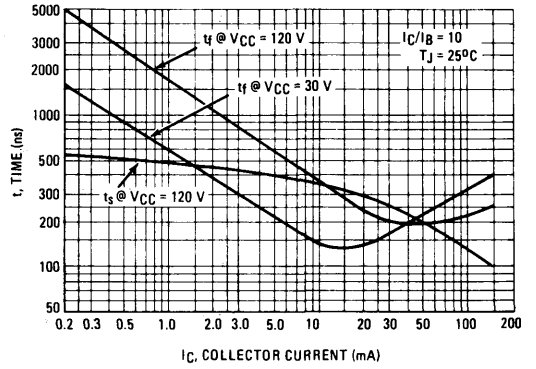


FIGURE 9 - TURN-OFF TIME



2N5771

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	15	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	50	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.625	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$
Lead Temperature	T_L	260	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 3.0 \text{ mA}(1)$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$)	$V_{(BR)CES}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}$)	$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 8.0 \text{ Vdc}$)	I_{CBO}	—	10	nA
Collector Cutoff Current ($V_{CE} = 8.0 \text{ Vdc}$) ($V_{CE} = 8.0 \text{ Vdc}, T_A = 125^\circ\text{C}$)	I_{CES}	—	10 5.0	nA μA
Emitter Cutoff Current ($V_{BE} = 4.5 \text{ Vdc}$)	I_{EBO}	—	1.0	μA

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0 \text{ mA}, V_{CE} = 0.5 \text{ Vdc}(1)$) ($I_C = 10 \text{ mA}, V_{CE} = 0.3 \text{ Vdc}(1)$) ($I_C = 50 \text{ mA}, V_{CE} = 1.0 \text{ Vdc}(1)$) ($I_C = 10 \text{ mA}, V_{CE} = 0.3 \text{ Vdc}, T_A = -55^\circ\text{C}$)	h_{FE}	35 50 40 20	— 120 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 1.0 \text{ mA}, I_B = 0.1 \text{ mA}$) ($I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA}$) ($I_C = 50 \text{ mA}, I_B = 5.0 \text{ mA}$)	$V_{CE(sat)}$	— — —	0.15 0.18 0.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 1.0 \text{ mA}, I_B = 0.1 \text{ mA}$) ($I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA}$) ($I_C = 50 \text{ mA}, I_B = 5.0 \text{ mA}$)	$V_{BE(sat)}$	— 0.75 —	0.8 0.95 1.5	Vdc

SMALL-SIGNAL CHARACTERISTICS

Collector-Base Capacitance ($V_{CB} = 5.0 \text{ Vdc}, f = 140 \text{ kHz}$)	C_{cb}	—	3.0	pF
Emitter-Base Capacitance ($V_{BE} = 0.5 \text{ Vdc}, f = 140 \text{ kHz}$)	C_{eb}	—	3.5	pF
Small-Signal Current Gain ($I_C = 10 \text{ mA}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	h_{fe}	8.5	—	—

SWITCHING CHARACTERISTICS

Storage Time ($I_C = 10 \text{ mA}, I_{B1} \approx I_{B2} \approx 10 \text{ mA}$)	t_s	—	20	ns
Turn-On Time ($I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA}$)	t_{on}	—	15	ns
Turn-Off Time ($I_C = 10 \text{ mA}, I_{B1} = I_{B2} = 1.0 \text{ mA}$)	t_{off}	—	20	ns

(1) Pulse Conditions: Pulse Length = 300 μs , Duty Cycle = 1.0%.

2N6426 2N6427

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	40	Vdc
Collector-Base Voltage	V_{CB0}	40	Vdc
Emitter-Base Voltage	V_{EB0}	12	Vdc
Collector Current — Continuous	I_C	500	mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	200	$^\circ\text{C}/\text{W}$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mA}_{dc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}_{dc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}_{dc}, I_C = 0$)	$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 25 \text{ Vdc}, I_B = 0$)	I_{CEO}	—	—	1.0	μA_{dc}
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	50	nA _{dc}
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	50	nA _{dc}
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 10 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	2N6426 2N6427	20,000 10,000	— —	200,000 100,000
($I_C = 100 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)		2N6426 2N6427	30,000 20,000	— —	300,000 200,000
($I_C = 500 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)		2N6426 2N6427	20,000 14,000	— —	200,000 140,000
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mA}_{dc}, I_B = 0.5 \text{ mA}_{dc}$) ($I_C = 500 \text{ mA}_{dc}, I_B = 0.5 \text{ mA}_{dc}$)	$V_{CE(sat)}$	— —	0.71 0.9	1.2 1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 500 \text{ mA}_{dc}, I_B = 0.5 \text{ mA}_{dc}$)	$V_{BE(sat)}$	—	1.52	2.0	Vdc
Base-Emitter On Voltage ($I_C = 50 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	1.24	1.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	5.4	7.0	pF
Input Capacitance ($V_{BE} = 1.0 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$)	C_{ibo}	—	10	15	pF

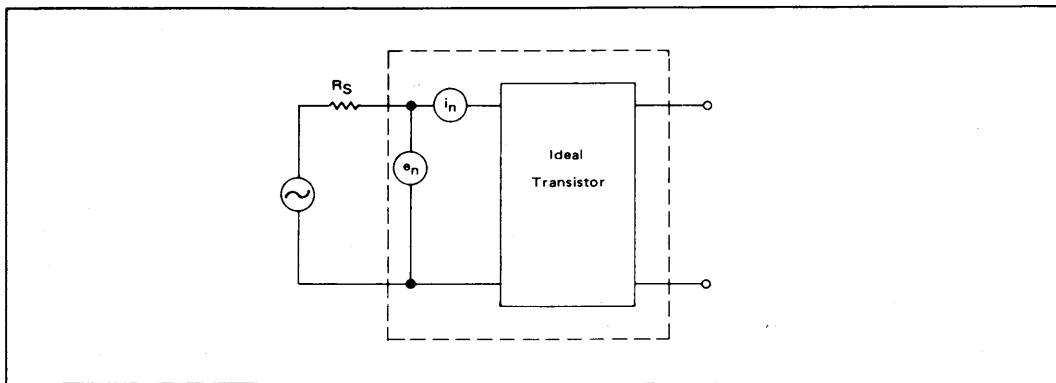
2N6426, 2N6427

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Impedance ($I_C = 10 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	2N6426	h_{ie}	100	—	2000	$k \Omega$
	2N6427		50	—	1000	
Small-Signal Current Gain ($I_C = 10 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	2N6426	h_{fe}	20,000	—	—	—
	2N6427		10,000	—	—	
Current Gain — High Frequency ($I_C = 10 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $f = 100 \text{ MHz}$)	2N6426	$ h_{fe} $	1.5	2.4	—	—
	2N6427		1.3	2.4	—	
Output Admittance ($I_C = 10 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $f = 1.0 \text{ kHz}$)		h_{oe}	—	—	1000	μmhos
Noise Figure ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $R_S = 100 \text{ k}\Omega$, $f = 10 \text{ kHz to } 15.7 \text{ kHz}$)		NF	—	3.0	10	dB

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 — TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS

($V_{CE} = 5.0 \text{ V dc}$, $T_A = 25^\circ\text{C}$)

FIGURE 2 — NOISE VOLTAGE

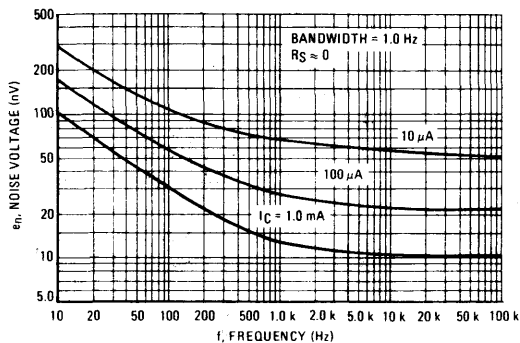
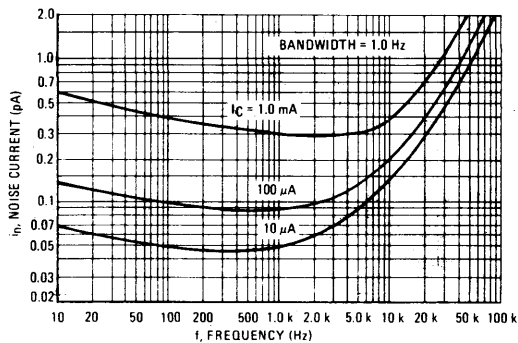


FIGURE 3 — NOISE CURRENT



2

FIGURE 4 - TOTAL WIDEBAND NOISE VOLTAGE

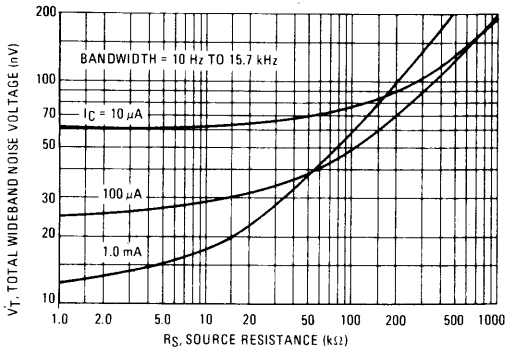
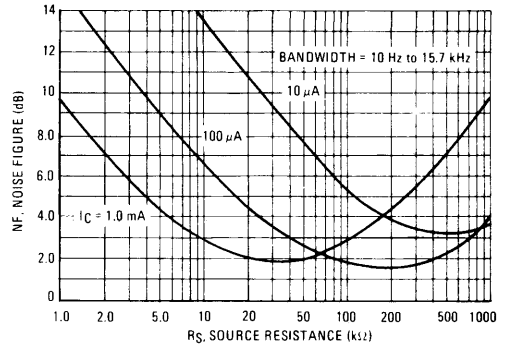


FIGURE 5 - WIDEBAND NOISE FIGURE



SMALL-SIGNAL CHARACTERISTICS

FIGURE 6 - CAPACITANCE

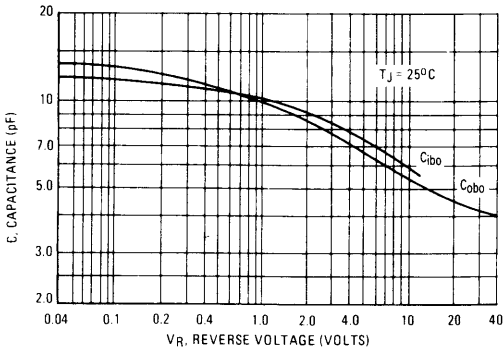


FIGURE 7 - HIGH FREQUENCY CURRENT GAIN

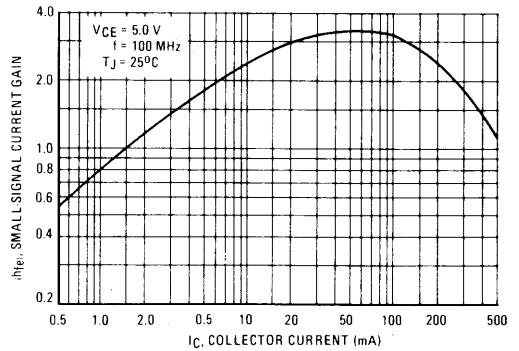


FIGURE 8 - DC CURRENT GAIN

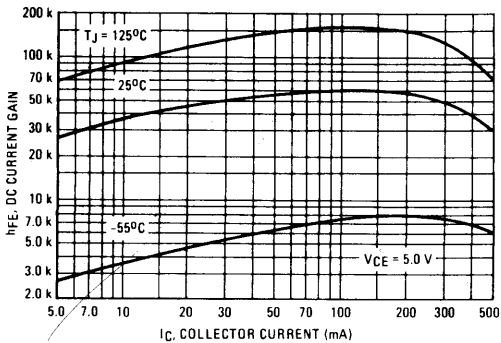


FIGURE 9 - COLLECTOR SATURATION REGION

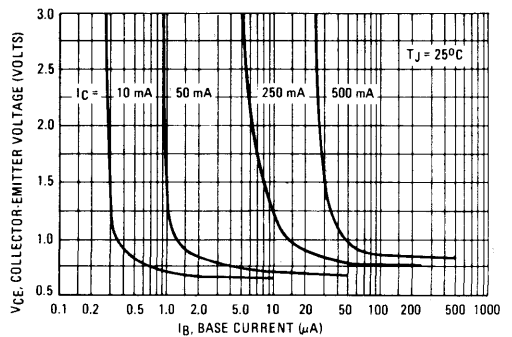


FIGURE 10 – "ON" VOLTAGES

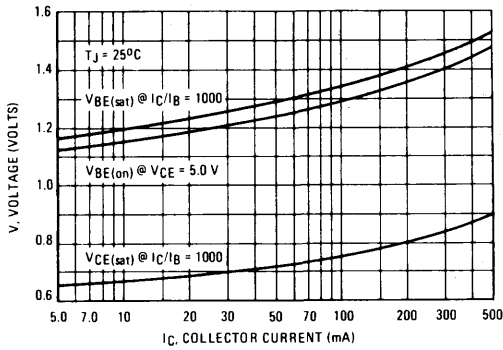


FIGURE 11 – TEMPERATURE COEFFICIENTS

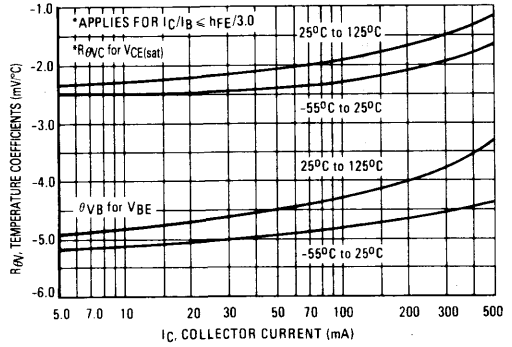


FIGURE 12 – THERMAL RESPONSE

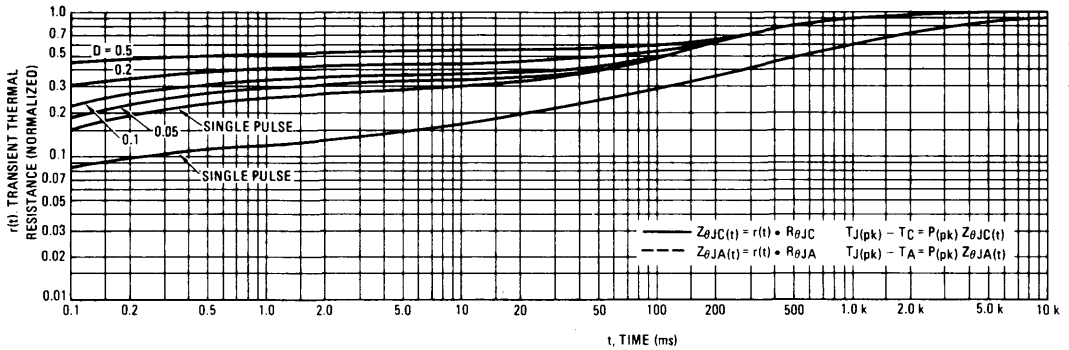
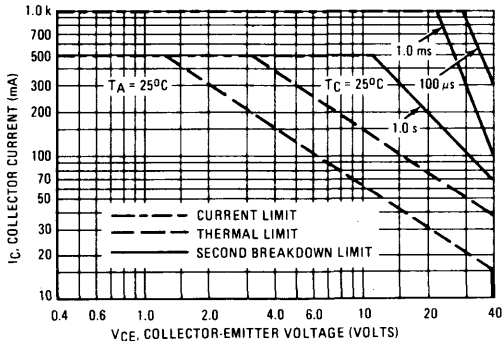
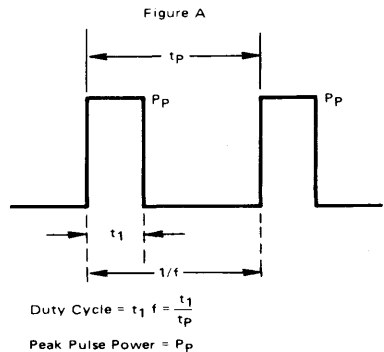


FIGURE 13 – ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



NPN
2N6515
thru
2N6517
PNP
2N6518
thru
2N6520

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE
TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	2N6515 2N6518	2N6516 2N6519	2N6517 2N6520	Unit
Collector-Emitter Voltage	V _{CEO}	250	300	350	Vdc
Collector-Base Voltage	V _{CBO}	250	300	350	Vdc
Emitter-Base Voltage 2N6515, 2N6516, 2N6517 2N6518, 2N6519, 2N6520	V _{EBO}	6.0 5.0			Vdc
Base Current	I _B	250			mAdc
Collector Current — Continuous	I _C	500			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.625 5.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C
Lead Temperature ≥ 1/16" from case for 10 seconds	T _L	260			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	250 300 350	— — —	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	250 300 350	— — —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0 5.0	— —	Vdc
Collector Cutoff Current (V _{CB} = 150 Vdc, I _E = 0) (V _{CB} = 200 Vdc, I _E = 0) (V _{CB} = 250 Vdc, I _E = 0)	I _{CBO}	— — —	50 50 50	nAdc
Emitter Cutoff Current (V _{EB} = 5.0 Vdc, I _C = 0) (V _{EB} = 4.0 Vdc, I _C = 0)	I _{EBO}	— —	50 50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	h _{FE}	35 30 20	— — —	—
(I _C = 10 mAdc, V _{CE} = 10 Vdc)		50 45 30	— — —	
(I _C = 30 mAdc, V _{CE} = 10 Vdc)		50 45 30	300 270 200	
(I _C = 50 mAdc, V _{CE} = 10 Vdc)		45 40 20	220 200 100	
(I _C = 100 mAdc, V _{CE} = 10 Vdc)		25 20 15	— — —	

NPN 2N6515 thru 2N6517, PNP 2N6518 thru 2N6520

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$) ($I_C = 20\text{ mAdc}, I_B = 2.0\text{ mAdc}$) ($I_C = 30\text{ mAdc}, I_B = 3.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}, I_B = 5.0\text{ mAdc}$)	$V_{CE(sat)}$	—	0.30 0.35 0.50 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$) ($I_C = 20\text{ mAdc}, I_B = 2.0\text{ mAdc}$) ($I_C = 30\text{ mAdc}, I_B = 3.0\text{ mAdc}$)	$V_{BE(sat)}$	—	0.75 0.85 0.90	Vdc
Base-Emitter On Voltage ($I_C = 100\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	$V_{BE(on)}$	—	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) ($I_C = 10\text{ mAdc}, V_{CE} = 20\text{ Vdc}, f = 20\text{ MHz}$)	f_T	40	200	MHz
Collector-Base Capacitance ($V_{CB} = 20\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5\text{ Vdc}, I_C = 0, f = 1.0\text{ MHz}$)	C_{eb}	—	80 100	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 100\text{ Vdc}, V_{BE(off)} = 2.0\text{ Vdc}, I_C = 50\text{ mAdc}, I_{B1} = 10\text{ mAdc}$)	t_{on}	—	200	ns
Turn-Off Time ($V_{CC} = 100\text{ Vdc}, I_C = 50\text{ mAdc}, I_{B1} = I_{B2} = 10\text{ mAdc}$)	t_{off}	—	3.5	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2

NPN

2N6515, 2N6516

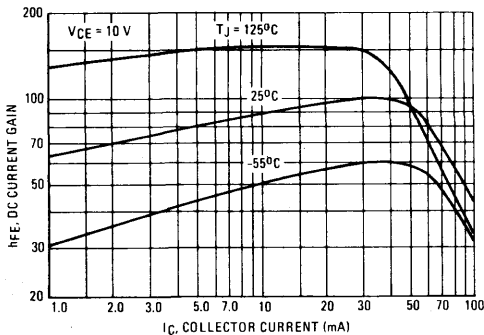
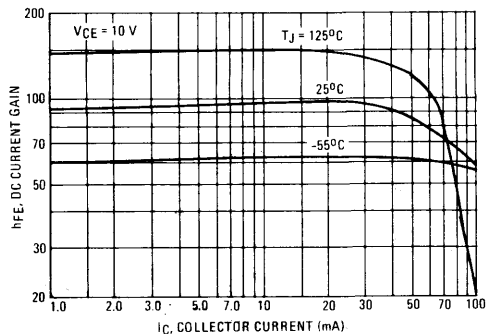


FIGURE 1 — DC CURRENT GAIN

PNP

2N6518, 2N6519



NPN 2N6515 thru 2N6517, PNP 2N6518 thru 2N6520

FIGURE 2 - DC CURRENT GAIN

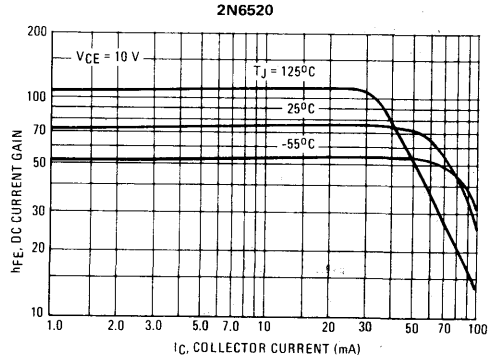
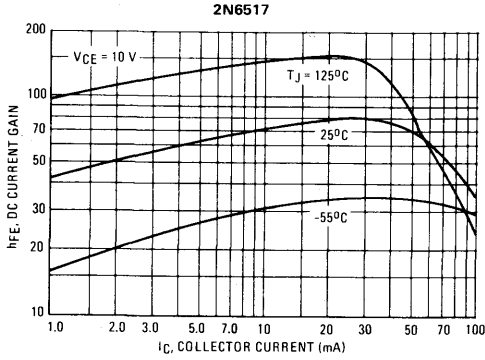


FIGURE 3 - CURRENT-GAIN - BANDWIDTH PRODUCT

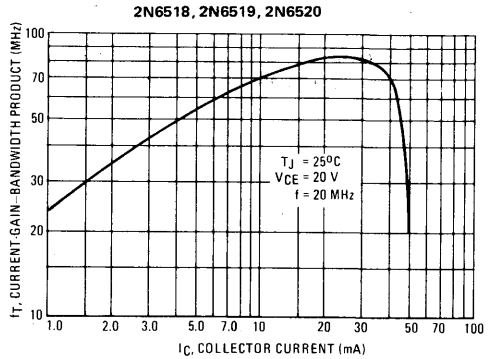
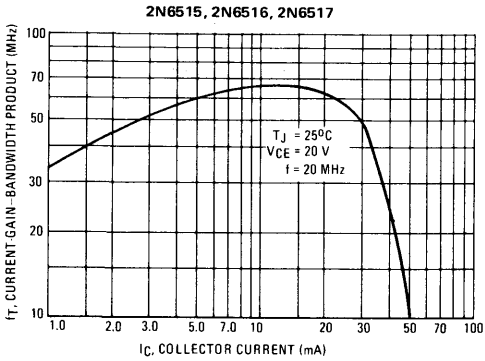
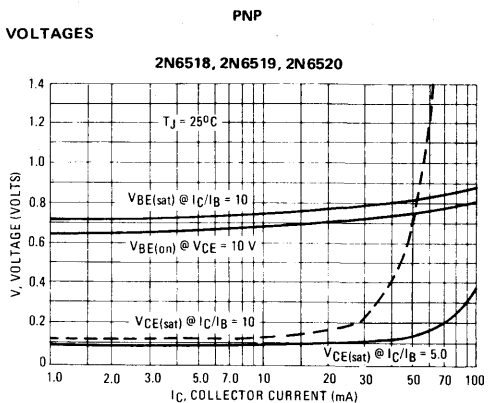
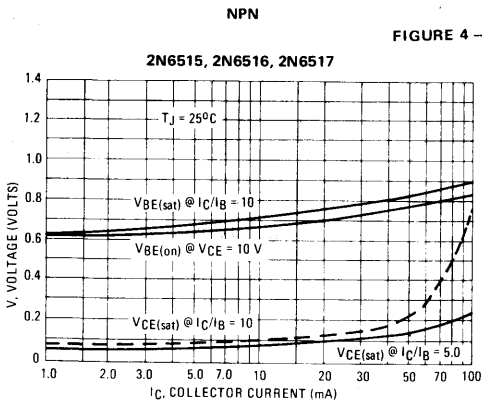


FIGURE 4 - "ON" VOLTAGES



NPN 2N6515 thru 2N6517, PNP 2N6518 thru 2N6520

FIGURE 5 - TEMPERATURE COEFFICIENTS

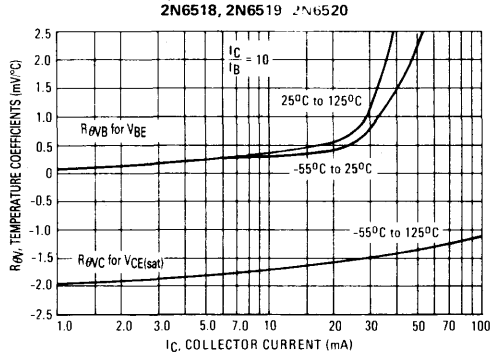
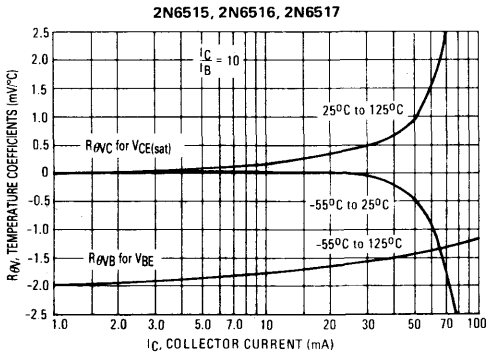
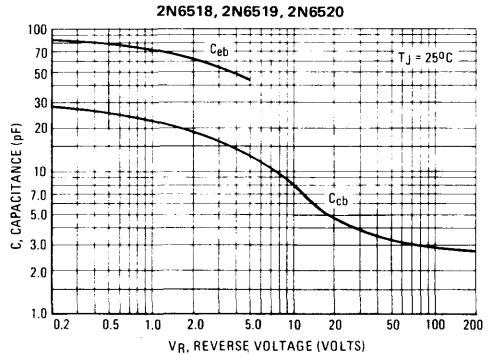
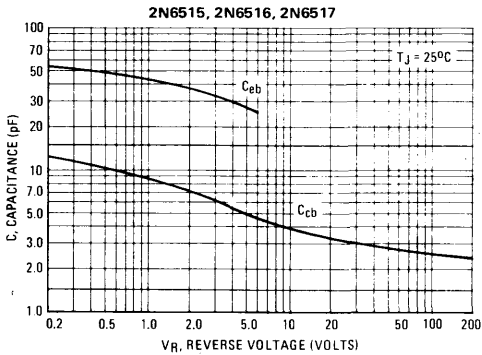


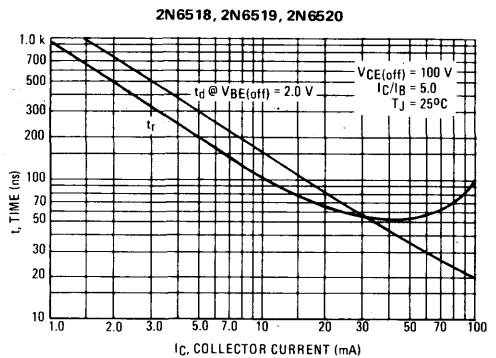
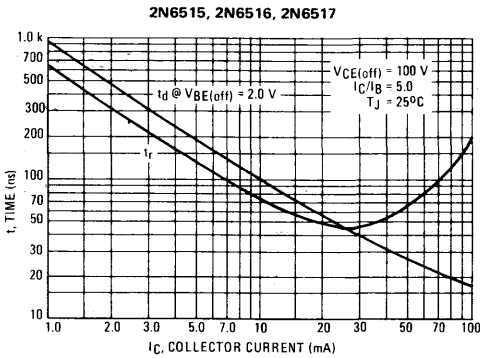
FIGURE 6 - CAPACITANCE



NPN

FIGURE 7 - TURN-ON TIME

PNP



PN 2N6515 thru 2N6517, PNP 2N6518 thru 2N6520

FIGURE 8 - TURN-OFF TIME

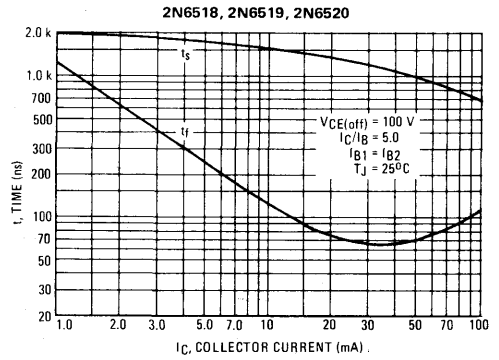
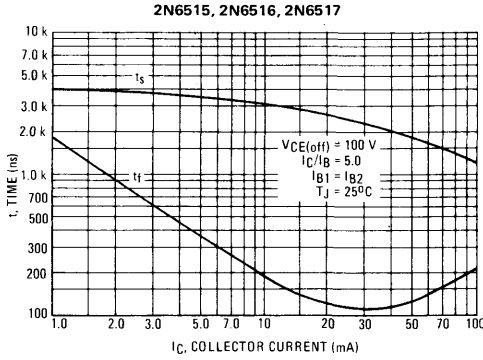


FIGURE 9 - SWITCHING TIME TEST CIRCUIT

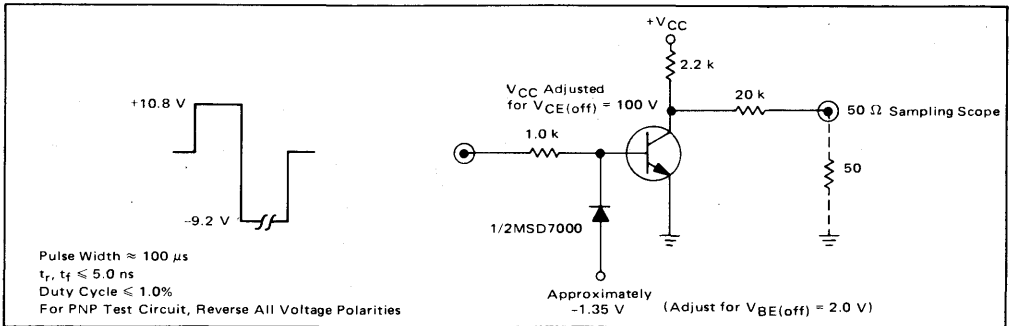
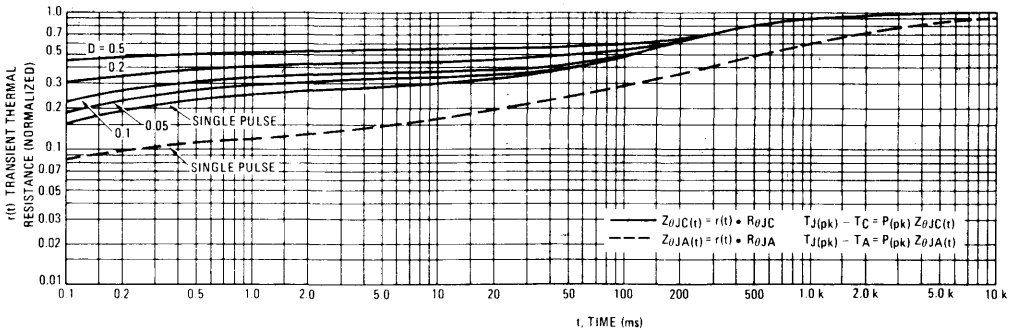
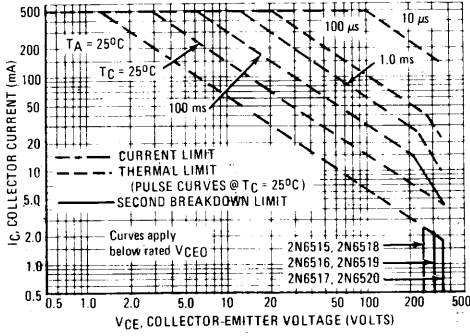


FIGURE 10 - THERMAL RESPONSE

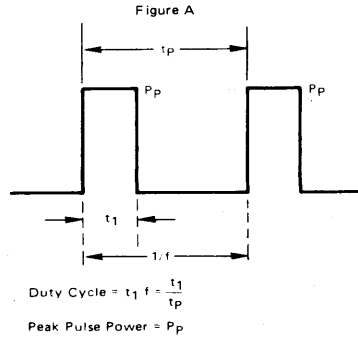


NPN 2N6515 thru 2N6517, PNP 2N6518 thru 2N6520

FIGURE 11 – ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



BC174 BC171 BC172

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 174	BC 171	BC 172	Unit
Collector-Emitter Voltage	V_{CE0}	65	45	25	Vdc
Collector-Base Voltage	V_{CBO}	80	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current - Continuous	I_C	100			mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350	2.8		mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0		8.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

Refer to BC546 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 1\text{ mA}, I_B = 0$)	BC174 BC171 BC172	$V_{(BR)CEO}$	65 45 25			V
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{A}, I_C = 0$)	BC171 BC172 BC174	$V_{(BR)EBO}$	6 6 6			V
Collector Cutoff Current ($V_{CE} = 70\text{ V}, V_{BE} = 0$) ($V_{CE} = 50\text{ V}, V_{BE} = 0$) ($V_{CE} = 35\text{ V}, V_{BE} = 0$) ($V_{CE} = 30\text{ V}, T_A = 125^\circ\text{C}$)	BC174 BC171 BC172 BC174 BC171 BC172	I_{CES}		0.20 0.20 0.20	15 15 15	nA μA

ON CHARACTERISTICS

DC Current Gain ($I_C = 10\ \mu\text{A}, V_{CE} = 5\text{ V}$) ($I_C = 2\text{ mA}, V_{CE} = 5\text{ V}$) ($I_C = 100\text{ mA}, V_{CE} = 5\text{ V}$)	BC171A/2A/4A BC171B/2B/4B BC172C BC174 BC171 BC172 BC171A/2A/4A BC171B/2B/4B BC172C BC171A/2A/4A BC171B/2B/4B BC172C	h_{FE}		90 150 270 120 120 120 120 180 180 380 120 180 300		450 800 800 220 460 800	
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}, I_B = 0.5\text{ mA}$) ($I_C = 100\text{ mA}, I_B = 5\text{ mA}$) ($I_C = 10\text{ mA}, I_B = \text{See Note 1}$)		$V_{CE(sat)}$		0.09 0.2 0.3	0.25 0.60 0.6	V	
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}, I_B = 0.5\text{ mA}$)		$V_{BE(sat)}$		0.7		V	
Base-Emitter On Voltage ($I_C = 2\text{ mA}, V_{CE} = 5\text{ V}$) ($I_C = 10\text{ mA}, V_{CE} = 5\text{ V}$)		$V_{BE(on)}$	0.55		0.70 0.77	V	

NOTE 1: I_B is value for which $I_C = 11\text{ mA}$ at $V_{CE} = 1\text{ V}$.

BC174, BC171, BC172

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS, SMALL SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product (I _C = 10 mA, V _{CE} = 5 V, f = 100 MHz)	BC171 BC172 BC174	f _T	150 150 150	300 300 300		MHz
Output Capacitance (V _{CB} = 10 V, I _C = 0, f = 1 MHz)		C _{obo}		1.7	4.5	pF
Input Capacitance (V _{BE} = 0.5 V, I _C = 0, f = 1 MHz)		C _{ibo}		10		pF
Input Impedance (I _C = 2 mA, V _{CE} = 5 V, f = 1 KHz)	BC171A/2A/4A BC171B/2B/4B BC172C	h _{ie}	1.6 3.2 6.0	2.7 4.5 8.7	4.5 8.5 15.0	Kohm
Voltage Feedback Ratio (I _C = 2 mA, V _{CE} = 5 V, f = 1 KHz)	BC171A/2A/4A BC171B/2B/4B BC172C	h _{re}		1.5 2.0 3.0		X10 ⁻⁴
Small-Signal Current Gain (I _C = 2 mA, V _{CE} = 5 V, f = 1 KHz)	BC171A/2A/4A BC171B/2B/4B BC172C	h _{fe}	125 240 450	220 330 600	260 500 900	
Output Admittance (I _C = 2 mA, V _{CE} = 5 V, f = 1 KHz)	BC171A/2A/4A BC171B/2B/4B BC172C	h _{oe}		8 10 12	25 35 50	μmhos
Noise Figure (I _C = 0.2 mA, V _{CE} = 5 V, R _S = 2 KOhms, f = 1 KHz, Δf = 200 Hz)	BC171 BC172 BC174	NF		2 2 2	10 10 10	dB

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BC182 BC183 BC184

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON



P2-3

Refer to BC237 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 182	BC 183	BC 184	Unit
Collector-Emitter Voltage	V_{CEO}	50	30	30	Vdc
Collector-Base Voltage	V_{CBO}	60	45	45	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current - Continuous	I_C	100			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350		2.8	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0		8.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 2.0\text{ mA}, I_B = 0$)	BC182 BC183 BC184	$V_{(BR)CEO}$	50 30 30	— — —	— — —	V
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{A}, I_E = 0$)	BC182 BC183 BC184	$V_{(BR)CBO}$	60 45 45	— — —	— — —	V
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{A}, I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	V
Collector Cutoff Current ($V_{CB} = 50\text{ V}, V_{BE} = 0$) ($V_{CB} = 30\text{ V}, V_{BE} = 0$)	BC182 BC183 BC184	I_{CBO}	— — —	0.20 0.20 0.20	15 15 15	nA
($V_{CB} = 50\text{ V}, V_{BE} = 0$) $T_A = 125^\circ\text{C}$ ($V_{CB} = 30\text{ V}, V_{BE} = 0$) $T_A = 125^\circ\text{C}$	BC182 BC183 BC184		— — —	0.20 0.20 0.20	4 4 4	μA
Emitter-Base Leakage Current ($V_{EB} = 4\text{ V}, I_C = 0$)		I_{EBO}	—	—	15	nA

ON CHARACTERISTICS

DC Current Gain ($I_C = 10\ \mu\text{A}, V_{CE} = 5\text{ V}$)	BC182 BC183 BC184	h_{FE}	40 40 100	— — —	— — —	
($I_C = 2\text{ mA}, V_{CE} = 5\text{ V}$)	BC182 BC183 BC184		100 100 250	— — —	480 850 850	
($I_C = 100\text{ mA}, V_{CE} = 5\text{ V}$)	BC182 BC183 BC184		80 80 130	— — —	— — —	
Collector-Emitter On Voltage ($I_C = 10\text{ mA}, I_B = 5\text{ mA}$) ($I_C = 100\text{ mA}, I_B = 5\text{ mA}$)*		$V_{CE(sat)}$	— —	0.07 0.20	0.25 0.60	V
Base-Emitter Saturation Voltage ($I_C = 100\text{ mA}, I_B = 5\text{ mA}$)		$V_{BE(sat)}$	—	1.05	—	V
Base-Emitter On Voltage ($I_C = 100\ \mu\text{A}, V_{CE} = 5\text{ V}$) ($I_C = 2\text{ mA}, V_{CE} = 5\text{ V}$) ($I_C = 100\text{ mA}, V_{CE} = 5\text{ V}$)		$V_{BE(on)}$	— 0.55 —	0.50 0.62 0.83	— 0.70 —	V

* Pulse-test: T_p 300 s, Duty-cycle 2%.

BC182, BC183, BC184

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product (I _C = 0.5 mA, V _{CE} = 3 V, f = 100 MHz)	BC182	f _T	—	100	—	MHz
	BC183		—	120	—	
(I _C = 10 mA, V _{CE} = 5 V, f = 100 MHz)	BC184	f _T	—	140	—	MHz
	BC182		150	200	—	
	BC183		150	240	—	
BC184	150	280	—	—	—	
Common Base Output Capacitance (V _{CB} = 10 V, I _C = 0, f = 1 MHz)		C _{ob}	—	—	5.0	pF
Common Base Input Capacitance (V _{BE} = 0.5 V, I _C = 0, f = 1 MHz)		C _{ib}	—	8.0	—	pF
Input Impedance (I _C = 2 mA, V _{CE} = 5 V, f = 1 KHz)	BC182	h _{ie}	1.6	2.2	4.5	Kohm
	BC183		3.2	6.0	8.5	
	BC184		6.0	8.7	15.0	
Voltage Feedback Ratio (I _C = 2 mA, V _{CE} = 5, f = 1 KHz)	BC182	h _{re}	—	1.5	—	X10 ⁻⁴
	BC183		—	2.0	—	
	BC184		—	3.0	—	
Small-Signal Current Gain (I _C = 2 mA, V _{CE} = 5 V, f = 1 KHz)	BC182	h _{fe}	125	—	500	
	BC183		125	—	900	
	BC184		240	—	900	
	BC182A, BC183A		125	—	260	
	BC182B, BC183B, BC184B		240	—	500	
	BC183C, BC184C		450	—	900	
Output Admittance (I _C = 2 mA, V _{CE} = 5 V, f = 1 KHz)	BC182	h _{oe}	—	8	25	μmhos
	BC183		—	10	35	
	BC184		—	12	50	
Noise Figure (I _C = 0.2 mA, V _{CE} = 5 V, R _S = 2 Kohms, f = 30 Hz to 15 KHz)	BC184	NF	—	2	4	dB
			—	2	10	
			—	2	10	
			—	2	4	
(I _C = 0.2 mA, V _{CE} = 5 V, R _S = 2 Kohms, f = 1 KHz, f = 200 Hz)	BC182	NF	—	2	10	dB
	BC183		—	2	10	
	BC184		—	2	4	

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BC212 BC213 BC214

CASE 29-02, STYLE 17
TO-92 (TO-226AA)
AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 212	BC 213	BC 214	Unit
Collector-Emitter Voltage	V_{CE0}	50	30	30	Vdc
Collector-Base Voltage	V_{CB0}	60	45	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current - Continuous	I_C	100			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350			mW
		2.8			mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0			Watt
		8.0			mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

Refer to BC307 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 2.0 \text{ mAdc}, I_B = 0$)	BC212 BC213 BC214	$V_{(BR)CEO}$	50 30 30	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}, I_E = 0$)	BC212 BC213 BC214	$V_{(BR)CBO}$	60 45 45	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	BC212 BC213 BC214	$V_{(BR)EBO}$	6 5.5 5.5	— — —	— — —	Vdc
Collector-Emitter Leakage Current ($V_{CB} = 30 \text{ V}$)	BC212 BC213 BC214	I_{CBO}	— — —	— — —	15 15 15	nAdc
($V_{CB} = 30 \text{ V}, T_A = 125^\circ\text{C}$)	BC212 BC213 BC214		— — —	— — —	4 4 4	μAdc
Emitter-Base Leakage Current ($V_{EB} = 4 \text{ V}, I_C = 0$)	BC212 BC213 BC214	I_{EBO}	— — —	— — —	15 15 15	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \mu\text{Adc}, V_{CE} = 5 \text{ Vdc}$)	Type	h_{FE}	Min	Typ	Max	Unit
	BC212 BC213 BC214		40 40 100	— — —	— — —	
($I_C = 2 \text{ mAdc}, V_{CE} = 5 \text{ Vdc}$)	BC212 BC213 BC214		60 80 140	— — —	— — 600	
($I_C = 100 \text{ mAdc}, V_{CE} = 5 \text{ Vdc}$)*	BC212, BC214 BC213		— —	120 140	— —	

BC212, BC213, BC214

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 0.5\text{ mA}$) ($I_C = 100\text{ mA}$, $I_B = 5\text{ mA}$)*		$V_{CE(sat)}$	—	0.10 0.25	—	Vdc
Base-Emitter Saturation Voltage ($I_C = 100\text{ mA}$, $I_B = 5\text{ mA}$)		$V_{BE(sat)}$	—	1.00	—	Vdc
Base-Emitter on Voltage ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ Vdc}$)		$V_{BE(on)}$	0.55	0.62	0.70	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 5\text{ Vdc}$, $f = 50\text{ MHz}$)	BC212 BC214 BC213	f_T	—	280 320 360	—	MHz
Common-Base Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_C = 0$, $f = \text{MHz}$)		C_{ob}	—	—	6.0	pF
Noise Figure ($I_C = 0.2\text{ mA}$, $V_{CE} = 5\text{ Vdc}$, $R_S = 2\text{ Kohms}$, $f = 30\text{ Hz to } 15\text{ KHz}$) ($I_C = 0.2\text{ mA}$, $V_{CE} = 5\text{ Vdc}$, $R_S = 2\text{ Kohms}$, $f = 1\text{ KHz}$, $f = 200\text{ Hz}$)	BC214 BC213 BC212	NF	—	—	2 10 10	dB
Input Impedance $I_C = 2\text{ mA}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BC212 BC213 BC214	h_{ie}	0.4 1.2 3.0	2.0 2.7 4.5	3.0 4.5 8.0	k Ω
Voltage Feedback Ratio ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BC212 BC213 BC214	h_{re}	—	2.5 3.0 3.5	—	10^{-4}
Small Signal Current Gain ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BC212 BC213 BC214 BC212A, BC213A BC212B, BC213B, BC214B BC213C, BC214C	h_{fe}	60 80 140 100 200 200 350	— — — — — — —	— — — 300 400 400 600	
Output Admittance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BC212 BC213 BC214	h_{oe}	—	20 25 30	40 50 70	$\mu\text{ mhos}$

*Pulse-test: $T_p = 300\text{ s}$, Duty-cycle 2%.

**BC237
BC238
BC239**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 237	BC 238	BC 239	Unit
Collector-Emitter Voltage	V _{CEO}	45	25	25	V _{dc}
Collector-Emitter Voltage	V _{CES}	50	30	30	V _{dc}
Emitter-Base Voltage	V _{EBO}	6.0	5.0	5.0	V _{dc}
Collector Current – Continuous	I _C	100			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350		2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0		8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I _C = 2.0 mA, I _B = 0)	BC237 BC238 BC239	V(BR)CEO	45 25 25			V
Emitter-Base Breakdown Voltage (I _E = 100 μA, I _C = 0)	BC237 BC238 BC239	V(BR)EBO	6 5 5			V
Collector Cutoff Current (V _{CE} = 30 V, V _{BE} = 0)	BC238 BC239	I _{CES}		0.20 0.20	15 15	nA
(V _{CE} = 50 V, V _{BE} = 0)	BC237			0.20	15	
(V _{CE} = 30 V, V _{BE} = 0) T _A = 125°C	BC238 BC239			0.20 0.20	4 4	μA
(V _{CE} = 50 V, V _{BE} = 0) T _A = 125°C	BC237		0.20	4		

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μA, V _{CE} = 5 V)	BC237A/238A BC237B/238B/239B BC237C/238C/239C	h _{FE}		90 150 270		
(I _C = 2 mA, V _{CE} = 5 V)				120 120 120	800 800 800	
(I _C = 100 mA, V _{CE} = 5 V)				120 180 380	170 290 500	220 460 800
Collector-Emitter On Voltage (I _C = 10 mA, I _B = 0.5 mA) (I _C = 100 mA, I _B = 5 mA)	BC237/BC238/BC239 BC237/BC239 BC238	V _{CE(sat)}		0.07 0.20	0.20 0.60 0.8	V
Base-Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.5 mA) (I _C = 100 mA, I _B = 5 mA)		V _{BE(sat)}		0.60	0.83 1.05	V
Base-Emitter On Voltage (I _C = 100 μA, V _{CE} = 5 V) (I _C = 2 mA, V _{CE} = 5 V) (I _C = 100 mA, V _{CE} = 5 V)		V _{BE(on)}	0.55	0.50 0.62 0.83	0.70	V

BC237, BC238, BC239

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product ($I_C = 0.5\text{ mA}$, $V_{CE} = 3\text{ V}$, $f = 100\text{ MHz}$) ($I_C = 10\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 100\text{ MHz}$)	BC237 BC238 BC239 BC237 BC238 BC239	f_T		100 120 140 150 150 150		MHz
Collector-Base Capacitance ($V_{CB} = 10\text{ V}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{ob0}			4.50	pF
Emitter-Base Capacitance ($V_{BE} = 0.5\text{ V}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{ibo}		8.0		pF
Input Impedance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC237A/238A BC237B/238B/239B BC237C/238C/239C	h_{ie}	1.6 3.2 6.0	2.2 6.0 8.7	4.5 8.5 15.0	Kohm
Voltage Feedback Ratio ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC237A/238A BC237B/238B/239B BC237C/238C/239C	h_{re}		1.5 2.0 3.0		$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC237A/238A BC237B/238B/239B BC237C/238C/239C	h_{fe}	125 240 450	220 330 600	260 500 900	
Output Admittance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC237A/238A BC237B/238B/239B BC237C/238C/239C	h_{oe}		8 10 12	30 60 110	μmhos
Noise Figure ($I_C = 0.2\text{ mA}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ Kohms}$, $f = 30\text{ Hz to }15\text{ KHz}$) ($I_C = 0.2\text{ mA}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ Kohms}$, $f = 1\text{ KHz}$, $\Delta f = 200\text{ Hz}$)	BC239 BC237 BC238 BC239	NF		2 2 2 2	4 10 10 4	dB

2

BC237, BC238, BC239

FIGURE 1 - NORMALIZED DC CURRENT GAIN

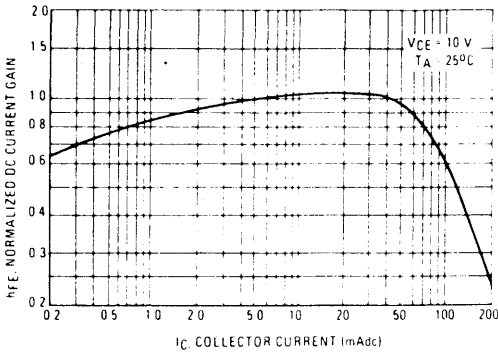


FIGURE 2 - "SATURATION" AND "ON" VOLTAGES

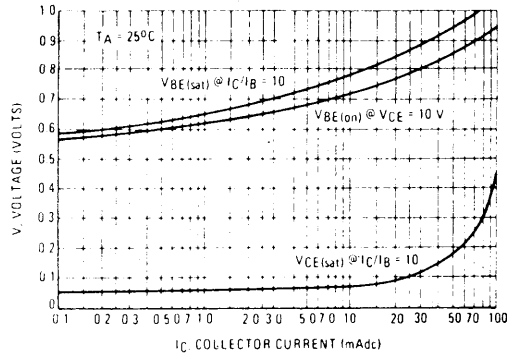


FIGURE 3 - CURRENT GAIN-BANDWIDTH PRODUCT

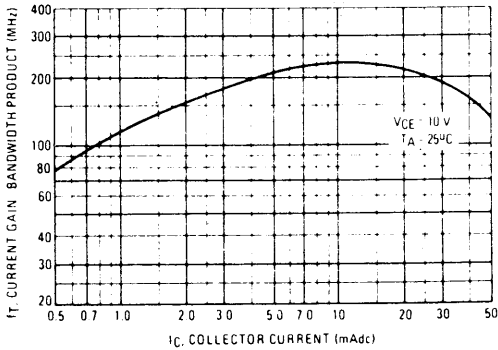


FIGURE 4 - CAPACITANCES

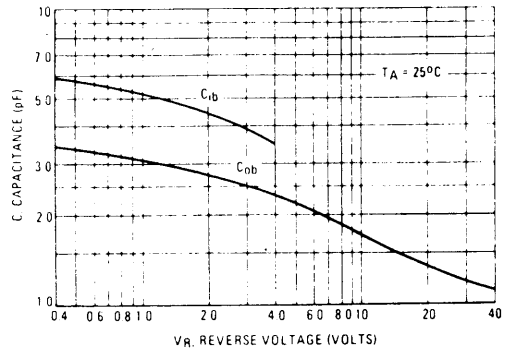


FIGURE 5 - OUTPUT ADMITTANCE

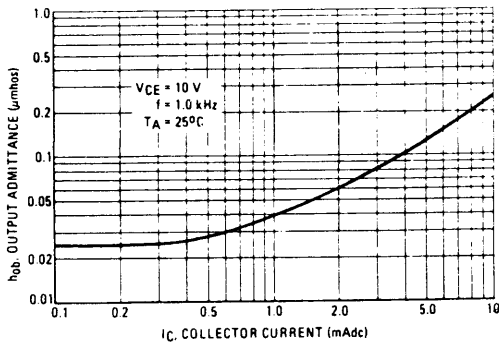
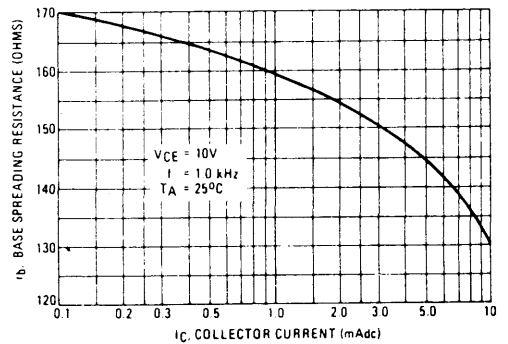


FIGURE 6 - BASE SPREADING RESISTANCE



MAXIMUM RATINGS

Rating	Symbol	BC 256	BC 251	BC 252	Unit
Collector-Emitter Voltage	V _{CEO}	65	45	30	V _{dc}
Collector-Base Voltage	V _{CBO}	80	50	30	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	100			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350	2.8		mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0	8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

**BC256
BC251
BC252**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

AMPLIFIER TRANSISTORS

PNP SILICON

Refer to BC556 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I _C = 2.0 mA, I _B = 0)	BC256 BC251 BC252	V _{(BR)CEO}	65 45 30			V
Emitter-Base Breakdown Voltage (I _E = 100 μA, I _C = 0)	BC256 BC251 BC252	V _{(BR)EBO}	5 5 5			V
Collector-Emitter Leakage Current (V _{CE} = 40 V) (V _{CE} = 20 V) (V _{CE} = 20 V, T _A = 125°C)	BC256 BC251 BC252 BC256 BC251 BC252	I _{CES}		2 2 2	100 100 100	nA μA

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μA, V _{CE} = 5 V) (I _C = 2 mA, V _{CE} = 5 V) (I _C = 100 mA, V _{CE} = 5 V)	BC251A/2A/6A BC251B/2B/6B BC252C BC256 BC251 BC252 BC251A/2A/6A BC251B/2B/6B BC252C BC251A/2A/6A BC251B/2B/6B BC252C	h _{FE}		90 150 270 125 120 120 120 170 180 290 380 500 800 800 120 180 300			
Collector-Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.5 mA) (I _C = 10 mA, I _B = see Note 1) (I _C = 100 mA, I _B = 5 mA)		V _{CE(sat)}		0.075 0.30 0.25	0.3 0.60 0.65	V	
Base-Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.5 mA) (I _C = 100 mA, I _B = 5 mA)		V _{BE(sat)}		0.70 1.00		V	
Base-Emitter on Voltage (I _C = 2 mA, V _{CE} = 5 V) (I _C = 10 mA, V _{CE} = 5 V)		V _{BE(on)}	0.55	0.62 0.7	0.70 0.82	V	

NOTE 1: I_C mAdc on the constant base current characteristic, which yields the point I_C = 11 mAdc, V_{CE} = 1 V.

BC256, BC251, BC252

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 50\text{ MHz}$)	BC256 BC251 BC252	f_T		280 320 360		MHz
Output Capacitance ($V_{CB} = 10\text{ V}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{ob}		3	6.0	pF
Noise Figure ($I_C = 0.2\text{ mA}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ Kohms}$, $f = 1\text{ KHz}$, $\Delta f = 200\text{ Hz}$)	BC256 BC251 BC252	NF		2 2 2	10 10 10	dB
Input Impedance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC251A/2A/4A BC251B/2B/4B BC252C	h_{ie}	1.2 3.0 5.0	2.7 4.5 8.0	4.5 8.0 14.0	k Ω
Voltage Feedback Ratio ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC251A/2A/4A BC251B/2B/4B BC252C	h_{re}		3.0 3.5 4.0		10^{-4}
Small-Signal Current Gain ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC256 BC251/2 BC251A/2A/6A BC251B/2B/6B BC252C	h_{fe}	125 125 125 240 450		500 900 260 500 900	
Output Admittance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC251A/2A/6A BC251B/2B/6B BC252C	h_{oe}		25 30 60	50 70 110	μhos

MAXIMUM RATINGS

Rating	Symbol	BC 307	BC 308	BC 309	Unit
Collector-Emitter Voltage	V _{CEO}	45	25	25	V _{dc}
Collector-Base Voltage	V _{CBO}	50	30	30	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	100			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350	2.8		mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0	8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

**BC307
BC308
BC309**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

AMPLIFIER TRANSISTORS

PNP SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
Collector-Emitter Breakdown Voltage (I _C = 2.0 mAdc, I _B = 0)	BC307	V _{(BR)CEO}	45	—	—	V _{dc}
	BC308		25	—	—	
	BC309		25	—	—	
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	BC307	V _{(BR)EBO}	5	—	—	V _{dc} V _{dc}
	BC308		5	—	—	
	BC309		5	—	—	
Collector-Emitter Leakage Current (V _{CE} = 50 V, V _{BE} = 0) (V _{CE} = 30 V, V _{BE} = 0) (V _{CE} = 50 V, V _{BE} = 0) T _A = 125°C (V _{CE} = 30 V, V _{BE} = 0) T _A = 125°C	BC307	I _{CES}	—	0.2	15	nA μA
	BC308		—	0.2	15	
	BC309		—	0.2	15	
	BC307		—	0.2	4.0	
	BC308		—	0.2	4.0	
	BC309		—	0.2	4.0	

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 Vdc)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h _{FE}	—	90	—	V _{dc}
			—	150	—	
			—	270	—	
(I _C = 2 mAdc, V _{CE} = 5 Vdc)	BC307 BC308 BC309 BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C		120	—	800	
			120	—	800	
			120	—	800	
			120	170	220	
			180	290	460	
			380	500	800	
(I _C = 100 mAdc, V _{CE} = 5 Vdc)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C		—	120	—	
			—	180	—	
			—	300	—	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 10 mAdc, I _B = see Note 1) (I _C = 100 mAdc, I _B = 5 mAdc)		V _{CE(sat)}	—	0.10	0.30	V _{dc}
			—	0.30	0.60	
			—	0.25	—	
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 100 mAdc, I _B = 5 mAdc)		V _{BE(sat)}	—	0.70	—	V _{dc}
			—	1.00	—	
Base-Emitter on Voltage (I _C = 2 mAdc, V _{CE} = 5 Vdc)		V _{BE(on)}	0.55	0.62	0.70	V _{dc}

Note 1: I_C = 10 mAdc on the constant base current characteristic, which yields the point I_C = 11 mAdc, V_{CE} = 1 V

BC307, BC308, BC309

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 50\text{ MHz}$)	BC307 BC308 BC309	f_T	— — —	280 320 360	— — —	MHz
Collector-Base Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{cbo}	—	—	6.0	pF
Noise Figure ($I_C = 0.2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $R_S = 2\text{ Kohms}$, $f = 30\text{ Hz to }15\text{ KHz}$) ($I_C = 0.2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $R_S = 2\text{ Kohms}$, $f = 1\text{ KHz}$, $f = 200\text{ Hz}$)	BC309 BC307 BC308 BC309	NF	— — —	2 2 2	4 10 10 4	dB
Input Impedance ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h_{ie}	1.2 3.0 5.0	2.7 4.5 8.0	4.5 8.0 15	$k\Omega$
Voltage Feedback Ratio ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h_{re}	— — —	3.0 3.5 4.0	— — —	10^{-4}
Small Signal Current Gain ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h_{fe}	125 240 450	220 330 600	260 500 900	—
Output Admittance ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h_{oe}	— — —	25 30 60	50 70 110	μmhos

BC307, BC308, BC309

FIGURE 1 - NORMALIZED DC CURRENT GAIN

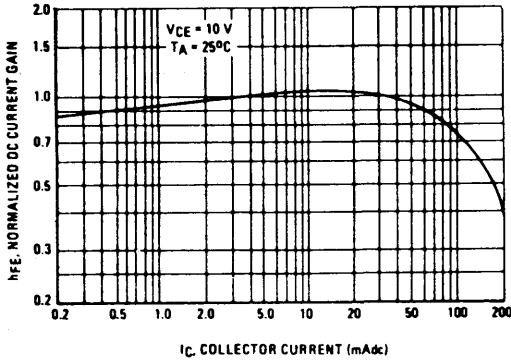


FIGURE 2 - "SATURATION" AND "ON" VOLTAGES

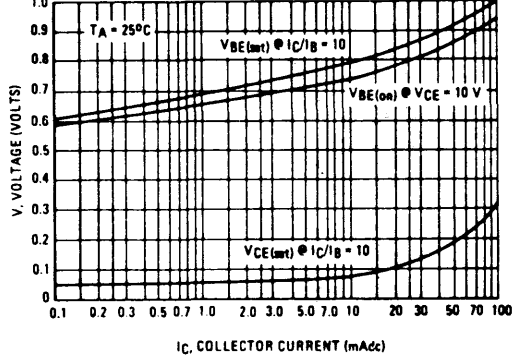


FIGURE 3 - CURRENT-GAIN-BANDWIDTH PRODUCT

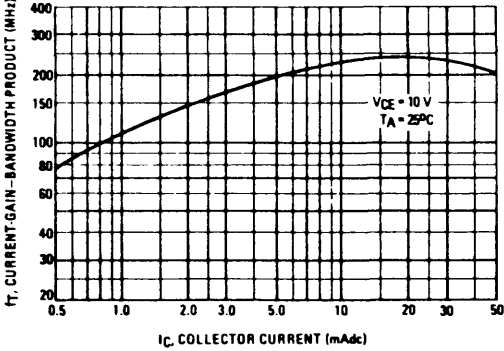


FIGURE 4 - CAPACITANCES

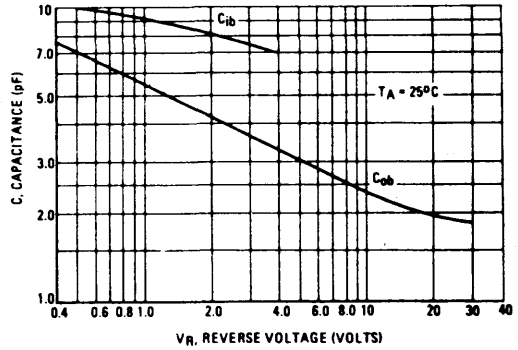


FIGURE 5 - OUTPUT ADMITTANCE

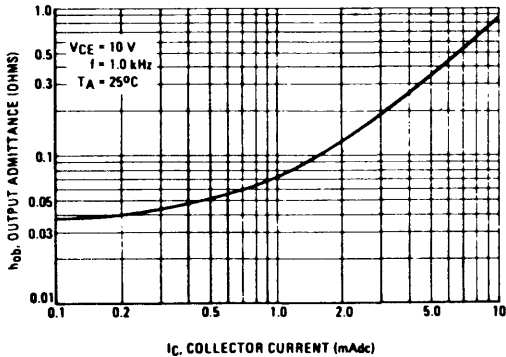
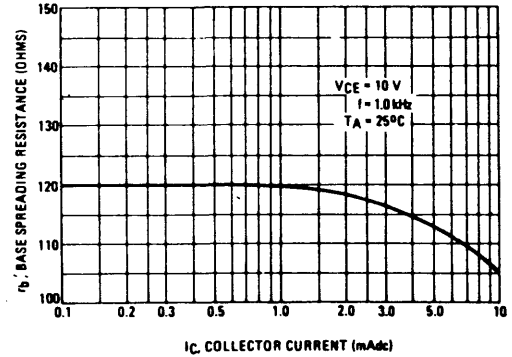


FIGURE 6 - BASE SPREADING RESISTANCE



BC317, A, B BC318, A, B, C BC319, A, B

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 317	BC 318	BC 319	Unit
Collector-Emitter Voltage	V_{CE0}	45	30	20	Vdc
Collector-Base Voltage	V_{CBO}	50	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	5.0	5.0	Vdc
Collector Current - Continuous	I_C	150			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8			mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0			Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	$^\circ\text{C}/\text{W}$

Refer to BC549 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage $I_C = 1\text{ mA}, I_B = 0$	BC317 BC318 BC319	$V_{(BR)CEO}$	45 30 20			Vdc
Collector-Emitter Breakdown Voltage $I_C = 100\ \mu\text{A}, V_{BE} = 0$	BC317 BC318 BC319	$V_{(BR)CES}$	50 40 30			Vdc
Collector-Base Breakdown Voltage $I_C = 100\ \mu\text{A}, I_E = 0$	BC317 BC318 BC319	$V_{(BR)CBO}$	50 40 30			Vdc
Emitter-Base Breakdown Voltage $I_E = 100\ \mu\text{A}, I_C = 0$	BC317 BC318 BC319	$V_{(BR)EBO}$	6 5 5			Vdc
Collector Cutoff Current $V_{CB} = 20\text{ V}, I_E = 0$		I_{CBO}			30	nAdc
ON CHARACTERISTICS						
Base-Emitter on Voltage $I_C = 2\text{ mA}, V_{CE} = 5\text{ V}$ $I_C = 10\text{ mA}, V_{CE} = 5\text{ V}$		$V_{BE(on)}$	0.57	0.63	0.72 0.77	Vdc
Collector-Emitter Saturation Voltage $I_C = 100\text{ mA}, I_B = 5\text{ mA}$		$V_{CE(sat)}$		0.14	0.50	Vdc
Base-Emitter Saturation Voltage $I_C = 10\text{ mA}, I_B = 0.5\text{ mA}$ $I_C = 100\text{ mA}, I_B = 5\text{ mA}$		$V_{BE(sat)}$		0.70 0.85		Vdc
DC Current Gain $I_C = 10\ \mu\text{A}, V_{CE} = 5\text{ V}$	BC317A BC318A BC317B BC318B BC319B BC318C BC319C	h_{FE}	— — 40 40 40 100 100	90 90 150 150 150 270 270	— — — — — — —	
$I_C = 2\text{ mA}, V_{CE} = 5\text{ V}$	BC317A BC318A BC317B BC318B BC319B BC318C BC319C		110 110 200 200 200 420 420	180 180 290 290 290 520 520	220 220 450 450 450 800 800	

BC317,A,B, BC318,A,B,C, BC319,A,B,

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Spot Noise Figure $I_C = 200\ \mu\text{A}$, $V_{CE} = 5\ \text{V}$ $R_S = 2\ \text{K}\Omega$, $f = 1\ \text{KHz}$, B.W. = 200 Hz	BC317 BC318 BC319	NF		2 2 1.5	6 6 4	dB
Wide Band Noise Figure $I_C = 200\ \mu\text{A}$, $V_{CE} = 5\ \text{V}$ $R_S = 2\ \text{K}\Omega$, B.W. = 30 Hz to 15 KHz	BC319	NF		1.8	4	dB
Output Capacitance $V_{CB} = 10\ \text{V}$, $I_E = 0$ $f = 1\ \text{MHz}$		C_{ob}		2.5	4	pF
Input Capacitance $V_{EB} = 0.5\ \text{V}$, $I_C = 0$ $f = 1\ \text{MHz}$		C_{ib}		11.5		pF
Current-Gain-Bandwidth Product $I_C = 10\ \text{mA}$, $V_{CE} = 5\ \text{V}$		f_T		280		MHz
Voltage Feedback Ratio $I_C = 2\ \text{mA}$, $V_{CE} = 5\ \text{V}$ $f = 1\ \text{KHz}$		h_{re}		2.0		$\times 10^{-4}$
Input Impedance $I_C = 2\ \text{mA}$, $V_{CE} = 5\ \text{V}$ $f = 1\ \text{KHz}$		h_{ie}		5.0		Kohms
Output Admittance $I_C = 2\ \text{mA}$, $V_{CE} = 5\ \text{V}$ $f = 1\ \text{KHz}$		h_{oe}		20		μhos
Small Signal Current Gain $I_C = 2\ \text{mA}$, $V_{CE} = 5\ \text{V}$ $f = 1\ \text{KHz}$	BC317A BC318A BC317B BC318B BC319B BC318C BC319C	h_{fe}	125 125 240 240 240 450 450	220 220 330 330 330 600 600	260 260 500 500 500 900 900	

2

BC320, A, B BC321, A, B BC322, B

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 320	BC 321	BC 322	Unit
Collector-Emitter Voltage	V_{CE0}	45	30	20	Vdc
Collector-Base Voltage	V_{CB0}	50	40	30	Vdc
Emitter-Base Voltage	V_{EB0}	6.0	5.0	5.0	Vdc
Collector Current – Continuous	I_C	150			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625			mW
		5.0			mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5			Watt
		12			mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	$^\circ\text{C}/\text{W}$

Refer to BC559 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage $I_C = 1 \text{ mA}, I_B = 0$	BC320 BC321 BC322	$V_{(BR)CEO}$	45 30 20			Vdc
Collector-Emitter Breakdown Voltage $I_C = 100 \mu\text{A}, V_{BE} = 0$	BC320 BC321 BC322	$V_{(BR)CES}$	50 40 30			Vdc
Collector-Base Breakdown Voltage $I_C = 100 \mu\text{A}, I_E = 0$	BC320 BC321 BC322	$V_{(BR)CBO}$	50 40 30			Vdc
Emitter-Base Breakdown Voltage $I_E = 100 \mu\text{A}, I_C = 0$	BC320 BC321 BC322	$V_{(BR)EBO}$	6 5 5			Vdc
Collector Cutoff Current $V_{CB} = 20 \text{ V}, I_E = 0$		I_{CBO}			30	nAdc
ON CHARACTERISTICS						
Base-Emitter on Voltage $I_C = 2 \text{ mA}, V_{CE} = 5 \text{ V}$ $I_C = 10 \text{ mA}, V_{CE} = 5 \text{ V}$		$V_{BE(on)}$	0.57	0.68	0.72 0.77	Vdc
Collector-Emitter Saturation Voltage $I_C = 100 \text{ mA}, I_B = 5 \text{ mA}$		$V_{CE(sat)}$		0.35	0.50	Vdc
Base-Emitter Saturation Voltage $I_C = 10 \text{ mA}, I_B = 0.5 \text{ mA}$ $I_C = 100 \text{ mA}, I_B = 5 \text{ mA}$		$V_{BE(sat)}$		0.77 0.99		Vdc
DC Current Gain $I_C = 10 \mu\text{A}, V_{CE} = 5 \text{ V}$	BC320A BC321A BC320B BC321B BC322B	h_{FE}	— — 40 40 40	50 50 100 100 100	— — — — —	
$I_C = 2 \text{ mA}, V_{CE} = 5 \text{ V}$	BC320A BC321A BC320B BC321B BC322B		110 110 200 200 200	180 180 290 290 290	220 220 450 450 450	

BC320,A,B, BC321,A,B, BC322,B

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Spot Noise Figure $I_C = 200 \mu\text{A}$, $V_{CE} = 5 \text{ V}$ $R_S = 2 \text{ K}\Omega$, $f = 1 \text{ KHz}$, B.W. = 200 Hz	BC320 BC321 BC322	NF		2 2 1.5	6 6 4	dB
Wide Band Noise Figure $I_C = 200 \mu\text{A}$, $V_{CE} = 5 \text{ V}$ $R_S = 2 \text{ K}\Omega$, B.W. = 30 Hz to 15 KHz	BC322	NF		1.8	4	dB
Output Capacitance $V_{CB} = 10 \text{ V}$, $I_E = 0$ $f = 1 \text{ MHz}$		C_{ob}		3	4	pF
Input Capacitance $V_{EB} = 0.5 \text{ V}$, $I_C = 0$ $f = 1 \text{ MHz}$		C_{ib}		16		pF
Current-Gain-Bandwidth Product $I_C = 10 \text{ mA}$, $V_{CE} = 5 \text{ V}$		f_T		250		MHz
Voltage Feedback Ratio $I_C = 2 \text{ mA}$, $V_{CE} = 5 \text{ V}$ $f = 1 \text{ KHz}$		h_{re}		2.0		$\times 10^{-4}$
Input Impedance $I_C = 2 \text{ mA}$, $V_{CE} = 5 \text{ V}$ $f = 1 \text{ KHz}$		h_{ie}		1.6		Kohms
Output Admittance $I_C = 2 \text{ mA}$, $V_{CE} = 5 \text{ V}$ $f = 1 \text{ KHz}$		h_{oe}		30		μmhos
Small Signal Current Gain $I_C = 2 \text{ mA}$, $V_{CE} = 5 \text{ V}$ $f = 1 \text{ KHz}$	BC320A BC321A BC320B BC321B BC322B	h_{fe}		125 125 240 240 240	220 220 290 290 290	260 260 500 500 500

BC327 BC328

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 327	BC 328	Unit
Collector-Emitter Voltage	V_{CE0}	45	25	Vdc
Collector-Base Voltage	V_{CB0}	50	30	Vdc
Emitter-Base Voltage	V_{EB0}	5.0		Vdc
Collector Current – Continuous	I_C	800		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
----------------	------	--------	------	------	------	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage $I_C = 10\text{ mA}, I_B = 0$	BC327 BC328	$V_{(BR)CEO}$	45 25			Vdc
Collector-Base Breakdown Voltage $I_C = 10\text{ }\mu\text{A}, I_E = 0$	BC327 BC328	$V_{(BR)CBO}$	50 30			Vdc
Emitter-Base Breakdown Voltage $I_E = 10\text{ }\mu\text{A}, I_C = 0$		$V_{(BR)EBO}$	5			vdc
Collector Cutoff Current BC327 – $V_{CB} = 30\text{ V}, I_E = 0$ BC328 – $V_{CB} = 20\text{ V}, I_E = 0$		I_{CBO}			100	nAdc
Emitter Cutoff Current $V_{EB} = 4\text{ V}, I_C = 0$		I_{EBO}			100	nAdc

ON CHARACTERISTICS

DC Current Gain $I_C = 100\text{ mA}, V_{CE} = 1\text{ V}$	BC327/BC328 BC327-16/BC328-16 BC327-25/BC328-25 BC327-40/BC328-40	h_{FE}	100 100 160 250 40		600 250 400 630	
Base-Emitter On Voltage $I_C = 300\text{ mA}, V_{CE} = 1\text{ V}$		$V_{BE(on)}$			1.2	Vdc
Collector-Emitter Saturation Voltage $I_C = 500\text{ mA}, I_B = 50\text{ mA}$		$V_{CE(sat)}$			0.7	Vdc

SMALL SIGNAL CHARACTERISTICS

Output Capacitance $V_{CB} = 10\text{ V}, I_E = 0$ $f = 1\text{ MHz}$		C_{ob}		5		pF
Current-Gain-Bandwidth Product $I_C = 10\text{ mA}, V_{CE} = 5\text{ V}$		f_T		260		MHz

FIGURE 1 - THERMAL RESPONSE

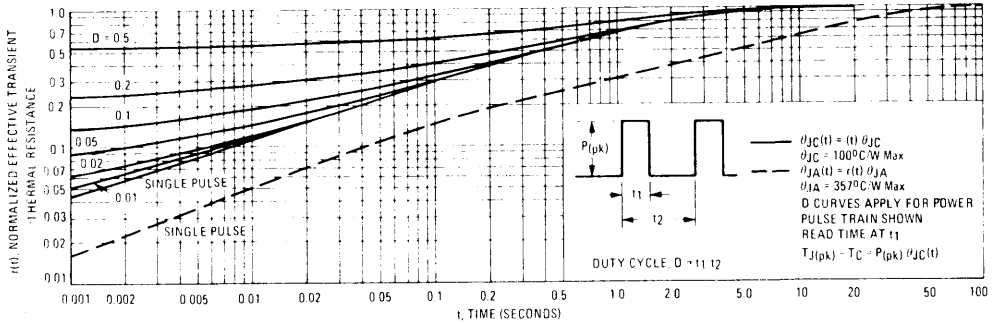


FIGURE 2 - ACTIVE REGION SAFE OPERATING AREA

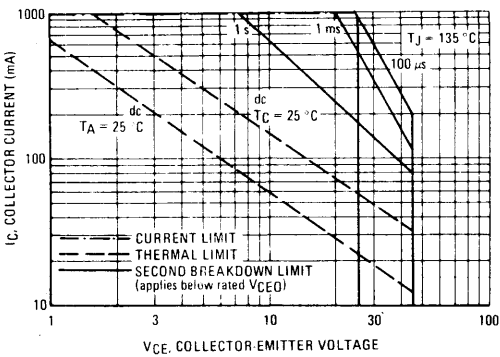


FIGURE 3 - DC CURRENT GAIN

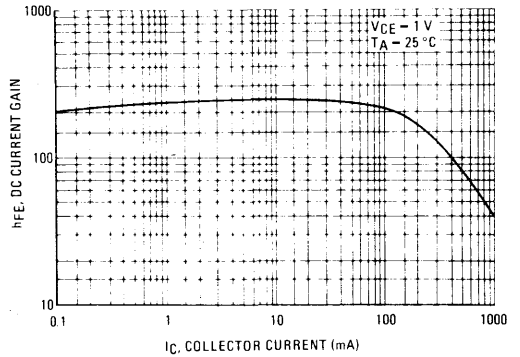


FIGURE 4 - SATURATION REGION

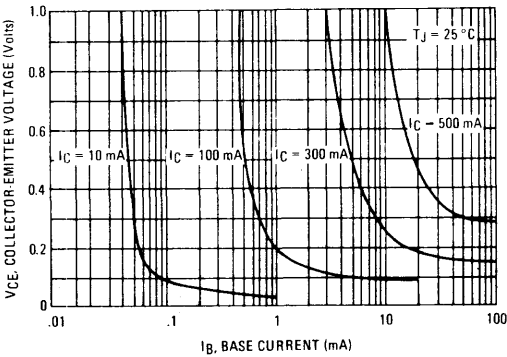


FIGURE 5 - "ON" VOLTAGES

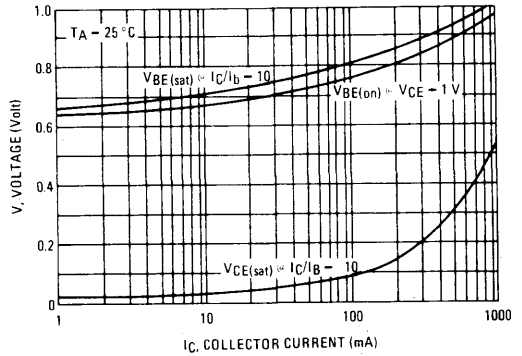


FIGURE 6 - TEMPERATURE COEFFICIENTS

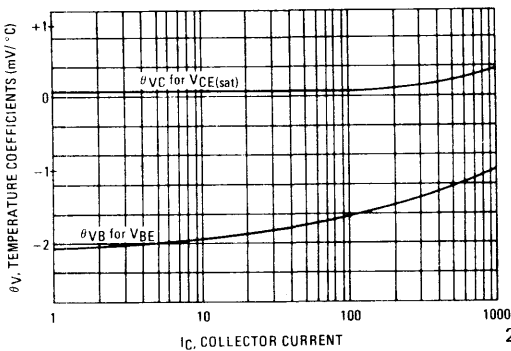
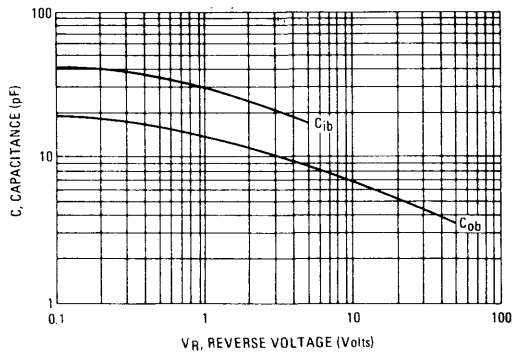


FIGURE 7 - CAPACITANCES



BC337 BC338

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 337	BC 338	Unit
Collector-Emitter Voltage	V_{CE0}	45	25	Vdc
Collector-Base Voltage	V_{CB0}	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current – Continuous	I_C	800		mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage $I_C = 10\text{ mA}, I_B = 0$	BC337 BC338	$V_{(BR)CEO}$	45 25			Vdc
Collector-Base Breakdown Voltage $I_C = 10\ \mu\text{A}, I_E = 0$	BC337 BC338	$V_{(BR)CBO}$	50 30			Vdc
Emitter-Base Breakdown Voltage $I_E = 10\ \mu\text{A}, I_C = 0$		$V_{(BR)EBO}$	5			Vdc
Collector Cutoff Current BC337 – $V_{CB} = 30\text{ V}, I_E = 0$ BC338 – $V_{CB} = 20\text{ V}, I_E = 0$		I_{CBO}			100	nA _{dc}
Emitter Cutoff Current $V_{EB} = 4\text{ V}, I_C = 0$		I_{EBO}			100	nA _{dc}
ON CHARACTERISTICS						
DC Current Gain $I_C = 100\text{ mA}, V_{CE} = 1\text{ V}$	BC337/BC338 BC337-16/BC338-16 BC337-25/BC338-25 BC337-40/BC338-40	h_{FE}	100 100 160 250 60		600 250 400 630	
Base-Emitter On Voltage $I_C = 300\text{ mA}, V_{CE} = 1\text{ V}$		$V_{BE(on)}$			1.2	Vdc
Collector-Emitter Saturation Voltage $I_C = 500\text{ mA}, I_B = 50\text{ mA}$		$V_{CE(sat)}$			0.7	Vdc
SMALL SIGNAL CHARACTERISTICS						
Output Capacitance $V_{CB} = 10\text{ V}, I_E = 0$ $f = 1\text{ MHz}$		C_{ob}		4		pF
Current-Gain-Bandwidth Product $I_C = 10\text{ mA}, V_{CE} = 5\text{ V}$		f_T		210		MHz

FIGURE 1 – THERMAL RESPONSE

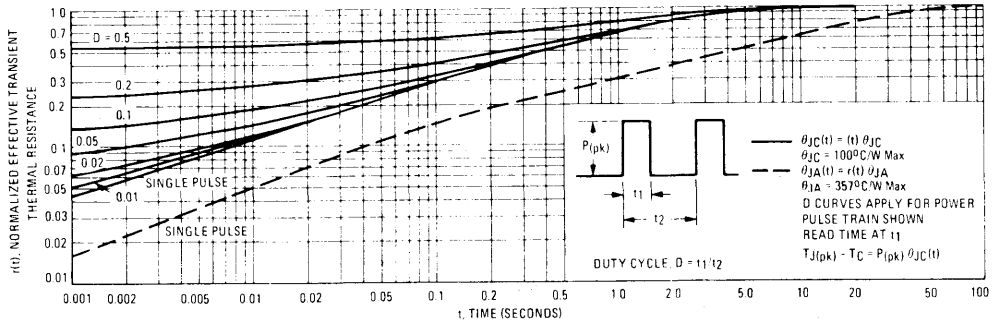


FIGURE 2 – ACTIVE REGION SAFE OPERATING AREA

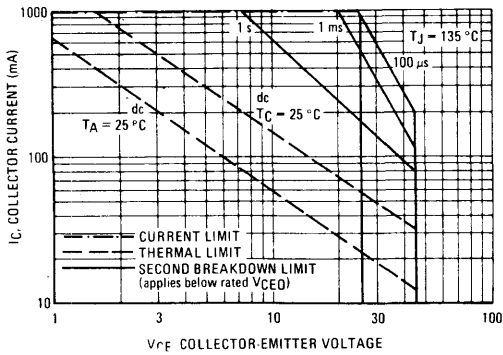


FIGURE 3 – DC CURRENT GAIN

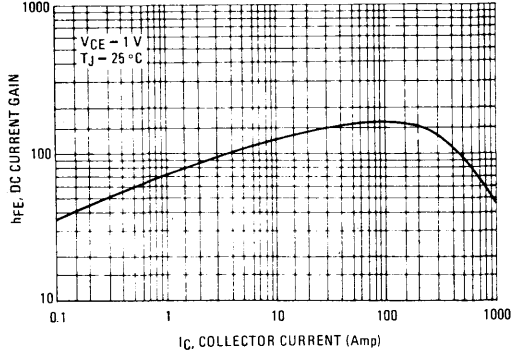


FIGURE 4 – SATURATION REGION

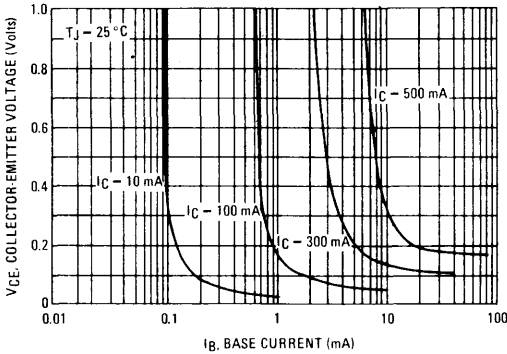


FIGURE 5 – "ON" VOLTAGES

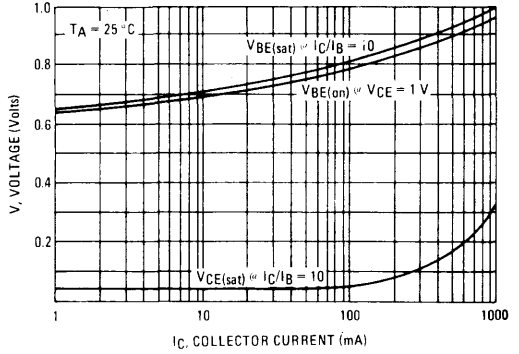


FIGURE 6 – TEMPERATURE COEFFICIENTS

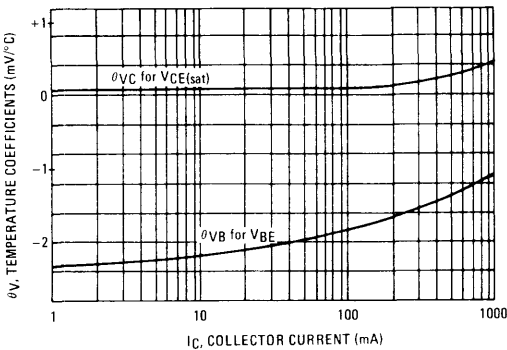
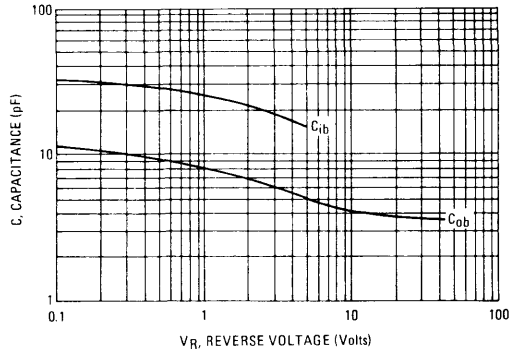


FIGURE 7 – CAPACITANCES



BC368 (NPN) BC369 (PNP)

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	V _{dc}
Collector-Emitter Voltage	V _{CES}	25	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	V _{dc}
Collector Current – Continuous	I _C	1.0	A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	800 6.4	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.75 22	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	45	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	156	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage I _C = 10 mA, I _B = 0	V _{(BR)CEO}	20			V _{dc}
Collector-Base Breakdown Voltage I _C = 100 μA, I _E = 0	V _{(BR)CBO}	25			V _{dc}
Emitter-Base Breakdown Voltage I _E = 100 μA, I _C = 0	V _{(BR)EBO}	5			V _{dc}
Collector Cutoff Current V _{CB} = 25 V, I _E = 0	I _{CBO}			10	μA _{dc}
Emitter Cutoff Current V _{EB} = 5 V, I _C = 0	I _{EBO}			10	μA _{dc}
ON CHARACTERISTICS					
DC Current Gain V _{CE} = 10 V, I _C = 5 mA V _{CE} = 1 V, I _C = 0.5 A V _{CE} = 1 V, I _C = 1 A	h _{FE}	50 85 60		375	
Bandwidth product V _{CE} = 5 V, I _C = 10 mA	f _T	65			Mhz
Collector emitter saturation voltage I _C = 1 A, I _B = 100 mA	V _{CE(sat)}			0.5	V

BC368 (NPN), BC369 (PNP)

FIGURE 1 — DC CURRENT GAIN

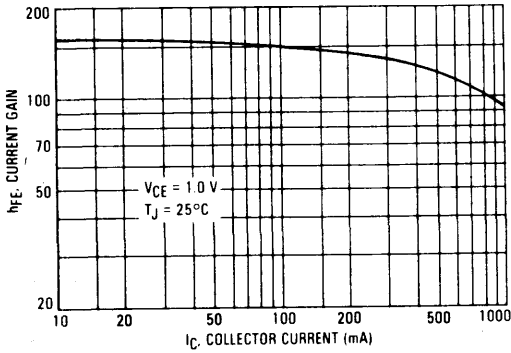


FIGURE 2 — COLLECTOR SATURATION REGION

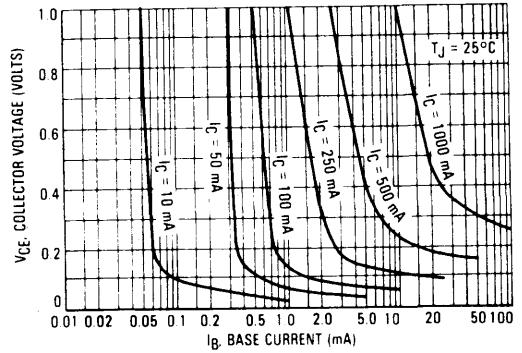


FIGURE 3 — ON VOLTAGES

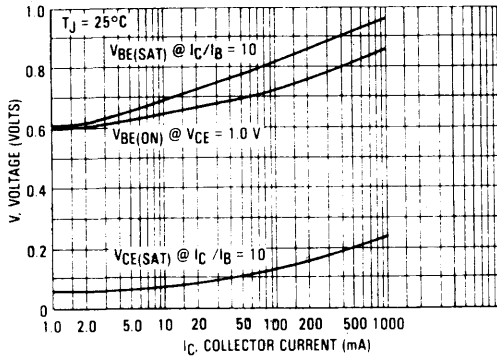


FIGURE 4 — TEMPERATURE COEFFICIENT

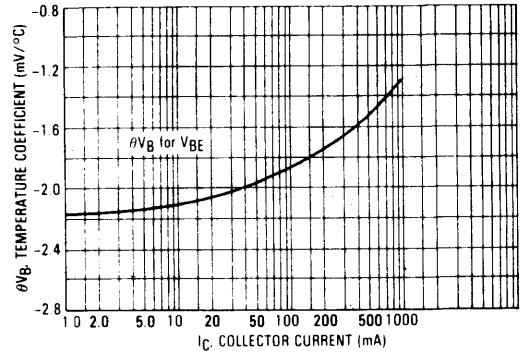


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

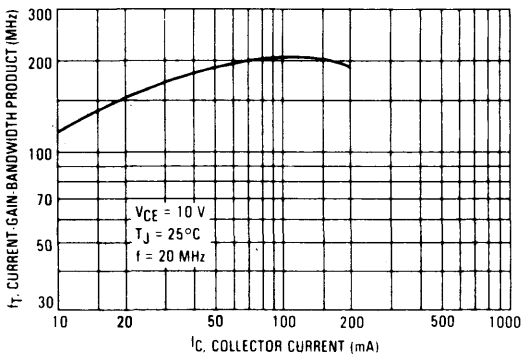
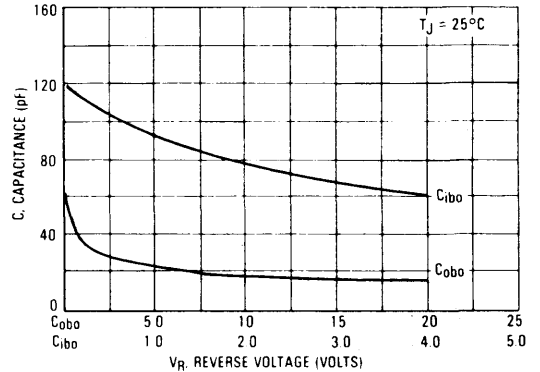


FIGURE 6 — CAPACITANCE



BC372 BC373

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE DARLINGTON

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 372	BC 373	Unit
Collector-Emitter Voltage	V _{CEO}	100	80	Vdc
Collector-Base Voltage	V _{CBO}	100	80	Vdc
Emitter-Base Voltage	V _{EBO}	12		Vdc
Collector Current - Continuous	I _C	1.0		Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0		mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I _C = 100 μAdc, I _B = 0) BC372 BC373	V(BR)CES	100 80			Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0) BC372 BC373	V(BR)CBO	100 80			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V(BR)EBO	12			Vdc
Collector Cutoff Current (V _{CB} = 80 Vdc, I _E = 0) BC372 (V _{CB} = 60 Vdc, I _E = 0) BC373	I _{CBO}			100 100	nAdc
Emitter Cutoff Current (V _{BE} = 10 V, I _C = 0)	I _{EBO}			100	nAdc

ON CHARACTERISTICS*

DC Current Gain (I _C = 100 mAdc, V _{CE} = 5 Vdc) plain range — 16 — 25 — 40 (I _C = 250 mAdc, V _{CE} = 5 Vdc) plain range — 16 — 25 — 40	h _{FE}	8 8 20 40 10 10 25 60		200 200 200 200 600 60 160 600	K
Collector-Emitter Saturation Voltage (I _C = 250 mAdc, I _B = 0.25 mAdc)	V _{CE(sat)}		0.8	1	Vdc
Base-Emitter Saturation Voltage (I _C = 250 mAdc, I _B = 0.25 mAdc)	V _{BE(sat)}		1.4	2	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 100 mAdc, V _{CE} = 5.0 Vdc, f = 20 MHz)	f _T	100	200		MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{ob}		10	25	pF
Noise Figure (I _C = 1 mAdc, V _{CE} = 5 Vdc, R _G = 100 Kohm, F = 1 KHz)	NF		2.0		dB

*Pulse test - Pulse width = 300 μs - Duty cycle 2%.

BC372, BC373

FIGURE 1 – DC CURRENT GAIN

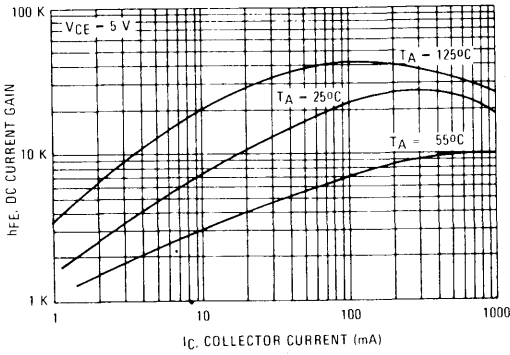
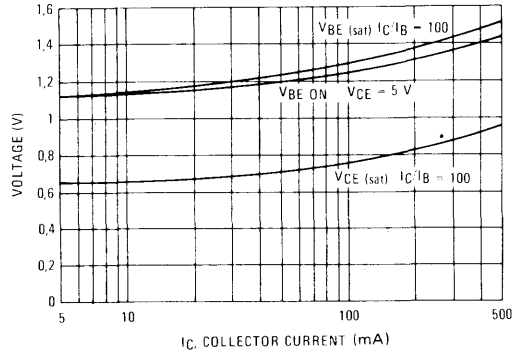


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES



2

FIGURE 3 – CURRENT GAIN BANDWIDTH PRODUCT

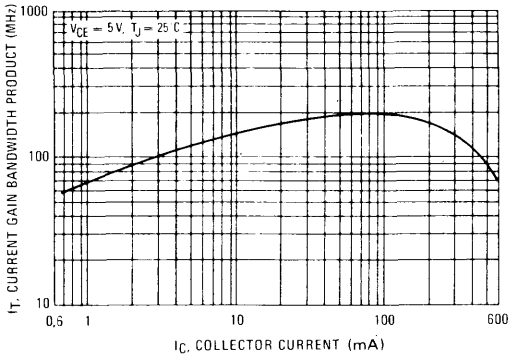
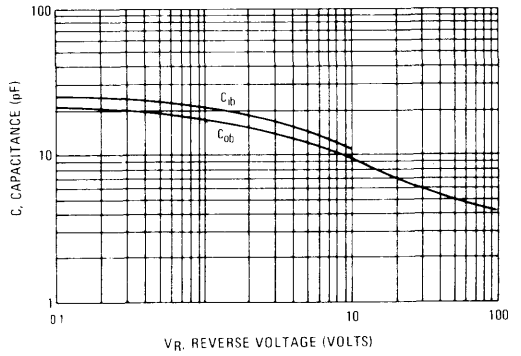


FIGURE 4 – CAPACITANCES



BC413 BC414

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

LOW NOISE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 413	BC 414	Unit
Collector-Emitter Voltage	V _{CEO}	30	45	Vdc
Collector-Base Voltage	V _{CBO}	45	50	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current – Continuous	I _C	100		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350	2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0	8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	357	°C/W

Refer to BC549 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0) BC413 BC414	V _{(BR)CEO}	30 45			Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0) BC413 BC414	V _{(BR)CBO}	45 50			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5			Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 30 Vdc, I _E = 0, T _A = +125°C)	I _{CBO}			15 5	nAdc μAdc
Emitter Cutoff Current (V _{EB} = 4 Vdc, I _C = 0)	I _{EBO}			15	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 Vdc) BC413B/BC414B BC413C/BC414C (I _C = 2 mAdc, V _{CE} = 5 Vdc) BC413B/BC414B BC413C/BC414C BC413/BC414	h _{FE}	100 100 180 380 180	150 270 290 500 350	460 800 800	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 10 mAdc, I _B = see note 1) (I _C = 100 mAdc, I _B = 5 mAdc, see note 2)	V _{CE(sat)}		0.075 0.3 0.25	0.25 0.6 0.6	Vdc
Base-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 5 mAdc)	V _{BE(sat)}		1.1		Vdc
Base-Emitter On Voltage (I _C = 10 μAdc, V _{CE} = 5 Vdc) (I _C = 100 μAdc, V _{CE} = 5 Vdc) (I _C = 2 mAdc, V _{CE} = 5 Vdc)	V _{BE(on)}	0.55	0.52 0.55 0.62	0.75	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 10 mAdc, V _{CE} = 5 Vdc, f = 100 MHz)	f _T		250		MHz
Collector-Base Capacitance (V _{CE} = 10 Vdc, I _E = 0, f = 1 MHz)	C _{cb0}		2.5		pF

Note 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V

Note 2: Pulse test = 300 μs – Duty cycle = 2%

BC413, BC414

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
Input Impedance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ kHz}$)	h_{ie}	3.2 6.0	6.0 8.7	8.5 15.0	$\text{K}\Omega$
Voltage Feedback Ratio ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ kHz}$)	h_{re}		2. 3.		10^{-4}
Small Signal Current Gain ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ kHz}$)	h_{fe}	240 450	330 600	500 900	
Output Admittance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ kHz}$)	h_{oe}		10 12	60 110	μmhos
Noise Figure ($I_C = 200\ \mu\text{Adc}$, $V_{CE} = 5\text{ Vdc}$, $R_S = 2\text{ K}\Omega$, $f = 30\text{ Hz} - 15\text{ KHz}$)	NF		0.6	2.5	dB
Equivalent Input Noise Voltage ($I_C = 200\ \mu\text{Adc}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ k}\Omega$, $f = 120\text{ Hz}$)	V_T		8.0	12	$\text{nV}/\sqrt{\text{Hz}}$
Equivalent Input Noise Voltage ($I_C = 200\ \mu\text{Adc}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ K}\Omega$, $f = 10\text{ Hz} - 50\text{ Hz}$)	V_T		74	135	$\text{nV}/\sqrt{\text{Hz}}$

BC415 BC416

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

LOW NOISE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 415	BC 416	Unit
Collector-Emitter Voltage	V _{CEO}	35	45	Vdc
Collector-Base Voltage	V _{CBO}	45	50	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current – Continuous	I _C	100		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350	2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0	8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

Refer to BC559 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0) BC415 BC416	V _{(BR)CEO}	35 45			Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0) BC415 BC416	V _{(BR)CBO}	45 50			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5			Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 30 Vdc, I _E = 0, T _A = +125°C)	I _{CBO}			15 5	nAdc μAdc
Emitter Cutoff Current (V _{EB} = 4 Vdc, I _C = 0)	I _{EBO}			15	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 Vdc) BC415B/BC416B BC415C/BC416C (I _C = 2 mAdc, V _{CE} = 5 Vdc) BC415B/BC416B BC415C/BC416C BC415/BC416	h _{FE}	100 100 180 380 120	150 270 290 500 350	460 800 800	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 10 mAdc, I _B = see note 1) (I _C = 100 mAdc, I _B = 5 mAdc, see note 2)	V _{CE(sat)}		0.075 0.3 0.25	0.25 0.6	Vdc
Base-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 5 mAdc)	V _{BE(sat)}		1.1		Vdc
Base-Emitter On Voltage (I _C = 10 μAdc, V _{CE} = 5 Vdc) (I _C = 100 μAdc, V _{CE} = 5 Vdc) (I _C = 2 mAdc, V _{CE} = 5 Vdc)	V _{BE(on)}		0.52 0.55 0.62	0.75	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 10 mAdc, V _{CE} = 5 Vdc, f = 100 MHz)	f _T		250		MHz
Collector-Base Capacitance (V _{CE} = 10 Vdc, I _E = 0, f = 1 MHz)	C _{cbo}		2.5		pF

Note 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V

Note 2: Pulse test = 300 μs – Duty cycle = 2%

BC415, BC416

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
Input Impedance ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ KHz}$)	h_{ie}	3.2 5.0	6.0 8.0	8.5 14.0	$\text{K}\Omega$
Voltage Feedback Ratio ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ KHz}$)	h_{re}		3.5 4.0		10^{-4}
Small Signal Current Gain ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ KHz}$)	h_{fe}	125 240 450	200 330 600	260 500 900	
Output Admittance ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ KHz}$)	h_{oe}		10 12	60 110	μmhos
Noise Figure ($I_C = 200 \mu\text{Adc}$, $V_{CE} = 5 \text{ Vdc}$, $R_S = 2 \text{ K}\Omega$, $f = 30 \text{ Hz} - 15 \text{ KHz}$)	NF		0.5	2.0	dB
Equivalent Input Noise Voltage ($I_C = 200 \mu\text{Adc}$, $V_{CE} = 5 \text{ V}$, $R_S = 2 \text{ k}\Omega$, $f = 120 \text{ Hz}$)	V_T		8.0	10	$\text{nV}/\sqrt{\text{Hz}}$
Equivalent Input Noise Voltage ($I_C = 200 \mu\text{Adc}$, $V_{CE} = 5 \text{ V}$, $R_S = 2 \text{ K}\Omega$, $f = 10 \text{ Hz} - 50 \text{ Hz}$)	V_T		74	110	$\text{nV}/\sqrt{\text{Hz}}$

**BC445
BC447
BC449**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPS8098 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 445	BC 447	BC 449	Unit
Collector-Emitter Voltage	V _{CEO}	60	80	100	Vdc
Collector-Base Voltage	V _{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V _{EBO}	5.0			Vdc
Collector Current - Continuous	I _C	300			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625		5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5		12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	60 80 100	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA, I _E = 0)	V _{(BR)CBO}	60 80 100	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5	—	—	Vdc
Collector Cutoff Current V _{CB} = 30 Vdc - I _E = 0 BC445 V _{CB} = 40 Vdc - I _E = 0 BC447 V _{CB} = 60 Vdc - I _E = 0 BC449	I _{CBO}	— — —	— — —	100 100 100	nAdc

ON CHARACTERISTICS*

DC Current Gain - I _C = 2 mA, V _{CE} = 5 V	full range	h _{FE}	50 120 180	—	460 220 460
I _C = 10 mA, V _{CE} = 5 V	BC445/447 only	A B	50 100	—	—
I _C = 100 mA, V _{CE} = 5 V	BC445/447 only	A B	160 50	—	—
	BC445/447 only	A B	60 90	—	—
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 10 mAdc)	V _{CE(sat)}	—	0.1	0.25	Vdc
Base-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 10 mAdc)	V _{BE(sat)}	—	0.85	—	Vdc
Base-Emitter On Voltage (I _C = 100 mAdc, V _{CE} = 5.0 Vdc)	V _{BE(on)}	—	0.8	1.2	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 50 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)	f _T	100	250	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{ob}	—	3.0	—	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ib}	—	16	—	pF

* Pulse test - Pulse width ≤ 300 μs - Duty Cycle 2%

MAXIMUM RATINGS

Rating	Symbol	BC	BC	BC	Unit
		446	448	450	
Collector-Emitter Voltage	V _{CEO}	60	80	100	Vdc
Collector-Base Voltage	V _{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V _{EBO}	5.0			Vdc
Collector Current - Continuous	I _C	300			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0			mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	200	°C/W

BC446
BC448
BC450

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPS8598 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I _C = 1.0 mA, I _B = 0)	V _{(BR)CEO}	60 80 100	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA, I _E = 0)	V _{(BR)CBO}	60 80 100	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	4.0	—	—	Vdc
Collector Cutoff Current V _{CB} = 30 Vdc - I _E = 0 V _{CB} = 40 Vdc - I _E = 0 V _{CB} = 60 Vdc - I _E = 0	I _{CBO}	— — —	— — —	100 100 100	nAdc

ON CHARACTERISTICS*

DC Current Gain - I _C = 2 mA, V _{CE} = 5 V	full range A B	hFE	50 120 180	—	460 220 460
I _C = 10 mA, V _{CE} = 5 V	BC446/448 only full range A B		50 100 160		
I _C = 100 mA, V _{CE} = 5 V	BC446/448 only full range A B		50 60 90		
Collector-Emitter Saturation Voltage (I _C = 100 mA, I _B = 10 mA)	V _{CE(sat)}	—	0.125	0.25	Vdc
Base-Emitter Saturation Voltage (I _C = 100 mA, I _B = 10 mA)	V _{BE(sat)}	—	0.85	—	Vdc
Base-Emitter On Voltage (I _C = 100 mA, V _{CE} = 5.0 Vdc)	V _{BE(on)}	—	0.76	1.2	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 50 mA, V _{CE} = 5.0 Vdc, f = 100 MHz)	f _T	100	200	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{ob}	—	3.0	—	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ib}	—	20	—	pF

* Pulse test - Pulse width ≤ 300 μs - Duty Cycle 2%

BC485 BC487 BC489

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH CURRENT TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 485	BC 487	BC 489	Unit
Collector-Emitter Voltage	V_{CE0}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current - Continuous	I_C	1.0			Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0			mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12			Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

Refer to MPSA05 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	45 60 80	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	45 60 80	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current $V_{CB} = 30 \text{ Vdc} - I_E = 0$ BC485 $V_{CB} = 40 \text{ Vdc} - I_E = 0$ BC487 $V_{CB} = 60 \text{ Vdc} - I_E = 0$ BC489	I_{CBO}	— — —	— — —	100 100 100	nAdc

ON CHARACTERISTICS*

DC Current Gain ($I_C = 10 \text{ mAdc} - V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc} - V_{CE} = 2.0 \text{ Vdc}$)	h_{FE}	40			
full range		60		400	
- L		60	120	150	
- A		100	160	250	
- B		160	260	400	
($I_C = 1 \text{ Adc} - V_{CE} = 5.0 \text{ Vdc}$)		15			
Collector Emitter Saturation Voltage ($I_C = 500 \text{ mAdc} - I_B = 50 \text{ mAdc}$) ($I_C = 1 \text{ Adc} - I_B = 100 \text{ mAdc}$)	$V_{CE(sat)}$	— —	0.2 0.3	0.50 —	Vdc
Base Emitter Saturation Voltage ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$) ($I_C = 1 \text{ Adc} - I_B = 100 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.85 0.90	1.20	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 2.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	—	200	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{ob}	—	7	—	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{ib}	—	50	—	pF

* Pulse test - Pulse width = $300 \mu\text{s}$ - Duty Cycle 2%.

MAXIMUM RATINGS

Rating	Symbol	BC 486	BC 488	BC 490	Unit
Collector-Emitter Voltage	V _{CEO}	45	60	80	Vdc
Collector-Base Voltage	V _{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V _{EBO}	4.0			Vdc
Collector Current - Continuous	I _C	1.0			Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0			mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

BC486 BC488 BC490

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

HIGH CURRENT TRANSISTORS

PNP SILICON

Refer to MPSA55 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	45 60 80	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	45 60 80	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	4.0	—	—	Vdc
Collector Cutoff Current V _{CB} = 30 Vdc - I _E = 0 BC486 V _{CB} = 40 Vdc - I _E = 0 BC488 V _{CB} = 60 Vdc - I _E = 0 BC490	I _{CBO}	—	—	100 100 100	nAdc

ON CHARACTERISTICS*

DC Current Gain (I _C = 10 mAdc - V _{CE} = 2.0 Vdc) (I _C = 100 mAdc - V _{CE} = 2.0 Vdc)	h _{FE}	40	—	—	—
full range - L - A - B		60	—	400	
		60	100	150	
		100	140	250	
		160	260	400	
(I _C = 1 Adc - V _{CE} = 5.0 Vdc)		15	—	—	
Collector Emitter Saturation Voltage (I _C = 500 mAdc - I _B = 50 mAdc) (I _C = 1 Adc - I _B = 100 mAdc)	V _{CE(sat)}	—	0.25 0.50	0.50 —	Vdc
Base Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc) (I _C = 1 Adc - I _B = 100 mAdc)	V _{BE(sat)}	—	0.90 1.00	1.20	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 50 mAdc, V _{CE} = 2.0 Vdc, f = 100 MHz)	f _T	—	150	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{ob}	—	9	—	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ib}	—	110	—	pF

* Pulse test - Pulse width = 300 μs - Duty Cycle 2%.

BC517

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC517	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current – Continuous	I_C	140	mAdc
Total Power Dissipation Derate above 25°C	P_D	625 12	mW mW/°C
Total Power Dissipation Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

Refer to 2N6426 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 2 \text{ mAdc}, V_{BE} = 0$)	$V_{(BR)CES}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	10	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}, V_{BE} = 0$)	I_{CES}	—	—	500	nAdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	100	nAdc

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 20 \text{ mAdc}, V_{CE} = 2 \text{ Vdc}$)	h_{FE}	30 000	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 0.1 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	1	Vdc
Base-Emitter On Voltage ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	—	1.4	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current Gain–Bandwidth Product (2) ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	125	200	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{ob}	—	5.0	8.0	pF

(1) Pulse Test Pulse Width $\leq 2.0\%$.

(2) $f_T = \beta h_{fe} \bullet f_{test}$

MAXIMUM RATINGS

Rating	Symbol	BC 546	BC 547	BC 548	Unit
Collector-Emitter Voltage	V _{CEO}	65	45	30	V _{dc}
Collector-Base Voltage	V _{CBO}	80	50	30	V _{dc}
Emitter-Base Voltage	V _{EBO}	6.0			V _{dc}
Collector Current – Continuous	I _C	100			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0			mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**BC546
BC547
BC548**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

AMPLIFIER TRANSISTORS

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1 mA, I _B = 0)	BC546 BC547 BC548	V _{(BR)CEO}	65 45 30			V
Emitter-Base Breakdown Voltage (I _E = 10 μA, I _C = 0)	BC546 BC547 BC548	V _{(BR)EBO}	6 6 6			V
Collector Cutoff Current (V _{CE} = 70 V, V _{BE} = 0) (V _{CE} = 50 V, V _{BE} = 0) (V _{CE} = 35 V, V _{BE} = 0) (V _{CE} = 30 V, T _A = 125 °C)	BC546 BC547 BC548 BC546 BC547 BC548	I _{CES}		0.20 0.20 0.20	15 15 15 4 4 4	nA μA

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μA, V _{CE} = 5 V)	BC546A/547A/548A BC436B/547B/548B BC548C	h _{FE}		90 150 270		
(I _C = 2 mA, V _{CE} = 5 V)	BC546 BC547 BC548 BC546A/547A/548A BC546B/547B/548B BC548C		125 110 110 110	180	500 800 800	
(I _C = 100 mA, V _{CE} = 5 V)	BC546A/547A/548A BC546B/547B/548B BC548C		200 420	290 520	450 800	
Collector-Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.5 mA) (I _C = 100 mA, I _B = 5 mA) (I _C = 10 mA, I _B = See Note 1)		V _{CE(sat)}		0.09 0.2 0.3	0.25 0.60 0.6	V
Base-Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.5 mA)		V _{BE(sat)}		0.7		V
Base-Emitter On Voltage (I _C = 2 mA, V _{CE} = 5 V) (I _C = 10 mA, V _{CE} = 5 V)		V _{BE(on)}	0.55		0.70 0.77	V

NOTE 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V.

BC546, BC547, BC548

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 100\text{ MHz}$)	BC546 BC547 BC548	f_T	150 150 150	300 300 300		MHz
Output Capacitance ($V_{CB} = 10\text{ V}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{obo}		1.7	4.5	pF
Input Capacitance ($V_{BE} = 0.5\text{ V}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{ibo}		10		pF
Input Impedance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC546A/547A/548A BC546B/547B/548B BC548C	h_{ie}	1.6 3.2 6.0	2.7 4.5 8.7	4.5 8.5 15.0	$K\Omega$
Voltage Feedback Ratio ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC546A/547A/548A BC546B/547B/548B BC548C	h_{re}		1.5 2.0 3.0		$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC546A/547A/548A BC546B/547B/548B BC548C	h_{fe}	125 240 450	220 330 600	260 500 900	
Output Admittance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC546A/547A/548A BC546B/547B/548B BC548C	h_{oe}		8 10 12	25 35 50	μmhos
Noise Figure ($I_C = 0.2\text{ mA}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ K}\Omega$, $f = 1\text{ KHz}$, $\Delta f = 200\text{ Hz}$)	BC546 BC547 BC548	NF		2 2 2	10 10 10	dB

2

FIGURE 1 - NORMALIZED DC CURRENT GAIN

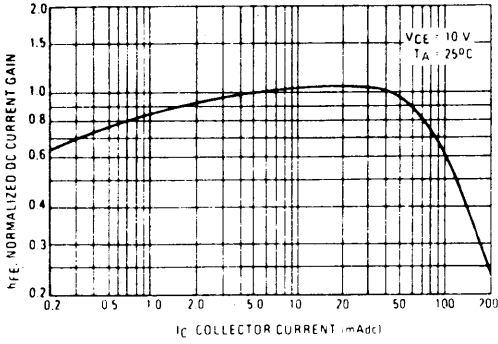


FIGURE 2 - "SATURATION" AND "ON" VOLTAGES

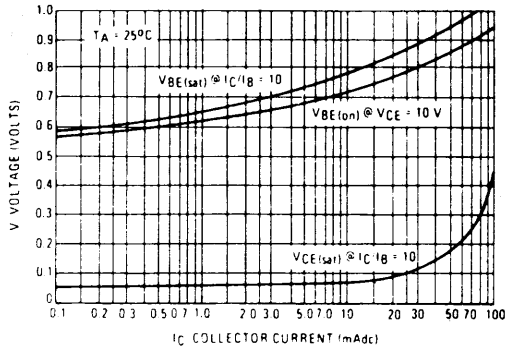


FIGURE 3 - COLLECTOR SATURATION REGION

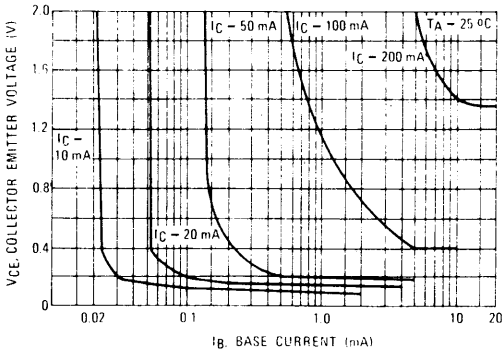


FIGURE 4 - BASE-EMITTER TEMPERATURE COEFFICIENT

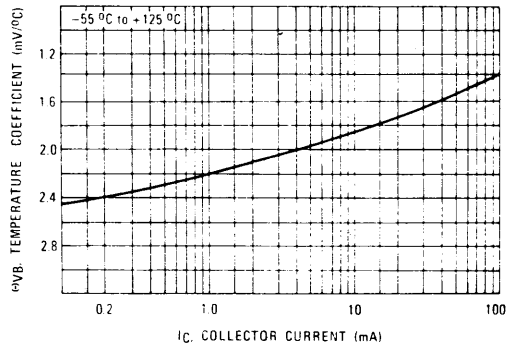


FIGURE 5 - CAPACITANCES

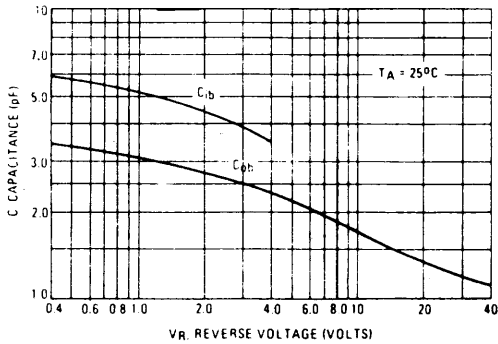


FIGURE 6 - CURRENT GAIN-BANDWIDTH PRODUCT

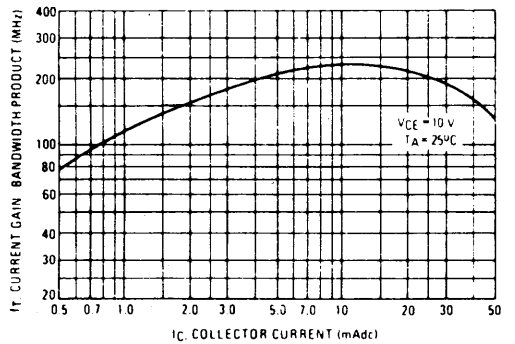


FIGURE 7 - DC CURRENT GAIN

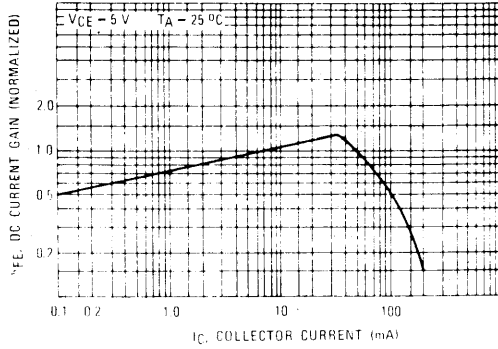


FIGURE 8 - "ON" VOLTAGE

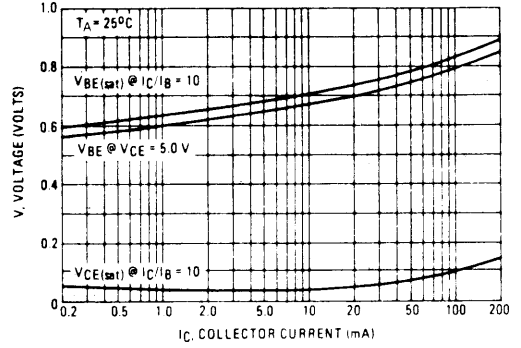


FIGURE 9 - COLLECTOR SATURATION REGION

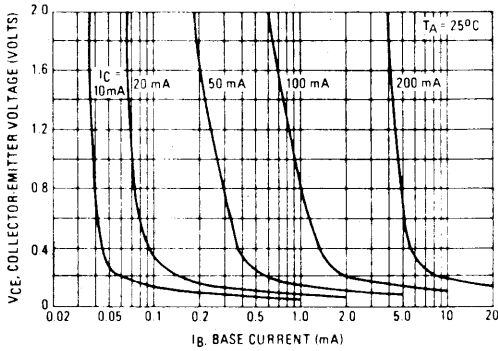


FIGURE 10 - BASE-EMITTER TEMPERATURE COEFFICIENT

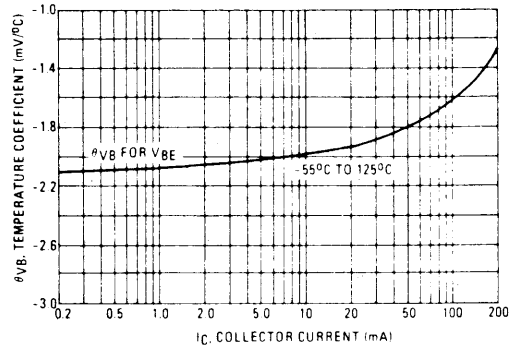


FIGURE 11 - CAPACITANCE

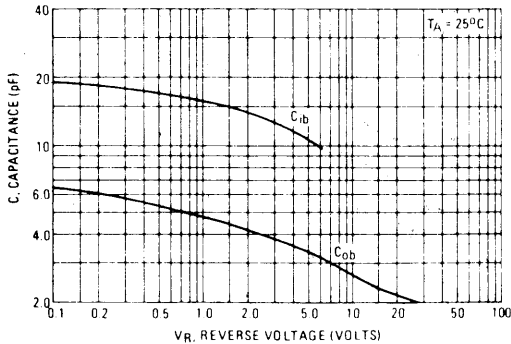
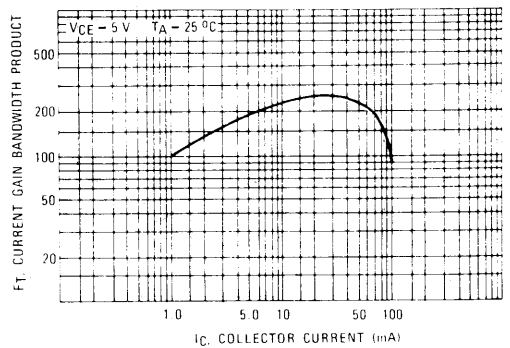


FIGURE 12 - CURRENT GAIN-BANDWIDTH PRODUCT



MAXIMUM RATINGS

Rating	Symbol	BC 549	BC 550	Unit
Collector-Emitter Voltage	V _{CEO}	30	45	Vdc
Collector-Base Voltage	V _{CBO}	30	50	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current – Continuous	I _C	100		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625	5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5	12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

BC549 BC550

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

LOW NOISE TRANSISTORS

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0) BC549 BC550	V _{(BR)CEO}	30 45			Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0) BC549 BC550	V _{(BR)CBO}	30 50			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5			Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 30 Vdc, I _E = 0, T _A = + 125 °C)	I _{CBO}			15 5	nAdc μAdc
Emitter Cutoff Current (V _{EB} = 4 Vdc, I _C = 0)	I _{EBO}			15	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 Vdc) BC549B/550B BC549C/550C (I _C = 2 mAdc, V _{CE} = 5 Vdc) BC549A BC549B/550B BC549C/550C BC549/550	h _{FE}	100 100 110 200 420 110	150 270	220 450 800 800	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 10 mAdc, I _B = see note 1) (I _C = 100 mAdc, I _B = 5 mAdc, see note 2)	V _{CE(sat)}		0.075 0.3 0.25	0.25 0.6 0.6	Vdc
Base-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 5 mAdc)	V _{BE(sat)}		1.1		Vdc
Base-Emitter On Voltage (I _C = 10 μAdc, V _{CE} = 5 Vdc) (I _C = 100 μAdc, V _{CE} = 5 Vdc) (I _C = 2 mAdc, V _{CE} = 5 Vdc)	V _{BE(on)}	0.55	0.52 0.55 0.62	0.75	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product (I _C = 10 mAdc, V _{CE} = 5 Vdc, f = 100 MHz)	f _T		250		MHz
Collector-Base Capacitance (V _{CE} = 10 Vdc, I _E = 0, f = 1 MHz)	C _{cbo}		2.5		pF

Note 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V

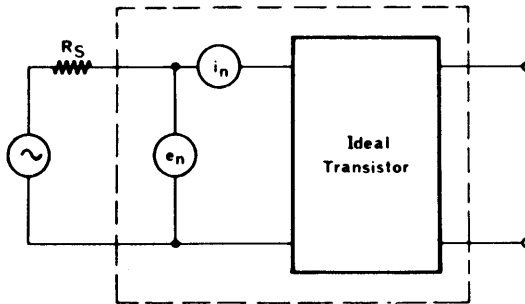
Note 2: Pulse test = 300 μs – Duty cycle = 2%

BC549, BC550

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
Input Impedance ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	h_{ie}	3.2 6.0	6.0 8.7	8.5 15.0	$\text{K}\Omega$
Voltage Feedback Ratio ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	h_{re}		2 3		10^{-4}
Small Signal Current Gain ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	h_{fe}	240 450	330 600	500 900	
Output Admittance ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	h_{oe}		10 12	60 110	μmhos
Noise Figure ($I_C = 200\ \mu\text{Adc}$, $V_{CE} = 5\text{ Vdc}$, $R_S = 2\text{ K}\Omega$, $f = 30\text{ Hz} - 15\text{ KHz}$)	NF		0.6	2.5	dB
Equivalent Input Noise Voltage ($I_C = 200\ \mu\text{Adc}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ k}\Omega$, $f = 120\text{ Hz}$) See Application note, Section I	V_T		8.0	12	$\text{nV}/\sqrt{\text{Hz}}$
Equivalent Input Noise Voltage ($I_C = 200\ \mu\text{Adc}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ K}\Omega$, $f = 10\text{ Hz} - 50\text{ Hz}$) See Application note, Section II	V_T		74	135	$\text{nV}/\sqrt{\text{Hz}}$

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE APPLICATION NOTE

I. NOISE FIGURE RELATED TO V_T , e_n , and i_n

For a transistor, total noise at the input may be expressed as:

$$V_T = \left[e_n^2 + 4 KT R_S + i_n^2 R_S^2 \right]^{1/2} \quad (1)$$

Where:

- V_T = total noise voltage at the transistor input (Volts/ $\sqrt{\text{Hz}}$)
- e_n = noise voltage of the transistor referred to the input (figures 2 & 3)
- i_n = noise current of the transistor referred to the input (figure 4)
- K = Boltzmann's constant ($1.38 \times 10^{-23} \text{ J/}^\circ\text{K}$)
- T = Temperature of the source resistance ($^\circ\text{K}$)
- R_S = Source resistance (Ohms)

Example:

Find the total noise at the input of a BC550 for a collector current of 1mA and a source impedance of $1\text{K}\Omega$ at a frequency of 120 Hz and a temperature of 25°C .

1. V_T is calculated from e_n , i_n

Read e_n 4.5 nV/ $\sqrt{\text{Hz}}$ from figure 3 (Note that this is for a one cycle bandwidth)

Read i_n 5.8 pA/ $\sqrt{\text{Hz}}$ from figure 4

$$V_T = \left[(3.5 \times 10^{-9})^2 + (4) \cdot (1.38 \times 10^{-23}) \cdot (300) \cdot (1 \times 10^3) + (5.8 \times 10^{-12})^2 \cdot (1 \times 10^3)^2 \right]^{1/2}$$

II. NOISE VARIATION WITH FREQUENCY

Noise over a frequency band can be handled in one of two ways depending upon whether total transistor noise is constant or variable over the bandwidth of interest:

1. For constant transistor noise, multiply, V_T by the square root of bandwidth. i.e., $V_T = V_T \cdot f^{1/2}$
2. For variable transistor noise integrate the spectral density V_T (where $\Delta f = 1 \text{ Hz}$), over the bandwidth of interest.

Example: Low Frequency Noise

Find the total noise at the input in the bandwidth $f_1 = 10 \text{ Hz}$, $f_2 = 50 \text{ Hz}$ at $I_C = 200 \mu\text{A}$ and $R_S = 2 \text{ K}\Omega$

This example corresponds to the popular "FLICKER NOISE" test shown on many data sheets.

$$V_T^2 = \int_{-\infty}^{+\infty} V_T(f) \times [G(f)]^2 df$$

$(f_1 - f_2)$

where:

$$V_T^2(f) = e_n^2 + 4 KT R_S + i_n^2 R_S^2$$

$e_n(f)$ and $4 KT R_S$ are constant in the bandwidth

Thus: $V_T = 8.2 \text{ nV}$.

This checks with the value of 8 nV shown in figure 6.

2. Noise figure is calculated from V_T

Noise figure is defined as:

$$NF = 20 \log_{10} \frac{\text{total noise voltage}}{\text{noise voltage contributed by source resistance}}$$

or

$$NF = 20 \log_{10} \left[\frac{V_T^2}{4 KT R_S} \right]^{1/2}$$

Noise figure can be calculated for the above example as follows:

$$NF = 20 \log_{10} \left[\frac{(8 \times 10^{-9})^2}{16.6 \times 10^{-18}} \right]^{1/2}$$

Thus: $NF = 5.9 \text{ dB}$

This checks with the values of 6 dB read from figure 7.

To minimize noise in a transistor stage, one might use figure is minimum. This is not necessarily true as shown by figure 6 where the total noise voltage is a minimum at small values of source impedance.

This can be seen from equation (1) which shows that total noise is a direct function of source resistance.

$$i_n(f) = \frac{i_n^2(1 \text{ Hz})}{f} \quad (1/f \text{ noise spectrum density})$$

$G(f)$ bandpass filter

$$= 1 \text{ for } f \in (f_1, f_2)$$

$$= 0 \text{ for } f \notin (f_1, f_2)$$

after integration:

$$V_T^2_{T(f_1-f_2)} = (e_n^2 + 4 KT R_S) \times (f_2 - f_1) + \frac{R_S^2 i_n^2}{S} \times f_1 \times i_n(f_1) \frac{f_2}{f_1}$$

Now:

$e_n = 5 \text{ nV}/\sqrt{\text{Hz}}$ at 10 Hz (from figure 2)

$i_n = 7 \text{ pA}/\sqrt{\text{Hz}}$ at 10 Hz (from figure 4)

$$V_T^2(10 \text{ Hz}-50 \text{ Hz}) = [(25 + 33.1) 40 + 196 \times 10 \times 1.6] \cdot 10^{-18}$$

Thus: $V_T(10 \text{ Hz}-50 \text{ Hz}) = 74 \text{ nV}$



FIGURE 2 – NOISE VOLTAGE vs FREQUENCY

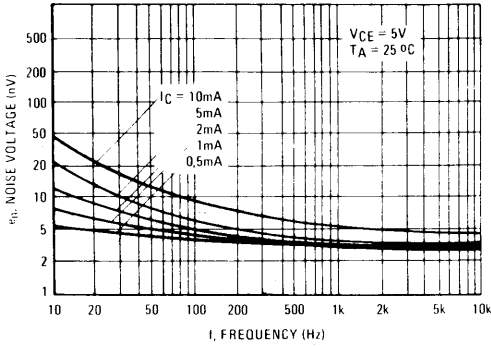


FIGURE 3 – NOISE VOLTAGE vs COLLECTOR CURRENT

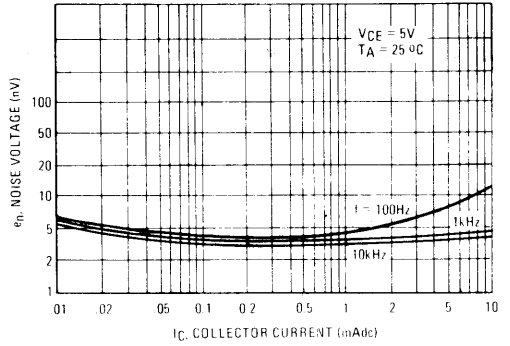


FIGURE 4 – NOISE CURRENT

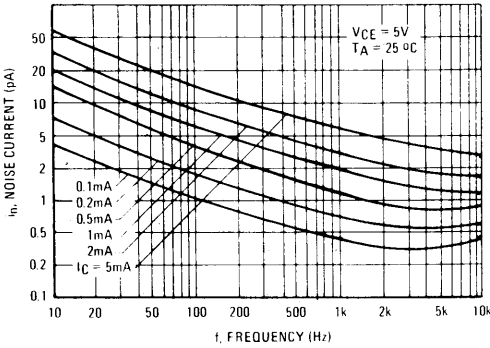


FIGURE 5 – WIDEBAND NOISE FIGURE

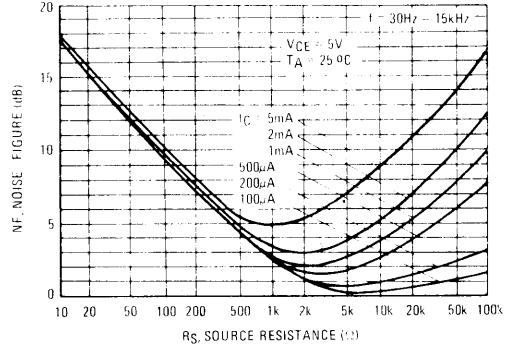


FIGURE 6 – TOTAL NOISE VOLTAGE (120 Hz)

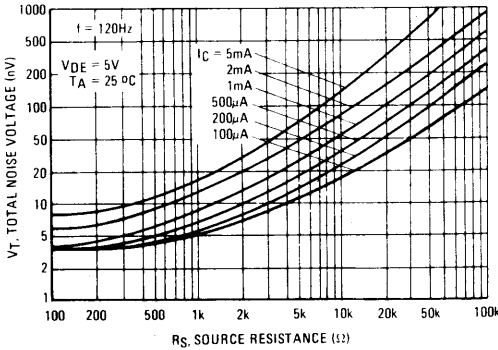
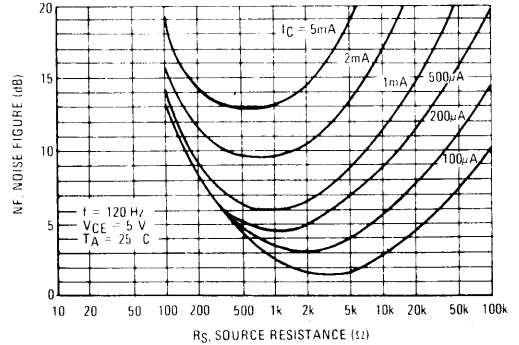


FIGURE 7 – NOISE FIGURE (120 Hz)



2

BC549, BC550

FIGURE 8 – NORMALIZED DC CURRENT GAIN

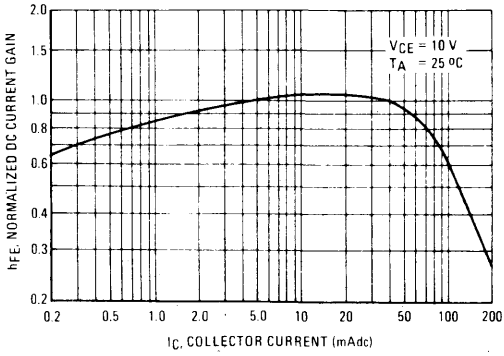
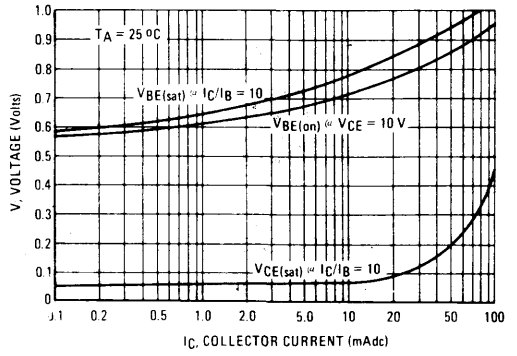


FIGURE 9 – "SATURATION" AND "ON" VOLTAGES



2

FIGURE 10 – CURRENT GAIN-BANDWIDTH PRODUCT

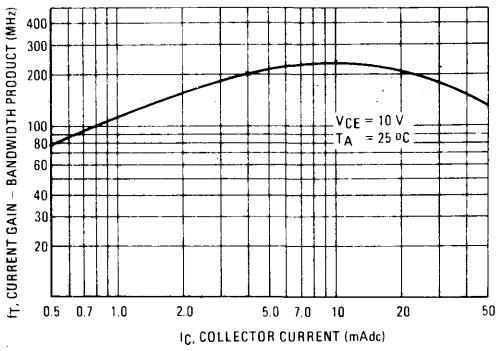


FIGURE 11 – CAPACITANCE

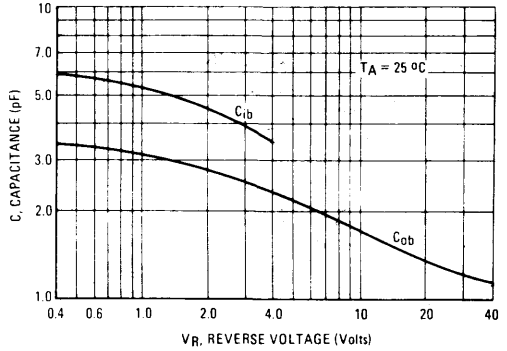


FIGURE 12 – OUTPUT ADMITTANCE

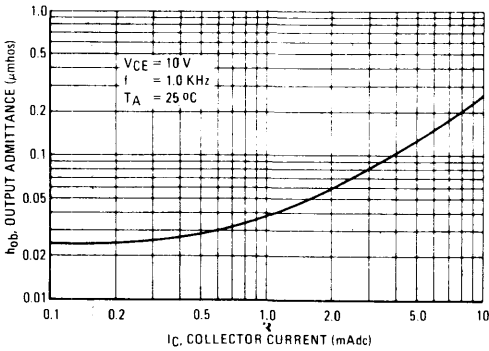
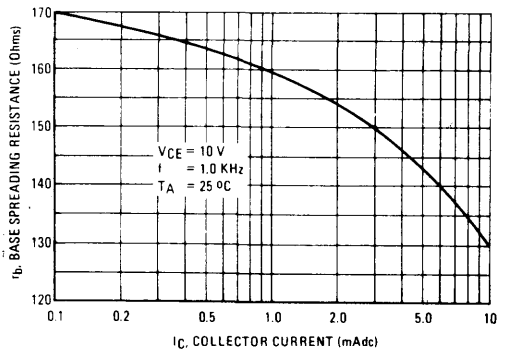


FIGURE 13 – BASE SPREADING RESISTANCE



**BC556
BC557
BC558**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 556	BC 557	BC 558	Unit
Collector-Emitter Voltage	V _{CEO}	65	45	30	V _{dc}
Collector-Base Voltage	V _{CBO}	70	50	30	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	100			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0			mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I _C = 2.0 mAdc, I _B = 0)	BC556 BC557 BC558	V _{(BR)CEO}	65 45 30	— — —	— — —	V
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	BC556 BC557 BC558	V _{(BR)EBO}	5 5 5	— — —	— — —	V
Collector-Emitter Leakage Current (V _{CE} = 40 V) (V _{CE} = 20 V) (V _{CE} = 20 V, T _A = 125°C)	BC556 BC557 BC558 BC556 BC557 BC558	I _{CES}		2 2 2 4 4 4	100 100 100	nA μA

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 V) (I _C = 2 mAdc, V _{CE} = 5 V) (I _C = 100 mAdc, V _{CE} = 5 V)	BC556A/557A/558A BC556B/557B/558B BC557C/558C BC556 BC557 BC558 BC556A/557A/558A BC556B/557B/558B BC557C/558C BC556A/557A/558A BC556B/557B/558B BC557C/558C	h _{FE}		90 150 270 125 110 110 120 180 420 120 180 300	— — — 170 290 500	500 800 800 220 460 800	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 10 mAdc, I _B = see Note 1) (I _C = 100 mAdc, I _B = 5 mAdc)		V _{CE(sat)}	— — —	0.075 0.30 0.25	0.3 0.60 0.65	V	
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mA) (I _C = 100 mAdc, I _B = 5 mA)		V _{BE(sat)}	— —	0.70 1.00	— —	V	
Base-Emitter on Voltage (I _C = 2 mAdc, V _{CE} = 5 V) (I _C = 10 mA, V _{CE} = 5 V)		V _{BE(on)}	0.55	0.62 0.7	0.70 0.82	V	

NOTE 1: I_C = 10 mAdc on the constant base current characteristic, which yields the point I_C = 11 mAdc, V_{CE} = 1 V.

BC556, BC557, BC558

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 50\text{ MHz}$)	BC556 BC557 BC558	f_T		280 320 360		MHz
Output Capacitance ($V_{CB} = 10\text{ V}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{ob}		3	6.0	pF
Noise Figure ($I_C = 0.2\text{ mA}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ Kohms}$, $f = 1\text{ KHz}$, $\Delta f = 200\text{ Hz}$)	BC556 BC557 BC558	NF		2 2 2	10 10 10	dB
Input Impedance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC556A/557A/558A BC556B/557B/558B BC557C/558C	h_{ie}	1.2 3.0 5.0	2.7 4.5 8.0	4.5 8.0 14.0	k Ω
Voltage Feedback Ratio ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC556A/557A/558A BC556B/557B/558B BC557C/558C	h_{re}		3.0 3.5 4.0		10^{-4}
Small-Signal Current Gain ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC556A/557A/558A BC556B/557B/558B BC557C/558C	h_{fe}	125 240 450	220 330 600	260 500 900	
Output Admittance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ KHz}$)	BC556A/557A/558A BC556B/557B/558B BC557C/558C	h_{oe}		25 30 60	50 70 110	μmhos

2

FIGURE 1 - NORMALIZED DC CURRENT GAIN

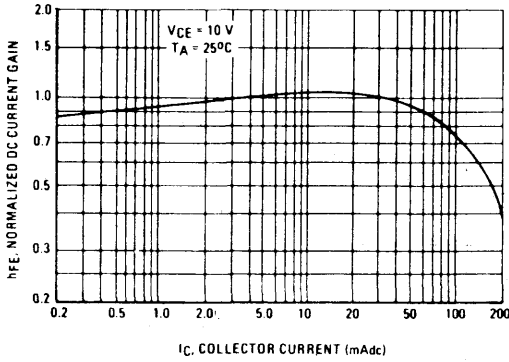


FIGURE 2 - "SATURATION" AND "ON" VOLTAGES

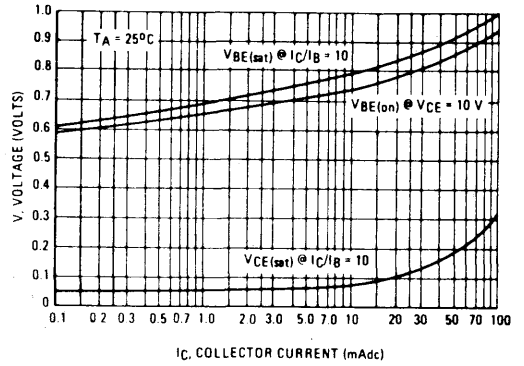


FIGURE 3 - COLLECTOR SATURATION REGION

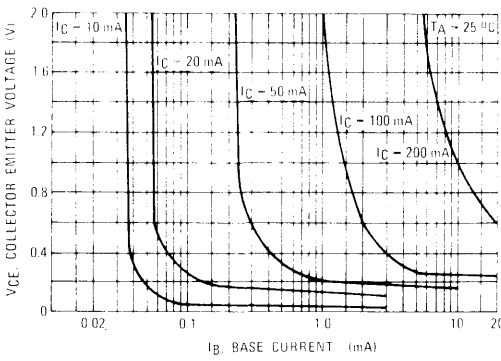


FIGURE 4 - BASE EMITTER TEMPERATURE COEFFICIENT

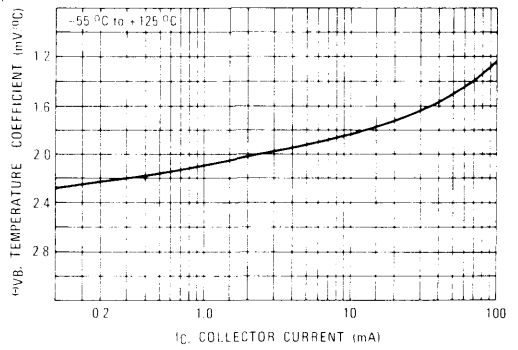


FIGURE 5 - CAPACITANCES

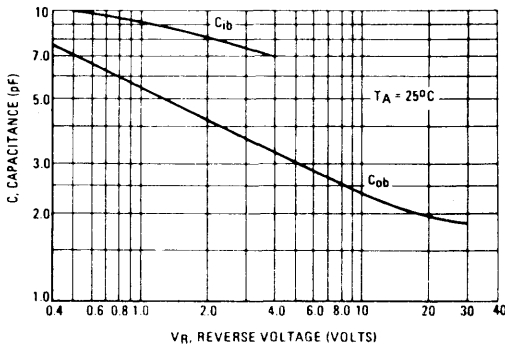


FIGURE 6 - CURRENT GAIN-BANDWIDTH PRODUCT

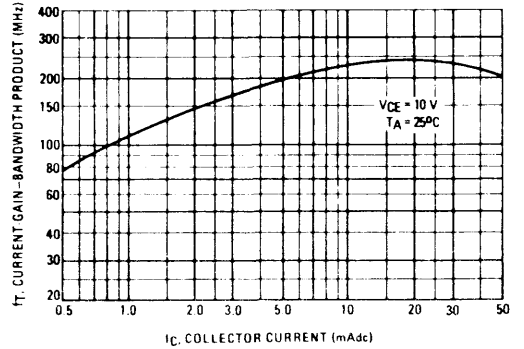


FIGURE 7 - DC CURRENT GAIN

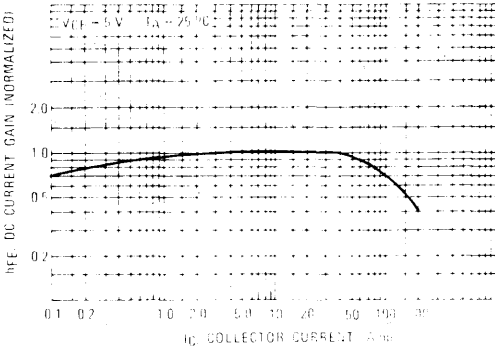


FIGURE 8 - "ON" VOLTAGE

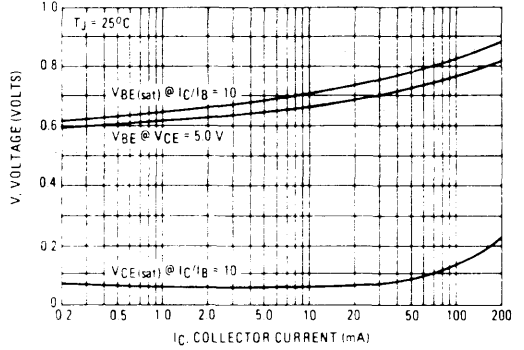


FIGURE 9 - COLLECTOR SATURATION REGION

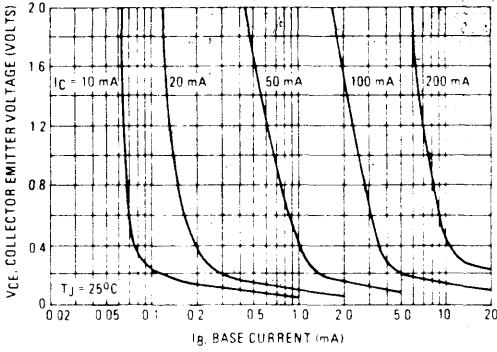


FIGURE 10 - BASE EMITTER TEMPERATURE COEFFICIENT

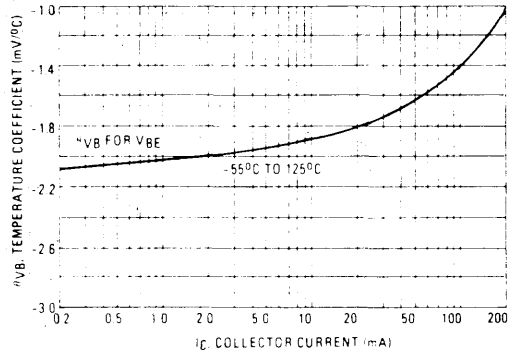


FIGURE 11 - CAPACITANCE

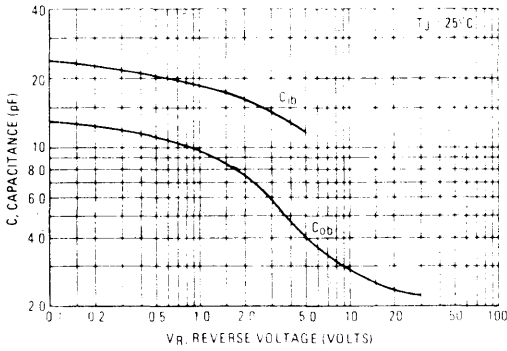


FIGURE 12 - CURRENT GAIN-BANDWIDTH PRODUCT

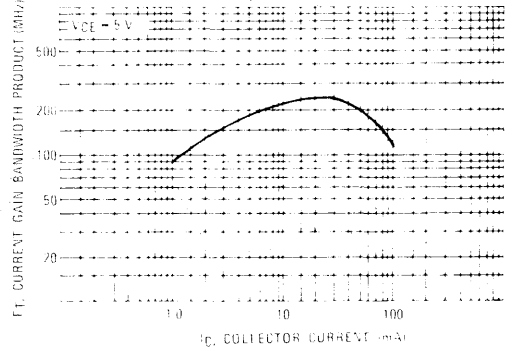


FIGURE 13 – THERMAL RESPONSE

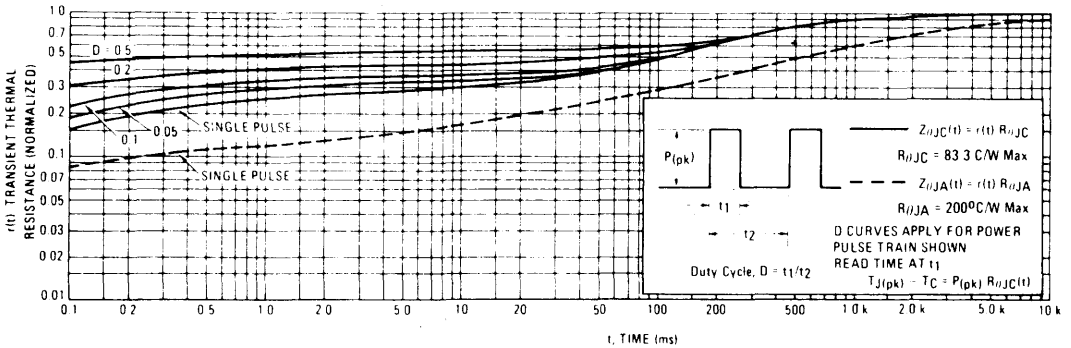
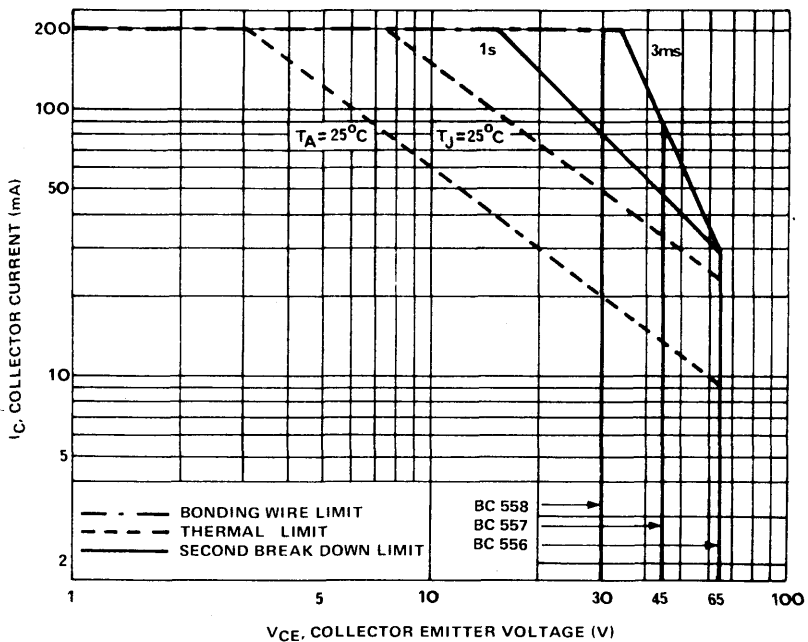


FIGURE 14 – ACTIVE REGION SAFE OPERATING AREA



The safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 14 is based upon $T_{J(pk)} = 150^\circ\text{C}$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data of Figure 13. At high case or ambient temperatures thermal limitations will reduce the power that can be handled to values less than the limitations imposed by the secondary breakdown. (see AN 415).

MAXIMUM RATINGS

Rating	Symbol	BC 559	BC 560	Unit
Collector-Emitter Voltage	V _{CEO}	30	45	Vdc
Collector-Base Voltage	V _{CBO}	30	50	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current – Continuous	I _C	100		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625	5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5	12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

BC559
BC560

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

LOW NOISE TRANSISTORS

PNP SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0) BC559 BC560	V _{(BR)CEO}	30 45			Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0) BC559 BC560	V _{(BR)CBO}	30 50			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5			Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 30 Vdc, I _E = 0, T _A = +125°C)	I _{CBO}			15 5	nAdc μAdc
Emitter Cutoff Current (V _{EB} = 4 Vdc, I _C = 0)	I _{EBO}			15	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 Vdc) BC559B/560B BC559C/560C (I _C = 2 mAdc, V _{CE} = 5 Vdc) BC559B/560B BC559C/560C BC559/560	h _{FE}	100 100 180 380 120	150 270 290 500	460 800 800	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 10 mAdc, I _B = see note 1) (I _C = 100 mAdc, I _B = 5 mAdc, see note 2)	V _{CE(sat)}		0.075 0.3 0.25	0.25 0.6	Vdc
Base-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 5 mAdc)	V _{BE(sat)}		1.1		Vdc
Base-Emitter On Voltage (I _C = 10 μAdc, V _{CE} = 5 Vdc) (I _C = 100 μAdc, V _{CE} = 5 Vdc) (I _C = 2 mAdc, V _{CE} = 5 Vdc)	V _{BE(on)}	0.55	0.52 0.55 0.62	0.75	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product (I _C = 10 mAdc, V _{CE} = 5 Vdc, f = 100 MHz)	f _T		250		MHz
Collector-Base Capacitance (V _{CE} = 10 Vdc, I _E = 0, f = 1 MHz)	C _{cbo}		2.5		pF

Note 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V

Note 2: Pulse test = 300 μs – Duty cycle = 2%

BC559, BC560

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
Input Impedance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ kHz}$) BC559B/BC560B BC559C/BC560C	h_{ie}	3.2 5.0	6.0 8.0	8.5 14.0	$\text{K}\Omega$
Voltage Feedback Ratio ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ kHz}$) BC559B/BC560B BC559C/BC560C	h_{re}		3.5 4.0		10^{-4}
Small Signal Current Gain ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ kHz}$) BC559B/BC560B BC559C/BC560C	h_{fe}	240 450	330 600	500 900	
Output Admittance ($I_C = 2\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ kHz}$) BC559B/BC560B BC559C/BC560C	h_{oe}		10 12	60 110	μmhos
Noise Figure ($I_C = 200\ \mu\text{A}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ K}\Omega$, $f = 30\text{ Hz} - 15\text{ kHz}$)	NF		0.5	2.0	dB
Equivalent Input Noise Voltage ($I_C = 200\ \mu\text{A}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ k}\Omega$, $f = 120\text{ Hz}$) See Application note, Section I	V_T		8.0	10	$\text{nV}/\sqrt{\text{Hz}}$
Equivalent Input Noise Voltage ($I_C = 200\ \mu\text{A}$, $V_{CE} = 5\text{ V}$, $R_S = 2\text{ K}\Omega$, $f = 10\text{ Hz} - 50\text{ Hz}$) See Application note, Section II	V_T		74	110	$\text{nV}/\sqrt{\text{Hz}}$

2

BC559, BC560

FIGURE 1 – NOISE VOLTAGE V_S FREQUENCY

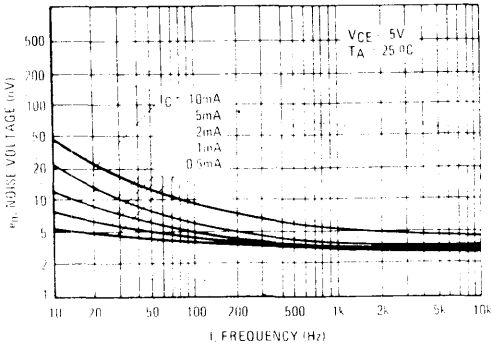
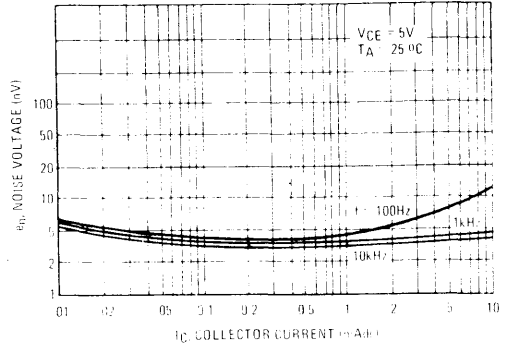


FIGURE 2 – NOISE VOLTAGE V_S COLLECTOR CURRENT



2

FIGURE 3 – NOISE CURRENT

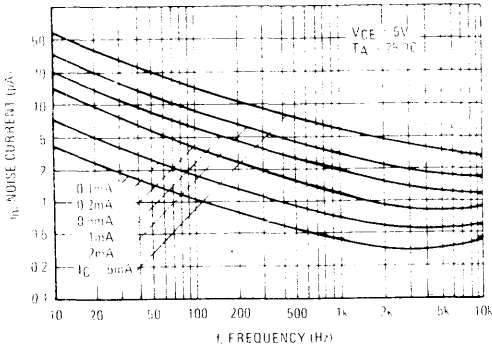


FIGURE 4 – WIDEBAND NOISE FIGURE

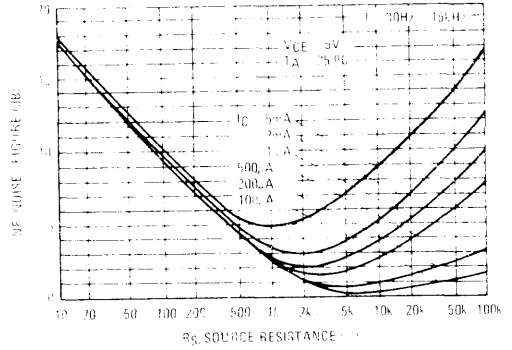


FIGURE 5 – TOTAL NOISE VOLTAGE (120 Hz)

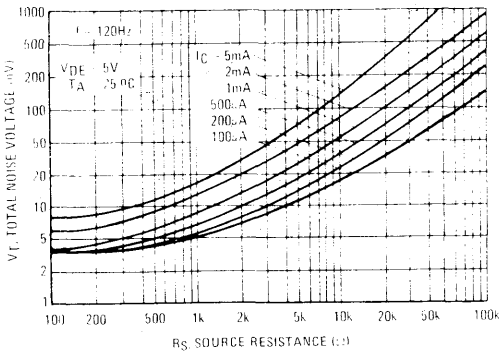
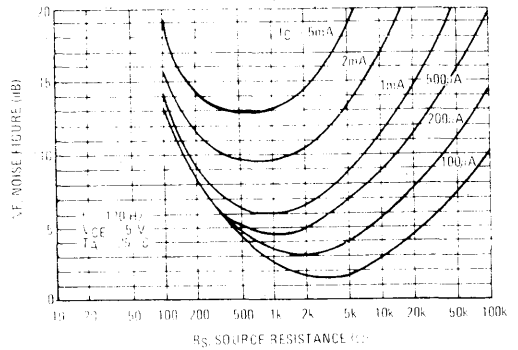


FIGURE 6 – NOISE FIGURE (120 Hz)



BC559, BC560

FIGURE 7 – NORMALIZED DC CURRENT GAIN

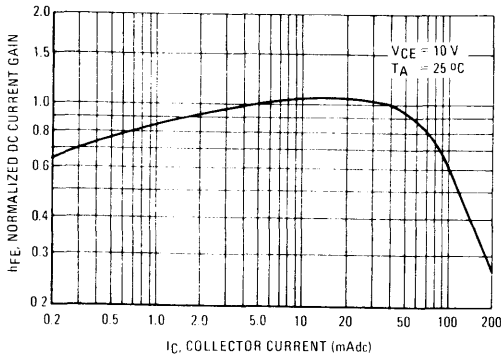


FIGURE 8 – "SATURATION" AND "ON" VOLTAGES

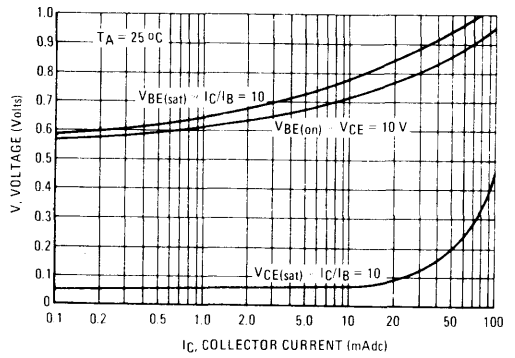


FIGURE 9 – CURRENT GAIN-BANDWIDTH PRODUCT

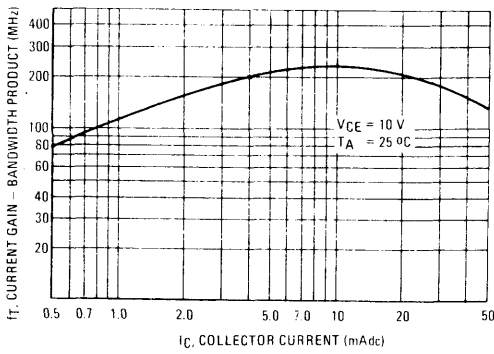


FIGURE 10 – CAPACITANCE

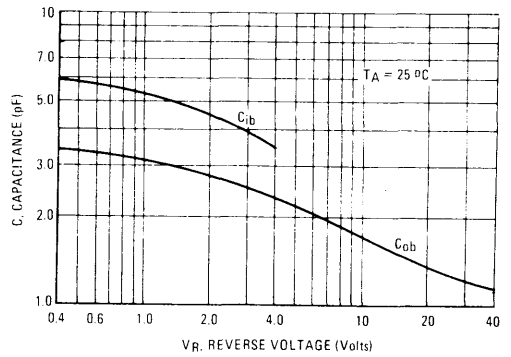


FIGURE 11 – OUTPUT ADMITTANCE

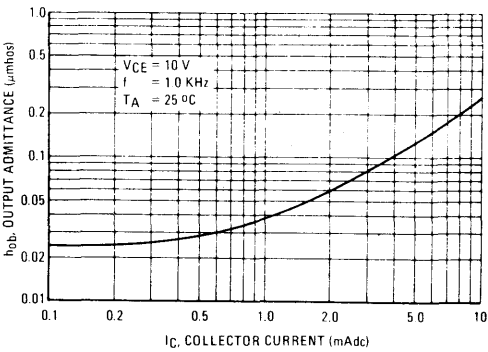
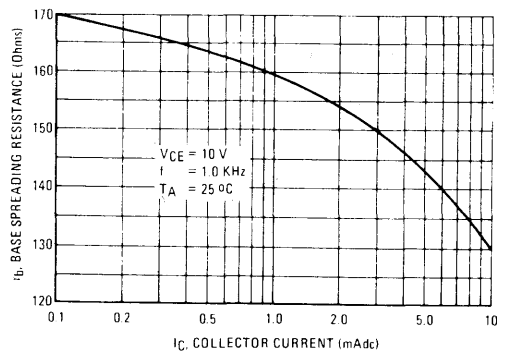


FIGURE 12 – BASE SPREADING RESISTANCE



2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	Vdc
Collector-Base Voltage	V _{CBO}	25	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current - Continuous	I _C	50	mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

**BC585 (NPN)
BC586 (PNP)**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

**SILICON TEMPERATURE
SENSORS**

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)	BV _{CEO}	20			Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA, I _E = 0)	BV _{CBO}	25			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA, I _C = 0)	BV _{EBO}	5			Vdc
Collector Cutoff Current (V _{CB} = 15 V, I _E = 0)	I _{CBO}			100	nA _{dc}
Emitter Cutoff Current (V _{EB} = 4 V, I _C = 0)	I _{EBO}			100	nA _{dc}
DC Current Gain (I _C = 0.5 mA, V _{CE} = 5 V)	h _{FE}	120		320	
Base-Emitter On Voltage (I _C = 0.5 mA, V _{CE} = 5 V)	V _{BE(on)}	0.57		0.69	Vdc
Thermal Time Constant in Oil Bath	τ		10		sec

BC585 (NPN), BC586 (PNP)

FIGURE 1 – TYPICAL APPLICATION BC 585

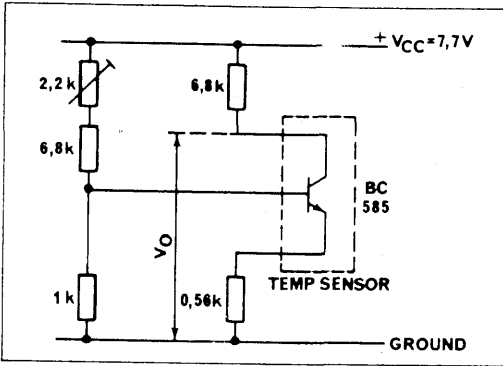


FIGURE 4 – TYPICAL APPLICATION BC 586

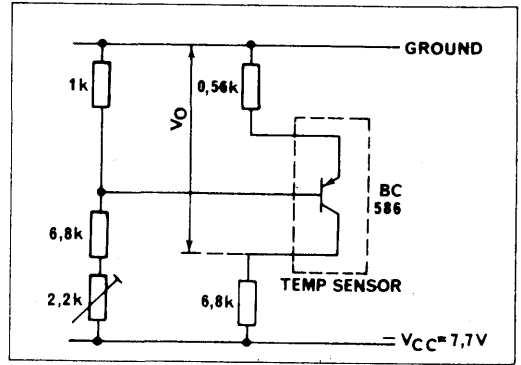


FIGURE 2 – OUTPUT VOLTAGE VERSUS TEMPERATURE

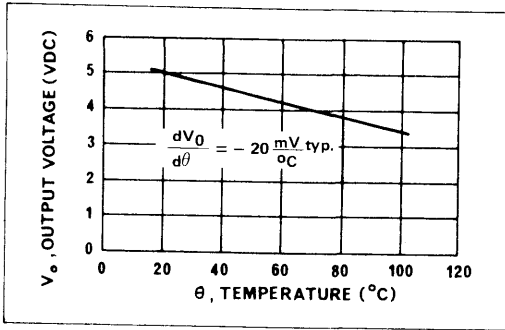


FIGURE 5 – OUTPUT VOLTAGE VERSUS TEMPERATURE

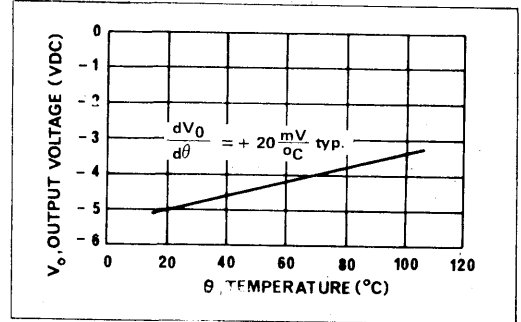


FIGURE 3 – TYP. ERROR DISTRIBUTION OF TEMP. COEF.

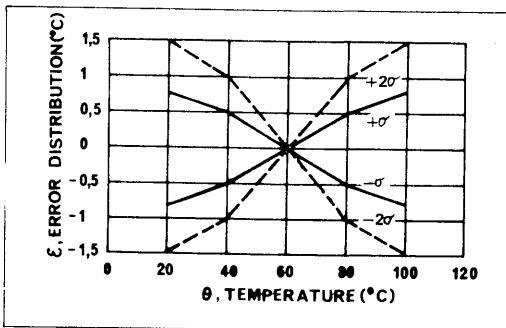
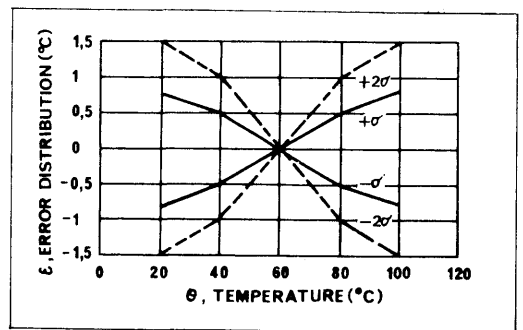


FIGURE 6 – TYP. ERROR DISTRIBUTION OF TEMP. COEF.



Note

These devices are mainly intended for use in temperature control applications using the following linear integrated circuits:

- UAA 1004 } zero voltage switch for on-off controls;
- UAA 1005 }
- UAA 1006 zero voltage switch for proportional controls.

MAXIMUM RATINGS

Rating	Symbol	BC 617	BC 618	Unit
Collector-Emitter Voltage	V _{CEO}	40	55	V _{dc}
Collector-Base Voltage	V _{CBO}	50	80	V _{dc}
Emitter-Base Voltage	V _{EBO}	12		V _{dc}
Collector Current - Continuous	I _C	1.0		A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625	5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5	12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

BC617 BC618

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

DARLINGTON TRANSISTORS

NPN SILICON

Refer to 2N6426 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mA _{dc} , V _{BE} = 0)	BC617 BC618	V _{(BR)CEO}	40 55	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	BC617 BC618	V _{(BR)CBO}	50 80	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	Both Types	V _{(BR)EBO}	12	—	V _{dc}
Collector Cutoff Current (V _{CE} = 40 V _{dc} , V _{BE} = 0) (V _{CE} = 60 V _{dc} , V _{BE} = 0)	BC617 BC618	I _{CES}	— —	50 50	nA _{dc}
Collector Cutoff Current (V _{CB} = 40 V _{dc} , I _E = 0) (V _{CB} = 60 V _{dc} , I _E = 0)	BC617 BC618	I _{CBO}	— —	50 50	nA _{dc}
Emitter Cutoff Current (V _{BE} = 10 V _{dc} , I _C = 0)	Both Types	I _{EBO}	—	50	nA _{dc}
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I _C = 200 mA) (I _B = 0.2 mA)	Both Types	V _{CE(sat)}		1.1	V
Base-Emitter Saturation Voltage (I _C = 200 mA) (I _B = 0.2 mA)	Both Types	V _{BE(sat)}		1.6	V
Current Gain (I _C = 100 μA, V _{CE} = 5 V) (I _C = 10 mA, V _{CE} = 5 V) (I _C = 200 mA, V _{CE} = 5 V) (I _C = 1 A, V _{CE} = 5 V)	BC617 BC618 BC617 BC618 BC617 BC618 BC617 BC618	h _{FE}	4000 2000 10000 4000 20000 10000 10000 4000	70000 50000	
DYNAMIC CHARACTERISTICS					
Current gain - Bandwidth product (I _C = 500 mA, V _{CE} = 5 V) (P = 100 MHz)	Both Types	f _T	150		MHz
Output Capacitance (V _{CB} = 10 V, I _E = 0, P = 1 MHz)		C _{ob}		4.5	pF

BC635 BC637 BC639

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

HIGH CURRENT TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 635	BC 637	BC 639	Unit
Collector-Emitter Voltage	V_{CE0}	45	60	80	Vdc
Collector-Base Voltage	V_{CB0}	45	60	80	Vdc
Emitter-Base Voltage	V_{EB0}	5.0			Vdc
Collector Current - Continuous	I_C	1.0			Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	800 6.4			mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.75 22			Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	156	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage* ($I_C = 10\text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	45 60 80	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	45 60 80	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current $V_{CB} = 30\text{ Vdc} - I_E = 0$ BC635 $V_{CB} = 30\text{ Vdc} - I_E = 0$ BC637 $V_{CB} = 30\text{ Vdc} - I_E = 0$ BC639	I_{CBO}	— — —	— — —	100 100 100	nAdc

ON CHARACTERISTICS*

DC Current Gain ($I_C = 5\text{ mAdc}, V_{CE} = 2.0\text{ Vdc}$) ($I_C = 150\text{ mAdc}, V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	25	—	—	
BC635		40	—	250	
BC637		40	—	160	
BC639		40	—	160	
($I_C = 500\text{ mA}, V_{CE} = 2\text{ V}$)		25	—	—	
Collector-Emitter Saturation Voltage ($I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$)	$V_{CE(sat)}$	—		0.50	Vdc
Base-Emitter on Voltage ($I_C = 500\text{ mAdc}, V_{CE} = 2\text{ Vdc}$)	$V_{BE(on)}$	—		1	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mAdc}, V_{CE} = 2.0\text{ Vdc}, f = 100\text{ MHz}$)	f_T	—	200	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$)	C_{ob}	—	7	—	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 1.0\text{ MHz}$)	C_{ib}	—	50	—	pF

* Pulse test - Pulse width $\leq 300\ \mu\text{s}$ - Duty Cycle 2%

BC635, BC637, BC639

FIG. 1 — ACTIVE REGION SAFE OPERATING AREA

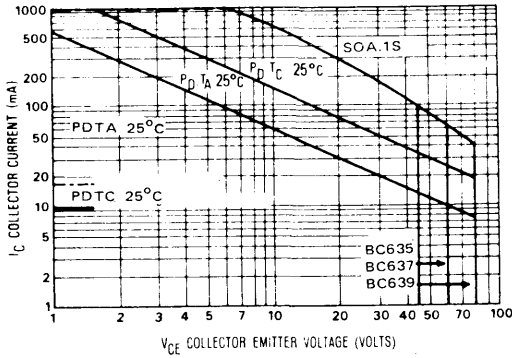


FIG. 2 — DC CURRENT GAIN

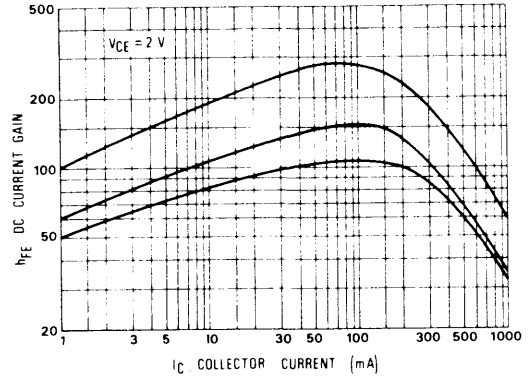


FIG. 3 — CURRENT GAIN BANDWIDTH PRODUCT

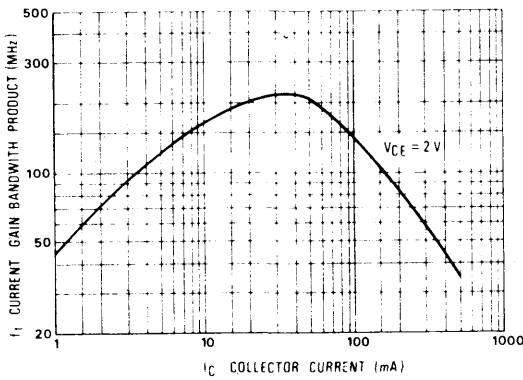


FIG. 4 — "SATURATION" AND "ON" VOLTAGES

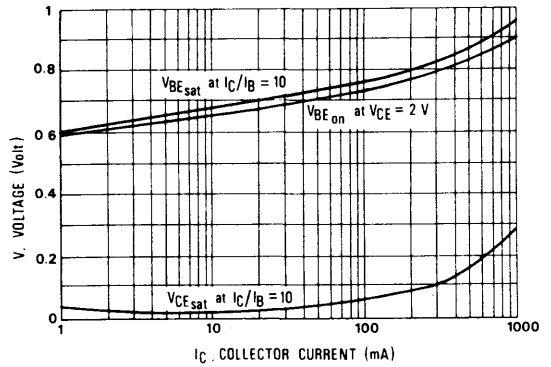
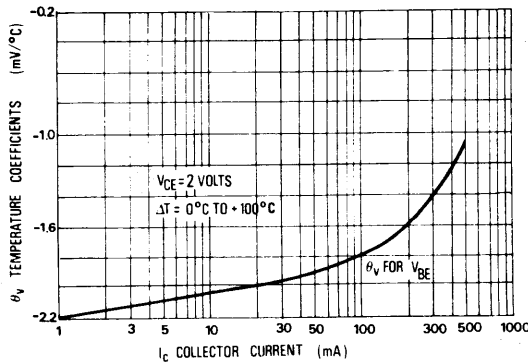


FIG. 5 — TEMPERATURE COEFFICIENTS



BC636 BC638 BC640

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

HIGH CURRENT TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 636	BC 638	BC 640	Unit
Collector-Emitter Voltage	V_{CE0}	45	60	80	Vdc
Collector-Base Voltage	V_{CB0}	45	60	80	Vdc
Emitter-Base Voltage	V_{EB0}	5.0			Vdc
Collector Current - Continuous	I_C	1.0			Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	800	6.4		mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.75	22		Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	156	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* ($I_C = 10\text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	45 60 80	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	45 60 80	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5	—	—	Vdc
Collector Cutoff Current $V_{CB} = 30\text{ Vdc} - I_E = 0$	I_{CBO}	—	—	100	nAdc
$V_{CB} = 30\text{ Vdc} - I_E = 0$	BC636	—	—	100	
$V_{CB} = 30\text{ Vdc} - I_E = 0$	BC638	—	—	100	
$V_{CB} = 30\text{ Vdc} - I_E = 0$	BC640	—	—	100	

ON CHARACTERISTICS*

DC Current Gain ($I_C = 5\text{ mAdc}, V_{CE} = 2.0\text{ Vdc}$) ($I_C = 150\text{ mAdc}, V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	25	—	—	
BC636		40	—	250	
BC638		40	—	160	
BC640		40	—	160	
($I_C = 500\text{ mA}, V_{CE} = 2\text{ V}$)		25	—	—	
Collector-Emitter Saturation Voltage ($I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$)	$V_{CE(sat)}$	—	0.25 0.50	0.50	Vdc
Base-Emitter on Voltage ($I_C = 500\text{ mAdc}, V_{CE} = 2\text{ Vdc}$)	$V_{BE(on)}$	—		1	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mAdc}, V_{CE} = 2.0\text{ Vdc}, f = 100\text{ MHz}$)	f_T	—	150	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$)	C_{ob}	—	9	—	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 1.0\text{ MHz}$)	C_{ib}	—	110	—	pF

* Pulse test - Pulse width $\leq 300\ \mu\text{s}$ - Duty Cycle 2%

BC636, BC638, BC640

FIG. 1 — ACTIVE REGION SAFE OPERATING AREA

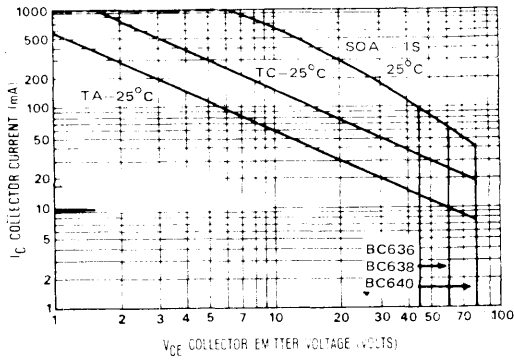


FIG. 2 — DC CURRENT GAIN

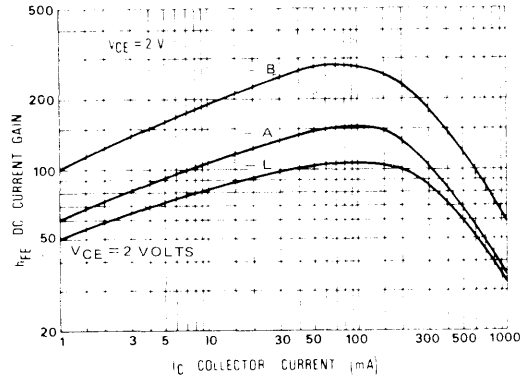


FIG. 3 — CURRENT GAIN BANDWIDTH PRODUCT

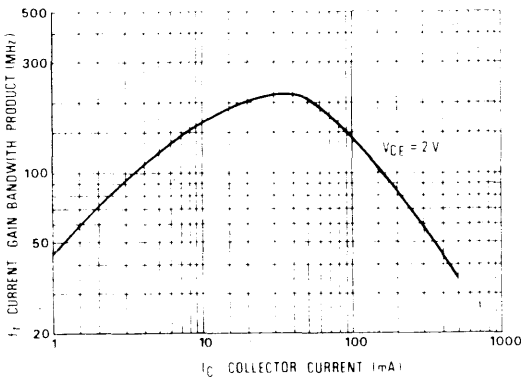


FIG. 4 — "SATURATION" AND "ON" VOLTAGES

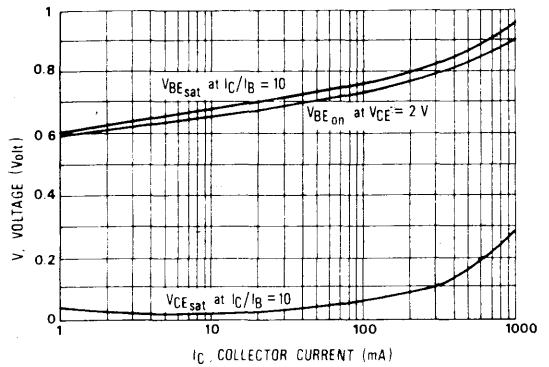
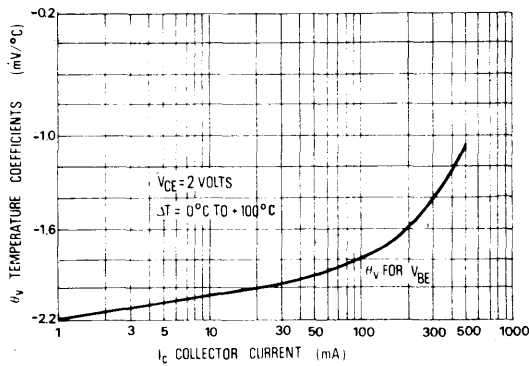


FIG. 5 — TEMPERATURE COEFFICIENTS



BC650, S BC651, S

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

LOW NOISE AUDIO
TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 650, S	BC 651, S	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	Vdc
Collector-Base Voltage	V_{CBO}	30	45	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current - Continuous	I_C	200		mAcd
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C}/\text{W}$

Refer to MPSA18 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAcd, $I_B = 0$)	BC650 BC651	$V_{(BR)CEO}$	30 45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAcd, $I_E = 0$)	BC650 BC651	$V_{(BR)CBO}$	30 45	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	0.015	μA
Collector-Emitter Leakage Current ($V_{CE} = 60$ V)		I_{CES}	—	0.025	μA
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.015	μA

ON CHARACTERISTICS

DC Current Gain ($I_C = 2$ mAcd, $V_{CE} = 5$ Vdc)	BC650/BC651 BC650C/BC651C BC650D/BC651D	h_{FE}	380 380 680	1400 820 1400	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAcd, $I_B = 0.5$ mAcd) ($I_C = 100$ mAcd, $I_B = 5.0$ mAcd)		$V_{CE(sat)}$	— —	0.2 0.6	Vdc
Base Emitter On Voltage ($I_C = 2$ mAcd, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	0.55	0.70	Vdc

SMALL SIGNAL CHARACTERISTICS

Input Impedance ($I_C = 2$ mAcd, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz)	BC650C/BC651C BC650D/BC651D	h_{ie}	2.0 4.0	20 60	k Ω
Voltage Feedback Ratio ($I_C = 2$ mAcd, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz)	BC650C/BC651C BC650D/BC651D	h_{re}	1.0 2.0	30 60	$\times 10^{-4}$
Output Admittance ($I_C = 2$ mAcd, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz)	BC650C/BC651C BC650D/BC651D	h_{oe}	10 20	60 120	μmhos
Small Signal Current Gain ($I_C = 2$ mAcd, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz)	BC650/BC651	h_{fe}	380	1600	—
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)		C_{ob}	—	3.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 1.0$ MHz)		C_{ib}	—	8.0	pF
Current Gain-Bandwidth Product ($I_C = 1.0$ mAcd, $V_{CE} = 5.0$ V, $f = 100$ MHz)		f_T	100	700	MHz

NOISE FIGURE/TOTAL NOISE VOLTAGE CHARACTERISTICS ($V_{CE} = 5.0$ V, $I_C = 0.2$ mA, $T_A = 25^\circ\text{C}$)

	NF Max. (1)	VT (1)	NF Max. (2)	VT (2)	NF Max. (3)	VT (3)	Unit	
BC650, BC651, C, D	8	14.4	3.5	8.6	2.8	8	dB	nV
BC650S, BC651S, CS, DS	5	10.2	2.3	7.5	2	7.2	dB	nV

(1) $R_S = 2$ k Ω , BW = 1.0 Hz, $f = 10$ Hz;

(2) $R_S = 2$ k Ω , BW = 1.0 Hz, $f = 120$ Hz;

(3) $R_S = 2$ k Ω , BW = 1.0 Hz, $f = 1$ KHz

**BCX25
BCX27
BCX29**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

HIGH VOLTAGE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BCX25	BCX27	BCX29	Unit
Collector-Emitter Voltage	V _{CEO}	60	80	100	V _{dc}
Collector-Base Voltage	V _{CBO}	60	80	100	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	200			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350			mW
		2.8			mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0			Watt
		8.0			mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

Refer to MPS8098 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	60 80 100			V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	45 80 100			V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0			V _{dc}
Collector Cutoff Current V _{CB} = 40 Vdc - I _E = 0 BCX25 V _{CB} = 60 Vdc - I _E = 0 BCX27 V _{CB} = 80 Vdc - I _E = 0 BCX29	I _{CBO}			100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain (I _C = 1 mAdc, V _{CE} = 5.0 Vdc) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc) (I _C = 100 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	50 70 50	150 250 300	400	
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 10 mAdc)	V _{CE(sat)}		0.1	0.25	V _{dc}
Base-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 10 mAdc)	V _{BE(sat)}		0.85		V _{dc}
Base-Emitter On Voltage (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	V _{BE(on)}		0.68	1.0	V _{dc}

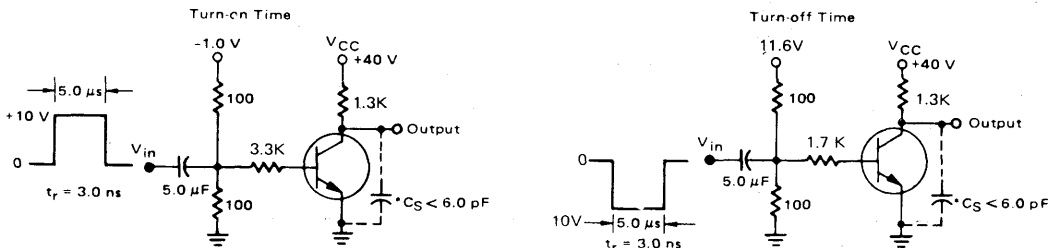
* Pulse test - Pulse width ≤ 300 μs - Duty cycle 2%

BCX25, BCX27, BCX29

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

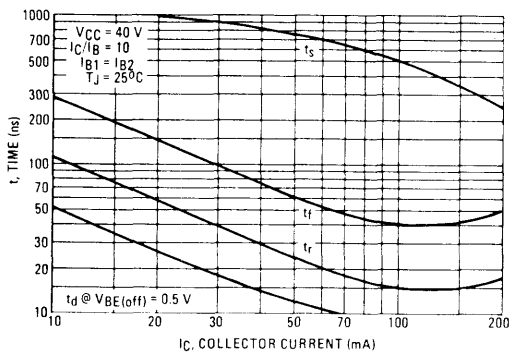
Characteristic	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS					
Current Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	100	250		MHz
Output Capacitance - Common Base ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}		3.0	6.0	pF
Input Capacitance - Common Base ($V_{CB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ib}		16	25	pF
Noise Figure ($I_C = 200\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 2.0\text{ Kohm}$, $f = 1.0\text{ KHz}$, $BW = 200\text{ Hz}$)	N_F		2.0		dB
Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{ie}		1.3		Kohm
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{re}		$1.6 \cdot 10^{-4}$		
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{fe}		360		
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{oe}		55		μmho
Turn - On delay Time ($V_{BE(\text{off})} = 0.5\text{ V}$, $I_{B1} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 30\text{ mAdc}$ (see Figure 1))	t_d		19		ns
Rise Time ($V_{BE(\text{off})} = 0.5\text{ V}$, $I_{B1} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 30\text{ mAdc}$ (see Figure 1))	t_r		40		ns
Storage Time ($I_{B1} = I_{B2} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 30\text{ mAdc}$ (see Figure 1))	t_s		900		ns
Fall Time ($I_{B1} = I_{B2} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 30\text{ mAdc}$ (see Figure 1))	t_f		100		ns

FIGURE 1 - SWITCHING TIME TEST CIRCUITS



* Total Shunt Capacitance of Test Jig and Connectors

FIGURE 2 - SWITCHING TIMES



MAXIMUM RATINGS

Rating	Symbol	BCX26	BCX28	BCX30	Unit
Collector-Emitter Voltage	V _{CEO}	60	80	100	V _{dc}
Collector-Base Voltage	V _{CBO}	60	80	100	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	200			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8			mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	357	°C/W

BCX26 BCX28 BCX30

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPS8598 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage* (I _C = 1 mAdc, I _B = 0)	V _{(BR)CEO}	60 80 100			V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	60 80 100			V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0			V _{dc}
Collector Cutoff Current (V _{CB} = 40 Vdc - I _E = 0) BCX26 (V _{CB} = 60 Vdc - I _E = 0) BCX28 (V _{CB} = 80 Vdc - I _E = 0) BCX30	I _{CBO}			100 100 100	nAdc

ON CHARACTERISTICS*

DC Current Gain (I _C = 1 mAdc, V _{CE} = 5.0 Vdc) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc) (I _C = 100 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	50 70 50	150 160 120	400	
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 10 mAdc)	V _{CE(sat)}		0.125	0.25	V _{dc}
Base-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 10 mAdc)	V _{BE(sat)}		0.85		V _{dc}
Base-Emitter On Voltage (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	V _{BE(on)}		0.65	1.0	V _{dc}

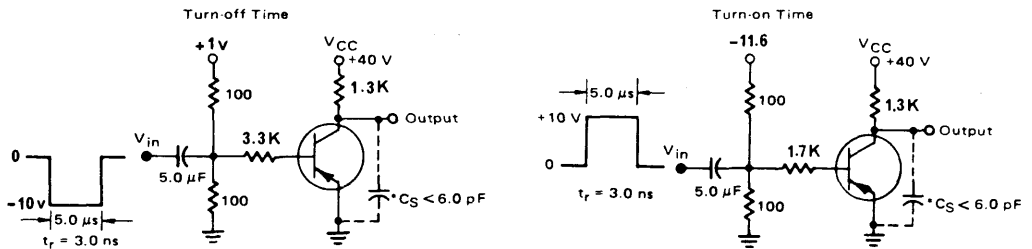
* Pulse test - Pulse width ≤ 300 μs - Duty cycle 2%

BCX26, BCX28, BCX30

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

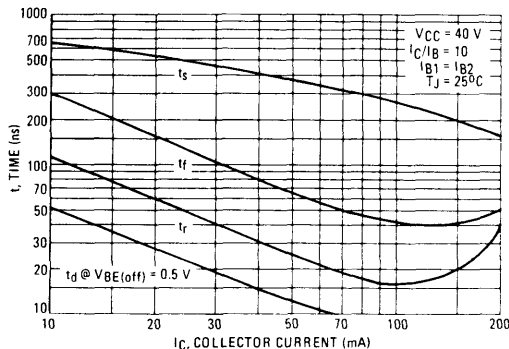
Characteristic	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS					
Current Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	100	220		MHz
Output Capacitance - Common Base ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}		3.0	6.0	pF
Input Capacitance - Common Base ($V_{CB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ib}		20	30	pF
Noise Figure ($I_C = 200\ \mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 2.0\text{ Kohm}$, $f = 1.0\text{ KHz}$, $BW = 200\text{ Hz}$)	NF		2.0		dB
Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{ie}		730		ohm
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{re}		$1.3 \cdot 10^{-4}$		
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{fe}		180		
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{oe}		140		μmho
Turn - On delay Time ($V_{BE}(\text{off}) = 0.5\text{ V}$, $I_{B1} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 30\text{ mAdc}$ (see Figure 1))	t_d		20		ns
Rise Time ($V_{BE}(\text{off}) = 0.5\text{ V}$, $I_{B1} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 30\text{ mAdc}$ (see Figure 1))	t_r		40		ns
Storage Time ($I_{B1} = I_{B2} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 30\text{ mAdc}$ (see Figure 1))	t_s		450		ns
Fall Time ($I_{B1} = I_{B2} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 30\text{ mAdc}$ (see Figure 1))	t_f		100		ns

FIGURE 1 - SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors

FIGURE 2 - SWITCHING TIMES



MAXIMUM RATINGS

Rating	Symbol	BCX45	BCX47	BCX49	Unit
Collector-Emitter Voltage	V _{CEO}	45	60	80	Vdc
Collector-Base Voltage	V _{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V _{EBO}	5.0			Vdc
Collector Current – Continuous	I _C	1.0			Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	PD	625 5.0			mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	PD	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**BCX45
BCX47
BCX49**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

HIGH CURRENT TRANSISTORS

NPN SILICON

Refer to MPSA05 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	45 60 80			Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	45 60 80			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0			Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc - I _E = 0) BCX45 (V _{CB} = 40 Vdc - I _E = 0) BCX47 (V _{CB} = 60 Vdc - I _E = 0) BCX49	I _{CBO}			100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain (I _C = 10 mAdc, V _{CE} = 2.0 Vdc) (I _C = 100 mAdc, V _{CE} = 2.0 Vdc) (I _C = 500 mAdc, V _{CE} = 2.0 Vdc) (I _C = 1 Adc, V _{CE} = 5.0 Vdc)	h _{FE}	40 50 30 15	130 140 60		
Collector-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc) (I _C = 1 Adc, I _B = 100 mAdc)	V _{CE(sat)}		0.2 0.3	0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc)	V _{BE(sat)}		0.85		Vdc
Base-Emitter On Voltage (I _C = 500 mAdc, V _{CE} = 2.0 Vdc)	V _{BE(on)}		0.85	1.2	Vdc

* Pulse test—Pulse width ≤ 300 μs – Duty cycle 2%

BCX45, BCX47, BCX49

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS					
Current Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	100	200		MHz
Output Capacitance - Common Base ($V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ MHz}$)	C_{ob}		7.0	12	pF
Input Capacitance - Common Base ($V_{CB} = 0.5\text{ Vdc}$, $f = 1.0\text{ MHz}$)	C_{ib}		50		pF
Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{ie}		530		ohms
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{re}		$1.1 \cdot 10^{-4}$		
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{fe}		120		
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{oe}		58		μmho
Turn - On delay Time ($V_{BE(\text{off})} = 0.5\text{ V}$, $I_{B1} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 250\text{ mAdc}$ (see Figure 1))	t_d		10		ns
Rise Time ($V_{BE(\text{off})} = 0.5\text{ V}$, $I_{B1} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 250\text{ mAdc}$ (see Figure 1))	t_r		20		ns
Storage Time ($I_{B1} = I_{B2} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 250\text{ mAdc}$ (see Figure 1))	t_s		330		ns
Fall Time ($I_{B1} = I_{B2} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 250\text{ mAdc}$ (see Figure 1))	t_f		50		ns

FIGURE 1 - SWITCHING TIME TEST CIRCUIT

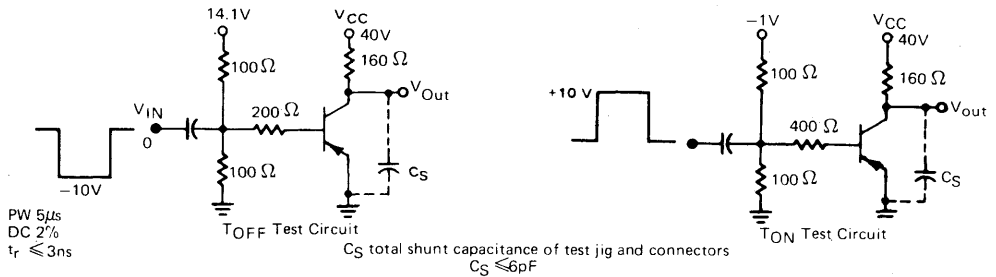
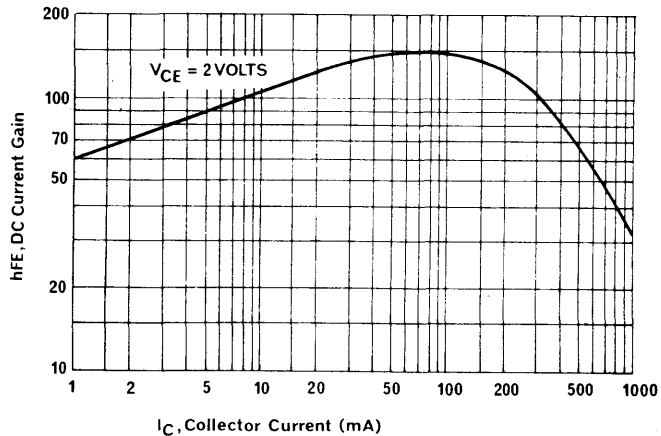


FIGURE 2 - DC CURRENT GAIN



MAXIMUM RATINGS

Rating	Symbol	BCX	BCX	BCX	Unit
		46	48	50	
Collector-Emitter Voltage	V _{CEO}	45	60	80	V _{dc}
Collector-Base Voltage	V _{CBO}	45	60	80	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	1.0			A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625			mW
		5.0			mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5			Watt
		12			mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**BCX46
BCX48
BCX50**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)
HIGH CURRENT TRANSISTORS
PNP SILICON**

Refer to MPSA55 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage* (I _C = 10 mA _{dc} , I _B = 0) BCX46 BCX48 BCX50	V _{(BR)CEO}	45 60 80			V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0) BCX46 BCX48 BCX50	V _{(BR)CBO}	45 60 80			V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0			V _{dc}
Collector Cutoff Current (V _{CB} = 30 V _{dc} - I _E = 0) BCX46 (V _{CB} = 40 V _{dc} - I _E = 0) BCX48 (V _{CB} = 60 V _{dc} - I _E = 0) BCX50	I _{CBO}			100 100 100	nA _{dc}

ON CHARACTERISTICS*

DC Current Gain (I _C = 10 mA _{dc} , V _{CE} = 2.0 V _{dc}) (I _C = 100 mA _{dc} , V _{CE} = 2.0 V _{dc}) (I _C = 500 mA _{dc} , V _{CE} = 2.0 V _{dc}) (I _C = 1 A _{dc} , V _{CE} = 5.0 V _{dc})	h _{FE}	40 50 30 15	130 140 60		
Collector-Emitter Saturation Voltage (I _C = 500 mA _{dc} , I _B = 50 mA _{dc}) (I _C = 1 A _{dc} , I _B = 100 mA _{dc})	V _{CE(sat)}		0.25 0.3	0.5	V _{dc}
Base-Emitter Saturation Voltage (I _C = 500 mA _{dc} , I _B = 50 mA _{dc})	V _{BE(sat)}		0.9		V _{dc}
Base-Emitter On Voltage (I _C = 500 mA _{dc} , V _{CE} = 2.0 V _{dc})	V _{BE(on)}		0.85	1.2	V _{dc}

* Pulse test - Pulse width ≤ 300 μs - Duty cycle 2%

BCX46, BCX48, BCX50

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS					
Current Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 50\text{ MHz}$)	f_T	60	130		MHz
Output Capacitance - Common Base ($V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ MHz}$)	C_{ob}		9.0	15	pF
Input Capacitance - Common Base ($V_{CB} = 0.5\text{ Vdc}$, $f = 1.0\text{ MHz}$)	C_{ib}		110		pF
Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{ie}		700		ohms
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{re}		$1.7 \cdot 10^{-4}$		
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{fe}		160		
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ KHz}$)	h_{oe}		110		μmho
Turn - On delay Time ($V_{BE(\text{off})} = 0.5\text{ V}$, $I_{B1} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 250\text{ mAdc}$ (see Figure 1))	t_d		12		ns
Rise Time ($V_{BE(\text{off})} = 0.5\text{ V}$, $I_{B1} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 250\text{ mAdc}$ (see Figure 1))	t_r		28		ns
Storage Time ($I_{B1} = I_{B2} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 250\text{ mAdc}$ (see Figure 1))	t_s		330		ns
Fall Time ($I_{B1} = I_{B2} = 3\text{ mA}$) ($V_{CC} = 40\text{ Vdc}$, $I_C = 250\text{ mAdc}$ (see Figure 1))	t_f		50		ns

FIGURE 1 - SWITCHING TIME TEST CIRCUITS

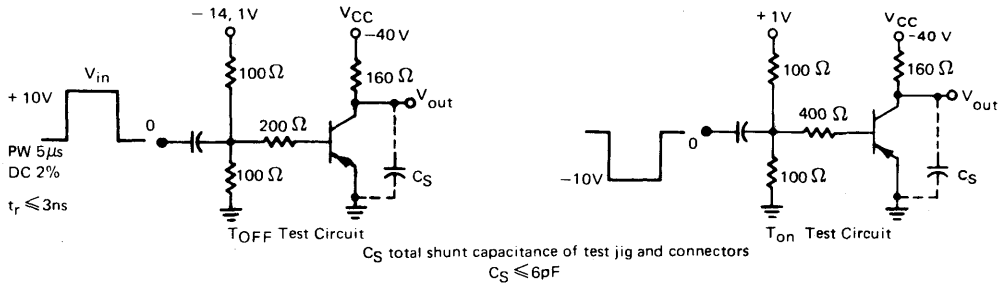
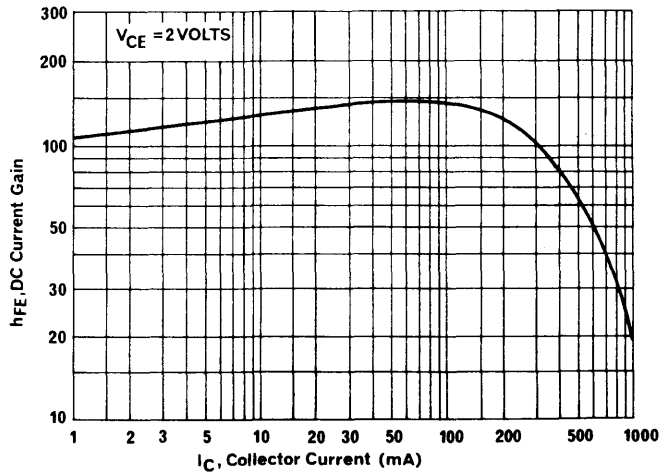


FIGURE 2 - DC CURRENT GAIN



MAXIMUM RATINGS

Rating	Symbol	BCX 58	BCX 59	Unit
Collector-Emitter Voltage	V _{CEO}	32	45	Vdc
Collector-Base Voltage	V _{CBO}	32	45	Vdc
Emitter-Base Voltage	V _{EBO}	7.0		Vdc
Collector Current - Continuous	I _C	100		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625	5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5	12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**BCX58
BCX59****CASE 29-02, STYLE 17
TO-92 (TO-226AA)****AMPLIFIER TRANSISTORS****NPN SILICON****ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	BCX58 BCX59	V _{(BR)CEO}	32 45			Vdc
Emitter-Base Breakdown Voltage (I _E = 1 μAdc, I _C = 0)	all	V _{(BR)EBO}	7	8.7		Vdc
Collector Cutoff Current (V _{CE} = 32 V (V _{CE} = 45 V) (V _{CE} = 32 V, T _A = 100°C, V _{BE} = 0.2 V) (V _{CE} = 45 V, T _A = 100°C, V _{BE} = 0.2 V) (V _{CE} = 32 V, T _A = 125°C) (V _{CE} = 45 V, T _A = 125°C)	BCX58 BCX59 BCX58 BCX59 BCX58 BCX59	I _{CES} I _{CES} I _{CES} I _{CES} I _{CES} I _{CES}			10 10 20 20 2.5 2.5	nAdc μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 Vdc)	BCX59-7, BCX58-7 BCX59-8, BCX58-8 BCX59-9, BCX58-9 BCX59-10, BCX58-10	h _{FE}	20 40 75 100	80 145 220 300		
(I _C = 2 mAdc, V _{CE} = 5 Vdc)	BCX59-7, BCX58-7 BCX59-8, BCX58-8 BCX59-9, BCX58-9 BCX59-10, BCX58-10		120 180 250 380	170 250 350 500	220 310 460 630	
(I _C = 10 mAdc, V _{CE} = 1 Vdc)	BCX59-7, BCX58-7 BCX59-8, BCX58-8 BCX59-9, BCX58-9 BCX59-10, BCX58-10		80 120 160 240	190 260 380 550	400 630 1000	
(I _C = 100 mAdc, V _{CE} = 2 Vdc)	BCX59-7, BCX58-7 BCX59-8, BCX58-8 BCX59-9, BCX58-9 BCX59-10, BCX58-10		40 45 60 60			
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 5 mAdc) (I _C = 10 mAdc, I _B = see note 1)		V _{CE(sat)}			0.5 0.6	Vdc
Base-Emitter Saturation Voltage (I _C = 100 mA, I _B = 5 mA)		V _{BE(sat)}			1.3	Vdc
Base-Emitter On Voltage (I _C = 2 mAdc, V _{CE} = 5 Vdc)		V _{BE(on)}	0.55	0.62	0.70	Vdc

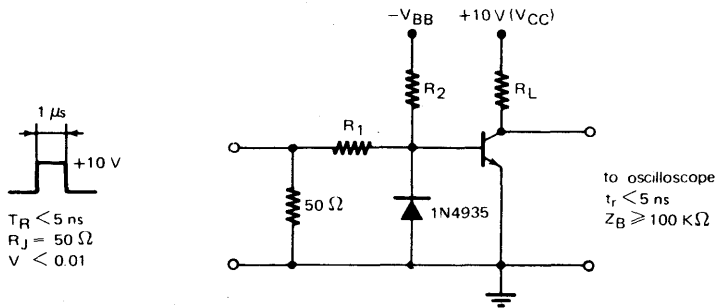
Note 1: I_C = 10 mA on the constant base current characteristic which yield the point I_C = 11 mA, V_{CE} = 5 V

BCX58, BCX59

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Current Gain-Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 5\text{ V}$, $f = 100\text{ MHz}$)		f_T	200	350		MHz
Output Capacitance ($V_{CE} = 10\text{ Vdc}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{ob}		1.8	4	pF
Input Capacitance ($V_{BE} = 0.5\text{ V}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{ib}		5.2	9	pF
Small Signal Current Gain ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BCX58-7, BCX59-7 BCX58-8, BCX59-8 BCX58-9, BCX59-9 BCX58-10, BCX59-10	h_{fe}	125 175 250 350		250 350 500 700	
Output Admittance ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BCX58-7, BCX59-7 BCX58-8, BCX59-8 BCX58-9, BCX59-9 BCX58-10, BCX59-10	h_{oe}			30 50 60 100	μmhos
Input Impedance ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BCX58-7, BCX59-7 BCX58-8, BCX59-8 BCX58-9, BCX59-9 BCX58-10, BCX59-10	h_{ie}	1.6 2.5 3.2	2.7 3.6 7.5	4.5 6 8.5	Kohms
Voltage Feedback Ratio ($I_C = 2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ KHz}$)	BCX58-7, BCX59-7 BCX58-8, BCX59-8 BCX58-9, BCX59-9 BCX58-10, BCX59-10	h_{re}		1.5 2 2 3		$\times 10^4$
Noise Figure ($I_C = 0.2\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $R_S = 2\text{ KOhms}$, $f = 1\text{ KHz}$)		NF		1	4	dB
($I_C = 10\text{ mA}$, $I_{B1} = 1\text{ mA}$, $I_{B2} = 1\text{ mA}$) ($V_{BB} = 3.6\text{ V}$, $R_1 = R_2 = 5\text{ k}\Omega$) ($R_L = 999\text{ ohms}$) * See test circuit		T_d T_r T_{on} T_s T_f T_{off}		16 29 45 475 40 515	100 750	nS
($I_C = 100\text{ mA}$, $I_{B1} = 10\text{ mA}$, $I_{B2} = 10\text{ mA}$) ($V_{BB} = 5\text{ V}$, $R_1 = 500\ \Omega$, $R_2 = 700\ \Omega$) ($R_L = 98\text{ ohms}$) * See test circuit		t_d t_r t_{on} t_s t_f t_{off}		5 40 45 135 80 215	100 650	ns

TEST CIRCUIT



BCX58, BCX59

FIGURE 1 – NORMALIZED DC CURRENT GAIN

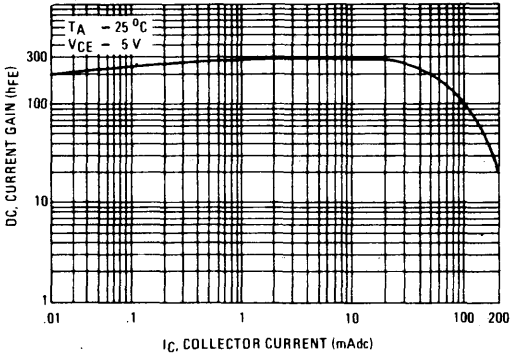


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

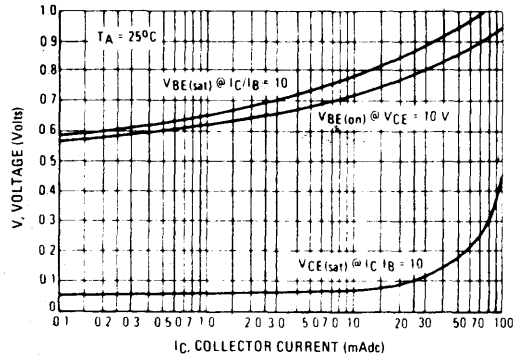


FIGURE 3 – COLLECTOR SATURATION REGION

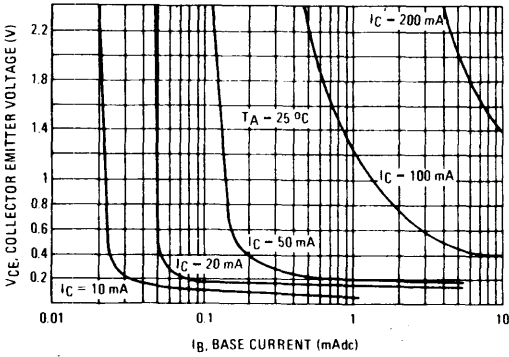


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT

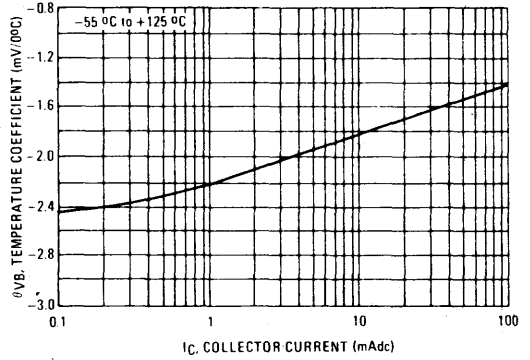


FIGURE 5 – CAPACITANCES

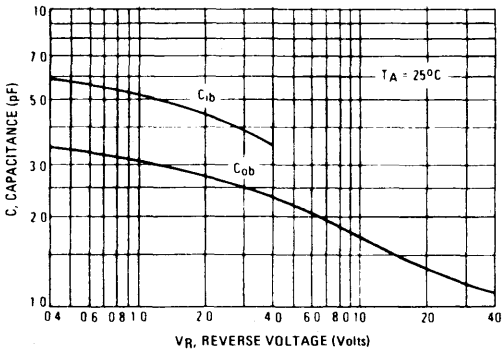
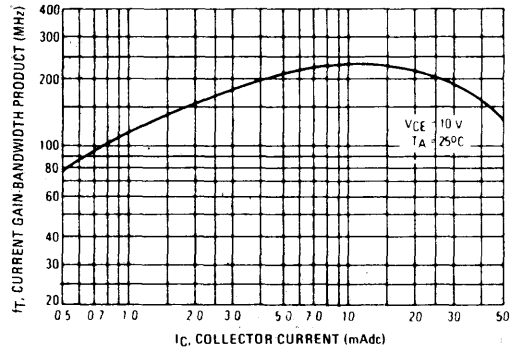


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT



BCX78 BCX79

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BCX 78	BCX 79	Unit
Collector-Emitter Voltage	V_{CE0}	32	45	Vdc
Collector-Base Voltage	V_{CB0}	32	45	Vdc
Emitter-Base Voltage	V_{EB0}	5.0		Vdc
Collector Current - Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	PD	625	5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	PD	1.5	12	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}, I_B = 0$)	BCX78 BCX79	$V_{(BR)CEO}$	32 45			Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ }\mu\text{Adc}, I_C = 0$)	all	$V_{(BR)EBO}$	5	6.8		Vdc
Collector Cutoff Current ($V_{CE} = 32 \text{ V}$ ($V_{CE} = 45 \text{ V}$) ($V_{CE} = 32 \text{ V}, T_A = 100^\circ\text{C}, V_{BE} = 0.2 \text{ V}$) ($V_{CE} = 45 \text{ V}, T_A = 100^\circ\text{C}, V_{BE} = 0.2 \text{ V}$) ($V_{CE} = 32 \text{ V}, T_A = 125^\circ\text{C}$) ($V_{CE} = 45 \text{ V}, T_A = 125^\circ\text{C}$)	BCX78 BCX79 BCX78 BCX79 BCX78 BCX79	I_{CES} I_{CES} I_{CEX} I_{CEX} I_{CES} I_{CES}			10 10 20 20 2.5 2.5	nAdc μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \text{ }\mu\text{Adc}, V_{CE} = 5 \text{ Vdc}$)	BCX79-7, BCX78-7 BCX79-8, BCX78-8 BCX79-9, BCX78-9 BCX79-10, BCX78-10	h_{FE}	20 40 75 100	140 200 270 340		
($I_C = 2 \text{ mAdc}, V_{CE} = 5 \text{ Vdc}$)	BCX79-7, BCX78-7 BCX79-8, BCX78-8 BCX79-9, BCX78-9 BCX79-10, BCX78-10		120 180 250 380	170 250 350 500	220 310 460 630	
($I_C = 10 \text{ mAdc}, V_{CE} = 1 \text{ Vdc}$)	BCX79-7, BCX78-7 BCX79-8, BCX78-8 BCX79-9, BCX78-9 BCX79-10, BCX78-10		80 120 160 240	180 260 360 500	400 630 1000	
($I_C = 100 \text{ mAdc}, V_{CE} = 2 \text{ Vdc}$)	BCX79-7, BCX78-7 BCX79-8, BCX78-8 BCX79-9, BCX78-9 BCX79-10, BCX78-10		40 45 60 60			
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 5 \text{ mAdc}$) ($I_C = 10 \text{ mAdc}, I_B = \text{see note 1}$)		$V_{CE(sat)}$			0.5 0.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 100 \text{ mA}, I_B = 5 \text{ mA}$)		$V_{BE(sat)}$			1.1	Vdc
Base-Emitter On Voltage ($I_C = 2 \text{ mAdc}, V_{CE} = 5 \text{ Vdc}$)		$V_{BE(on)}$	0.55	0.62	0.70	Vdc

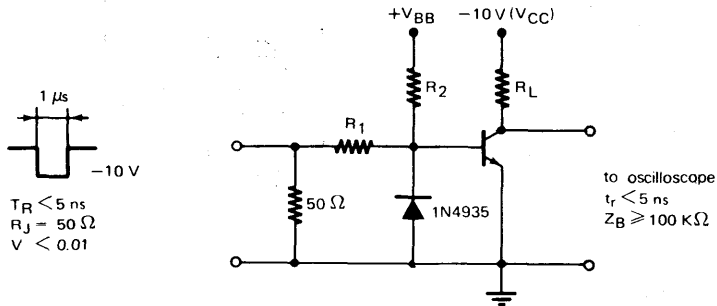
Note 1: $I_C = 10 \text{ mA}$ on the constant base current characteristic which yield the point $I_C = 11 \text{ mA}, V_{CE} = 5 \text{ V}$

BCX78, BCX79

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Current Gain-Bandwidth Product ($I_C = 10\text{ mA}, V_{CE} = 5\text{ V}, f = 100\text{ MHz}$)		f_T	250	400		MHz
Output Capacitance ($V_{CE} = 10\text{ Vdc}, I_C = 0, f = 1\text{ MHz}$)		C_{ob}		2.6	4.5	pF
Input Capacitance ($V_{BE} = 0.5\text{ V}, I_C = 0, f = 1\text{ MHz}$)		C_{ib}		8.5	11	pF
Small Signal Current Gain ($I_C = 2\text{ mA}, V_{CE} = 5\text{ Vdc}, f = 1\text{ KHz}$)	BCX78-7, BCX79-7 BCX78-8, BCX79-8 BCX78-9, BCX79-9 BCX78-10, BCX79-10	h_{fe}	125 175 250 350	200 260 330 520	250 350 500 700	
Output Admittance ($I_C = 2\text{ mA}, V_{CE} = 5\text{ Vdc}, f = 1\text{ KHz}$)	BCX78-7, BCX79-7 BCX78-8, BCX79-8 BCX78-9, BCX79-9 BCX78-10, BCX79-10	h_{oe}			30 50 60 100	μmhos
Input Impedance ($I_C = 2\text{ mA}, V_{CE} = 5\text{ Vdc}, f = 1\text{ KHz}$)	BCX78-7, BCX79-7 BCX78-8, BCX79-8 BCX78-9, BCX79-9 BCX78-10, BCX79-10	h_{ie}	1.6 2.5 3.2	2.7 3.6 4.5 7.5	4.5 6 8.5	Kohms
Voltage Feedback Ratio ($I_C = 2\text{ mA}, V_{CE} = 5\text{ Vdc}, f = 1\text{ KHz}$)	BCX78-7, BCX79-7 BCX78-8, BCX79-8 BCX78-9, BCX79-9 BCX78-10, BCX79-10	h_{re}		1.5 2 2 3		$\times 10^4$
Noise Figure ($I_C = 0.2\text{ mA}, V_{CE} = 5\text{ Vdc}, R_g = 2\text{ KOhms}, f = 1\text{ KHz}$)		NF		1	3	dB
($I_C = 10\text{ mA}, I_{B1} = 1\text{ mA}, I_{B2} = 1\text{ mA}$) ($V_{BB} = 3.6\text{ V}, R_1 = R_2 = 5\text{ k}\Omega$) ($R_L = 999\text{ ohms}$) * See test circuit		T_d T_r T_{on} T_s T_f T_{off}		17 27 44 400 60 460	100	nS
($I_C = 100\text{ mA}, I_{B1} = 10\text{ mA}, I_{B2} = 10\text{ mA}$) ($V_{BB} = 5\text{ V}, R_1 = 500\ \Omega, R_2 = 700\ \Omega$) ($R_L = 98\text{ ohms}$) * See test circuit		t_d t_r t_{on} t_s t_f t_{off}		5 20 25 130 40 170	100	ns

TEST CIRCUIT



BCX78, BCX79

FIGURE 1 - NORMALIZED DC CURRENT GAIN

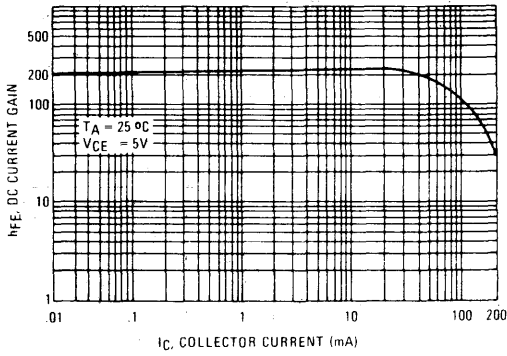


FIGURE 2 - "SATURATION" AND "ON" VOLTAGES

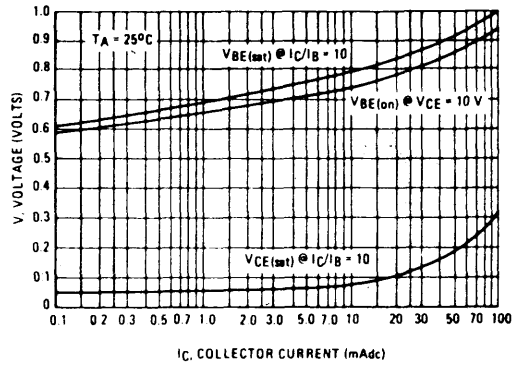


FIGURE 3 - COLLECTOR SATURATION REGION

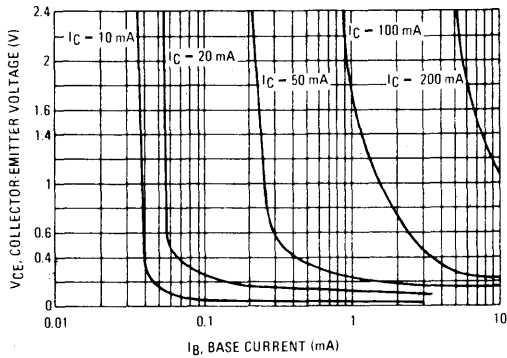


FIGURE 4 - BASE-EMITTER TEMPERATURE COEFFICIENT

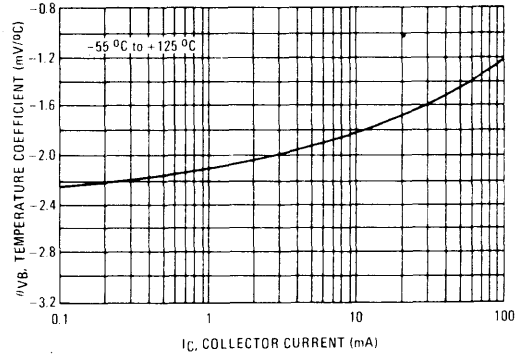


FIGURE 5 - CAPACITANCES

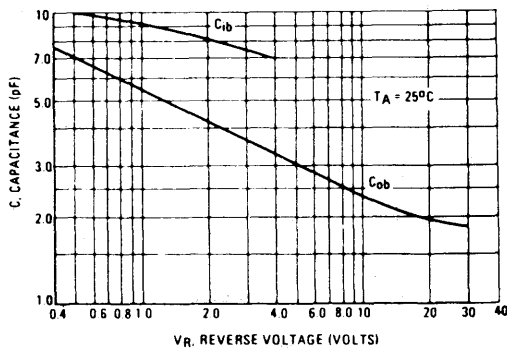
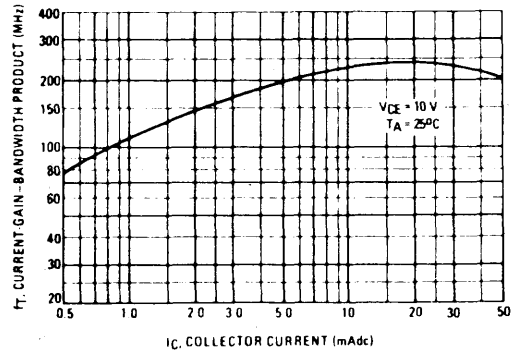


FIGURE 6 - CURRENT GAIN-BANDWIDTH PRODUCT



BDB01A Thru BDB01D

**CASE 29-03, STYLE 1
TO-92 (TO-226AE)**

**ONE WATT
AMPLIFIER TRANSISTORS**

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BDB 01A	BDB 01B	BDB 01C	BDB 01D	Unit
Collector-Emitter Voltage	V _{CEO}	45	60	80	100	V _{dc}
Collector-Base Voltage	V _{CES}	45	60	80	100	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0				V _{dc}
Collector Current - Continuous	I _C	0.5				A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0				Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20				Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	1-25	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage (I _C = 10 mA, I _B = 0) BDB01A BDB01B BDB01C BDB01D	V _{(BR)CEO}	45 60 80 100		V _{dc}
Collector Cutoff Current (V _{CB} = 45 V, I _E = 0) (V _{CB} = 60 V, I _E = 0) (V _{CB} = 80 V, I _E = 0) (V _{CB} = 100 V, I _E = 0)	I _{CBO}		0.1 0.1 0.1 0.1	μA _{dc}
Emitter Cutoff Current (I _C = 0, V _{EB} = 5.0 V)	I _{EBO}		100	nA _{dc}
ON CHARACTERISTICS				
DC Current Gain (I _C = 100 mA, V _{CE} = 1 V) (I _C = 500 mA, V _{CE} = 2 V)	h _{FE}	40 25	400	
Collector-Emitter Saturation Voltage (I _C = 1000 mA, I _B = 100 mA)	V _{CE(sat)}		0.7	V _{dc}
Collector-Emitter on Voltage (I _C = 1000 mA, V _{CE} = 1 V)	V _{BE(on)}		1.2	V _{dc}
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product (I _C = 200 mA, V _{CE} = 5 V, f = 100 MHz)	f _T	50		MHz
Output Capacitance (V _{CB} = 10 V, I _E = 0, f = 1 MHz)	C _{ob}		30	pF

BDB01A Thru BDB01D

FIGURE 1 - D.C. CURRENT GAIN

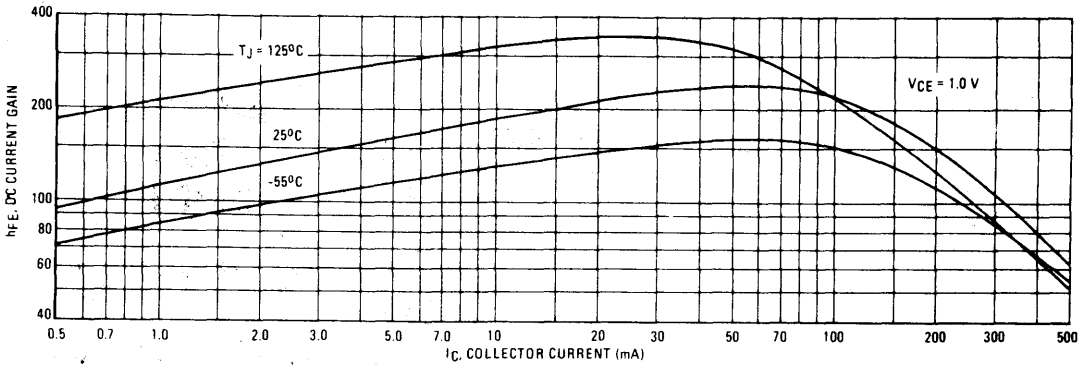


FIGURE 2 - COLLECTOR SATURATION REGION

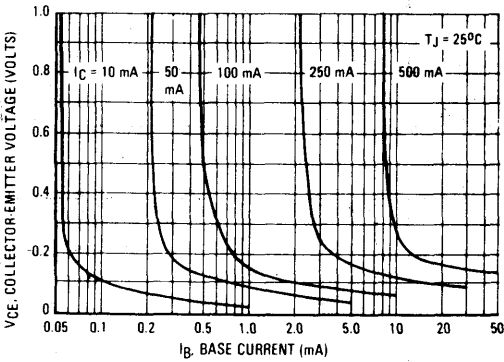


FIGURE 4 - BASE-EMITTER TEMPERATURE COEFFICIENT

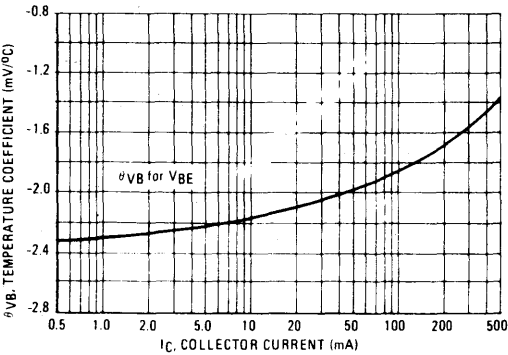


FIGURE 6 - CURRENT GAIN-BANDWIDTH PRODUCT

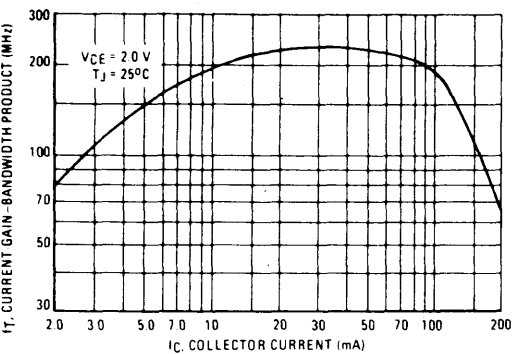


FIGURE 3 - ON VOLTAGES

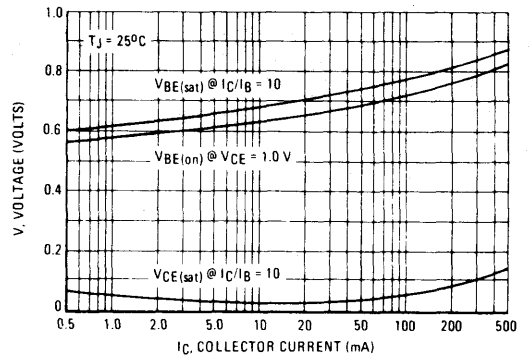


FIGURE 5 - CAPACITANCE

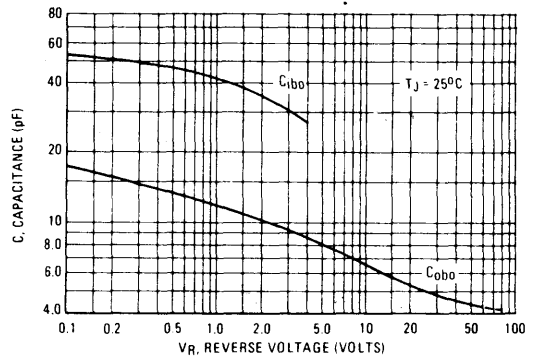
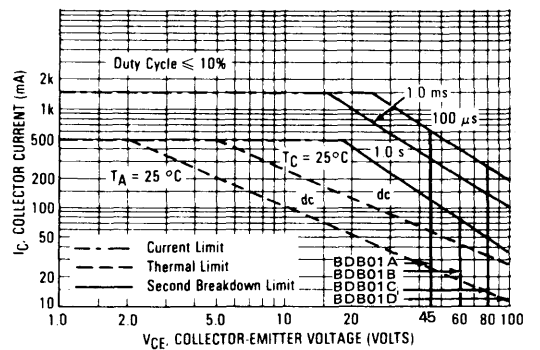


FIGURE 7 - ACTIVE REGION-SAFE OPERATING AREA



MAXIMUM RATINGS

Rating	Symbol	BDB	BDB	BDB	BDB	Unit
		02A	02B	02C	02D	
Collector-Emitter Voltage	V _{CE0}	45	60	80	100	V _{dc}
Collector-Base Voltage	V _{CS}	45	60	80	100	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0				V _{dc}
Collector Current - Continuous	I _C	0.5				Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0				Watt mW/°C
		8.0				
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5				Watt mW/°C
		20				
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

**BDB02A
Thru
BDB02D**

**CASE 29-03, STYLE 1
TO-92 (TO-226AE)**

**ONE WATT
AMPLIFIER TRANSISTORS**

PNP SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Voltage (I _C = 10 mA, I _B = 0) BDB02A BDB02B BDB02C BDB02D	V _{(BR)CEO}	45 60 80 100		V _{dc}
Collector Cutoff Current (V _{CB} = 45 V, I _E = 0) (V _{CB} = 60 V, I _E = 0) (V _{CB} = 80 V, I _E = 0) (V _{CB} = 100 V, I _E = 0)	I _{CBO}		0.1 0.1 0.1 0.1	μAdc
Emitter Cutoff Current (I _C = 0, V _{EB} = 5.0 V)	I _{EBO}		100	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 100 mA, V _{CE} = 1 V) (I _C = 500 mA, V _{CE} = 2 V)	h _{FE}	40 25	400	
Collector-Emitter Saturation Voltage (I _C = 1000 mA, I _B = 100 mA)	V _{CE(sat)}		0.7	V _{dc}
Collector-Emitter on Voltage (I _C = 1000 mA, V _{CE} = 1 V)	V _{BE(on)}		1.2	V _{dc}

DYNAMIC CHARACTERISTICS

Current Gain Bandwidth Product (I _C = 200 mA, V _{CE} = 5 V, f = 100 MHz)	f _T	50		MHz
Output Capacitance (V _{CB} = 10 V, I _E = 0, f = 1 MHz)	C _{ob}		30	pF

BDB02A Thru BDB02D

FIGURE 1 – D.C. CURRENT GAIN

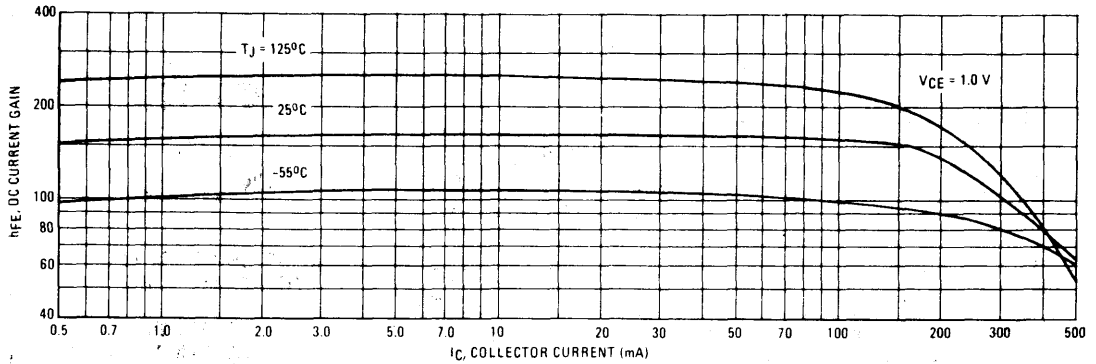


FIGURE 2 – COLLECTOR SATURATION REGION

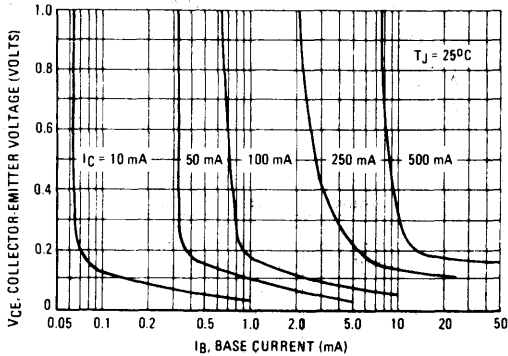


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT

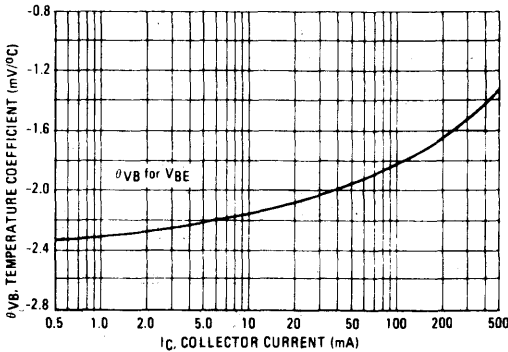


FIGURE 6 – CURRENT GAIN-BANDWIDTH PRODUCT

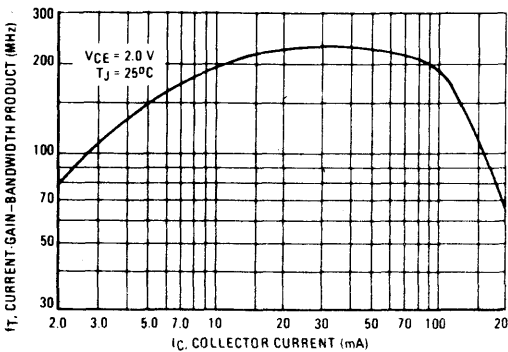


FIGURE 3 – ON VOLTAGES

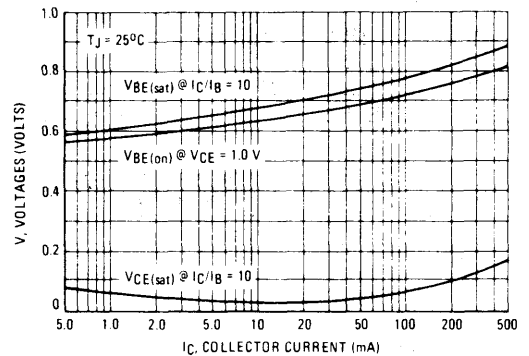


FIGURE 5 – CAPACITANCE

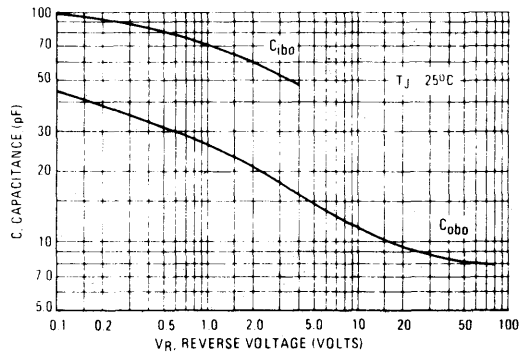
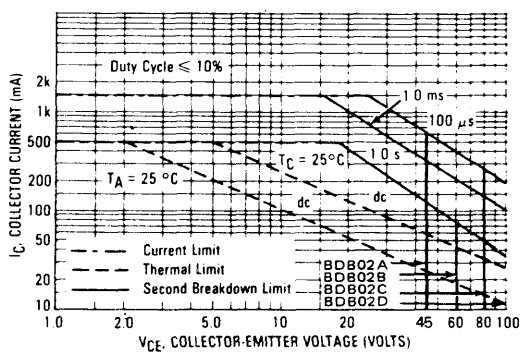


FIGURE 7 – ACTIVE REGION-SAFE OPERATING AREA



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	45	V _{dc}
Collector-Base Voltage	V _{CBO}	60	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	V _{dc}
Collector Current - Continuous	I _C	1.0	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

BDB03**CASE 29-03, STYLE 1
TO-92 (TO-226AE)****ONE WATT
AMPLIFIER TRANSISTORS****NPN SILICON**

Refer to BDB01A for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)	V _{(BR)CES}	45	—	—	V _{dc}
Collector Cutoff Current (V _{CB} = 45 V, I _E = 0)	I _{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current (V _{EB} = 4 V, I _C = 0)	I _{EBO}	—	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 150 mA, V _{CE} = 10 V) (I _C = 1 A, V _{CE} = 10 V)	h _{FE}	100 15	— —	300 —	—
Collector-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA)	V _{CE(sat)}	—	—	1.1	V _{dc}
Base-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA)	V _{BE(sat)}	—	—	1.1	V _{dc}
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain Bandwidth Product (I _C = 50 mA, V _{CE} = 10 V, f = 100 MHz)	f _T	150	—	—	MHz
Collector-Base Capacitance (V _{CB} = 10 V, f = 1 MHz)	C _{cb}	—	—	15	pF

BDB04

**CASE 29-03, STYLE 1
TO-92 (TO-226AE)**

**ONE WATT
AMPLIFIER TRANSISTORS**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	45	V _{dc}
Collector-Base Voltage	V _{CBO}	60	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	V _{dc}
Collector Current – Continuous	I _C	1.0	A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

Refer to BDB02A for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mA _{dc} , I _B = 0)	V _{(BR)CES}	45	—	—	V _{dc}
Collector Cutoff Current (V _{CB} = 45 V, I _E = 0)	I _{CBO}	—	—	0.1	μA _{dc}
Emitter Cutoff Current (V _{EB} = 4 V, I _C = 0)	I _{EBO}	—	—	0.1	μA _{dc}
ON CHARACTERISTICS					
DC Current Gain (I _C = 150 mA, V _{CE} = 10 V) (I _C = 1 A, V _{CE} = 10 V)	h _{FE}	100 15	— —	300 —	—
Collector-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA)	V _{CE(sat)}	—	—	1.1	V _{dc}
Base-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA)	V _{BE(sat)}	—	—	1.1	V _{dc}
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain Bandwidth Product (I _C = 50 mA, V _{CE} = 10 V, f = 100 MHz)	f _T	150	—	—	MHz
Collector-Base Capacitance (V _{CB} = 10 V, f = 1 MHz)	C _{cb}	—	—	15	pF

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	80	Vdc
Collector-Base Voltage	V _{CB0}	120	Vdc
Emitter-Base Voltage	V _{EBO}	7.0	Vdc
Collector Current – Continuous	I _C	1.0	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

BDB05

**CASE 29-03, STYLE 1
TO-92 (TO-226AE)**

**ONE WATT
HIGH VOLTAGE TRANSISTOR**

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 30 mA, I _B = 0)	V _{(BR)CEO}	80		Vdc
Collector-Base Breakdown Voltage	V _{(BR)CBO}	120		Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	7.0		Vdc
Collector Cutoff Current (V _{CB} = 90 Vdc, I _E = 0) (V _{CB} = 90 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}		10 10	nA μA
Emitter Cutoff Current (V _{BE} = 5 Vdc, I _C = 0)	I _{EBO}		10	nA
ON CHARACTERISTICS				
DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 150 mAdc, V _{CE} = 10 Vdc) (I _C = 500 mAdc, V _{CE} = 10 Vdc) (1) (I _C = 1 mAdc, V _{CE} = 10 Vdc) (1)	HFE	50 90 100 50 15	300	
Collector Emitter Saturation Voltage (1) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}		0.2 0.5	Vdc
Base Emitter Saturation Voltage (1) (I _C = 150 mAdc, I _B = 15 mAdc)	V _{BE(sat)}		1.1	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain-Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	100		MHz
Output Capacitance (V _{CB} = 10 Vdc, I _C = 0, f = 1 MHz)	C _{ob}		12	pF
Input Capacitance (V _{BF} = 0.5 Vdc, I _C = 0, f = 1 MHz)	C _{ib}		60	pF
Small Signal Current Gain (I _C = 1 mAdc, V _{CE} = 5 Vdc, f = 1 KHz)	h _{fe}	80		400

(1) Pulse Test: Pulse width < 300 μs — duty cycle ≤ 2%.

BDB06

**CASE 29-03, STYLE 1
TO-92 (TO-226AE)**

**ONE WATT
AMPLIFIER TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	80	Vdc
Collector-Base Voltage	V _{CBO}	80	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current - Continuous	I _C	1.0	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)	V _{(BR)CEO}	80		V
Collector-Base Breakdown Voltage (I _C = 10 μA, I _E = 0)	V _{(BR)CBO}	80		V
Emitter-Base Breakdown Voltage (I _E = 10 μA, I _C = 0)	V _{(BR)EBO}	5		V
Emitter Cutoff Current (V _{BE} = 5 Vdc, I _C = 0)	I _{EBO}		10	μA
Collector Cutoff Current (V _{CB} = 50 V, I _E = 0) (V _{CB} = 50 V, I _E = 0, T _A = 150°C)	I _{CBO}		50 50	nA μA

ON CHARACTERISTICS

DC Current Gain (I _C = 0.1 mA, V _{CE} = 5 V) (I _C = 100 mA, V _{CE} = 5 Vdc) (I _C = 500 mA, V _{CE} = 5 Vdc) (1) (I _C = 1 A, V _{CE} = 5 Vdc) (1)	H _{FE}	75 100 70 25	300	
Collector-Emitter Saturation Voltage (1) (I _C = 150 mA, I _B = 15 mA) (I _C = 500 mA, I _B = 50 mA)	V _{CE(sat)}		0.15 0.5	Vdc
Base-Emitter Saturation Voltage (1) (I _C = 150 mA, I _B = 15 mA)	V _{BE(sat)}		0.9	V
Base-Emitter On Voltage (I _C = 500 mA, V _{CE} = 0.5 V)	V _{BE(on)}		1.1	V

DYNAMIC CHARACTERISTICS

Current Gain-Bandwidth Product (I _C = 50 mA, V _{CE} = 10 Vdc)	f _T	150		MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1 MHz)	C _{ob}		20	pF
Input Capacitance (V _{BE} = 2.0 Vdc, I _C = 0, f = 1 MHz)	C _{ib}		110	pF
Turn on Time (V _{CC} = 30 V, I _C = 500 mA) I _B = 50 mA)	T _{on}		100	ns
Turn off Time	T _{off}		400	

(1) Pulse Test: Pulse width < 300 μs — Duty Cycle < 2%.

BDC01A Thru BDC01D

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTORS

NPN SILICON

Refer to BDB01A for graphs.

MAXIMUM RATINGS

Rating	Symbol	BDC 01A	BDC 01B	BDC 01C	BDC 01D	Unit
Collector-Emitter Voltage	V _{CEO}	45	60	80	100	V _{dc}
Collector-Base Voltage	V _{CBO}	45	60	80	100	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0				V _{dc}
Collector Current - Continuous	I _C	1.5				A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0			8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5			20	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Voltage (I _C = 10 mA, I _B = 0) BDC01A BDC01B BDC01C BDC01D	V _{(BR)CEO}	45 60 80 100		V _{dc}
Collector Cutoff Current (V _{CB} = 45 V, I _E = 0) (V _{CB} = 60 V, I _E = 0) (V _{CB} = 80 V, I _E = 0) (V _{CB} = 100 V, I _E = 0)	I _{CBO}		0.1 0.1 0.1 0.1	μA _{dc}
Emitter Cutoff Current (I _C = 0, V _{EB} = 5.0 V)	I _{EBO}		100	nA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 100 mA, V _{CE} = 1 V) (I _C = 500 mA, V _{CE} = 2 V)	h _{FE}	40 25	400	
Collector-Emitter Saturation Voltage (I _C = 1000 mA, I _B = 100 mA)	V _{CE(sat)}		0.7	V _{dc}
Collector-Emitter on-Voltage (I _C = 1000 mA, V _{CE} = 1 V)	V _{BE(on)}		1.2	V _{dc}

DYNAMIC CHARACTERISTICS

Current Gain Bandwidth Product (I _C = 200 mA, V _{CE} = 5 V, f = 100 MHz)	f _T	50		MHz
Output Capacitance (V _{CB} = 10 V, I _E = 0, f = 1 MHz)	C _{ob}		30	pF

BDC02A Thru BDC02D

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTORS

Refer to BDB02A for graphs.

MAXIMUM RATINGS

Rating	Symbol	BDC 02A	BDC 02B	BDC 02C	BDC 02D	Unit
Collector-Emitter Voltage	V_{CE0}	45	60	80	100	Vdc
Collector-Base Voltage	V_{CB0}	45	60	80	100	Vdc
Emitter-Base Voltage	V_{EB0}	5.0				Vdc
Collector Current - Continuous	I_C	1.5				Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0			8.0	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5			20	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150				$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage ($I_C = 10\text{ mA}, I_B = 0$) BDC02A BDC02B BDC02C BDC02D	$V_{(BR)CE0}$	45 60 80 100		Vdc
Collector Cutoff Current ($V_{CB} = 45\text{ V}, I_E = 0$) ($V_{CB} = 60\text{ V}, I_E = 0$) ($V_{CB} = 80\text{ V}, I_E = 0$) ($V_{CB} = 100\text{ V}, I_E = 0$)	I_{CBO}		0.1 0.1 0.1 0.1	μAdc
Emitter Cutoff Current ($I_C = 0, V_{EB} = 5.0\text{ V}$)	I_{EBO}		100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 100\text{ mA}, V_{CE} = 1\text{ V}$) ($I_C = 500\text{ mA}, V_{CE} = 2\text{ V}$)	h_{FE}	40 25	400	
Collector-Emitter Saturation Voltage ($I_C = 1000\text{ mA}, I_B = 100\text{ mA}$)	$V_{CE(sat)}$		0.7	Vdc
Collector-Emitter on Voltage ($I_C = 1000\text{ mA}, V_{CE} = 1\text{ V}$)	$V_{BE(on)}$		1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product ($I_C = 200\text{ mA}, V_{CE} = 5\text{ V}, f = 100\text{ MHz}$)	f_T	50		MHz
Output Capacitance ($V_{CB} = 10\text{ V}, I_E = 0, f = 1\text{ MHz}$)	C_{ob}		30	pF

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	V _{dc}
Collector-Base Voltage	V _{CBO}	25	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	V _{dc}
Collector Current - Continuous	I _C	1.0	A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	125	°C/W

BDC03

**CASE 29-03, STYLE 14
TO-92 (TO-226AE)**

**ONE WATT
AMPLIFIER TRANSISTOR**

NPN SILICON

Refer to MPSW01 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I _C = 10 mA _{dc} , I _B = 0)	V _{(BR)CEO}	20	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBO}	25	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 25 V _{dc} , I _E = 0)	I _{CBO}	—	0.1	μA _{dc}
Emitter Cutoff Current (V _{EB} = 5.0 V _{dc} , I _C = 0)	I _{EBO}	—	0.1	μA _{dc}
ON CHARACTERISTICS (1)				
DC Current Gain (I _C = 500 mA _{dc} , V _{CE} = 1 V _{dc}) (I _C = 5 mA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 1000 mA _{dc} , V _{CE} = 1 V _{dc})	h _{FE}	87 50 60	375 — —	—
Collector-Emitter Saturation Voltage (I _C = 1000 mA _{dc} , I _B = 100 mA _{dc})	V _{CE(sat)}	—	0.5	V _{dc}
Base-Emitter On Voltage (I _C = 1000 mA _{dc} , V _{CE} = 1.0 V _{dc})	V _{BE(on)}	—	1.2	V _{dc}
DYNAMIC CHARACTERISTICS				
Current Gain-Bandwidth Product (I _C = 50 mA _{dc} , V _{CE} = 10 V _{dc} , f = 20 MHz)	f _T	50	—	MHz
Output Capacitance (V _{CB} = 10 V _{dc} , I _E = 0, f = 1.0 MHz)	C _{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BDC04

**CASE 29-03, STYLE 14
TO-92 (TO-226AE)**

**ONE WATT
AMPLIFIER TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	V _{dc}
Collector-Base Voltage	V _{CBO}	25	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	V _{dc}
Collector Current - Continuous	I _C	1.0	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

Refer to MPSW51 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	20	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	25	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 25 Vdc, I _E = 0)	I _{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V _{EB} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	0.1	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I _C = 500 mAdc, V _{CE} = 1 Vdc) (I _C = 5 mAdc, V _{CE} = 10 Vdc) (I _C = 1000 mAdc, V _{CE} = 1 Vdc)	h _{FE}	85 50 60	375 — —	—
Collector-Emitter Saturation Voltage (I _C = 1000 mAdc, I _B = 100 mAdc)	V _{CE(sat)}	—	0.7	V _{dc}
Base-Emitter On Voltage (I _C = 1000 mAdc, V _{CE} = 1.0 Vdc)	V _{BE(on)}	—	1.2	V _{dc}
DYNAMIC CHARACTERISTICS				
Current Gain-Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	50	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	BDC 05	BDC 07	Unit
Collector-Emitter Voltage	V _{CEO}	300	250	Vdc
Collector-Base Voltage	V _{CBO}	300	250	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current – Continuous	I _C	500		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1 8.0		Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 50		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	–55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

BDC05 BDC07

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSW42 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I _C = 1 mAdc, I _B = 0)	V _{(BR)CEO}	300 250	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	300 250	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0 5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 200 Vdc, I _E = 0)	I _{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 25 mAdc, V _{CE} = 20 Vdc)	h _{FE}	40 50	—	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{CE(sat)}		2	Vdc
Base-Emitter Saturation Voltage (I _C = 20 mA, I _B = 2.0 mA)	V _{BE(sat)}		2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain–Bandwidth Product (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 50 MHz)	f _T	60	—	MHz
Collector-Base Capacitance (V _{CB} = 30 Vdc, I _E = 0, f = 1.0 MHz)	C _{re}		2.8	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BDC06 BDC08

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BDC 06	BDC 08	Unit
Collector-Emitter Voltage	V_{CE0}	300	250	Vdc
Collector-Base Voltage	V_{CB0}	300	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current - Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1	8.0	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5	20	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

Refer to MPSW92 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 1 \text{ mAdc}, I_B = 0$)	BDC06 BDC08 $V_{(BR)CEO}$	300 250	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	BDC06 BDC08 $V_{(BR)CBO}$	300 250	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	BDC06 BDC08 $V_{(BR)EBO}$	5.0 5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200 \text{ Vdc}, I_E = 0$)	BDC06 BDC08 I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)	BDC06 BDC08 I_{EBO}	—	10	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 25 \text{ mA}, V_{CE} = 20 \text{ Vdc}$)	BDC06 BDC08 h_{FE}	40 50	— —	—
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)	$V_{CE(sat)}$		2	Vdc
Base-Emitter Saturation Voltage ($I_C = 20 \text{ mA}, I_B = 2.0 \text{ mA}$)	$V_{BE(sat)}$		2.0	Vdc

DYNAMIC CHARACTERISTICS

Current Gain-Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 50 \text{ MHz}$)	f_T	60	—	MHz
Collector-Base Capacitance ($V_{CB} = 30 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{re}		2.8	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	25	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	Vdc
Collector Current - Continuous	I _C	100	mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	357	°C/W

BF199

**CASE 29-02, STYLE 21
TO-92 (TO-226AA)**

RF TRANSISTOR

NPN SILICON

Refer to BF240 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 2 mA _{dc} , I _B = 0)	V _{(BR)CEO}	25			Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBO}	40			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	4			Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0)	I _{CBO}			100	nA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 7 mA _{dc} , V _{CE} = 10 Vdc)	h _{FE}	40	85		
Base-Emitter On Voltage (I _C = 7 mA _{dc} , V _{CE} = 10 Vdc)	V _{BE(on)}		770	900	mVdc

SMALL-SIGNAL CHARACTERISTICS

Current Gain-Bandwidth Product (2) (I _C = 5 mA _{dc} , V _{CE} = 10 Vdc, f = 100 MHz)	f _T	400	750		MHz
Common Emitter Feedback Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{re}		0.25	0.35	pF
Noise Figure (I _C = 4 mA, V _{CE} = 10 V, R _S = 50 Ω, f = 35 MHz)	N _f		2.5		dB

BF224

**CASE 29-02, STYLE 21
TO-92 (TO-226AA)**

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	30	Vdc
Collector-Base Voltage	V _{CBO}	45	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	Vdc
Collector Current - Continuous	I _C	50	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	357	°C/W

Refer to BF240 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 1 mAdc, I _B = 0)	V _{(BR)CEO}	30			Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	45			Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	4			Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0)	I _{CBO}			100 10	nAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	I _{EBO}			100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 7 mAdc, V _{CE} = 10 Vdc)	h _{FE}	30			
Base-Emitter On Voltage (I _C = 7 mAdc, V _{CE} = 10 Vdc)	V _{BE(on)}		0.77	0.9	mVdc
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}			0.15	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain-Bandwidth Product (I _C = 1.5 mAdc, V _{CE} = 10 Vdc, f = 100 MHz) (I _C = 7 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	300	600 850		MHz
Common Emitter Feedback Capacitance (V _{CE} = 10 Vdc, I _E = 0, f = 1 MHz)	C _{re}		0.28		pF
Noise Figure (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, R _S = 50 ohms, f = 100 MHz) f = 200 MHz	N _f		2.5 3.5		dB

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	Vdc
Collector Current - Continuous	I _C	25	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

**BF240
BF241**CASE 29-02, STYLE 18
TO-92 (TO-226AA)

AM/FM TRANSISTORS

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I _C = 2 mAdc, I _B = 0)	V(BR)CEO	40			Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V(BR)CBO	40			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V(BR)EBO	4			Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0)	I _{CBO}			100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 1 mAdc, V _{CE} = 10 Vdc)	BF240 BF241	hFE	65 35	220 125	—
Base-Emitter On Voltage (I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	V _{BE(on)}	.65	.70	.74	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain-Bandwidth Product (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	BF240 BF241	f _T		600 470	MHz
Common Emitter Feedback Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{re}		.28	.34	pF
Noise Figure (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, R _S = 200 Ω, f = 100 KHz) R _S = 50 Ω, f = 100 MHz	N _f		2.5	3.5	dB
Output Admittance (I _C = 1 mAdc, V _{CE} = 10 Vdc, f = 450 KHz) (f = 10.7 MHz)	g _{oe}			8.3 10.5	μmho

(1) Pulse test: Pulse Width ≤ 300 μs. Duty cycle ≤ 2.0%.

BF240, BF241

FIGURE 1 – CURRENT GAIN-BANDWIDTH PRODUCT

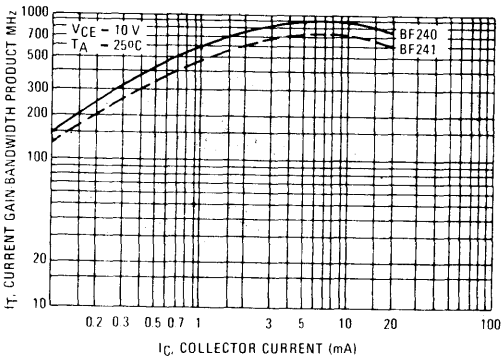


FIGURE 2 – CAPACITANCES

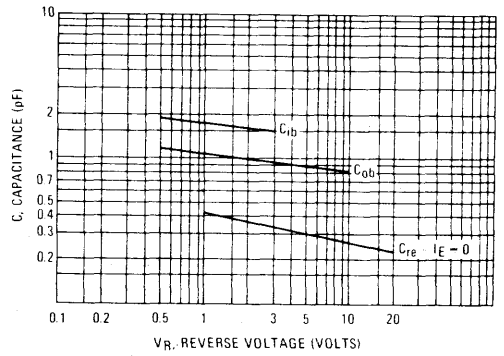


FIGURE 3 – DC CURRENT GAIN

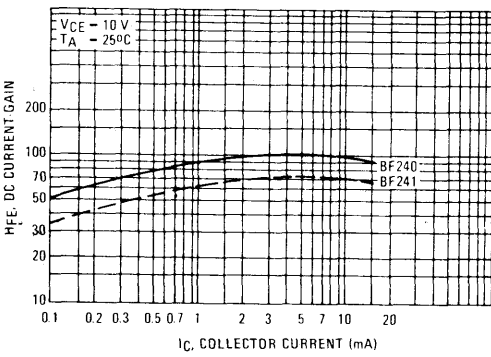


FIGURE 4 – b_{11e}

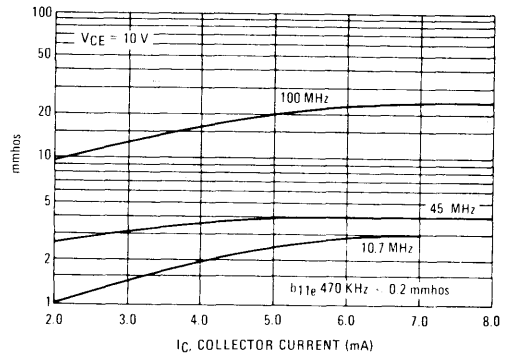


FIGURE 5 – b_{21e}

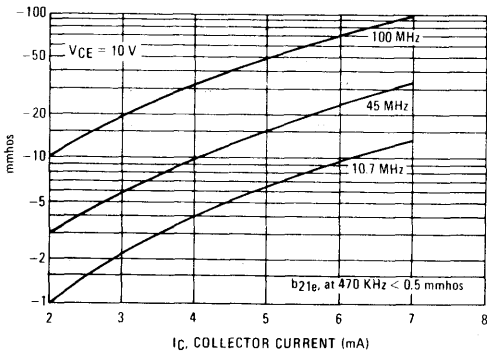
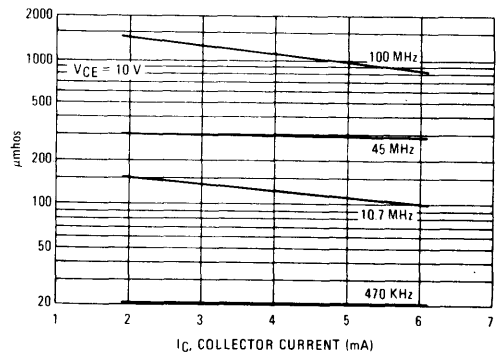


FIGURE 6 – b_{22e} (boe)



BF240, BF241

FIGURE 7 - g_{11e} (gie)

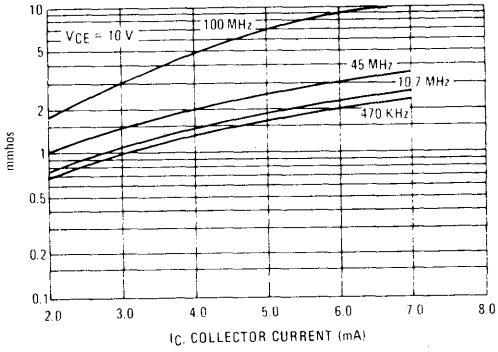


FIGURE 8 - g_{21e} (Yfe)

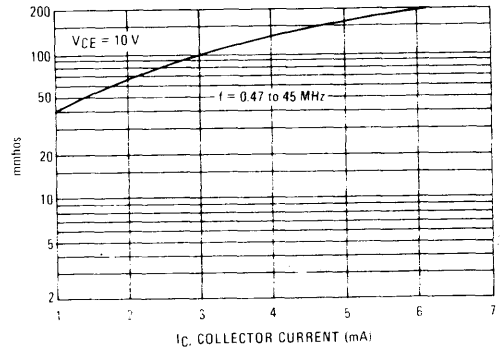
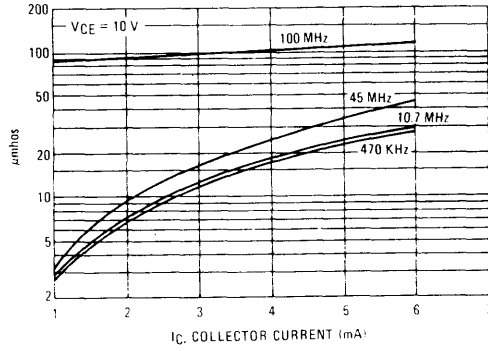


FIGURE 9 - g_{22e} (goe)



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BF254 BF255

CASE 29-02, STYLE 21
TO-92 (TO-226AA)

AM/FM TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	Vdc
Collector-Base Voltage	V _{CBO}	30	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current - Continuous	I _C	100	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	20			Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	30			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0			Vdc
Collector Cutoff Current (V _{CB} = 10 Vdc, I _E = 0)	I _{CBO}			100	nAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	I _{EBO}			100	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mA, V _{CE} = 10 Vdc)	BF254	h _{FE}	65		220
	BF254-3		65		125
	BF254-4		100		220
	BF255		35		125
	BF255-2		35		75
	BF255-3		65		125
Base-Emitter On Voltage (I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	BF254 BF255	V _{BE(on)}		.68	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current Gain-Bandwidth Product (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	BF254 BF255	f _T	260 200		MHz
Common Emitter Feedback Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)		C _{re}	0.90		pF
Noise Figure (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1 MHz, R _S = 50 ohms)		N _f	1.7		dB

BF254, BF255

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

TYPICAL ADMITTANCE PARAMETERS ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ V}$, frequency as stated)

Symbol	f = 450 KHz		f = 10.7 MHz		Unit
	BF254	BF255	BF254	BF255	
g _{11e}	0.20	0.40	0.26	0.5	mmhos
b _{11e}	0.05	0.06	1.2	1.6	mmhos
g _{22e}	3.0	1.5	5.3	4.5	μmhos
b _{22e}	8.0	8.0	190	190	μmhos
b _{12e}	- 5.0	- 5.0	- 130	- 130	μmhos
g _{12e}	- 0.7	- 0.4	- 3.0	- 3.5	μmhos
g _{21e}	30	30	30	30	mmhos
b _{21e}	- 0.003	- 0.004	- 0.7	- 1.0	mmhos

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FIGURE 1 - DC CURRENT GAIN

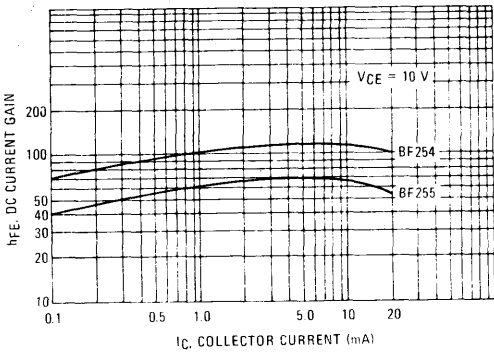


FIGURE 2 - CURRENT GAIN - BANDWIDTH PRODUCT

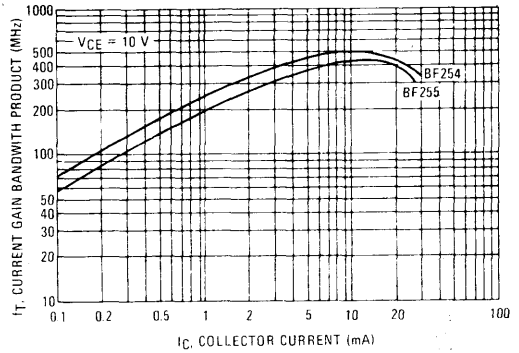


FIGURE 3 - "ON" VOLTAGE

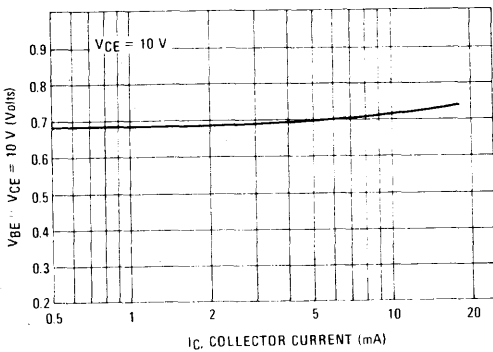
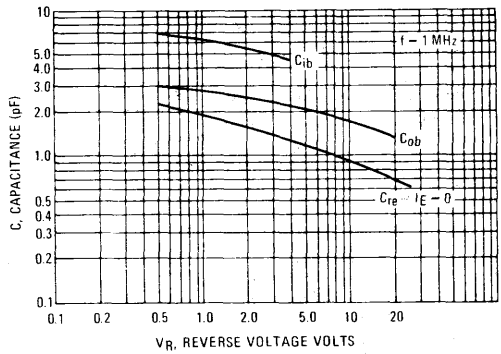


FIGURE 4 - CAPACITANCES



BF366

**CASE 29-02, STYLE 2
TO-92 (TO-226AA)**

VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	30	Vdc
Collector-Base Voltage	V _{CBO}	35	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	Vdc
Collector Current - Continuous	I _C	25	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	30	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc
Collector Cutoff Current (V _{CE} = 12 Vdc, I _B = 0)	I _{CEO}	—	—	500	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 3.0 mAdc, V _{CE} = 10 Vdc) (I _C = 12 mAdc, V _{CE} = 7.0 Vdc)	h _{FE}	15 5.5	— —	— —	—
Base-Emitter On Voltage (I _C = 12 mAdc, V _{CE} = 7.0 Vdc)	V _{BE(on)}	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain-Bandwidth Product (I _C = 3.0 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	400	—	—	MHz
Feedback Capacitance (Common Emitter) (V _{CE} = 10 Vdc, f = 1 MHz)	C _{rb}	—	—	0.3	pF
Noise Figure (I _C ≈ 3.0 mAdc, V _{CB} ≈ 10 Vdc, R _S = 50 Ohms, f = 200 MHz)	N _f	—	—	3.5	dB
Common-Emitter Amplifier Power Gain (I _C ≈ 3.0 mAdc, V _{CB} ≈ 10 Vdc, R _S = 50 Ohms, f = 200 MHz)	G _{pb}	14	—	—	dB
Forward AGC Current (Gain Reduction = 30 dB, V _{CB} = 10 V, f = 200 MHz)	I _{AGC}	5	—	8	mAdc

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	30	V _{dc}
Collector-Base Voltage	V _{CBO}	40	V _{dc}
Emitter-Base Voltage	V _{EBO}	4.0	V _{dc}
Collector Current - Continuous	I _C	25	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

BF367**CASE 29-02, STYLE 2
TO-92 (TO-226AA)****VHF TRANSISTOR****NPN SILICON****ELECTRICAL CHARACTERISTICS** (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	30	—	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	4.0	—	—	V _{dc}
Collector Cutoff Current (V _{CB} = 10 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 4.0 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	27	35	200	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 5.0 mAdc)	V _{CE(sat)}	—	1.5	3.0	V _{dc}
Base-Emitter On Voltage (I _C = 4 mAdc, V _{CE} = 10 Vdc)	V _{BE(on)}	—	0.75	0.9	V _{dc}
SMALL-SIGNAL CHARACTERISTICS					
Current Gain-Bandwidth Product (I _C = 4.0 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	300	440	—	MHz
Feedback Capacitance (Common Emitter) (V _{CE} = 10 Vdc, I _E = 1 mA, f = 1.0 MHz)	C _{re}	—	0.2	0.22	pF
Noise Figure (Figure 3) (I _E ≈ 4.0 mAdc, V _{CC} ≈ 10 Vdc, V _{AGC} = 2.75 Vdc, R _S = 50 Ohms, f = 35 MHz)	N _f	—	3.0	—	dB
Common-Emitter Amplifier Power Gain (Figure 3) (I _E ≈ 4.0 mAdc, V _{CC} ≈ 12 Vdc, V _{AGC} = 2.75 Vdc, R _S = 50 Ohms, f = 35 MHz)	G _{pe}	—	25	—	dB
Forward AGC Voltage (Figure 3) (Gain Reduction = 30 dB, R _S = 50 Ohms, f = 35 MHz)	V _{AGC}	—	5.5	—	V _{dc}

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

TYPICAL ADMITTANCE PARAMETERS ($V_{CE} = 10\text{ Vdc}$, $I_C = 4.0\text{ mAdc}$, $f = 35\text{ MHz}$)

Input Conductance	g_{ie}	—	5.0	—	mmhos
Input Capacitance	C_{ie}	—	30	—	pF
Forward Transfer Admittance Magnitude	$ Y_{fe} $	—	100	—	mmhos
Forward Transfer Admittance Phase Angle	ϕ_{fe}	—	19	—	Degrees
Feedback Capacitance	C_{re}	—	0.2	—	pF
Output Conductance	g_{oe}	—	18	—	μmhos
Output Capacitance	C_{oe}	—	1.3	—	pF
Maximum Unilateralized Power Gain	G_{um}	—	41	—	dB
$G_{um} = \frac{ Y_{fe} ^2}{4 g_{ie} g_{oe}}$					

$V_{CC} = 12\text{ Vdc}$, $R_G = 50\text{ Ohms}$, $f = 35\text{ MHz}$, See Figure 3

FIGURE 1 – POWER GAIN

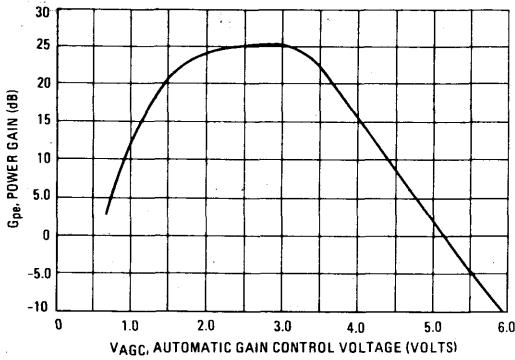


FIGURE 2 – NOISE FIGURE

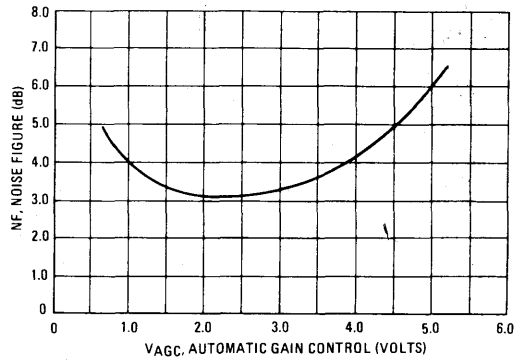
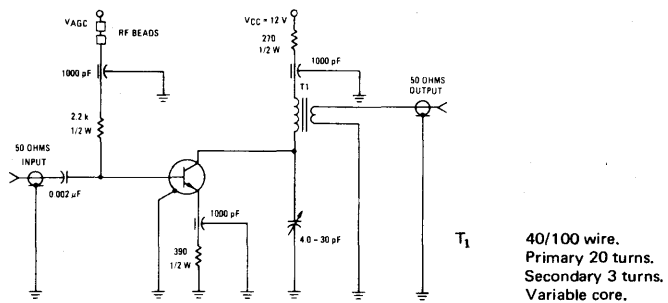


FIGURE 3 – 35 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



MAXIMUM RATINGS

Rating	Symbol	BF 371	BF 373	Unit
Collector-Emitter Voltage	V _{CEO}	30	45	Vdc
Collector-Base Voltage	V _{CBO}	40	45	Vdc
Emitter-Base Voltage	V _{EBO}	4.0		Vdc
Collector Current - Continuous	I _C	100		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350	2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0	8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

BF371
BF373

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	BF371 BF373	V _{(BR)CEO}	30 45	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	BF371 BF373	V _{(BR)CBO}	40 45	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)		V _{(BR)EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)		I _{CBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I _C = 7.0 mAdc, V _{CE} = 10 Vdc) (I _C = 20 mAdc, V _{CE} = 2.0 Vdc)		h _{FE}	40 15	— —	— —	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)		V _{CE(sat)}	—	—	0.50	Vdc
Base-Emitter On Voltage (I _C = 7.0 mA, V _{CE} = 10 Vdc)		V _{BE(on)}	—	—	0.90	Vdc
DYNAMIC CHARACTERISTICS						
Current Gain - Bandwidth Product (I _C = 5 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	BF371 BF373	f _T	400 500	720 720	—	MHz
Common Emitter Feedback Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)		C _{re}	—	0.20	0.32	pF

BF374 BF375

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	25	Vdc
Collector-Base Voltage	V _{CB0}	30	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current - Continuous	I _C	100	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	357	°C/W

Refer to MPS110 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	25			Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	30			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	3.0			Vdc
Collector Cutoff Current (V _{CB} = 25 Vdc, I _E = 0)	I _{CBO}			100	nAdc
Emitter Cutoff Current (V _{EB} = 2.0 Vdc, I _C = 0)	I _{EBO}			100	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	h _{FE}	70 35 70 35		250 120 120 90	
Collector-Emitter Saturation Voltage (I _C = 1.0 mAdc, I _B = 0.1 mAdc) (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}		50 70		mVdc mVdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}		830		mVdc
Base-Emitter On Voltage (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc)	V _{BE(on)}		700 770		mVdc mVdc

SMALL-SIGNAL CHARACTERISTICS

Current Gain-Bandwidth Product (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	400	800		MHz
Common Emitter Feedback Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{re}		0.55	0.6	pF
Collector-Base Time Constant (I _C = 4.0 mAdc, V _{CE} = 10 Vdc, f = 31.8 MHz)	r _b C _C		6		ps
Noise Figure (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 100 MHz, R _s = 50 ohms)	N _f		4		dB
Common-Emitter Amplifier Power Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 200 MHz)	G _{pe}		20		dB

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

TYPICAL ADMITTANCE PARAMETERS ($I_C = 1.0\text{ mA}$; $V_{CE} = 10\text{ Vdc}$, frequency as stated)

Symbol	$f = 10.7\text{ MHz}$	$f = 30\text{ MHz}$	$f = 100\text{ MHz}$	Unit
G_{11e}	0.28	0.4	1.4	mmho
B_{11e}	0.6	1.6	5.0	mmho
G_{22e}	6.5	7	20	μmho
B_{22e}	0.1	0.3	1.0	mmho
G_{21e}	36	34	30	mmho
B_{21e}	- 0.8	- 2.5	- 9	mmho
B_{12e}	- 52	- 150	- 500	μmho

FIGURE 1 — INPUT ADMITTANCE
(Output short circuit)

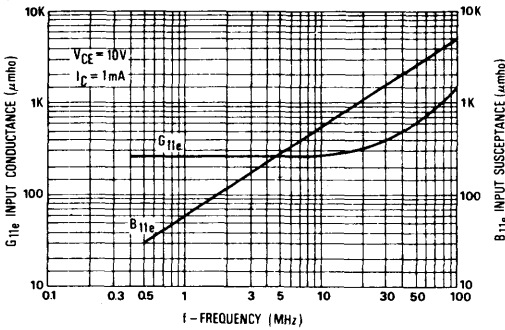


FIGURE 2 — OUTPUT ADMITTANCE
(Input short circuit)

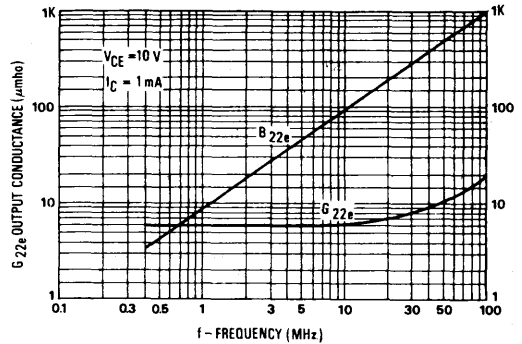


FIGURE 3 — FORWARD TRANSFER ADMITTANCE
(Output short circuit)

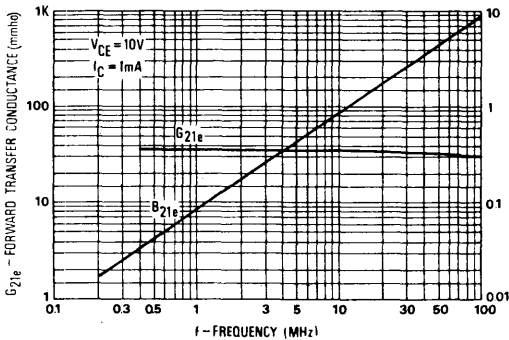
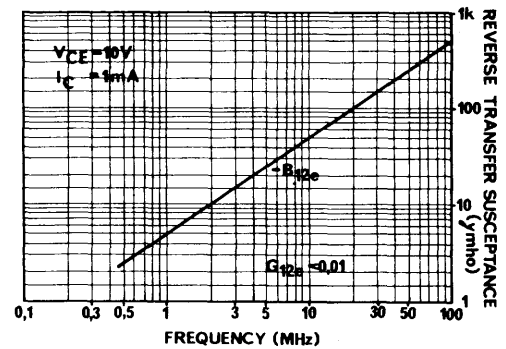


FIGURE 4 — REVERSE TRANSFER ADMITTANCE
(Input short circuit)



BF391 BF392 BF393

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BF 391	BF 392	BF 393	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	300	Vdc
Collector-Base Voltage	V_{CBO}	200	250	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current - Continuous	I_C	500			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0			mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 1.2			Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C}/\text{W}$

Refer to MPSA42 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	BF391 BF392 BF393	$V_{(BR)CEO}$	200 250 300	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	BF391 BF392 BF393	$V_{(BR)CBO}$	200 250 300	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	BF391 BF392 BF393	$V_{(BR)EBO}$	6.0 6.0 6.0	— — —	Vdc
Collector Cutoff Current ($V_{CB} = 160 \text{ Vdc}, I_E = 0$) ($V_{CB} = 200 \text{ Vdc}, I_E = 0$) ($V_{CB} = 200 \text{ Vdc}, I_E = 0$)	BF391 BF392 BF393	I_{CBO}	— — —	0.1 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{CB} = 4.0 \text{ Vdc}, I_C = 0$) ($V_{CB} = 6.0 \text{ Vdc}, I_C = 0$) ($V_{CB} = 6.0 \text{ Vdc}, I_C = 0$)	BF391 BF392 BF393	I_{EBO}	— — —	0.1 0.1 0.1	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	All Types All Types	h_{FE}	25 40	— —	—
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)		$V_{CE(sat)}$		2.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 20 \text{ mA}, I_B = 2.0 \text{ mA}$)		$V_{BE(sat)}$		2.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain - Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 20 \text{ MHz}$)		f_T	50	—	MHz
Common Emitter Feedback Capacitance ($V_{CB} = 60 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)		C_{re}		1.6	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

BF420
BF422

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BF 420	BF 422	Unit
Collector-Emitter Voltage	V _{CEO}	300	250	Vdc
Collector-Base Voltage	V _{CBO}	300	250	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current - Continuous	I _C	500		mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	800	6.4	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.75	22	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	45	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	156	°C/W

Refer to MPSA42 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I _C = 1 mA _{dc} , I _B = 0)	V _{(BR)CEO}	300 250	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBO}	300 250	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0 5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 200 Vdc, I _E = 0)	I _{CBO}	—	0.01	μA _{dc}
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	10	μA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 25 mA _{dc} , V _{CE} = 20 Vdc)	h _{FE}	50 50	— —	—
Collector-Emitter Saturation Voltage (I _C = 20 mA _{dc} , I _B = 2.0 mA _{dc})	V _{CE(sat)}		0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 20 mA, I _B = 2.0 mA)	V _{BE(sat)}		2.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain - Bandwidth Product (I _C = 10 mA _{dc} , V _{CE} = 10 Vdc, f = 50 MHz)	f _T	60	—	MHz
Common Emitter Feedback Capacitance (V _{CB} = 30 Vdc, I _E = 0, f = 1.0 MHz)	C _{re}		2.8	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BF421 BF423

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BF 421	BF 423	Unit
Collector-Emitter Voltage	V_{CE0}	300	250	Vdc
Collector-Base Voltage	V_{CB0}	300	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current - Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	800	6.4	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.75	22	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	156	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 1 \text{ mAdc}, I_B = 0$)	BF421 BF423	$V_{(BR)CEO}$	300 250	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	BF421 BF423	$V_{(BR)CBO}$	300 250	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	BF421 BF423	$V_{(BR)EBO}$	5.0 5.0	— —	Vdc
Collector Cutoff Current ($V_{CB} = 200 \text{ Vdc}, I_E = 0$)	BF421 BF423	I_{CB0}	—	0.01	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)	BF421 BF423	I_{EBO}	—	10	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 25 \text{ mA}, V_{CE} = 20 \text{ Vdc}$)	BF421 BF423	h_{FE}	50 50	— —	—
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)		$V_{CE(sat)}$		0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20 \text{ mA}, I_B = 2.0 \text{ mA}$)		$V_{BE(sat)}$		2.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain - Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 50 \text{ MHz}$)		f_T	60	—	MHz
Common Emitter Feedback Capacitance ($V_{CB} = 30 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)		C_{re}		2.8	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	BF 491	BF 492	BF 493	Unit
Collector-Emitter Voltage	V _{CEO}	200	250	300	V _{dc}
Collector-Base Voltage	V _{CBO}	200	250	300	V _{dc}
Emitter-Base Voltage	V _{EBO}	6.0			V _{dc}
Collector Current - Continuous	I _C	500			mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625	5.0		mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5	12		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

BF491 BF492 BF493

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I _C = 1 mAdc, I _B = 0)	BF491 BF492 BF493	V _{(BR)CEO}	200 250 300	— — —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	BF491 BF492 BF493	V _{(BR)CBO}	200 250 300	— — —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	BF491 BF492 BF493	V _{(BR)EBO}	6.0 6.0 6.0	— — —	V _{dc}
Collector Cutoff Current (V _{CB} = 160 Vdc, I _E = 0) (V _{CB} = 200 Vdc, I _E = 0) (V _{CB} = 200 Vdc, I _E = 0)	BF491 BF492 BF493	I _{CBO}	— — —	0.1 0.1 0.1	μAdc
Emitter Cutoff Current (V _{CB} = 4.0 Vdc, I _C = 0) (V _{CB} = 6.0 Vdc, I _C = 0) (V _{CB} = 6.0 Vdc, I _C = 0)	BF491 BF492 BF493	I _{EBO}	— — —	0.1 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc), (I _C = 10 mAdc, V _{CE} = 10 Vdc)	All Types All Types	h _{FE}	25 40	— —	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)		V _{CE(sat)}		2.0	V _{dc}
Base-Emitter Saturation Voltage (I _C = 20 mA, I _B = 2.0 mA)		V _{BE(sat)}		2.0	V _{dc}
SMALL SIGNAL CHARACTERISTICS					
Current-Gain - Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 20 MHz)		f _T	50	—	MHz
Common Emitter Feedback Capacitance (V _{CB} = 100 Vdc, I _E = 0, f = 1.0 MHz)		C _{re}		1.6	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BF493SCASE 29-03, STYLE 1
TO-92 (TO-226AA)**HIGH VOLTAGE TRANSISTOR**

PNP SILICON

Refer to MPSA93 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CBO}	350	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current - Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 250 \text{ Vdc}$)	I_{CES}	—	10	nAdc
Emitter Cutoff Current ($V_{BE} = 6 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 250 \text{ Vdc}, I_E = 0, T_A = 25^\circ\text{C}$) ($V_{CB} = 250 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$)	I_{CBO}	—	0.005 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	HFE	25 40	— —	—
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	2.0	Vdc
Base-Emitter Voltage ($I_C = 20 \text{ mA}, I_B = 2.0 \text{ mA}$)	$V_{BE(sat)}$	—	2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	50	—	MHz
Common Emitter Feedback Capacitance ($V_{CB} = 100 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{re}	—	1.6	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$ — Duty Cycle $\leq 2\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	Vdc
Collector-Base Voltage	V _{CBO}	30	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current – Continuous	I _C	100	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	357	°C/W

BF494

BF495

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SILICON

Refer to BF254 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	20			Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	30			Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0			Vdc
Collector Cutoff Current (V _{CB} = 10 Vdc, I _E = 0)	I _{CBO}			100	nAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	I _{EBO}			100	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mA, V _{CE} = 10 Vdc)	h _{FE}	BF494 BF494A BF494B BF495 BF495A BF495B	65 65 125 35 35 65		220 125 220 125 75 125	
Base-Emitter On Voltage (I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	V _{BE(on)}			0.74	Vdc	

SMALL-SIGNAL CHARACTERISTICS

Current Gain–Bandwidth Product (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	150			MHz
Common Emitter Feedback Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{re}		0.90		pF
Noise Figure (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1 MHz, R _S = 50 ohms)	N _f		1.7		dB

TYPICAL ADMITTANCE PARAMETERS (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, frequency as stated)

Symbol	f = 450 KHz		f = 10.7 MHz		Unit
	BF494	BF495	BF494	BF495	
g _{11e}	0.20	0.40	0.26	0.5	mmhos
b _{11e}	0.05	0.06	1.2	1.6	mmhos
g _{22e}	3.0	1.5	5.3	4.5	μmhos
b _{22e}	8.0	8.0	190	190	μmhos
b _{12e}	- 5.0	- 5.0	- 130	- 130	μmhos
g _{12e}	- 0.7	- 0.4	- 3.0	- 3.5	μmhos
g _{21e}	30	30	30	30	mmhos
b _{21e}	- 0.003	- 0.004	- 0.7	- 1.0	mmhos

BF506

**CASE 29-03, STYLE 17
TO-92 (TO-226AA)**

VHF TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

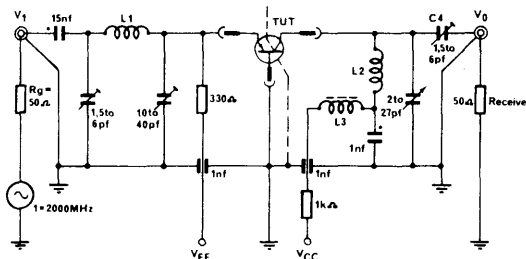
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}, I_E = 0$)	$V_{(BR)CEO}$	35	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ V}, I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 3 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20	—	—	
SMALL SIGNAL CHARACTERISTICS					
Current-Gain - Bandwidth Product ($I_C = 1 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	400	600	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{CBO}	—	0.6	0.9	pF
Feedback Capacitance (Grounded Base) ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{rb}	—	0.15	0.25	pF
Noise Figure ($I_C = 1 \text{ mA}, R_S = 50 \Omega, f = 200 \text{ MHz}, V_{CC} = 6 \text{ V}$)	NF	—	2.5	4	dB
Power Gain ($I_C = 3 \text{ mA}, R_L = 1 \text{ K}\Omega, f = 200 \text{ MHz}, V_{CC} = 10.8 \text{ V}$)	G_{pb}	14	22	—	dB

200 MHz POWER GAIN NOISE FIGURE TEST CIRCUIT

*Leadless ceramic disc capacitor
L1 - 3 turns 0.0 mm enamel, 4 mm dia
L2 - 2 turns 1 mm enamel, 6.5 mm dia

FIGURE 1 – CURRENT GAIN – BANDWIDTH PRODUCT

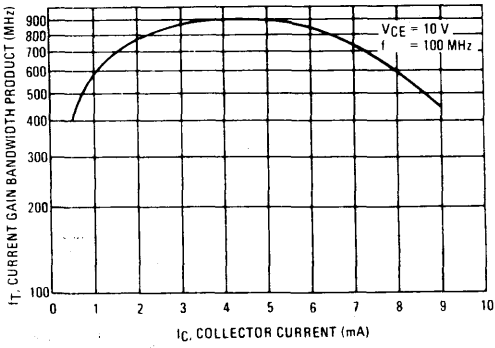


FIGURE 2 – NOISE FIGURE

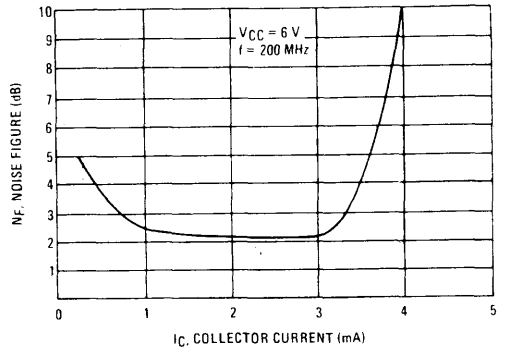


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

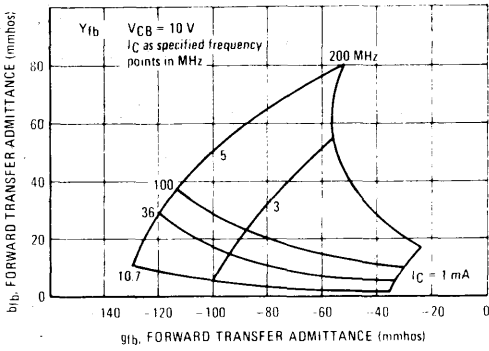


FIGURE 4 – INPUT ADMITTANCE

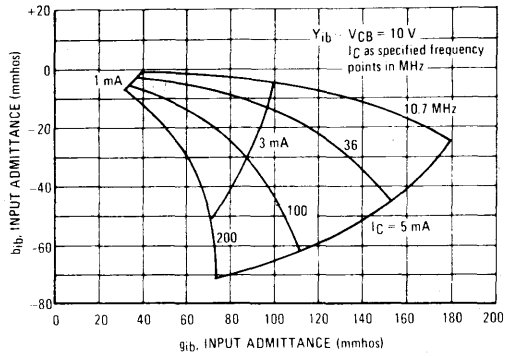
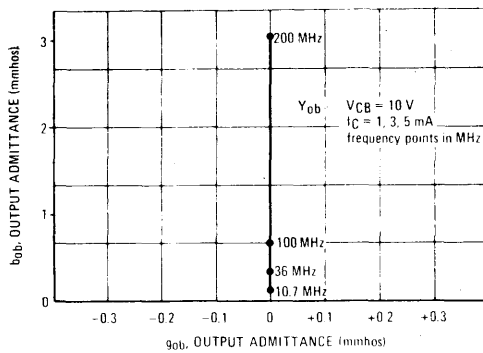


FIGURE 5 – OUTPUT ADMITTANCE



BF509

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

VHF TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

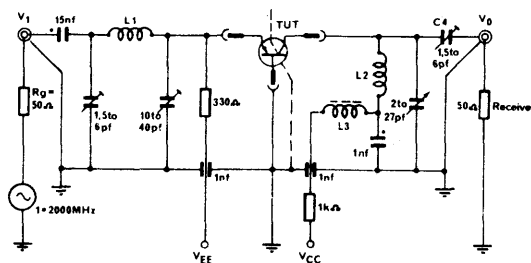
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	35	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CE0}$	35	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc , $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc , $I_C = 0$)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ V, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 3$ mAdc, $V_{CE} = 10$ Vdc)	hFE	20	—	—	
SMALL SIGNAL CHARACTERISTICS					
Current-Gain - Bandwidth Product ($I_C = 3$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	600	850	—	MHz
Feedback Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{rb}	—	0.15	0.25	pF
Collector-Base Capacitance ($V_{CB} = 10$ V, $I_E = 0$, $f = 1.0$ MHz)	$C_{CBO}(C_{re})$	—	0.6	0.9	pF
Noise Figure ($I_C = 3$ mAdc, $V_{CC} = 10.8$ V, $R_S = 50$ Ohms, $f = 200$ MHz)	NF	—	—	2.5	dB
Common-Base Amplifier Power Gain ($I_C = 3$ mAdc, $V_{CC} = 10.8$ V, $R_L = 1$ K Ω , $f = 200$ MHz)	G_{pb}	15	22	—	dB
Forward AGC Current ($I_C(\text{Agc})$ (Gain Reduction = 30 dB, $R_S = 50$ Ohms, $V_{CC} = 10.8$ V, $f = 200$ MHz)	$I_C(\text{Agc})$	7	—	8.8	mAdc

200 MHz POWER GAIN NOISE FIGURE TEST CIRCUIT

* Leadless ceramic disc capacitor
L1 = 3 turns, 0.0 mm enamel, 4 mm dia
L2 = 2 turns, 1 mm enamel, 6.5 mm dia

FIGURE 1 - DC CURRENT GAIN

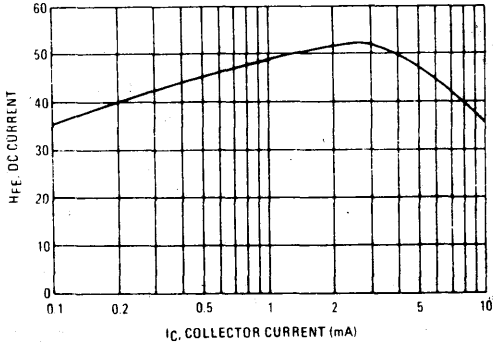


FIGURE 2 - CURRENT GAIN - BANDWIDTH PRODUCT

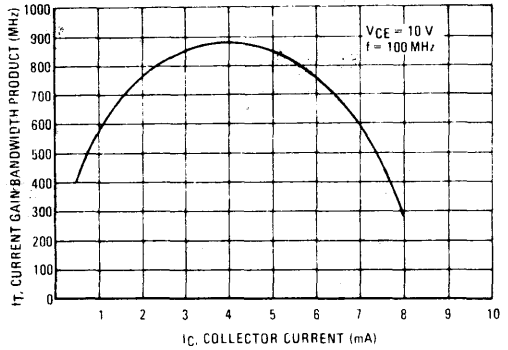


FIGURE 3 - CAPACITANCES

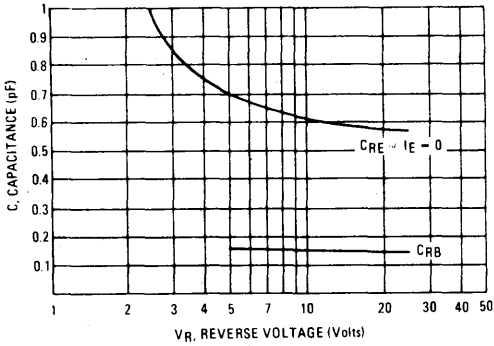


FIGURE 4 - TYPICAL POWER GAIN

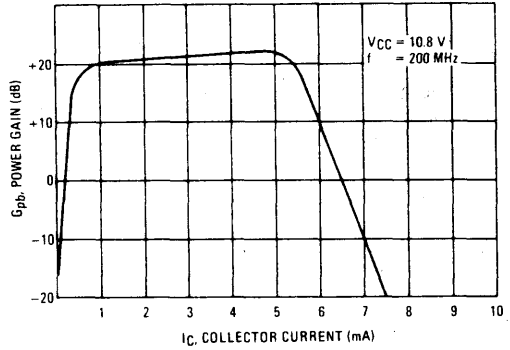


FIGURE 5 - FORWARD TRANSFER ADMITTANCE

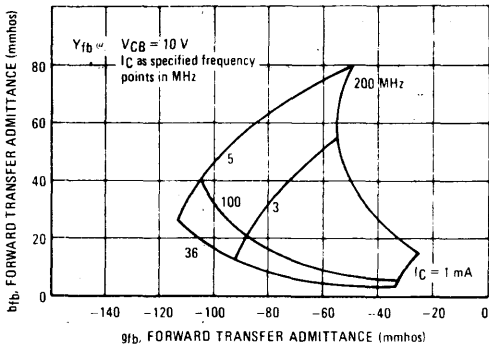
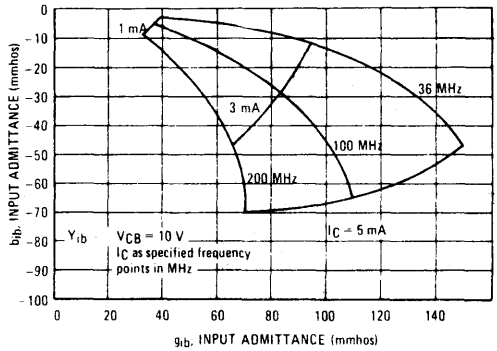


FIGURE 6 - INPUT ADMITTANCE



BF844 BF845

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BF 844	BF 845	Unit
Collector-Emitter Voltage	V_{CEO}	400	350	Vdc
Collector-Base Voltage	V_{CBO}	450	400	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current – Continuous	I_C	300		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	$^\circ\text{C}/\text{W}$

Refer to MPSA44 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0$ mAdc, $I_B = 0$)	BF844 BF845	$V_{(BR)CEO}$	400 350	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc , $V_{BE} = 0$)	BF844 BF845	$V_{(BR)CES}$	450 400	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc , $I_E = 0$)	BF844 BF845	$V_{(BR)CBO}$	450 400	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc , $I_C = 0$)	Both Types	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 400$ Vdc, $I_E = 0$) ($V_{CB} = 320$ Vdc, $I_E = 0$)	BF844 BF845	I_{CBO}	—	0.1 0.1	μAdc
Collector Cutoff Current ($V_{CE} = 400$ Vdc, $V_{BE} = 0$) ($V_{CE} = 320$ Vdc, $V_{BE} = 0$)	BF844 BF845	I_{CES}	—	500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	Both Types	I_{EBO}	—	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc)	Both Types Both Types Both Types Both Types	h_{FE}	40 50 45 20	— 200 — —	—
Collector-Emitter Saturation Voltage (1) ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	Both Types Both Types Both Types	$V_{CE(sat)}$	— — —	0.4 0.5 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{BE(sat)}$	—	0.75	Vdc

(1) Pulse Test: Pulse Width ≤ 300 μs — Duty Cycle $\leq 2.0\%$.

BF844, BF845

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS				
High Frequency Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 10\text{ MHz}$)	Both Types	h_{fe}	2.0	—
Collector-Base Capacitance ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	Both Types	C_{ob}	—	6.0 pF
Emitter-Base Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	Both Types	C_{ib}	—	110 pF
Turn-On Time ($V_{CC} = 150\text{ Vdc}$, $V_{BE(off)} = 4.0\text{ V}$, $I_C = 30\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$)	Both Types	t_{on}	—	0.6 μs
Turn-Off Time ($V_{CC} = 150\text{ Vdc}$, $I_C = 30\text{ mAdc}$, $I_{B1} = I_{B2} = 3.0\text{ mAdc}$)	Both Types	t_{off}	—	10 μs

FIGURE 1 — DC CURRENT GAIN

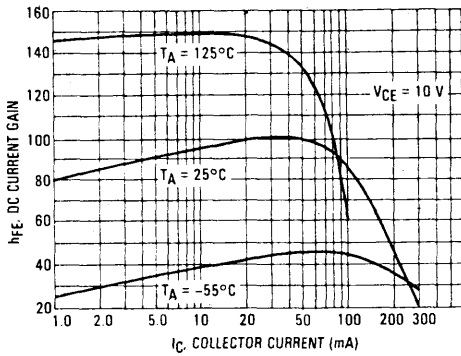
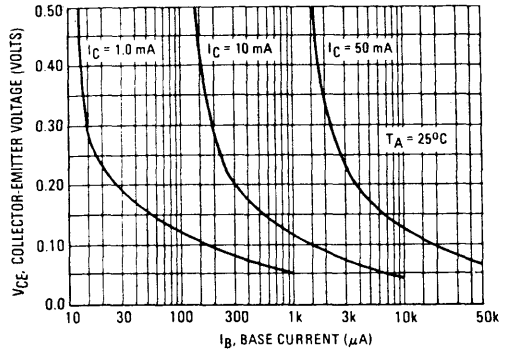


FIGURE 2 — COLLECTOR SATURATION REGION



BF959

**CASE 29-02, STYLE 21
TO-92 (TO-226AA)**

VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	Vdc
Collector-Base Voltage	V _{CBO}	30	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current - Continuous	I _C	50	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	20	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0)	I _{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 5 mAdc, V _{CE} = 10 Vdc) (I _C = 20 mAdc, V _{CE} = 10 Vdc)	h _{FE}	35 40	— —	— —	
Collector-Emitter Saturation Voltage (I _C = 30 mAdc, I _B = 2.0 mAdc)	V _{CE(sat)}	—	—	1.0	Vdc
Base-Emitter Saturation Voltage (I _C = 30 mAdc, I _B = 2.0 mAdc)	V _{BE(sat)}	—	—	1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain - Bandwidth Product (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 100 MHz) (I _C = 30 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _t	700 600	— —	— —	MHz
Common Emitter Feedback Capacitance (V _{CB} = 10 Vdc, P _f = 0, f = 10 MHz)	C _{re}	—	0.65	—	pF
Noise Figure (I _C = 4 mA, V _{CE} = 10 V, R _S = 50 Ω, f = 200 MHz)	N _f	—	3	—	dB

FIGURE 1 - H_{fe} AT 10 V

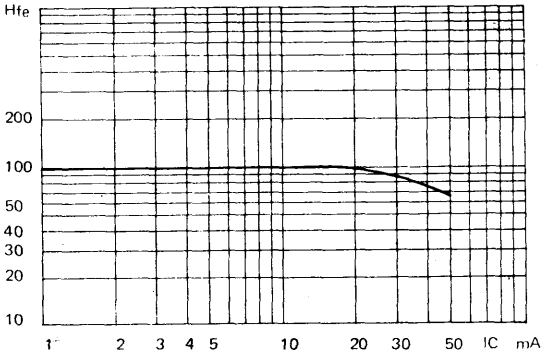
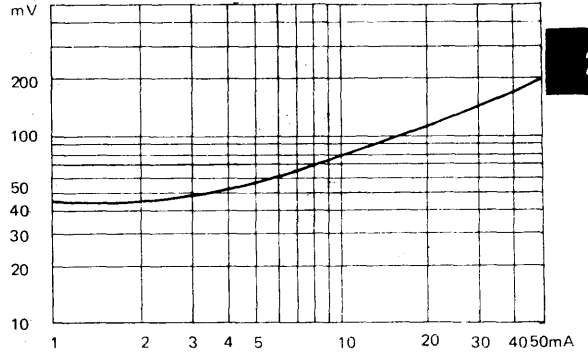


FIGURE 2 - V_{CE} Sat AT $I_C/I_B = 10$



2

FIGURE 3 - CURRENT-GAIN - BANDWIDTH-PRODUCT

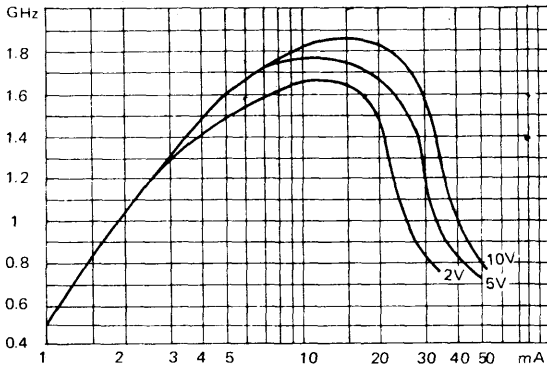


FIGURE 4 - CAPACITANCES

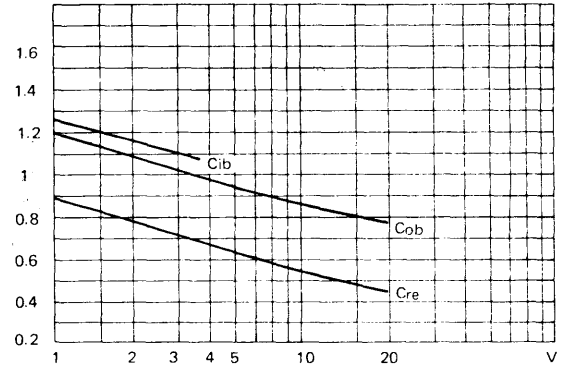


FIGURE 5 - INPUT IMPEDANCE AT 30 MHz

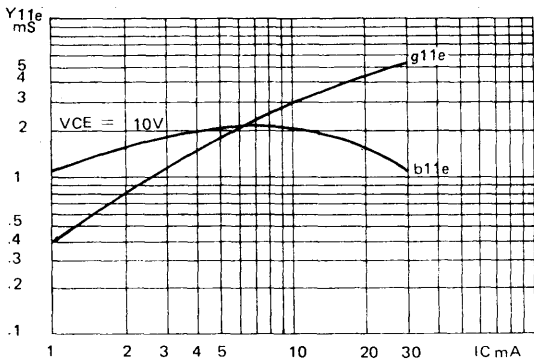
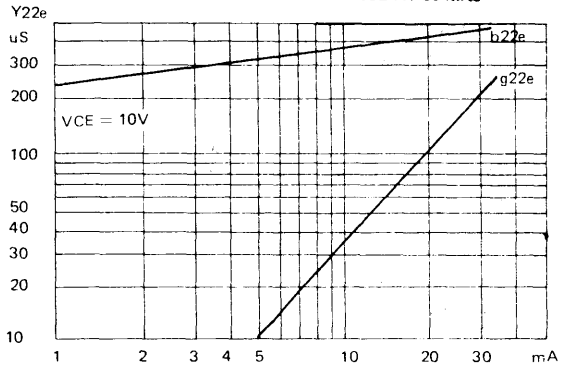


FIGURE 6 - OUTPUT IMPEDANCE AT 30 MHz



MPS404 MPS404A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

CHOPPER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS404	MPS404A	Unit
Collector-Emitter Voltage	V_{CE0}	24	35	Vdc
Collector-Base Voltage	V_{CBO}	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	25	Vdc
Collector Current — Continuous	I_C	150		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mAdc}, I_B = 0$)	MPS404 MPS404A	$V_{(BR)CEO}$	24 35	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	MPS404 MPS404A	$V_{(BR)CBO}$	25 40	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	MPS404 MPS404A	$V_{(BR)EBO}$	12 25	50 50	— —	Vdc
Collector Cutoff Current ($V_{CB} = 10 \text{ Vdc}, I_E = 0$)		I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}, I_C = 0$)		I_{EBO}	—	—	100	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 12 \text{ mAdc}, V_{CE} = 0.15 \text{ Vdc}$)		h_{FE}	30	100	400	—
Collector-Emitter Saturation Voltage ($I_C = 12 \text{ mAdc}, I_B = 0.4 \text{ mAdc}$) ($I_C = 24 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)		$V_{CE(sat)}$	— —	0.1 0.12	0.15 0.20	Vdc
Base-Emitter Saturation Voltage ($I_C = 12 \text{ mAdc}, I_B = 0.4 \text{ mAdc}$) ($I_C = 24 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)		$V_{BE(sat)}$	— —	0.7 0.74	0.85 1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Common-Base Cutoff Frequency ($I_C = 1.0 \text{ mAdc}, V_{CB} = 6.0 \text{ Vdc}$)		f_{ob}	4.0	—	—	MHz
Output Capacitance ($V_{CB} = 6.0 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)		C_{obo}	—	6.8	20	pF

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MPS404, MPS404A

FIGURE 1 - COLLECTOR-EMITTER VOLTAGE

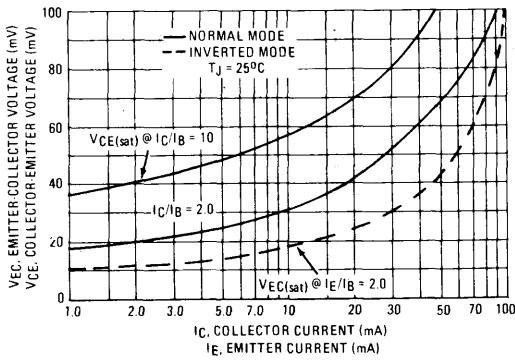
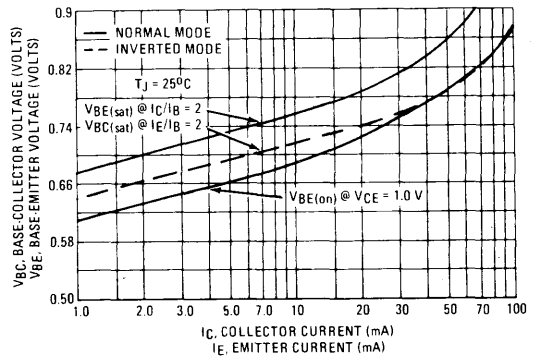
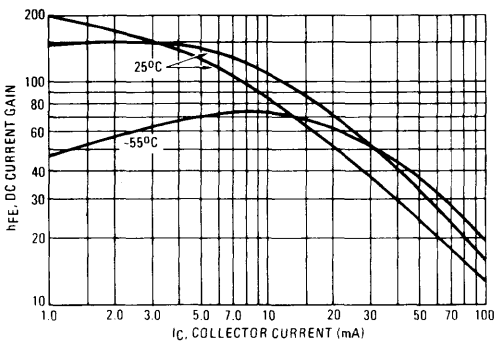


FIGURE 2 - BASE "ON" VOLTAGE



NORMAL MODE

FIGURE 3 - DC CURRENT GAIN @ V_{CE} = 0.15 Vdc



INVERTED MODE

FIGURE 4 - DC CURRENT GAIN @ V_{EC} = 0.15 Vdc

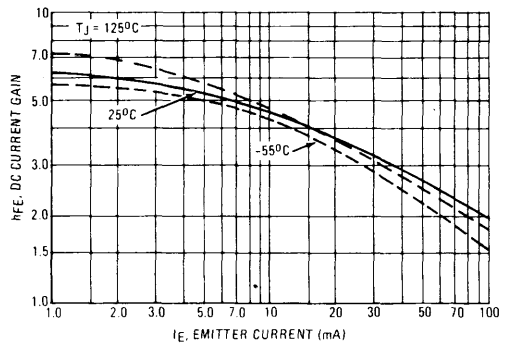


FIGURE 5 - DC CURRENT GAIN @ V_{CE} = 1.0 Vdc

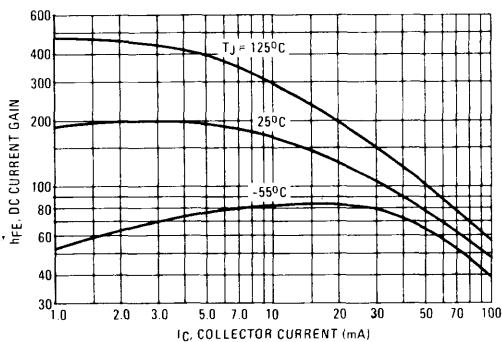


FIGURE 6 - DC CURRENT GAIN @ V_{EC} = 1.0 Vdc

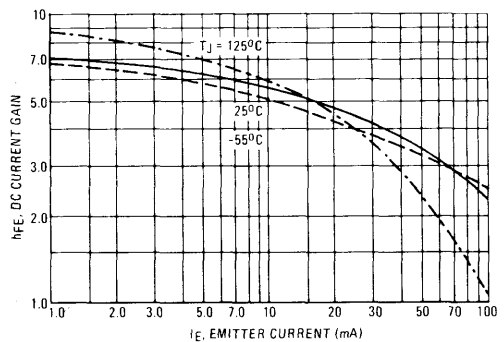


FIGURE 7 – COLLECTOR SATURATION REGION

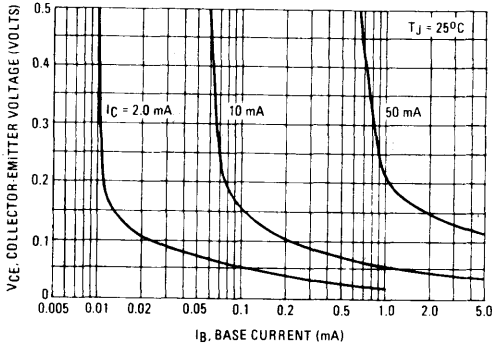


FIGURE 8 – EMITTER SATURATION REGION

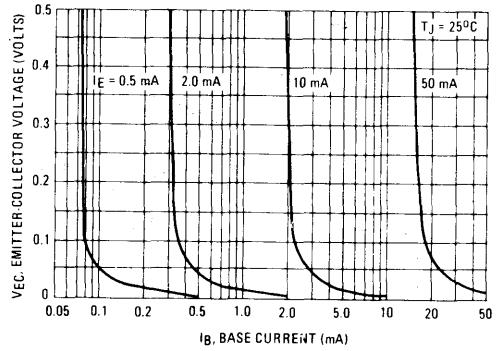


FIGURE 9 – EMITTER-COLLECTOR "ON" RESISTANCE

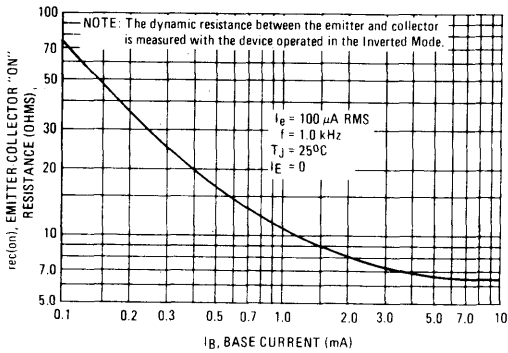


FIGURE 10 – CAPACITANCE

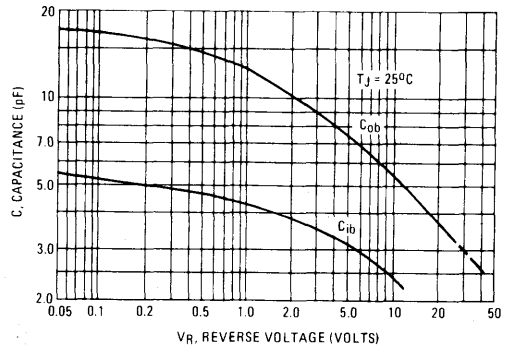


FIGURE 11 – TURN-ON TIME

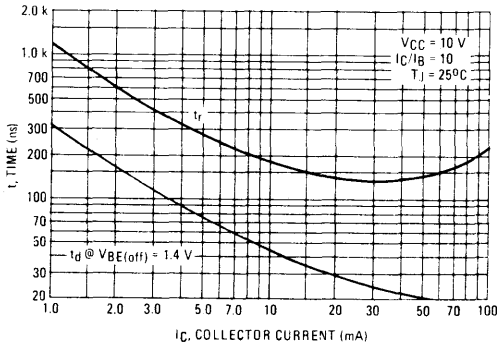
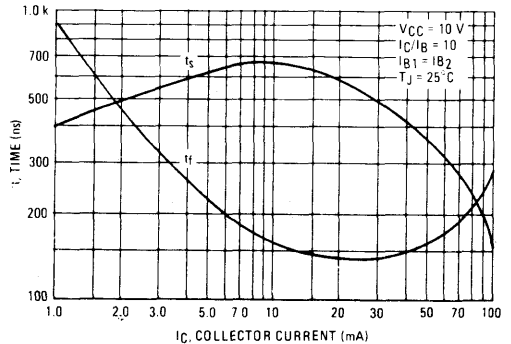
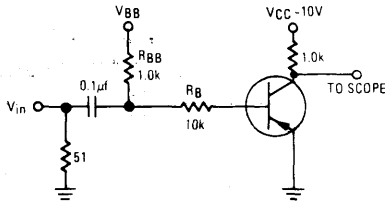


FIGURE 12 – TURN-OFF TIME



MPS404, MPS404A

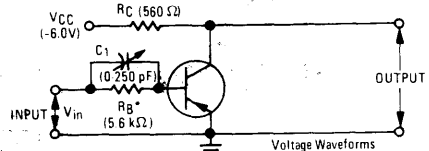
FIGURE 13 – SWITCHING TIME TEST CIRCUIT



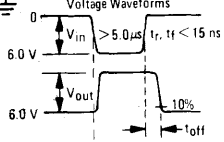
	V _{in} (Volts)	V _{BB} (Volts)
t _{on} , t _d and t _r	-12	+1.4
t _{off} , t _s and t _f	+20.6	-11.6

Voltages and resistor values shown are for I_C = 10 mA, I_C/I_B = 10 and I_{B1} = I_{B2}. Resistor values changed to obtain curves in Figures 11 and 12.

FIGURE 14 – STORED BASE CHARGE TEST CIRCUIT



MEASUREMENT PROCEDURE
 C₁ is increased until the t_{off} time of the output waveform is decreased to 0.2 μs. Q_S is then calculated by Q_S = C₁ V_{in}.
 Q_{S3} or Q_{S7} by B-Line Electronics or equivalent may also be used.



**MPS650
MPS651
NPN SILICON**

**MPS750
MPS751
PNP SILICON**

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

AMPLIFIER TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	MPS650 MPS750	MPS651 MPS751	Unit
Collector-Emitter Voltage	V_{CE0}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40 60	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60 80	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$) ($V_{CB} = 80 \text{ Vdc}, I_E = 0$)	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ V}, I_C = 0$)	I_{EBO}	—	0.1	μAdc

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 50 \text{ mA}, V_{CE} = 2.0 \text{ V}$) ($I_C = 500 \text{ mA}, V_{CE} = 2.0 \text{ V}$) ($I_C = 1.0 \text{ A}, V_{CE} = 2.0 \text{ V}$) ($I_C = 2.0 \text{ A}, V_{CE} = 2.0 \text{ V}$)	h_{FE}	75 75 75 40	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = 2.0 \text{ A}, I_B = 200 \text{ mA}$) ($I_C = 1.0 \text{ A}, I_B = 100 \text{ mA}$)	$V_{CE(sat)}$	— —	0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ A}, I_B = 100 \text{ mA}$)	$V_{BE(sat)}$	—	1.2	Vdc
Base-Emitter On Voltage ($I_C = 1.0 \text{ A}, V_{CE} = 2.0 \text{ V}$)	$V_{BE(on)}$	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 50 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	75	—	MHz
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(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MAXIMUM RATINGS

Rating	Symbol	MPS918	MPS3563	Unit
Collector-Emitter Voltage	V _{CEO}	15	12	V _{dc}
Collector-Base Voltage	V _{CBO}	30	30	V _{dc}
Emitter-Base Voltage	V _{EBO}	3.0	2.0	V _{dc}
Collector Current — Continuous	I _C	50		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625	5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5	12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	200	°C/W

MPS918
MPS3563

CASE 29-02, STYLE 1
TO-92 (TO-226AA)
AMPLIFIER TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) (I _C = 3.0 mAdc, I _B = 0)	MPS918 MPS3563	V _{(BR)CEO}	15 12	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 1.0 μAdc, I _E = 0) (I _C = 100 μAdc, I _E = 0)	MPS918 MPS3563	V _{(BR)CBO}	30 30	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	MPS918 MPS3563	V _{(BR)EBO}	3.0 2.0	— —	V _{dc}
Collector Cutoff Current (V _{CB} = 15 V _{dc} , I _E = 0)	MPS918 MPS3563	I _{CBO}	— —	10 50	nAdc

ON CHARACTERISTICS

DC Current Gain(2) (I _C = 3.0 mAdc, V _{CE} = 1.0 V _{dc}) (I _C = 8.0 mAdc, V _{CE} = 10 V _{dc})	MPS918	h _{FE}	20 20	— 200	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	MPS918	V _{CE(sat)}	—	0.4	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	MPS918	V _{BE(sat)}	—	1.0	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) (I _C = 4.0 mAdc, V _{CE} = 10 V _{dc} , f = 100 MHz) (I _C = 8.0 mAdc, V _{CE} = 10 V _{dc} , f = 100 MHz)	MPS918 MPS3563	f _T	600 600	— 1500	MHz
Output Capacitance (V _{CB} = 0 V _{dc} , I _E = 0, f = 140 kHz) (V _{CB} = 10 V _{dc} , I _E = 0, f = 140 kHz) (V _{CB} = 10 V _{dc} , I _E = 0, f = 1.0 MHz)	MPS918 MPS918 MPS3563	C _{obo}	— — —	3.0 1.7 1.7	pF
Input Capacitance (V _{EB} = 0.5 V _{dc} , I _C = 0, f = 140 kHz)	MPS918	C _{ibo}	—	2.0	pF
Small-Signal Current Gain (I _C = 8.0 mAdc, V _{CE} = 10 V _{dc} , f = 1.0 kHz)	MPS3563	h _{fe}	20	250	—
Noise Figure (I _C = 1.0 mAdc, V _{CE} = 6.0 V _{dc} , R _S = 400 ohms, f = 60 MHz)	MPS918	NF	—	6.0	dB

MPS918, MPS3563

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain ($I_C = 6.0\text{ mA}$, $V_{CB} = 12\text{ Vdc}$, $f = 200\text{ MHz}$) ($I_C = 8.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 200\text{ MHz}$) ($G_{fd} + G_{re} < -20\text{ dB}$)	MPS918	G_{pe}	15	—	dB
	MPS3563		14	—	
Power Output ($I_C = 8.0\text{ mA}$, $V_{CB} = 15\text{ Vdc}$, $f = 500\text{ MHz}$)	MPS918	P_{out}	30	—	mW
Oscillator Collector Efficiency ($I_C = 8.0\text{ mA}$, $V_{CB} = 15\text{ Vdc}$, $P_{out} = 30\text{ mW}$, $f = 500\text{ MHz}$)	MPS918	η	25	—	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 1.0\%$.

MAXIMUM RATINGS

Rating	Symbol	MPS2222	MPS2222A	Unit
Collector-Emitter Voltage	V _{CEO}	30	40	Vdc
Collector-Base Voltage	V _{CBO}	60	75	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I _C	600		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625	5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5	12	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

MPS2222

MPS2222A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	MPS2222 MPS2222A	V _{(BR)CEO}	30 40	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	MPS2222 MPS2222A	V _{(BR)CBO}	60 75	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	MPS2222 MPS2222A	V _{(BR)EBO}	5.0 6.0	— —	Vdc
Collector Cutoff Current (V _{CE} = 60 Vdc, V _{EB(off)} = 3.0 Vdc)	MPS2222A	I _{CEX}	—	10	nAdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0, T _A = 125°C) (V _{CB} = 50 Vdc, I _E = 0, T _A = 125°C)	MPS2222 MPS2222A MPS2222 MPS2222A	I _{CBO}	— — — —	0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	MPS2222A	I _{EBO}	—	10	nAdc
Base Cutoff Current (V _{CE} = 60 Vdc, V _{EB(off)} = 3.0 Vdc)	MPS2222A	I _{BL}	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 10 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc, T _A = -55°C) (I _C = 150 mAdc, V _{CE} = 10 Vdc)(1) (I _C = 150 mAdc, V _{CE} = 1.0 Vdc)(1) (I _C = 500 mAdc, V _{CE} = 10 Vdc)(1)	MPS2222A only MPS2222 MPS2222A	h _{FE}	35 50 75 35 100 50 30 40	— — — — 300 — — —	—
Collector-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	MPS2222 MPS2222A MPS2222 MPS2222A	V _{CE(sat)}	— — — —	0.4 0.3 1.6 1.0	Vdc

MPS2222, MPS2222A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	$V_{BE(sat)}$	—	1.3	Vdc
($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$)		0.6	1.2	
		—	2.6	
		—	2.0	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 20 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	250 300	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{ibo}	—	30 25	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ie}	2.0 0.25	8.0 1.25	k Ω
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{re}	—	8.0 4.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	50 75	300 375	—
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	5.0 25	35 200	μmhos
Collector Base Time Constant ($I_E = 20 \text{ mAdc}$, $V_{CB} = 20 \text{ Vdc}$, $f = 31.8 \text{ MHz}$)	$rb'C_C$	—	150	ps
Noise Figure ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 1.0 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$)	NF	4.0	4.0	dB

SWITCHING CHARACTERISTICS MPS2222A only

Delay Time	$(V_{CC} = 30 \text{ Vdc}$, $V_{BE(off)} = 0.5 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = 15 \text{ mAdc}$) (Figure 1)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	$(V_{CC} = 30 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = I_{B2} = 15 \text{ mAdc}$) (Figure 2)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

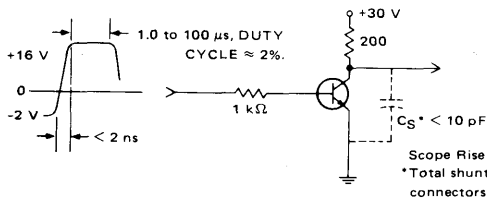


FIGURE 2 — TURN-OFF TIME

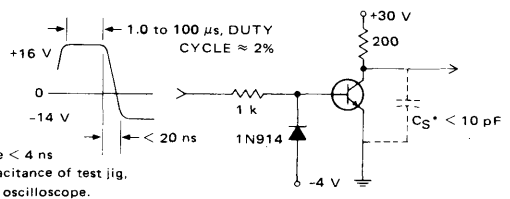


FIGURE 3 - DC CURRENT GAIN

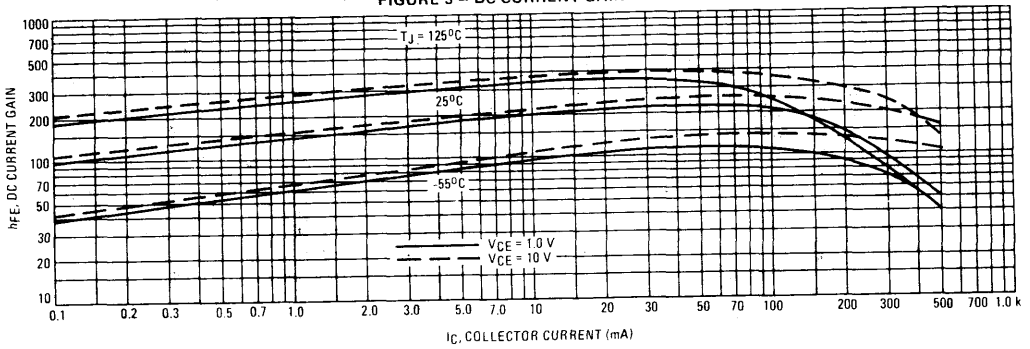


FIGURE 4 - COLLECTOR SATURATION REGION

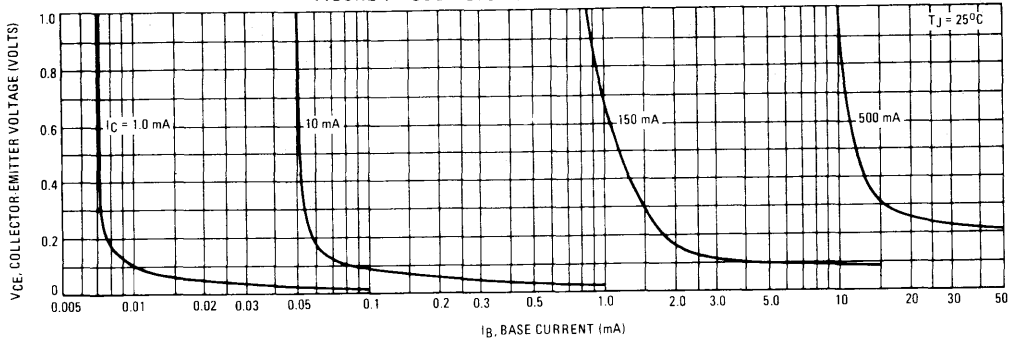


FIGURE 5 - TURN-ON TIME

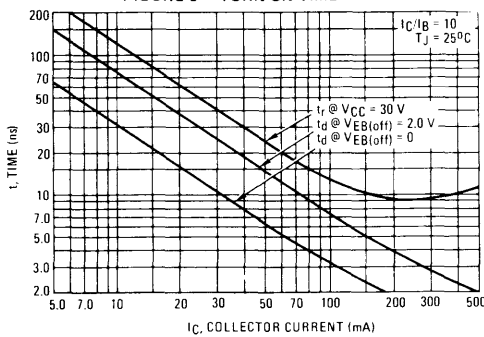


FIGURE 6 - TURN-OFF TIME

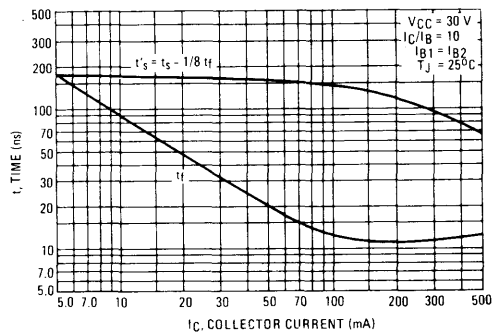


FIGURE 7 - FREQUENCY EFFECTS

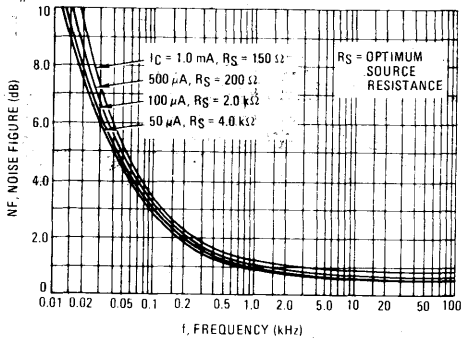


FIGURE 8 - SOURCE RESISTANCE EFFECTS

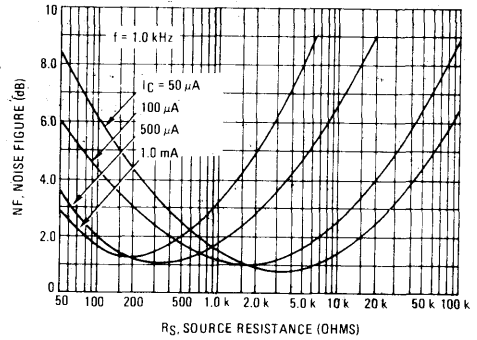


FIGURE 9 - CAPACITANCES

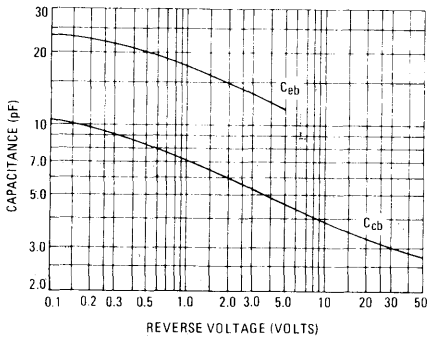


FIGURE 10 - CURRENT-GAIN BANDWIDTH PRODUCT

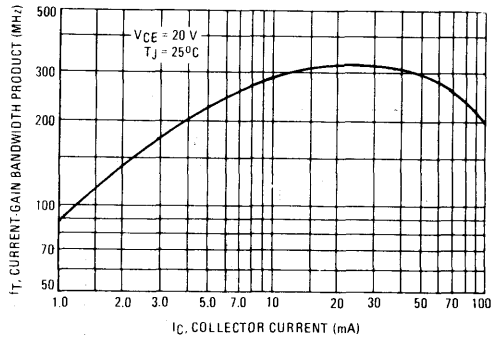


FIGURE 11 - "ON" VOLTAGES

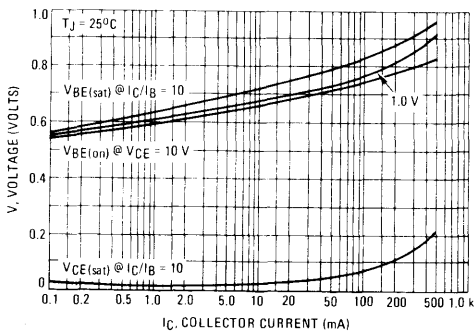
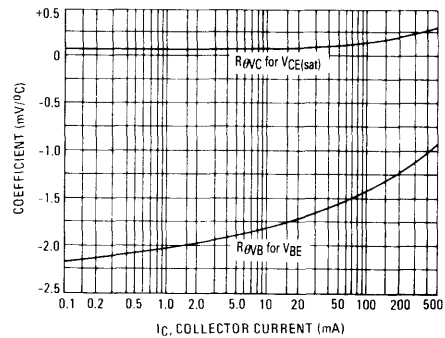


FIGURE 12 - TEMPERATURE COEFFICIENTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	15	Vdc
Collector-Emitter Voltage	V _{CES}	40	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	4.5	Vdc
Collector Current — Continuous	I _C	500	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

MPS2369

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

SWITCHING TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I _C = 10 μAdc, V _{BE} = 0)	V _{(BR)CES}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	4.5	—	—	Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0) (V _{CB} = 20 Vdc, I _E = 0, T _A = 125°C)	I _{CBO}	— —	— —	0.4 30	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I _C = 10 mAdc, V _{CE} = 1.0 Vdc) (I _C = 10 mAdc, V _{CE} = 1.0 Vdc, T _A = -55°C) (I _C = 100 mAdc, V _{CE} = 2.0 Vdc)	h _{FE}	40 20 20	— — —	120 — —	—
Collector-Emitter Saturation Voltage(1) (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	0.70	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	—	4.0	pF
Small-Signal Current Gain (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	h _{fe}	5.0	—	—	—
SWITCHING CHARACTERISTICS					
Storage Time (I _{B1} = I _{B2} = I _C = 10 mAdc) (Figure 3)	t _s	—	5.0	13	ns
Turn-On Time (V _{CC} = 3.0 Vdc, I _C = 10 mAdc, I _{B1} = 3.0 mAdc) (Figure 1)	t _{on}	—	8.0	12	ns
Turn-Off Time (V _{CC} = 3.0 Vdc, I _C = 10 mAdc, I _{B1} = 3.0 mAdc, I _{B2} = 1.5 mAdc) (Figure 2)	t _{off}	—	10	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

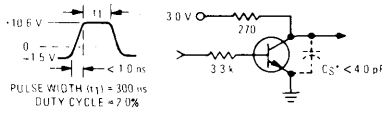


FIGURE 1 - t_{on} CIRCUIT

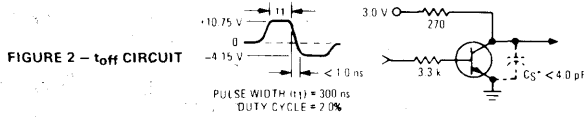


FIGURE 2 - t_{off} CIRCUIT

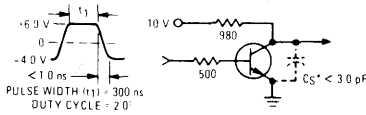


FIGURE 3 - STORAGE TEST CIRCUIT

*Total shunt capacitance of test jig and connectors.

MAXIMUM RATINGS

Rating	Symbol	MPS2907	MPS2907A	Unit
Collector-Emitter Voltage	V_{CE0}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

MPS2907 MPS2907A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE
TRANSISTOR

PNP SILICON

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10\text{ mAdc}, I_E = 0$)	$V_{(BR)CEO}$	40 60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}, V_{BE(off)} = 0.5\text{ Vdc}$)	I_{CEX}	—	50	nAdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}, I_E = 0$)	I_{CBO}	— —	0.020 0.010	μAdc
($V_{CB} = 50\text{ Vdc}, I_E = 0, T_A = 125^\circ\text{C}$)		— —	20 10	
Base Current ($V_{CE} = 30\text{ Vdc}, V_{BE(off)} = 0.5\text{ Vdc}$)	I_B	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.1\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	h_{FE}	35 75	— —	—
($I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)		50 100	— —	
($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)		75 100	— —	
($I_C = 150\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)(1)		100	300	
($I_C = 500\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)(1)		30 50	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.4 1.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$)	$V_{BE(sat)}$	— —	1.3 2.6	Vdc

MPS2907, MPS2907A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1),(2) ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 2.0\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS				
Turn-On Time	t_{on}	—	45	ns
Delay Time	t_d	—	10	ns
Rise Time	t_r	—	40	ns
Turn-Off Time	t_{off}	—	100	ns
Storage Time	t_s	—	80	ns
Fall Time	t_f	—	30	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — DELAY AND RISE TIME TEST CIRCUIT

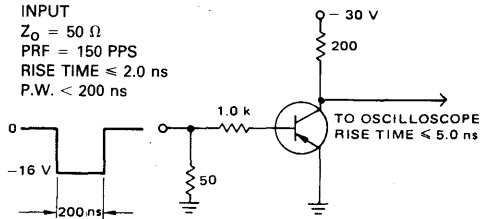
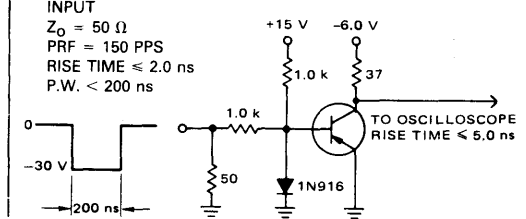


FIGURE 2 — STORAGE AND FALL TIME TEST CIRCUIT



TYPICAL CHARACTERISTICS

FIGURE 3 — DC CURRENT GAIN

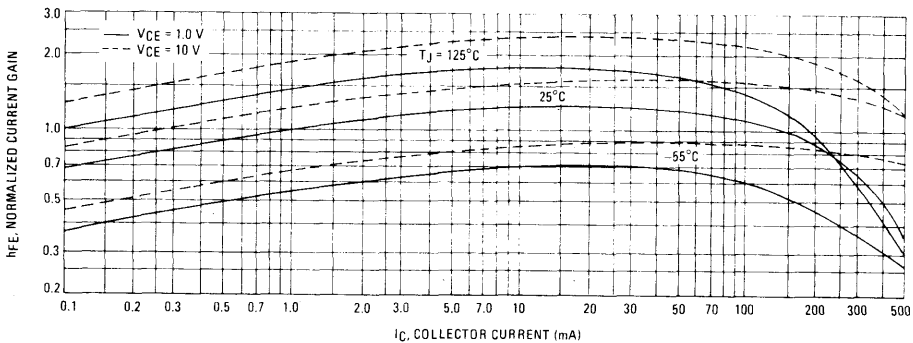


FIGURE 4 – COLLECTOR SATURATION REGION

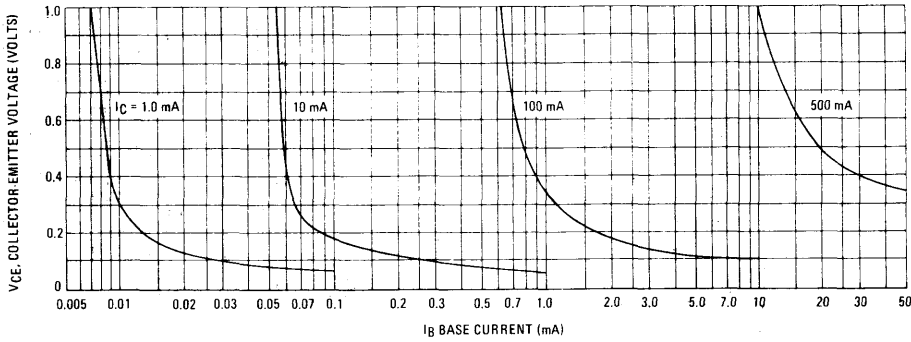


FIGURE 5 – TURN-ON TIME

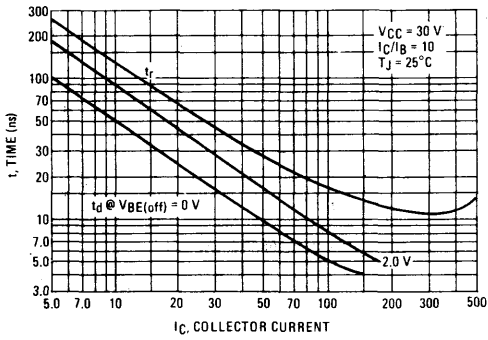
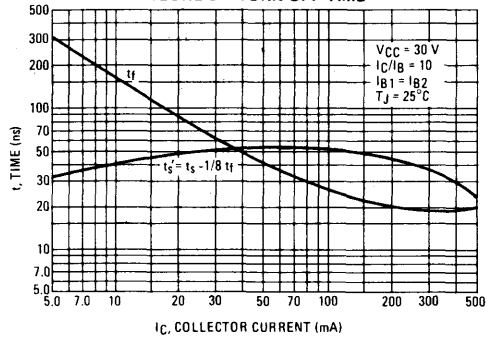


FIGURE 6 – TURN-OFF TIME



TYPICAL SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10$ Vdc, $T_A = 25^\circ\text{C}$

FIGURE 7 – FREQUENCY EFFECTS

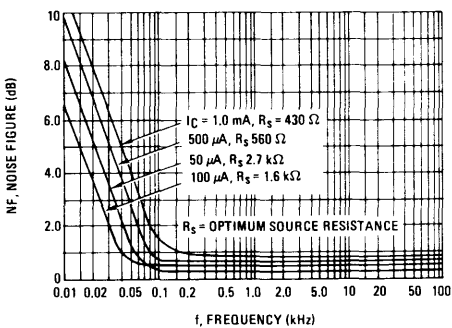
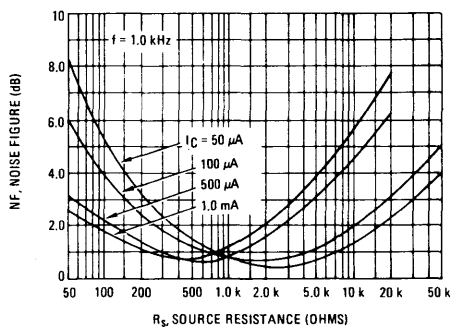


FIGURE 8 – SOURCE RESISTANCE EFFECTS



MPS2907, MPS2907A

2

FIGURE 9 - CAPACITANCES

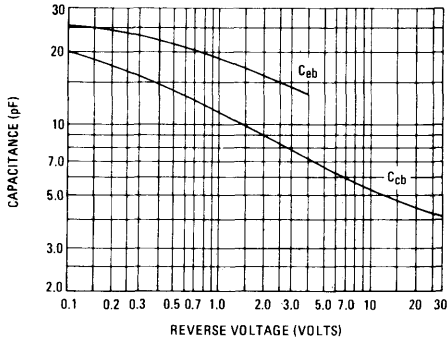


FIGURE 10 - CURRENT-GAIN - BANDWIDTH PRODUCT

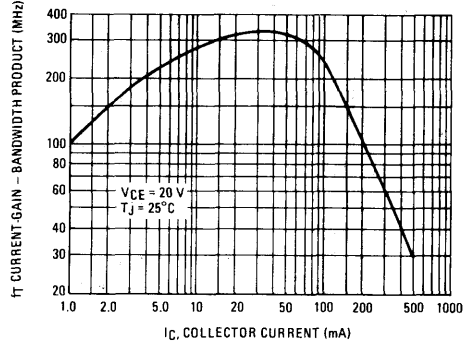


FIGURE 11 - "ON" VOLTAGE

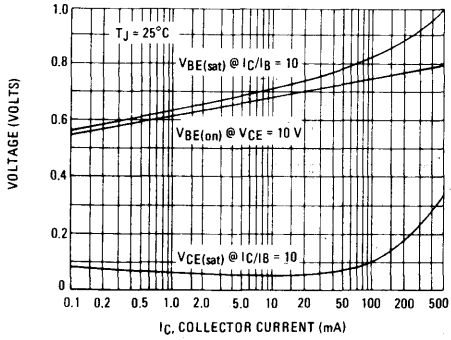
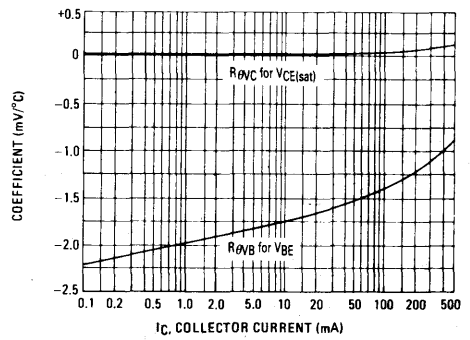


FIGURE 12 - TEMPERATURE COEFFICIENTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	25	Vdc
Collector-Emitter Voltage	V _{CES}	25	Vdc
Collector-Base Voltage	V _{CBO}	25	Vdc
Emitter-Base Voltage	V _{EBO}	40	Vdc
Collector Current — Continuous	I _C	500	mAdc
Total Device Dissipation @ T _A = 25°C	P _D	625	mW
Derate above 25°C		5.0	mW/°C
Total Device Dissipation @ T _C = 25°C	P _D	1.5	Watts
Derate above 25°C		12	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	200	°C/W

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

**MPS3638
MPS3638A**

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit			
OFF CHARACTERISTICS							
Collector-Emitter Breakdown Voltage (I _C = 100 μAdc, V _{BE} = 0)	V _{(BR)CES}	25	—	Vdc			
Collector-Emitter Sustaining Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{CEO(sus)}	25	—	Vdc			
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	25	—	Vdc			
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	4.0	—	Vdc			
Collector Cutoff Current (V _{CE} = 15 Vdc, V _{BE} = 0) (V _{CE} = 15 Vdc, V _{BE} = 0, T _A = -65°C)	I _{CES}	—	0.035 2.0	μAdc			
Emitter Cutoff Current (V _{EB} = 3.0 V, I _C = 0)	I _{EBO}	—	35	nA			
Base Current (V _{CE} = 15 Vdc, V _{BE} = 0)	I _B	—	0.035	μAdc			
ON CHARACTERISTICS(1)							
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	h _{FE}	80	—	—			
(I _C = 10 mAdc, V _{CE} = 10 Vdc)					MPS3638 MPS3638A	20 100	— —
(I _C = 50 mAdc, V _{CE} = 1.0 Vdc)					MPS3638 MPS3638A	30 100	— —
(I _C = 300 mAdc, V _{CE} = 2.0 Vdc)					MPS3638 MPS3638A	20 20	— —
Collector-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 2.5 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc)	V _{CE(sat)}	— —	0.25 1.0	Vdc			
Base-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 2.5 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc)	V _{BE(sat)}	— 0.80	1.1 2.0	Vdc			

MPS3638, MPS3638A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($V_{CE} = 3.0\text{ Vdc}$, $I_C = 50\text{ mAdc}$, $f = 100\text{ MHz}$)	MPS3638 MPS3638A	f_T	100 150	— —	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	MPS3638 MPS3638A	C_{obo}	— —	20 10	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	MPS3638 MPS3638A	C_{ibo}	— —	65 25	pF
Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{ie}	—	2000	Ω ms
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	MPS3638 MPS3638A	h_{re}	— —	26 15	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	MPS3638 MPS3638A	h_{fe}	25 100	— —	—
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{oe}	—	1.2	mmhos

SWITCHING CHARACTERISTICS

Delay Time	($V_{CC} = 10\text{ Vdc}$, $I_C = 300\text{ mAdc}$, $I_{B1} = 30\text{ mAdc}$)	t_d	—	20	ns
Rise Time		t_r	—	70	ns
Storage Time	($V_{CC} = 10\text{ Vdc}$, $I_C = 300\text{ mAdc}$, $I_{B1} = 30\text{ mAdc}$, $I_{B2} = 30\text{ mAdc}$)	t_s	—	140	ns
Fall Time		t_f	—	70	ns
Turn-On Time	($I_C = 300\text{ mAdc}$, $I_{B1} = 30\text{ mAdc}$)	t_{on}	—	75	ns
Turn-Off Time	($I_C = 300\text{ mAdc}$, $I_{B1} = 30\text{ mAdc}$, $I_{B2} = 30\text{ mAdc}$)	t_{off}	—	170	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	80	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

MPS3640

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

PNP SILICON

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}, V_{BE} = 0$)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0$) ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0, T_A = 65^\circ\text{C}$)	I_{CES}	— —	0.01 1.0	μAdc
Base Current ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0$)	I_B	—	10	nAdc

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 0.3 \text{ Vdc}$) ($I_C = 50 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30 20	120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}, T_A = 65^\circ\text{C}$)	$V_{CE(sat)}$	— — —	0.2 0.6 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 0.5 \text{ mAdc}$) ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$)	$V_{BE(sat)}$	0.75 0.8 —	0.95 1.0 1.5	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	500	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	3.5	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$)	C_{ibo}	—	3.5	pF

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 6.0 \text{ Vdc}, I_C = 50 \text{ mAdc}, V_{BE(off)} = 1.9 \text{ Vdc}, I_{B1} = 5.0 \text{ mAdc})$	t_d	—	10	ns
Rise Time		t_r	—	30	ns
Storage Time	$(V_{CC} = 6.0 \text{ Vdc}, I_C = 50 \text{ mAdc}, I_{B1} = I_{B2} = 5.0 \text{ mAdc})$	t_s	—	20	ns
Fall Time		t_f	—	12	ns
Turn-On Time	$(V_{CC} = 6.0 \text{ Vdc}, I_C = 50 \text{ mAdc}, V_{BE(off)} = 1.9 \text{ Vdc}, I_{B1} = 5.0 \text{ mAdc})$ $(V_{CC} = 1.5 \text{ Vdc}, I_C = 10 \text{ mAdc}, I_{B1} = 0.5 \text{ mAdc})$	t_{on}	—	25 60	ns
Turn-Off Time		$(V_{CC} = 6.0 \text{ Vdc}, I_C = 50 \text{ mAdc}, V_{BE(off)} = 1.9 \text{ Vdc}, I_{B1} = I_{B2} = 5.0 \text{ mAdc})$ $(V_{CC} = 1.5 \text{ Vdc}, I_C = 10 \text{ mAdc}, I_{B1} = I_{B2} = 0.5 \text{ mAdc})$	t_{off}	—	35 75

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1

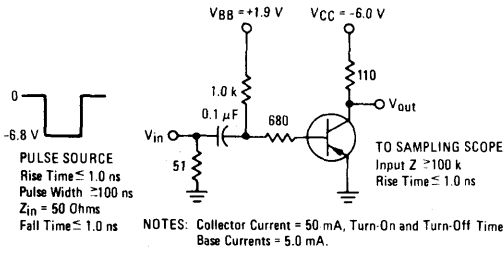


FIGURE 2

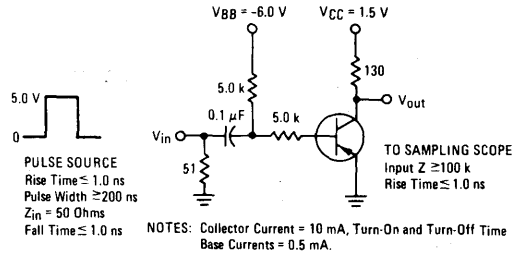


FIGURE 3 - DC CURRENT GAIN

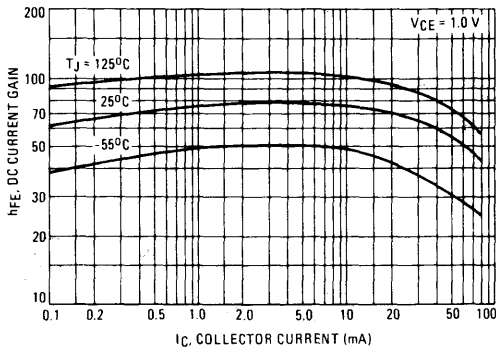


FIGURE 4 - "ON" VOLTAGES

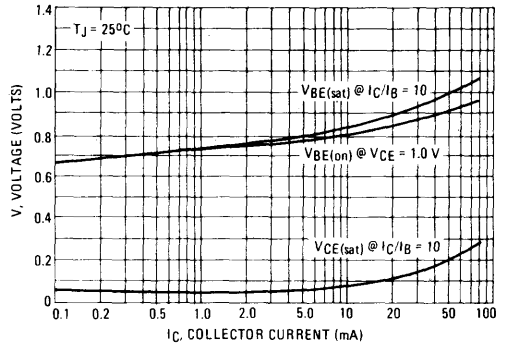


FIGURE 5 - COLLECTOR SATURATION REGION

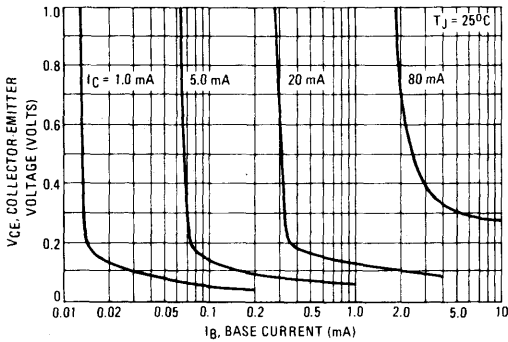


FIGURE 6 - TEMPERATURE COEFFICIENTS

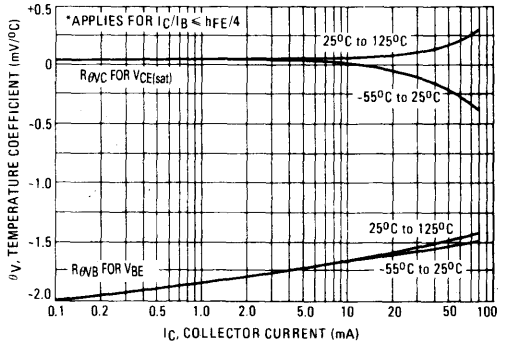


FIGURE 7 - CURRENT-GAIN-BANDWIDTH PRODUCT

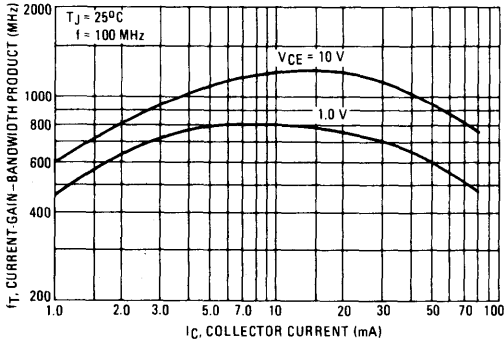
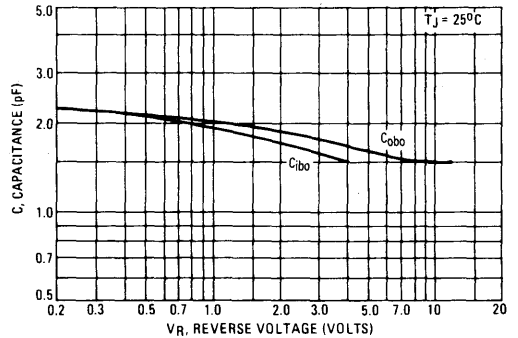


FIGURE 8 - CAPACITANCE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	15	Vdc
Collector-Emitter Voltage	V _{CES}	40	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous — 10 μs Pulse	I _C	300 500	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to + 150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

MPS3646

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N4264 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 100 μAdc, V _{BE} = 0)	V _{(BR)CES}	40	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{CEO(sus)}	15	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CE} = 20 Vdc, V _{BE} = 0) (V _{CE} = 20 Vdc, V _{BE} = 0, T _A = 65°C)	I _{CES}	—	0.5 3.0	μAdc

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 30 mAdc, V _{CE} = 0.4 Vdc) (I _C = 100 mAdc, V _{CE} = 0.5 Vdc) (I _C = 300 mA, V _{CE} = 1.0 Vdc)	h _{FE}	30 25 15	120 — —	—
Collector-Emitter Saturation Voltage (I _C = 30 mAdc, I _B = 3.0 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc) (I _C = 30 mA, I _B = 3.0 mA, T _A = 65°C)	V _{CE(sat)}	—	0.2 0.28 0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I _C = 30 mAdc, I _B = 3.0 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc) (I _C = 300 mAdc, I _B = 30 mA)	V _{BE(sat)}	0.73 — —	0.95 1.2 1.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 30 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	350	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	5.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	—	pF

SWITCHING CHARACTERISTICS

Turn-On Time	(V _{CC} = 10 Vdc, V _{BE(off)} = 3.0 Vdc, I _C = 300 mAdc, I _{B1} = 30 mAdc) (Figure 1)	t _{on}	—	18	ns
Delay Time		t _d	—	10	ns
Rise Time		t _r	—	15	ns
Turn-Off Time	(V _{CC} = 10 Vdc, I _C = 300 mAdc, I _{B1} = I _{B2} = 30 mAdc) (Figure 1)	t _{off}	—	28	ns
Fall Time		t _f	—	15	ns
Storage Time (V _{CC} = 10 Vdc, I _C = 10 mAdc, I _{B1} = I _{B2} = 10 mAdc) (Figure 2)		t _s	—	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

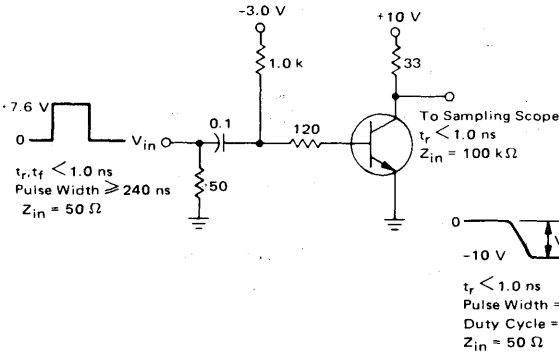
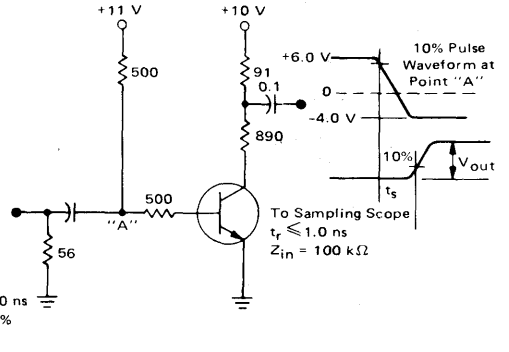


FIGURE 2 – CHARGE STORAGE TIME TEST CIRCUIT



MAXIMUM RATINGS

Rating	Symbol	MPS3702	MPS3703	Unit
Collector-Emitter Voltage	V _{CEO}	25	30	Vdc
Collector-Base Voltage	V _{CBO}	40	50	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	600		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625	5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

MPS3702

MPS3703

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	MPS3702 MPS3703	V _{(BR)CEO}	25 30	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	MPS3702 MPS3703	V _{(BR)CBO}	40 50	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)		V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0)		I _{CBO}	—	100	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)		I _{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I _C = 50 mAdc, V _{CE} = 5.0 Vdc)	MPS3702 MPS3703	h _{FE}	60 30	300 150	—
Collector-Emitter Saturation Voltage(1) (I _C = 50 mAdc, I _B = 5.0 mAdc)		V _{CE(sat)}	—	0.25	Vdc
Base-Emitter On Voltage(1) (I _C = 50 mAdc, V _{CE} = 5.0 Vdc)		V _{BE(on)}	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product (I _C = 50 mAdc, V _{CE} = 5.0 Vdc, f = 20 MHz)		f _T	100	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, f = 1.0 MHz)		C _{obo}	—	12	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MPS3704 thru MPS3706

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N4400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS3704	MPS3706	Unit
		MPS3705		
Collector-Emitter Voltage	V_{CEO}	30	20	Vdc
Collector-Base Voltage	V_{CBO}	50	40	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_E = 0$)	MPS3704 MPS3705 MPS3706	$V_{(BR)CEO}$	30 30 20	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	MPS3704 MPS3705 MPS3706	$V_{(BR)CBO}$	50 50 40	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}, I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}, I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 50 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$)	MPS3704 MPS3705 MPS3706	h_{FE}	100 50 30	300 150 600	—
Collector-Emitter Saturation Voltage(1) ($I_C = 100 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$)	MPS3704 MPS3705 MPS3706	$V_{CE(sat)}$	— — —	0.6 0.8 1.0	Vdc
Base-Emitter On Voltage(1) ($I_C = 100 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$)		$V_{BE(on)}$	0.5	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}, f = 20 \text{ MHz}$)		f_T	100	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)		C_{obo}	—	12	pF

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	25	Vdc
Collector-Base Voltage	V _{CBO}	25	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	100	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

MPS5172

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

AMPLIFIER TRANSISTOR

NPN SILICON*

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	25	—	—	Vdc
Collector Cutoff Current (V _{CB} = 25 Vdc, I _E = 0) (V _{CB} = 25 Vdc, I _E = 0, T _A = 100°C)	I _{CBO}	—	—	100 10	nAdc μAdc
Collector Cutoff Current (V _{CE} = 25 Vdc, V _{BE} = 0)	I _{CES}	—	—	100	nAdc
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I _C = 10 mAdc, V _{CE} = 10 Vdc)	h _{FE}	100	—	500	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	—	0.75	—	Vdc
Base-Emitter On Voltage (I _C = 10 mAdc, V _{CE} = 10 Vdc)	V _{BE(on)}	0.5	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 2.0 mAdc, V _{CE} = 5.0 Vdc)	f _T	—	120	—	MHz
Collector-Base Capacitance (V _{CB} = 0, I _E = 0, f = 1.0 MHz)	C _{cb}	1.6	—	10	pF
Small-Signal Current Gain (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	100	—	750	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

NPN
MPS6512
thru
MPS6515
PNP
MPS6516
thru
MPS6519

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

Refer to 2N4125 for graphs.

MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage MPS6512, MPS6513 MPS6514, MPS6515 MPS6516 thru MPS6518 MPS6519	V_{CE0}	30 25 — —	— — 40 25	Vdc
Collector-Base Voltage MPS6512 thru MPS6515 MPS6516 thru MPS6518 MPS6519	V_{CBO}	40 — —	— 40 25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	100	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0		mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12		Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 0.5 \text{ mAdc}, I_B = 0$)	MPS6512, MPS6513 MPS6514, MPS6515	$V_{(BR)CEO}$	30 25	— —	— —	Vdc
($I_C = 0.5 \text{ mAdc}, I_B = 0$)	MPS6516 thru MPS6518 MPS6519		40 25	— —	— —	
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$) ($I_E = 10 \mu\text{Adc}, I_C = 0$)		$V_{(BR)EBO}$	4.0 4.0	— —	— —	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$) ($V_{CB} = 30 \text{ Vdc}, I_E = 0$) ($V_{CB} = 20 \text{ Vdc}, I_E = 0$)	MPS6516 thru MPS6518 MPS6519	I_{CBO}	— — —	— — —	0.05 0.05 0.05	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 2.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MPS6512 MPS6513 MPS6514 MPS6515	h_{FE}	50 90 150 250	— — — —	100 180 300 500	—
($I_C = 100 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)(1)	MPS6512 MPS6513 MPS6514 MPS6515		30 60 90 150	— — — —	— — — —	
($I_C = 2.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MPS6516 MPS6517 MPS6518 MPS6519		50 90 150 250	— — — —	100 180 300 500	
($I_C = 100 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)(1)	MPS6516 MPS6517 MPS6518 MPS6519		30 60 90 150	— — — —	— — — —	
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$)		$V_{CE(sat)}$	— —	— —	0.5 0.5	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$) ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	— —	— —	3.5 4.0	pF
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(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage MPS6520, MPS6521 MPS6522, MPS6523	V _{CEO}	25 —	— 25	V _{dc}
Collector-Base Voltage MPS6520, MPS6521 MPS6522, MPS6523	V _{CBO}	40 —	— 25	V _{dc}
Emitter-Base Voltage	V _{EBO}	4.0		V _{dc}
Collector Current — Continuous	I _C	100		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0		mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	R _{θJA}	200	°C/W
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W

NPN
MPS6520
MPS6521

PNP
MPS6522
MPS6523

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

Refer to BC559 for PNP graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 0.5 mAdc, I _B = 0) (I _C = 0.5 mAdc, I _B = 0)	V _{(BR)CEO}	25 25	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0) (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	4.0 4.0	— —	V _{dc}
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 20 Vdc, I _E = 0)	I _{CBO}	— —	0.05 0.05	μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 100 μAdc, V _{CE} = 10 Vdc)	h _{FE}	MPS6520 MPS6521	100 150	— —	—
(I _C = 2.0 mAdc, V _{CE} = 10 Vdc)		MPS6520 MPS6521	200 300	400 600	
(I _C = 100 μAdc, V _{CE} = 10 Vdc)		MPS6522 MPS6523	100 150	— —	
(I _C = 2.0 mAdc, V _{CE} = 10 Vdc)		MPS6522 MPS6523	200 300	400 600	
Collector-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 5.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)	V _{CE(sat)}		— —	0.5 0.5	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz) (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	— —	3.5 3.5	pF
Noise Figure (I _C = 10 μAdc, V _{CE} = 5.0 Vdc, R _S = 10 kohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz) (I _C = 10 μAdc, V _{CE} = 5.0 Vdc, R _S = 10 kohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)	NF	— —	3.0 3.0	dB

MPS6530 thru MPS6532

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6530, MPS6531 MPS6532	V_{CE0}	40 30	Vdc
Collector-Base Voltage MPS6530, MPS6531 MPS6532	V_{CBO}	60 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	mW
Junction Temperature	T_J, T_{stg}	150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	$^\circ\text{C}/\text{mW}$

Refer to 2N4400 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}, I_B = 0$)	MPS6530, MPS6531 MPS6532	$V_{(BR)CEO}$	40 30	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	MPS6530, MPS6531 MPS6532	$V_{(BR)CBO}$	60 50	Vdc
Emitter-Base Breakdown Voltage ($I_B = 10 \mu\text{Adc}, I_C = 0$) ($I_B = 10 \mu\text{Adc}, I_C = 0$)	All Types All Types	$V_{(BR)EBO}$	5.0 4.0	Vdc
Collector Cutoff Current ($V_{CB} = 40 \text{ Vdc}, I_E = 0$) ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	MPS6530, MPS6531 MPS6532	I_{CBO}	— —	μAdc
($V_{CB} = 40 \text{ Vdc}, I_E = 0, T_A = 60^\circ\text{C}$) ($V_{CB} = 30 \text{ Vdc}, I_E = 0, T_A = 60^\circ\text{C}$)	MPS6530, MPS6531 MPS6532		— —	2.0 5.0

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	MPS6530 MPS6531	h_{FE}	30 60	— —	—
($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	MPS6530 MPS6531 MPS6532		40 90 30	120 270 —	
($I_C = 500 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MPS6530 MPS6531		25 50	— —	
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	MPS6530, MPS6532 MPS6531	$V_{CE(sat)}$	— —	0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	MPS6530, MPS6531 MPS6532	$V_{BE(sat)}$	— —	1.0 1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$) ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	All Types All Types	C_{obo}	— —	5.0 7.0	pF
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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6533, MPS6534 MPS6535	V_{CEO}	40 30	Vdc
Collector-Base Voltage MPS6533, MPS6534 MPS6535	V_{CBO}	40 30	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	mW
Junction Temperature	T_J, T_{stg}	150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	$^\circ\text{C}/\text{mW}$

MPS6533 thru MPS6535

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10\text{ mAdc}, I_B = 0$)	MPS6533, MPS6534 MPS6535	$V_{(BR)CEO}$	40 30	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}, I_E = 0$)	MPS6533, MPS6534 MPS6535	$V_{(BR)CBO}$	40 30	— —	Vdc
Emitter-Base Breakdown Voltage ($I_B = 10\ \mu\text{Adc}, I_C = 0$) ($I_B = 10\ \mu\text{Adc}, I_C = 0$)	All Types All Types	$V_{(BR)EBO}$	5.0 4.0	— —	Vdc
Collector Cutoff Current ($V_{CB} = 30\text{ Vdc}, I_E = 0$)	All Types	I_{CBO}	—	0.05	μAdc
($V_{CB} = 30\text{ Vdc}, I_E = 0, T_A = 60^\circ\text{C}$)	MPS6533, MPS6534		—	2.0	
($V_{CB} = 20\text{ Vdc}, I_E = 0, T_A = 60^\circ\text{C}$)	MPS6535		—	5.0	

ON CHARACTERISTICS

DC Current Gain ($I_C = 10\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$)	MPS6533 MPS6534	h_{FE}	30 60	— —	—
($I_C = 100\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$)	MPS6533 MPS6534 MPS6535		40 90 30	120 270 —	
($I_C = 500\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	MPS6533 MPS6534		25 50	— —	
Collector-Emitter Saturation Voltage ($I_C = 100\text{ mAdc}, I_B = 10\text{ mAdc}$)	MPS6533, MPS6535 MPS6534	$V_{CE(sat)}$	— —	0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 100\text{ mAdc}, I_B = 10\text{ mAdc}$)	MPS6533, MPS6534 MPS6535	$V_{BE(sat)}$	— —	1.0 1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$) ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$)	All Types All Types	C_{obo}	— —	5.0 7.0	pF
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NPN
MPS8098
MPS8099

PNP
MPS8598
MPS8599

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	MPS8098	MPS8099	Unit
		MPS8598	MPS8599	
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
		MPS8098	MPS8598	
		MPS8099	MPS8599	
Emitter-Base Voltage	V_{EBO}	6.0	5.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12.0	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

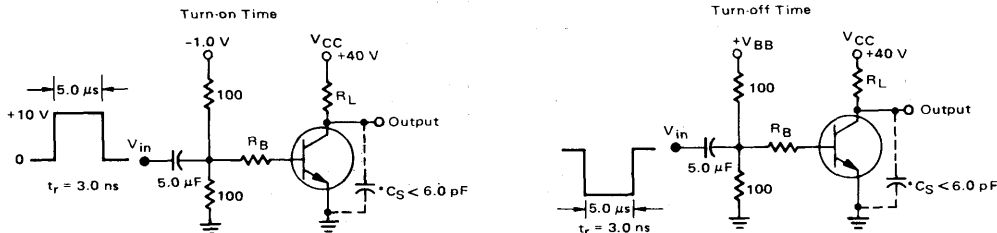
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10\text{ mAdc}, I_B = 0$)	MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CEO}$	60 80	— — Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}, I_E = 0$)	MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CBO}$	60 80	— — Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}, I_C = 0$)	MPS8098, MPS8099 MPS8598, MPS8599	$V_{(BR)EBO}$	6.0 5.0	— — Vdc
Collector Cutoff Current ($V_{CE} = 60\text{ Vdc}, I_B = 0$)		I_{CEO}	—	0.1 μAdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}, I_E = 0$) ($V_{CB} = 80\text{ Vdc}, I_E = 0$)	MPS8098, MPS8598 MPS8099, MPS8599	I_{CBO}	— —	0.1 0.1 μAdc
Emitter Cutoff Current ($V_{EB} = 6.0\text{ Vdc}, I_C = 0$) ($V_{EB} = 4.0\text{ Vdc}, I_C = 0$)	MPS8098, MPS8099 MPS8598, MPS8599	I_{EBO}	— —	0.1 0.1 μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 1.0\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}$) 0($I_C = 100\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}$)		h_{FE}	100 100 75	300 — — —
Collector-Emitter Saturation Voltage ($I_C = 100\text{ mAdc}, I_B = 5.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}, I_B = 10\text{ mAdc}$)		$V_{CE(sat)}$	— —	0.4 0.3 Vdc
Base-Emitter On Voltage ($I_C = 1.0\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}$)	MPS8098, MPS8598 MPS8099, MPS8599	$V_{BE(on)}$	0.5 0.6	0.7 0.8 Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}, f = 100\text{ MHz}$)		f_T	150	— MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$)	MPS8098, MPS8099 MPS8598, MPS8599	C_{obo}	— —	6.0 8.0 pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 1.0\text{ MHz}$)	MPS8098, MPS8099 MPS8598, MPS8599	C_{ibo}	— —	25 30 pF

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle = 2.0%.

NPN MPS8098, MPS8099, PNP MPS8598, MPS8599

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

FIGURE 2 – CURRENT-GAIN – BANDWIDTH PRODUCT

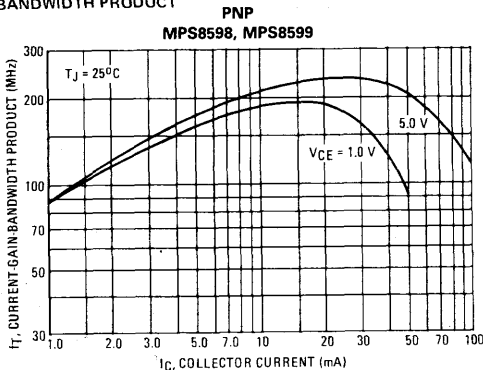
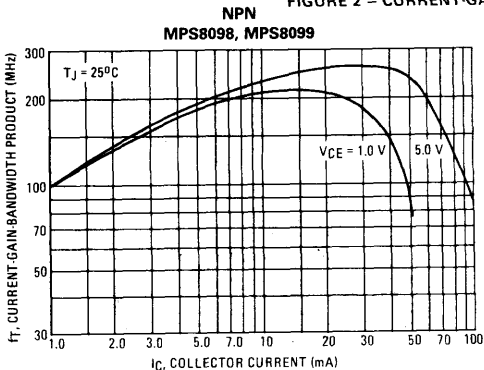


FIGURE 3 – CAPACITANCE

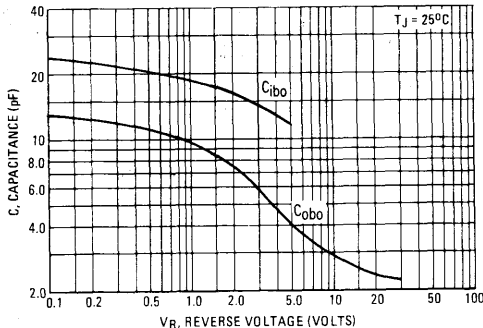
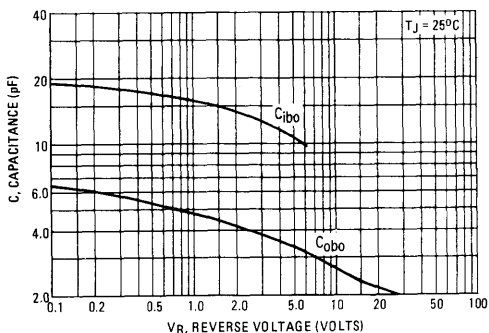
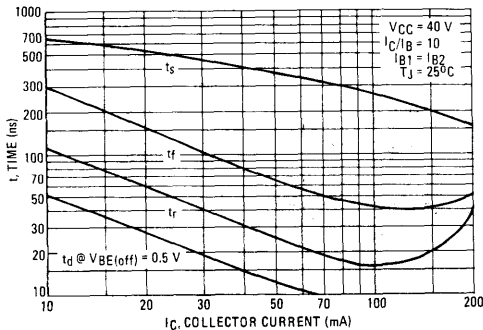
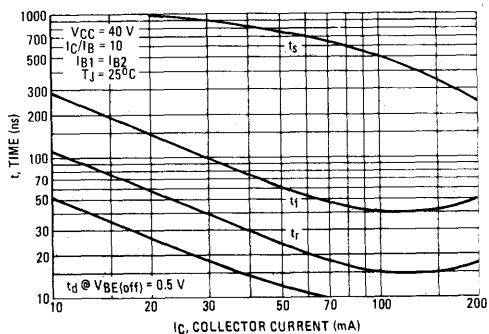
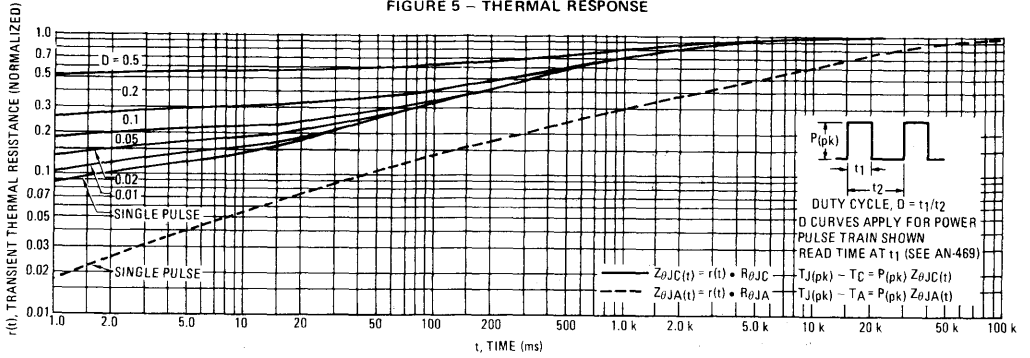


FIGURE 4 – SWITCHING TIMES

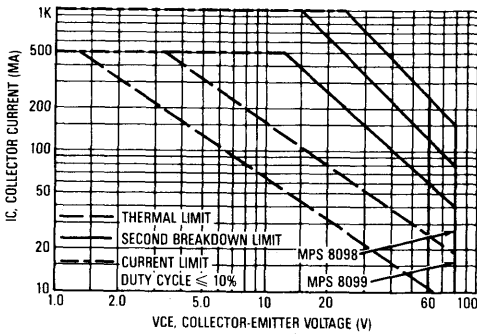


NPN MPS8098, MPS8099, PNP MPS8598, MPS8599

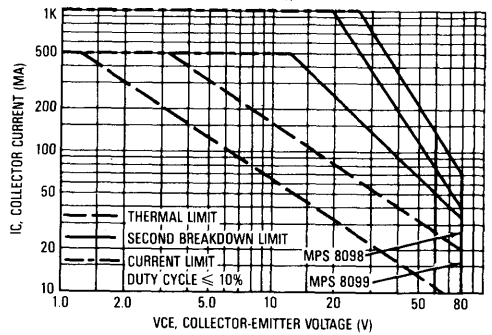
FIGURE 5 - THERMAL RESPONSE



**FIGURE 6—ACTIVE REGION, SAFE OPERATING AREA
MPS 8098, MPS 8099**

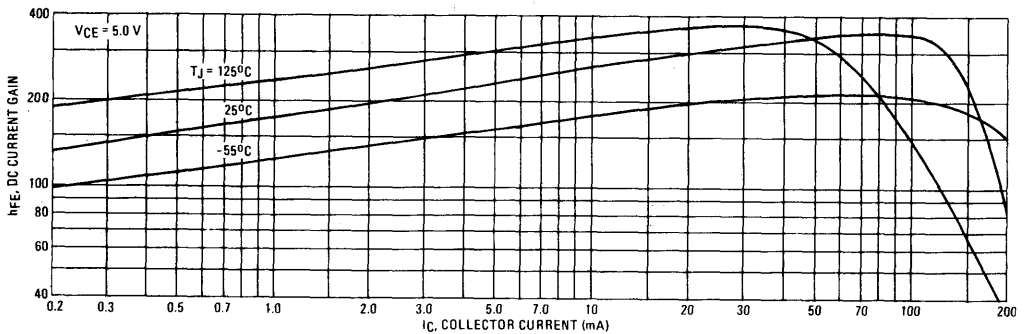


**FIGURE 6—ACTIVE REGION, SAFE OPERATING AREA
MPS 8598, MPS 8599**



MPS8098, MPS8099

FIGURE 7 - DC CURRENT GAIN



NPN MPS8098, MPS8099, PNP MPS8598, MPS8599

FIGURE 8 - "ON" VOLTAGES

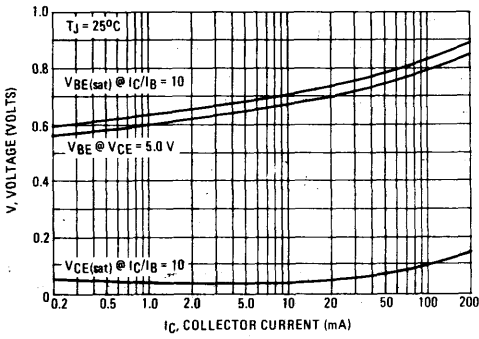


FIGURE 9 - COLLECTOR SATURATION REGION

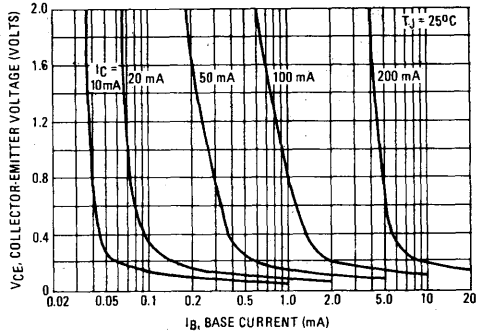
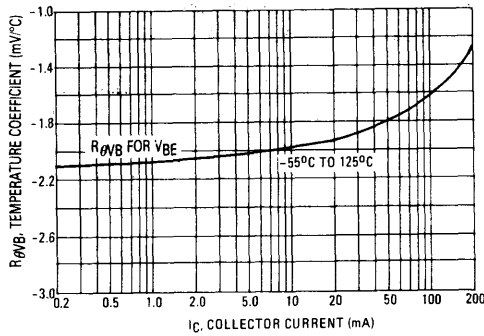


FIGURE 10 - BASE-EMITTER TEMPERATURE COEFFICIENT



MPS8598, MPS8599

FIGURE 11 - DC CURRENT GAIN

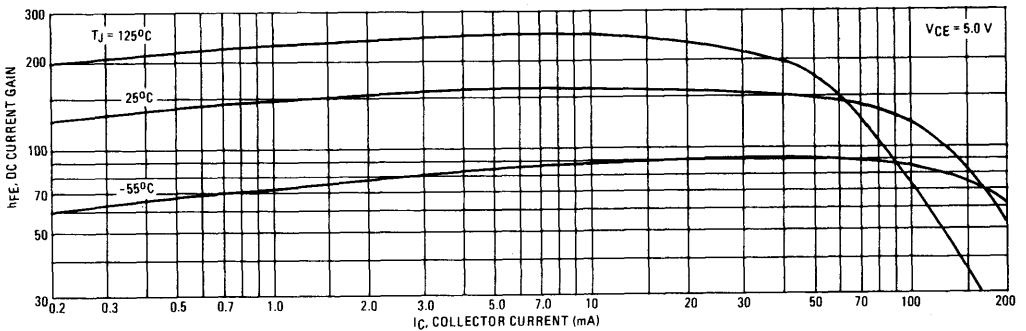


FIGURE 12 - "ON" VOLTAGES

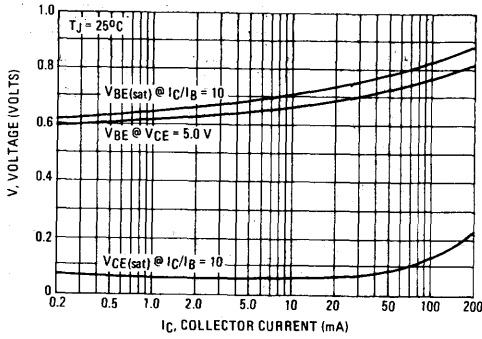


FIGURE 13 - COLLECTOR SATURATION REGION

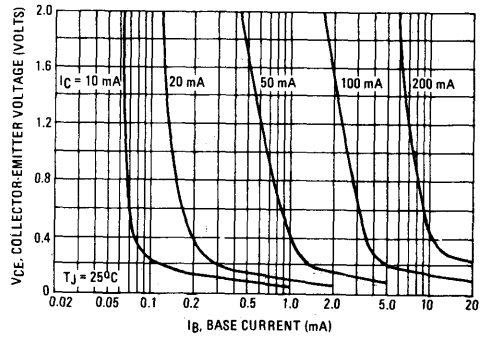
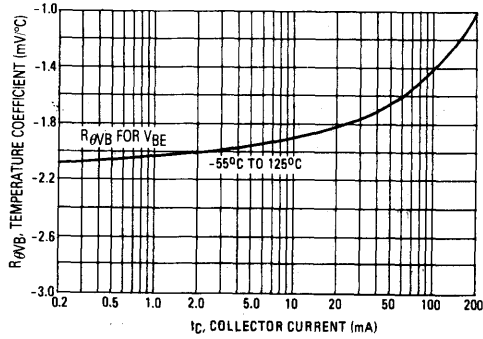


FIGURE 14 - BASE-EMITTER TEMPERATURE COEFFICIENT



MAXIMUM RATINGS

Rating	Symbol	MPSA05 MPSA55	MPSA06 MPSA56	Unit
Collector-Emitter Voltage	V_{CE0}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	60 80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 60 \text{ Vdc}, I_B = 0$)	I_{CEO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$) ($V_{CB} = 80 \text{ Vdc}, I_E = 0$)	I_{CBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	50 50	—	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) ($I_C = 10 \text{ mA}, V_{CE} = 2.0 \text{ V}, f = 100 \text{ MHz}$)	f_T	100	—	MHz
($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, f = 100 \text{ MHz}$)		50	—	

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.
 (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

NPN
MPSA05
MPSA06

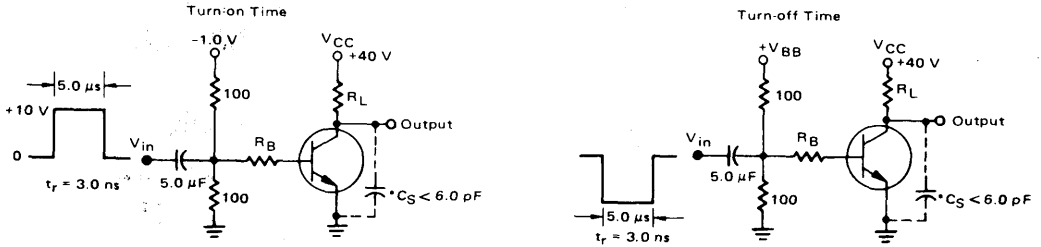
PNP
MPSA55
MPSA56

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN MPSA05, MPSA06, PNP MPSA55, MPSA56

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



* Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

FIGURE 2 – CURRENT GAIN-BANDWIDTH PRODUCT

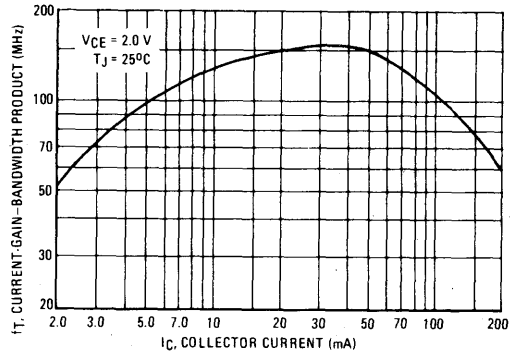
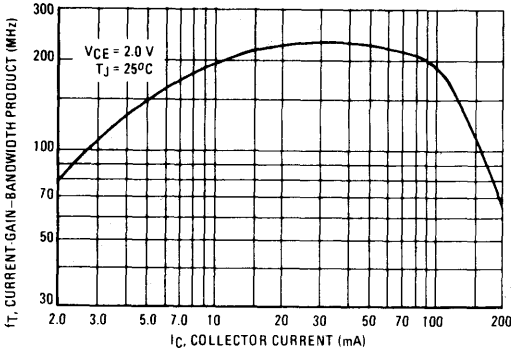
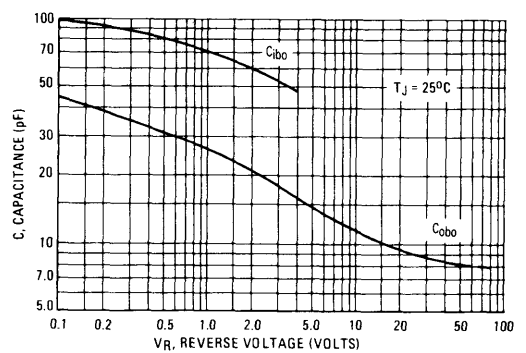
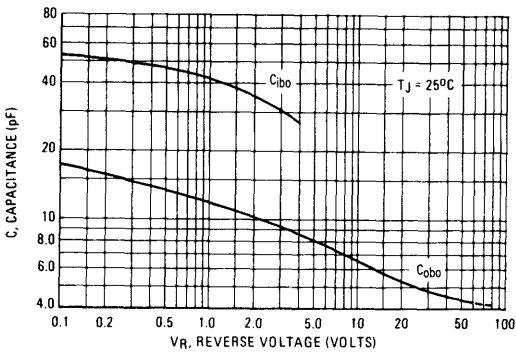


FIGURE 3 – CAPACITANCE



NPN MPSA05, MPSA06, PNP MPSA55, MPSA56

FIGURE 4 – SWITCHING TIME

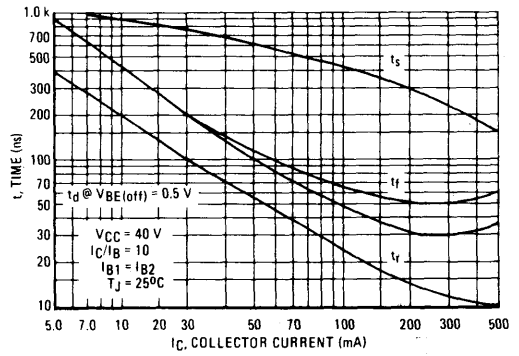
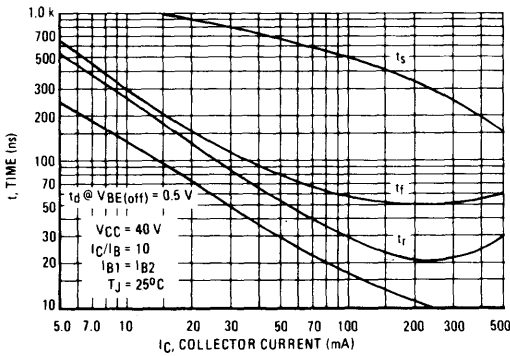


FIGURE 5 – THERMAL RESPONSE

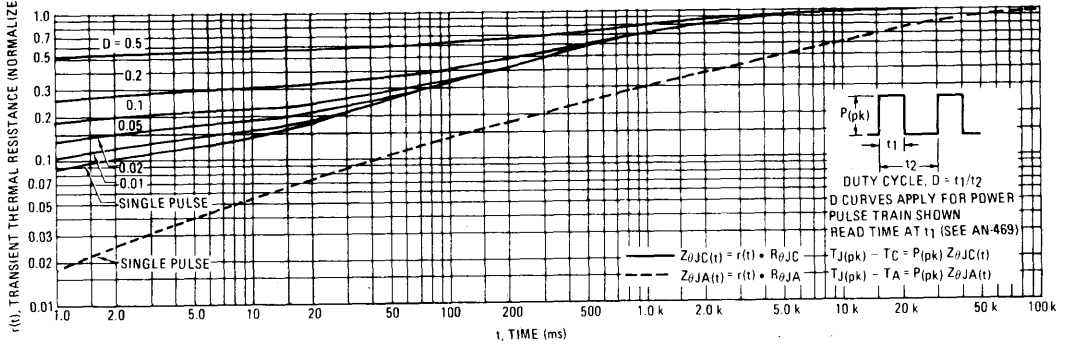
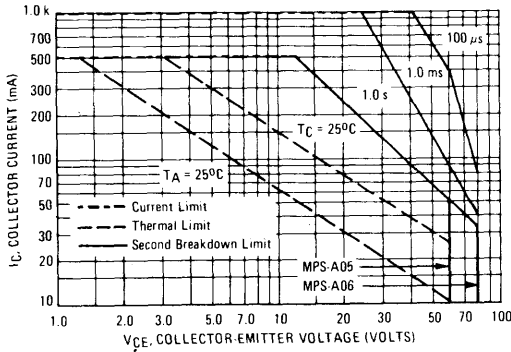
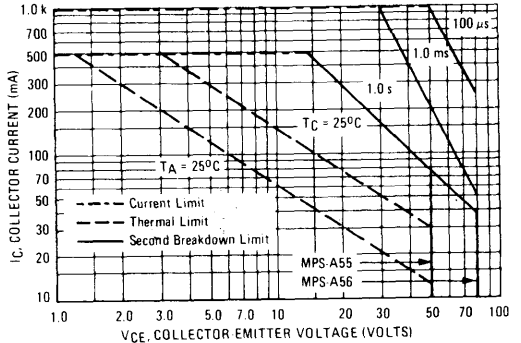


FIGURE 6 – ACTIVE – REGION SAFE OPERATING AREA

MPS-A05, MPS-A06



MPS-A55, MPS-A56



NPN MPSA05, MPSA06, PNP MPSA55, MPSA56

NPN
MPS-A05, MPS-A06

2

FIGURE 7 - DC CURRENT GAIN

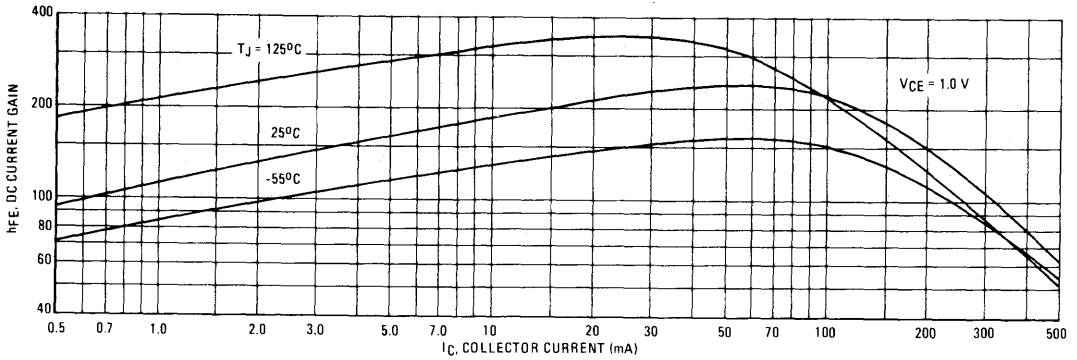


FIGURE 8 - "ON" VOLTAGES

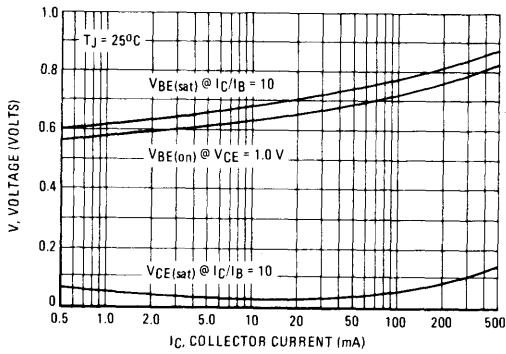


FIGURE 9 - COLLECTOR SATURATION REGION

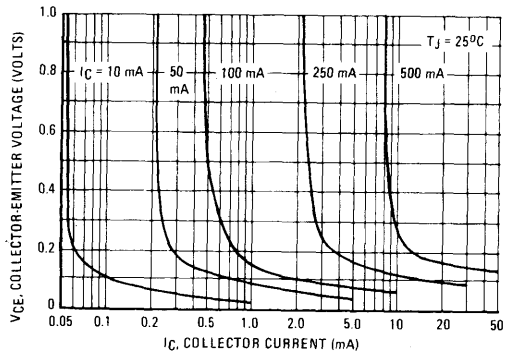
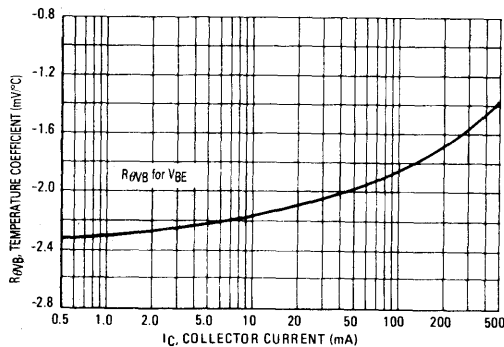


FIGURE 10 - BASE-EMITTER TEMPERATURE COEFFICIENT



NPN MPSA05, MPSA06, PNP MPSA55, MPSA56

**PNP
MPS-A55, MPS-A56**

FIGURE 11 – DC CURRENT GAIN

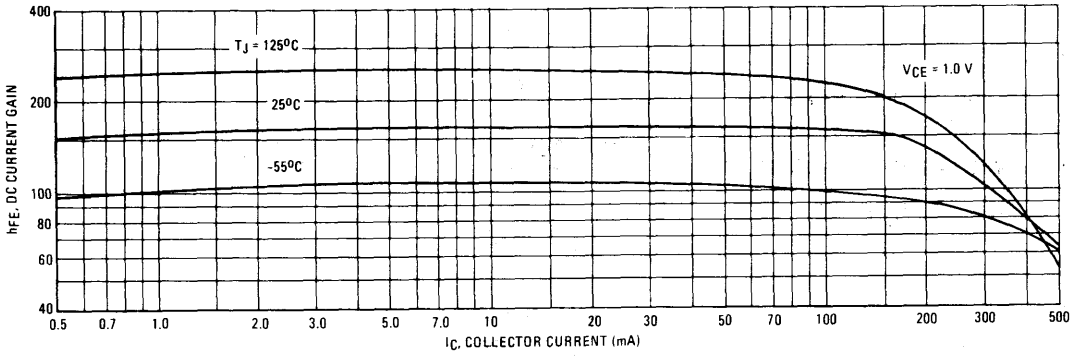


FIGURE 12 – "ON" VOLTAGES

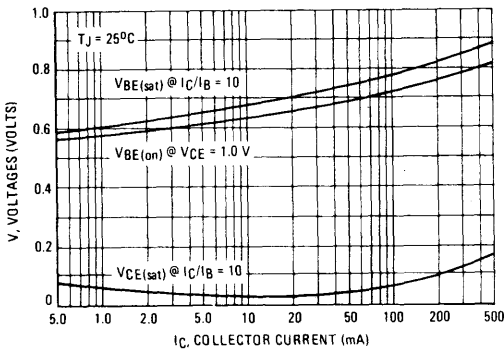


FIGURE 13 – COLLECTOR SATURATION REGION

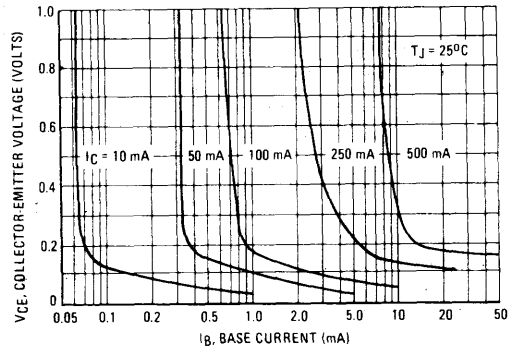
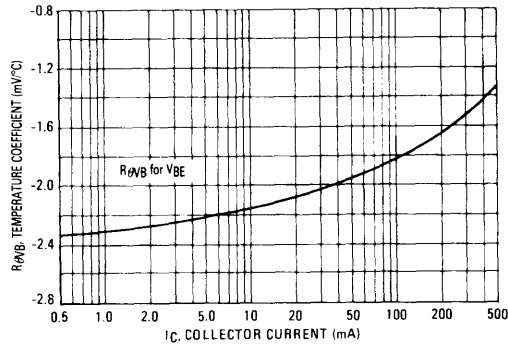


FIGURE 14 – BASE-EMITTER TEMPERATURE COEFFICIENT



MPSA12

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	20	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

Refer to 2N6426 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_B = 0$)	$V_{(BR)CES}$	20	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{Vdc}, I_E = 0$)	I_{CBO}	—	—	100	nAdc
Collector Cutoff Current ($V_{CE} = 15 \text{Vdc}, V_{BE} = 0$)	I_{CES}	—	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10 \text{Vdc}, I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10 \text{mAdc}, V_{CE} = 5.0 \text{Vdc}$)	h_{FE}	20,000	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{mAdc}, I_B = 0.01 \text{mAdc}$)	$V_{CE(sat)}$	—	—	1.0	Vdc
Base-Emitter On Voltage ($I_C = 10 \text{mAdc}, V_{CE} = 5.0 \text{Vdc}$)	V_{BE}	—	—	1.4	Vdc

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CES}	30	Vdc
Collector-Base Voltage	V _{CBO}	30	Vdc
Emitter-Base Voltage	V _{EBO}	10	Vdc
Collector Current — Continuous	I _C	500	mAdc
Total Device Dissipation @ T _A = 25°C	P _D	625	mW
Derate above 25°C		5.0	mW/°C
Total Device Dissipation @ T _C = 25°C	P _D	1.5	Watts
Derate above 25°C		12	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**MPSA13
MPSA14**

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 100 μAdc, I _B = 0)	V _{(BR)CES}	30	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	100	nAdc
Emitter Cutoff Current (V _{BE} = 10 Vdc, I _C = 0)	I _{EBO}	—	100	nAdc

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	MPSA13 MPSA14	h _{FE}	5000	—	—
			10,000	—	—
(I _C = 100 mAdc, V _{CE} = 5.0 Vdc)	MPSA13 MPSA14		10,000 20,000	—	—
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 0.1 mAdc)	V _{CE(sat)}	—	1.5	Vdc	
Base-Emitter On Voltage (I _C = 100 mAdc, V _{CE} = 5.0 Vdc)	V _{BE}	—	2.0	Vdc	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)	f _T	125	—	MHz
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(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) f_T = |h_{fe}| · f_{test}.

MPSA16 MPSA17

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS-A16	MPS-A17	Unit
Collector-Emitter Voltage	V_{CE0}	40		Vdc
Emitter-Base Voltage	V_{EBO}	12	15	Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	12 15	—	Vdc
				MPS-A16 MPS-A17
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	200	600	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	100 80	—	MHz
				MPS-A16 MPS-A17
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{obo}	—	4.0	pF

FIGURE 1 - DC CURRENT GAIN

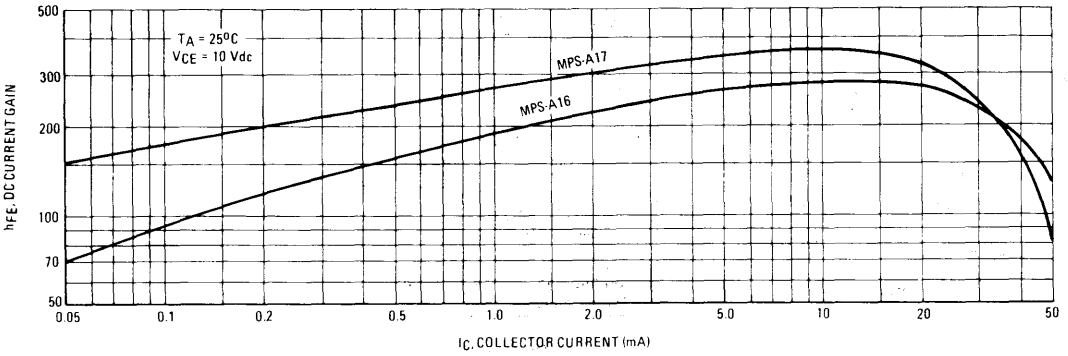


FIGURE 2 - SMALL SIGNAL CURRENT GAIN

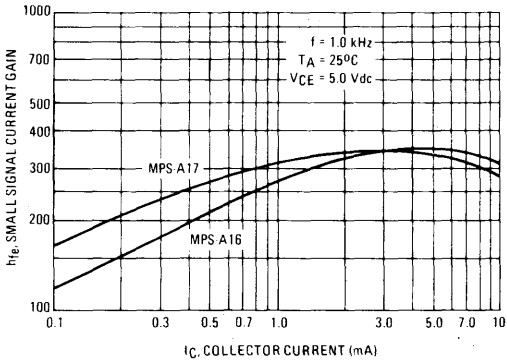


FIGURE 3 - SATURATION AND ON VOLTAGES

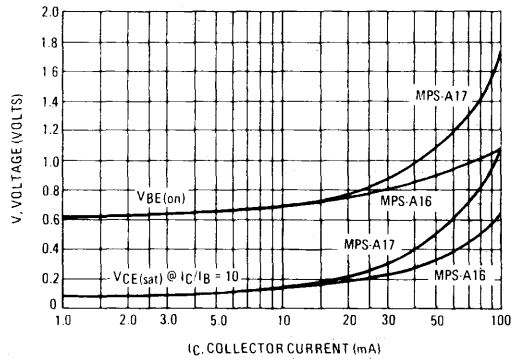


FIGURE 4 - CURRENT-GAIN-BANDWIDTH PRODUCT

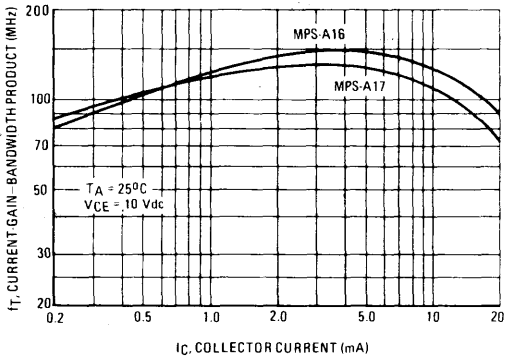
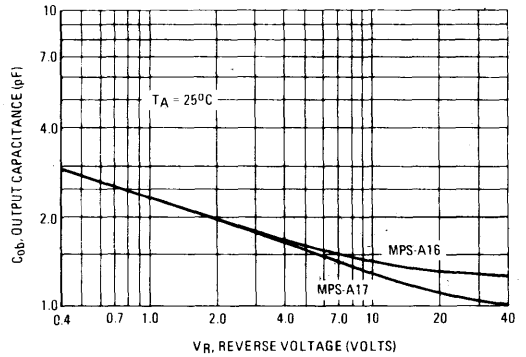


FIGURE 5 - OUTPUT CAPACITANCE



MPSA18

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

LOW NOISE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	45	Vdc
Collector-Base Voltage	V _{CBO}	45	Vdc
Emitter-Base Voltage	V _{EBO}	6.5	Vdc
Collector Current — Continuous	I _C	200	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	200	°C/W

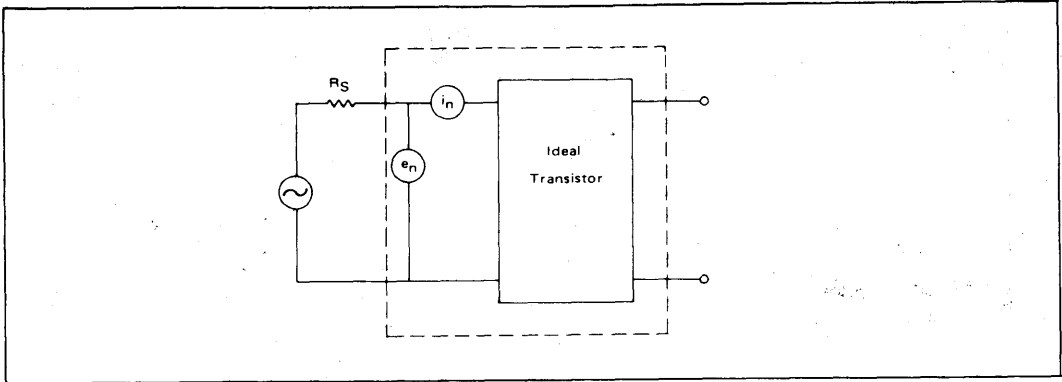
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	45	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	45	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.5	—	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	1.0	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I _C = 10 μAdc, V _{CE} = 5.0 Vdc) (I _C = 100 μAdc, V _{CE} = 5.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	400 500 500 500	580 850 1100 1150	— — — 1500	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)	V _{CE(sat)}	— —	— 0.08	0.2 0.3	Vdc
Base-Emitter On Voltage (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)	V _{BE(on)}	—	0.6	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)	f _T	100	160	—	MHz
Collector-Base Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	1.7	3.0	pF
Emitter-Base Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{eb}	—	5.6	6.5	pF
Noise Figure (I _C = 100 μAdc, V _{CE} = 5.0 Vdc, R _S = 10 kΩ, f = 10 Hz to 15.7 kHz) (I _C = 100 μAdc, V _{CE} = 5.0 Vdc, R _S = 1.0 kΩ, f = 100 Hz)	NF	— —	0.5 4.0	1.5 —	dB
Equivalent Short Circuit Noise Voltage (I _C = 100 μAdc, V _{CE} = 5.0 Vdc, R _S = 1.0 kΩ, f = 100 Hz)	V _T	—	6.5	—	nV/√Hz

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS
($V_{CE} = 5.0 \text{ Vdc}$, $T_A = 25^\circ\text{C}$)

NOISE VOLTAGE

FIGURE 2 – EFFECTS OF FREQUENCY

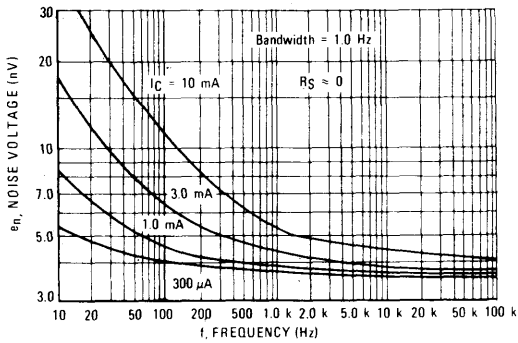


FIGURE 3 – EFFECTS OF COLLECTOR CURRENT

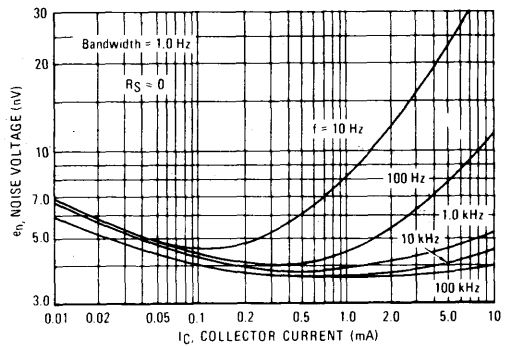


FIGURE 4 – NOISE CURRENT

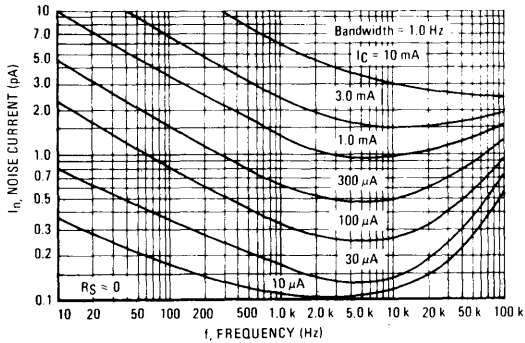
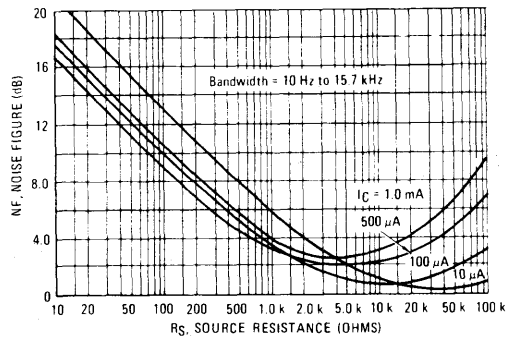


FIGURE 5 – WIDEBAND NOISE FIGURE



100 Hz NOISE DATA

FIGURE 6 - TOTAL NOISE VOLTAGE

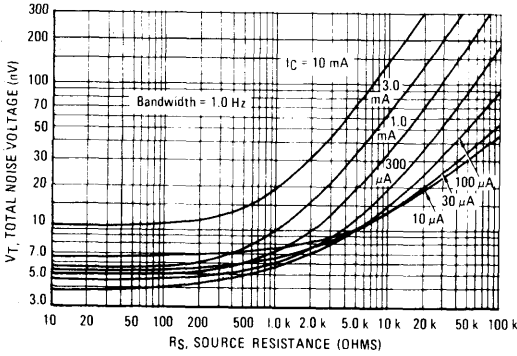


FIGURE 7 - NOISE FIGURE

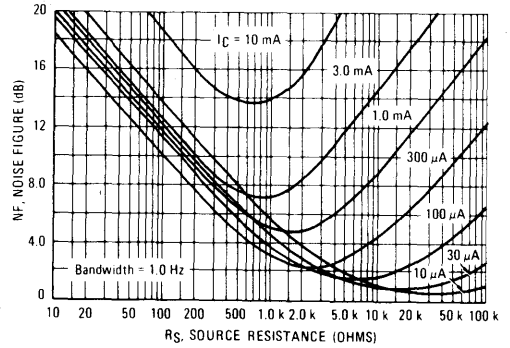


FIGURE 8 - DC CURRENT GAIN

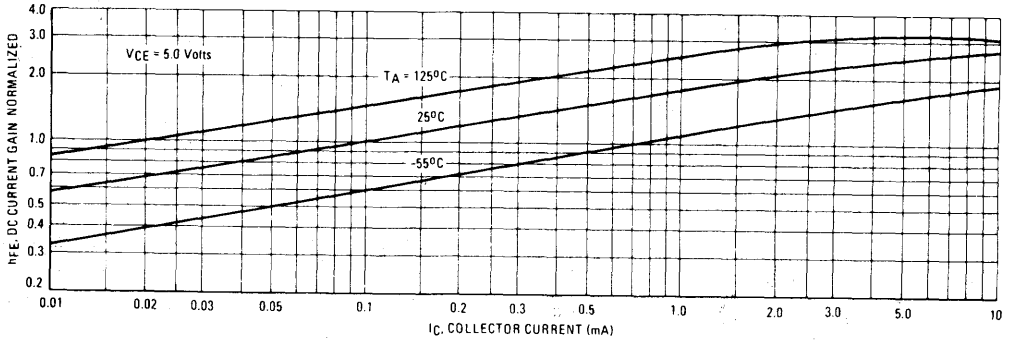


FIGURE 9 - "ON" VOLTAGES

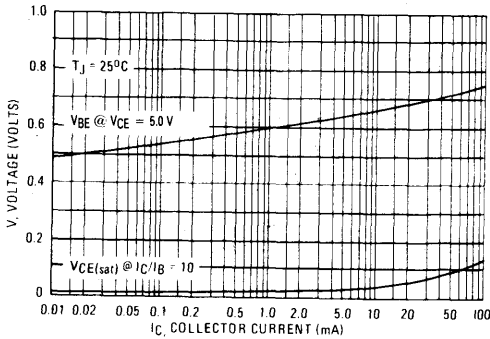
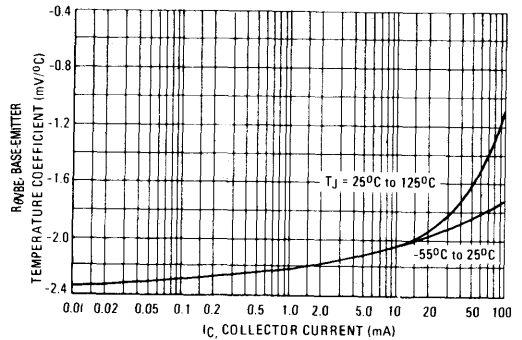


FIGURE 10 - TEMPERATURE COEFFICIENTS



MPSA18

FIGURE 11 – CAPACITANCE

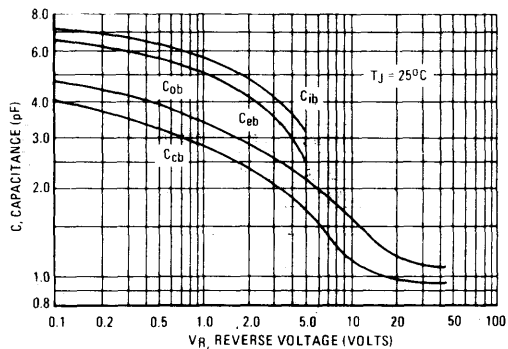
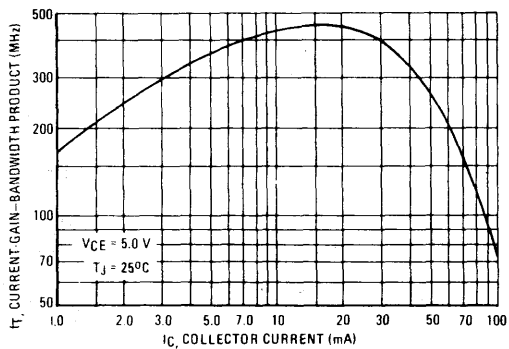


FIGURE 12 – CURRENT-GAIN-BANDWIDTH PRODUCT



MPSA25 MPSA26 MPSA27

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS-A25	MPS-A26	MPS-A27	Unit
Collector-Emitter Voltage	$V_{CE\bar{S}}$	40	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	10			Vdc
Collector Current — Continuous	I_C	500			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0			mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}, V_{BE} = 0$)	$V_{(BR)CES}$	MPSA25 40 MPSA26 50 MPSA27 60	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	MPSA25 40 MPSA26 50 MPSA27 60	— — —	— — —	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ V}, I_E = 0$) ($V_{CB} = 40 \text{ V}, I_E = 0$) ($V_{CB} = 50 \text{ V}, I_E = 0$)	I_{CBO}	MPSA25 — MPSA26 — MPSA27 —	— — —	100 100 100	nAdc
Collector Cutoff Current ($V_{CE} = 30 \text{ V}, V_{BE} = 0$) ($V_{CE} = 40 \text{ V}, V_{BE} = 0$) ($V_{CE} = 50 \text{ V}, V_{BE} = 0$)	I_{CES}	MPSA25 — MPSA26 — MPSA27 —	— — —	500 500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10 \text{ mA}, V_{CE} = 5.0 \text{ V}$) ($I_C = 100 \text{ mA}, V_{CE} = 5.0 \text{ V}$)	h_{FE}	10,000 10,000	— —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mA}, I_B = 0.1 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ mA}, V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small Signal Current Gain ($I_C = 10 \text{ mA}, V_{CE} = 5.0 \text{ V}, f = 100 \text{ MHz}$)	h_{fe}	1.25	2.4	—	—

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MPSA25, MPSA26, MPSA27

FIGURE 1 — DC CURRENT GAIN

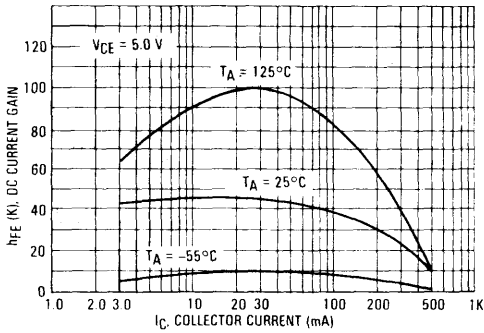


FIGURE 2 — "ON" VOLTAGES

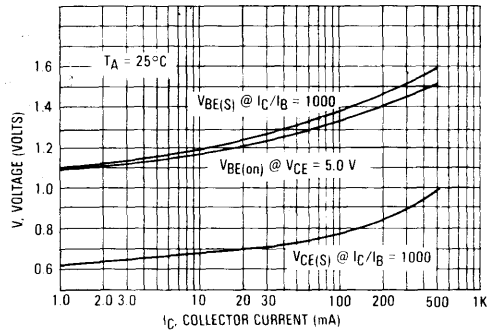


FIGURE 3 — COLLECTOR SATURATION REGION

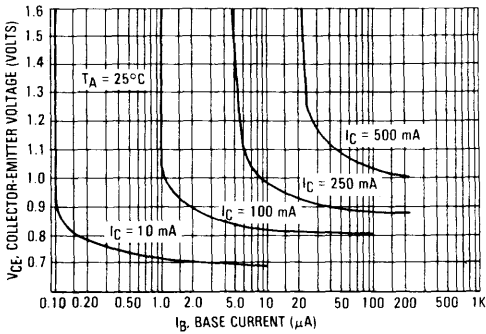


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

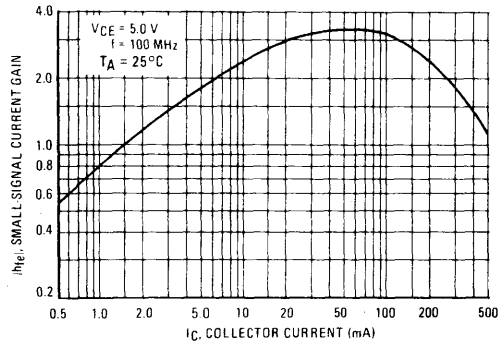
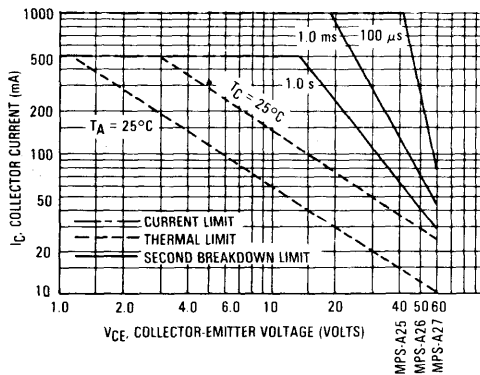


FIGURE 5 — ACTIVE REGION SAFE OPERATING AREA



MPSA28 MPSA29

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA28	MPSA29	Unit
Collector-Emitter Voltage	V_{CES}	80	100	Vdc
Collector-Base Voltage	V_{CBO}	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}, V_{BE} = 0$)	MPSA28 MPSA29	$V_{(BR)CES}$	80 100	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	MPSA28 MPSA29	$V_{(BR)CBO}$	80 100	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	Both Types	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$) ($V_{CB} = 80 \text{ Vdc}, I_E = 0$)	MPSA28 MPSA29	I_{CBO}	— —	— 100	nAdc
Collector Cutoff Current ($V_{CE} = 60 \text{ Vdc}, V_{BE} = 0$) ($V_{CE} = 80 \text{ Vdc}, V_{BE} = 0$)	MPSA28 MPSA29	I_{CES}	— —	— 500	nAdc
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}, I_C = 0$)	Both Types	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	Both Types Both Types	h_{FE}	10,000 10,000	— —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 0.01 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 0.1 \text{ mAdc}$)	Both Types Both Types	$V_{CE(sat)}$	— —	0.7 0.8	1.2 1.5
Base-Emitter On Voltage ($I_C = 100 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	Both Types	$V_{BE(on)}$	—	1.4	2.0
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 100 \text{ MHz}$)	Both Types	f_T	125	200	—
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	Both Types	C_{obo}	—	5.0	8.0

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) $f_T = h_{fe} \cdot f_{test}$.

FIGURE 1 — DC CURRENT GAIN

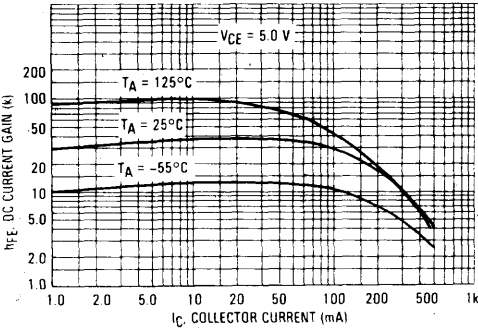


FIGURE 2 — ON VOLTAGES

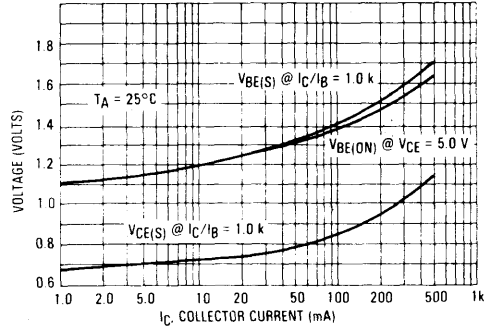


FIGURE 3 — TEMPERATURE COEFFICIENTS

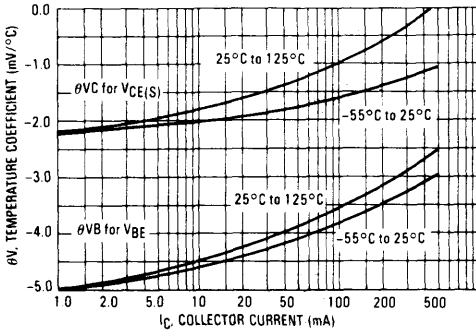


FIGURE 4 — COLLECTOR SATURATION REGION

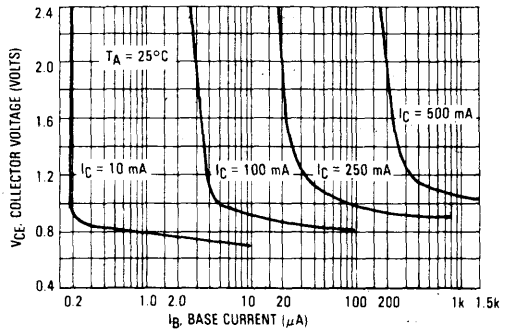


FIGURE 5 — ACTIVE REGION — SAFE OPERATING AREA

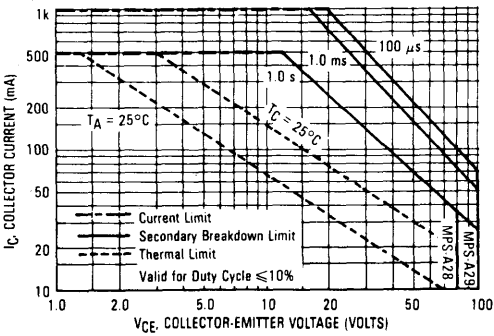
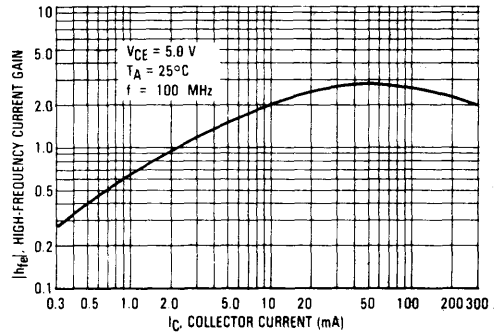


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN



MPSA42 MPSA43

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA42	MPSA43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	MPSA42 MPSA43 $V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	MPSA42 MPSA43 $V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200 \text{ Vdc}, I_E = 0$) ($V_{CB} = 160 \text{ Vdc}, I_E = 0$)	MPSA42 MPSA43 I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 6.0 \text{ Vdc}, I_C = 0$) ($V_{BE} = 4.0 \text{ Vdc}, I_C = 0$)	MPSA42 MPSA43 I_{EBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 30 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	Both Types Both Types MPSA42 MPSA43 h_{FE}	25 40 40 40	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)	MPSA42 MPSA43 $V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	MPSA42 MPSA43 C_{cb}	— —	3.0 4.0	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 - DC CURRENT GAIN

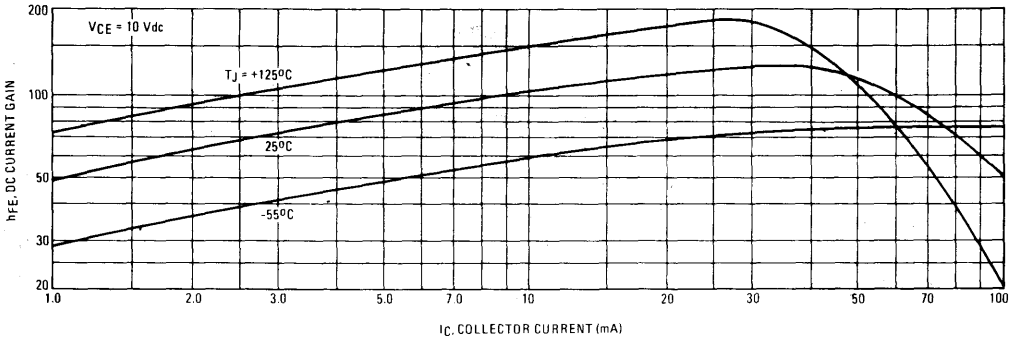


FIGURE 2 - CAPACITANCES

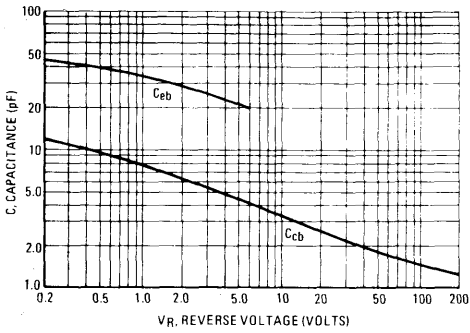


FIGURE 3 - CURRENT-GAIN-BANDWIDTH PRODUCT

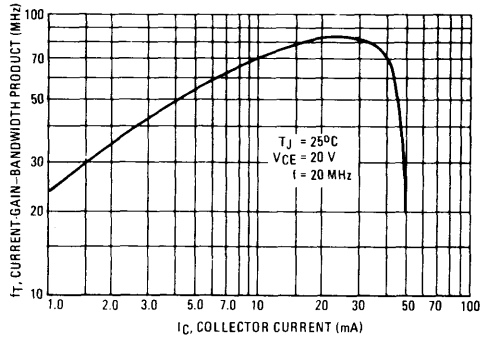


FIGURE 4 - "ON" VOLTAGES

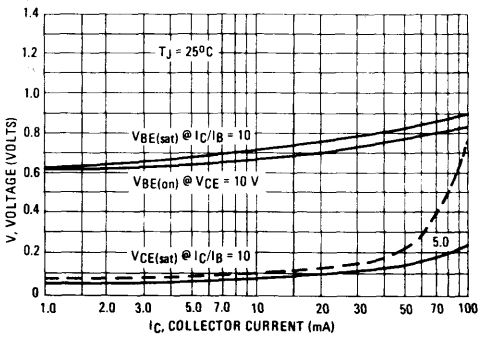
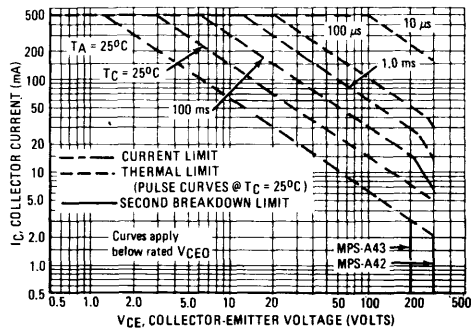


FIGURE 5 - MAXIMUM FORWARD BIAS SAFE OPERATING AREA



MPSA44 MPSA45

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA44	MPSA45	Unit
Collector-Emitter Voltage	V_{CE0}	400	350	Vdc
Collector-Base Voltage	V_{CBO}	500	400	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	300		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$. Derate above 25°C	P_D	625	5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$. Derate above 25°C	P_D	1.5	12	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	400 350	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc , $V_{BE} = 0$)	$V_{(BR)CES}$	500 400	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc , $I_E = 0$)	$V_{(BR)CBO}$	500 400	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc , $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 400$ Vdc, $I_E = 0$) ($V_{CB} = 320$ Vdc, $I_E = 0$)	I_{CBO}	— —	0.1 0.1	μAdc
Collector Cutoff Current ($V_{CE} = 400$ Vdc, $V_{BE} = 0$) ($V_{CE} = 320$ Vdc, $V_{BE} = 0$)	I_{CES}	— —	500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain(1) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40 50 45 40	— 200 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	— — —	0.4 0.5 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 1.0$ MHz)	C_{ibo}	—	110	pF
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 10$ MHz)	h_{fe}	2.0	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs , Duty Cycle $\leq 2.0\%$.

MPSA55, MPSA56

For Specifications, See MPSA05

MPSA44, MPSA45

FIGURE 1 — DC CURRENT GAIN

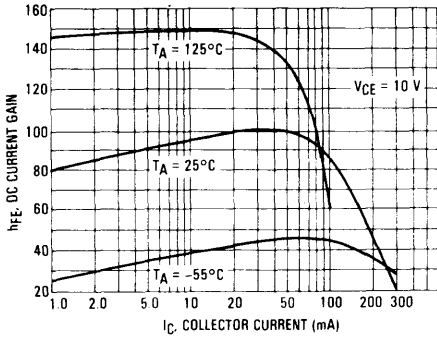


FIGURE 2 — COLLECTOR SATURATION REGION

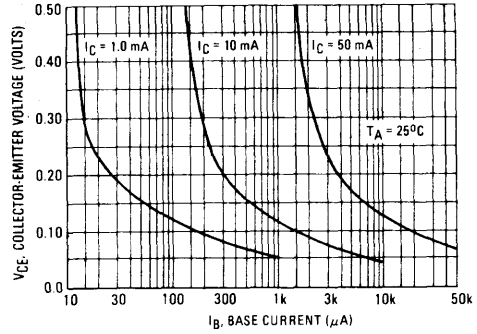


FIGURE 3 — ON VOLTAGES

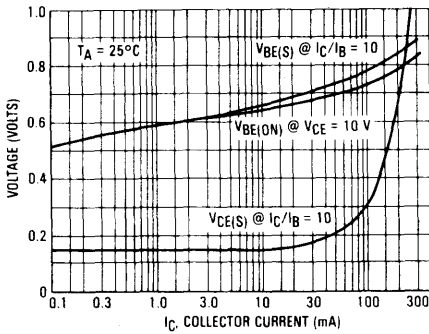


FIGURE 4 — ACTIVE REGION — SAFE OPERATING AREA

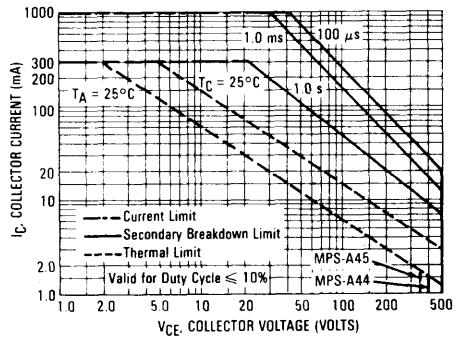


FIGURE 5 — CAPACITANCE

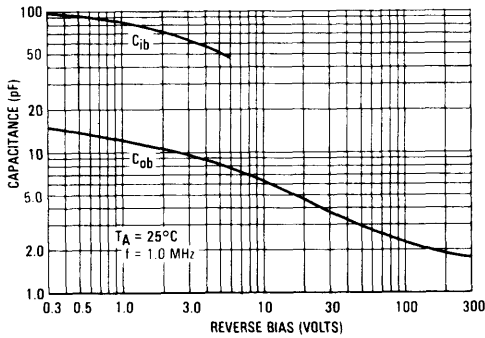


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN

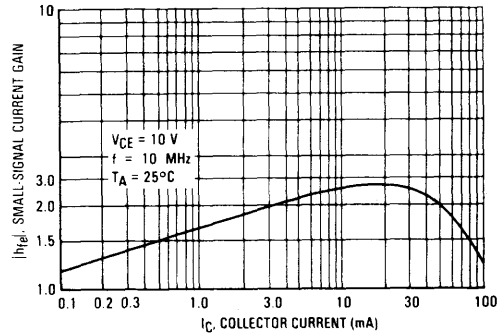


FIGURE 7 — TURN-ON SWITCHING TIMES AND TEST CIRCUIT

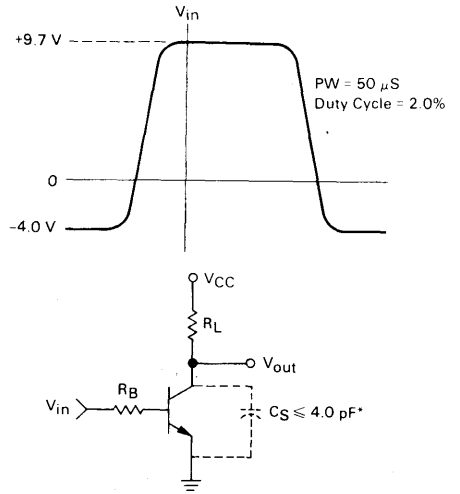
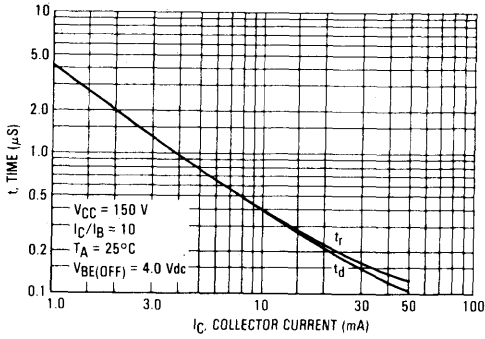
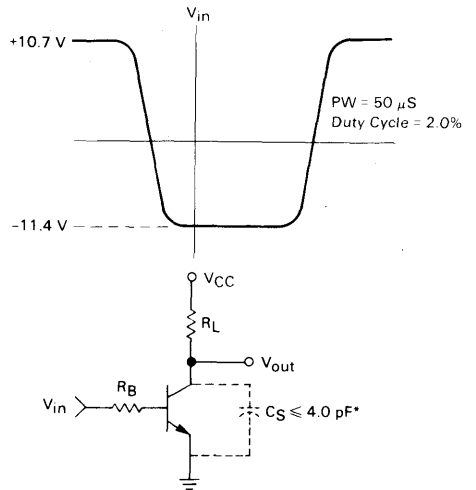
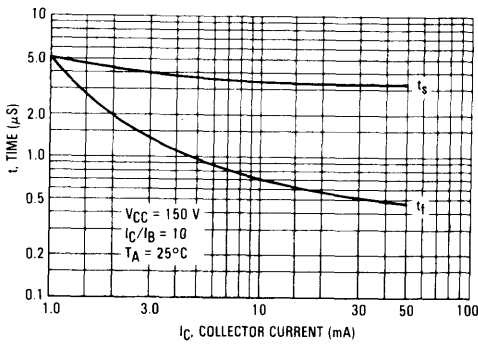


FIGURE 8 — TURN-OFF SWITCHING TIMES AND TEST CIRCUIT



*Total Shunt Capacitance of Test Jig and Connectors.

MAXIMUM RATINGS

Rating	Symbol	MPSA62	MPSA63 MPSA64	Unit
Collector-Emitter Voltage	V _{CES}	20	30	Vdc
Collector-Base Voltage	V _{CBO}	20	30	Vdc
Emitter-Base Voltage	V _{EBO}	10		Vdc
Collector Current — Continuous	I _C	500		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0		mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to + 150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**MPSA62
MPSA63
MPSA64**

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

DARLINGTON TRANSISTOR

PNP SILICON

Refer to MPSA75 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 100 μAdc, V _{BE} = 0)	V _{(BR)CES}	20 30	— —	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0) (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	— —	100 100	nAdc
Emitter Cutoff Current (V _{BE} = 10 Vdc, I _C = 0)	I _{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	5000 10,000 20,000	— — —	—
(I _C = 100 mAdc, V _{CE} = 5.0 Vdc)		10,000 20,000	— —	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.01 mAdc) (I _C = 100 mAdc, I _B = 0.1 mAdc)	V _{CE(sat)}	— —	1.0 1.5	Vdc
Base-Emitter On Voltage (I _C = 10 mAdc, V _{CE} = 5.0 Vdc) (I _C = 100 mAdc, V _{CE} = 5.0 Vdc)	V _{BE(on)}	— —	1.4 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I _C = 100 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)	f _T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) f_T = |h_{FE}| · f_{test}.

MPSA75
MPSA76
MPSA77

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA75	MPSA76	MPSA77	Unit
Collector-Emitter Voltage	V_{CES}	40	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	10			Vdc
Collector Current — Continuous	I_C	500			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0			mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $V_{BE} = 0$)	MPSA75 MPSA76 MPSA77 $V_{(BR)CES}$	40 50 60	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	MPSA75 MPSA76 MPSA77 $V_{(BR)CBO}$	40 50 60	— — —	— — —	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ V}$, $I_E = 0$) ($V_{CB} = 40 \text{ V}$, $I_E = 0$) ($V_{CB} = 50 \text{ V}$, $I_E = 0$)	MPSA75 MPSA76 MPSA77 I_{CBO}	— — —	— — —	100 100 100	nAdc
Collector Cutoff Current ($V_{CE} = 30 \text{ V}$, $V_{BE} = 0$) ($V_{CE} = 40 \text{ V}$, $V_{BE} = 0$) ($V_{CE} = 50 \text{ V}$, $V_{BE} = 0$)	MPSA75 MPSA76 MPSA77 I_{CES}	— — —	— — —	500 500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$) ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$)	h_{FE}	10,000 10,000	— —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mA}$, $I_B = 0.1 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$)	V_{BE}	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — High Frequency ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$, $f = 100 \text{ MHz}$)	$ h_{fe} $	1.25	2.4	—	—

FIGURE 1 — DC CURRENT GAIN

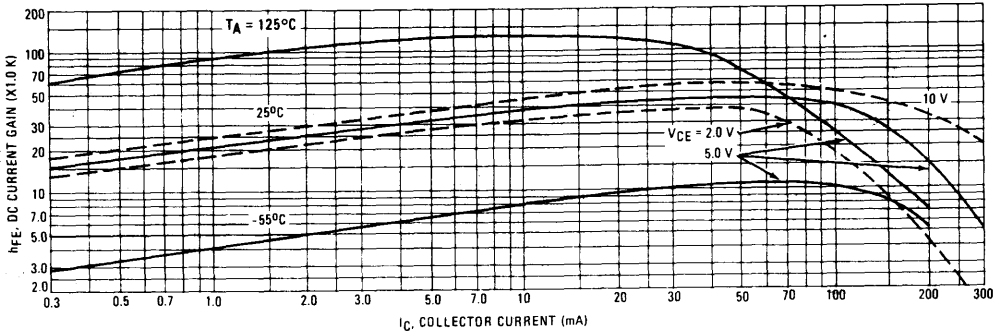


FIGURE 2 — "ON" VOLTAGE

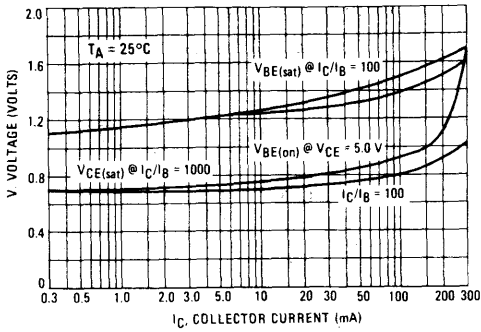


FIGURE 3 — COLLECTOR SATURATION REGION

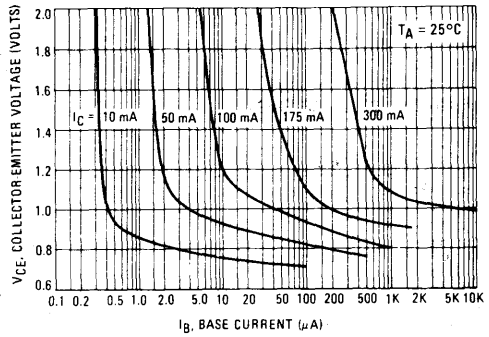


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

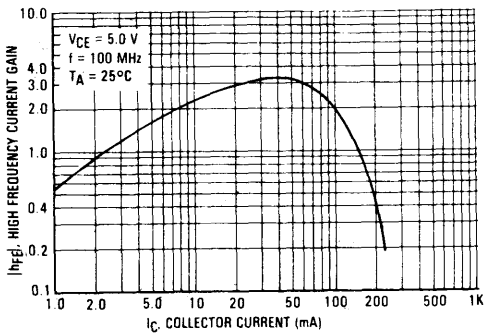
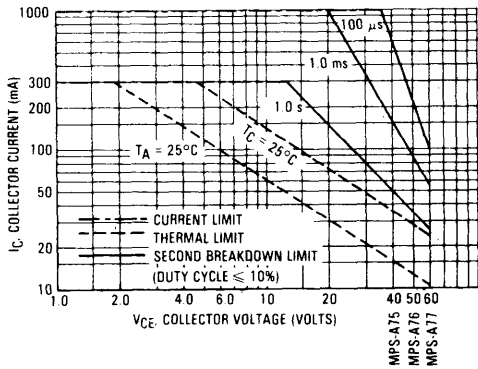


FIGURE 5 — ACTIVE REGION, SAFE OPERATING AREA



MPSA92 MPSA93

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS-A92	MPS-A93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5	12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	MPSA92 MPSA93 $V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	MPSA92 MPSA93 $V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	MPSA92 MPSA93 I_{CBO}	— —	0.25 0.25	μ Adc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μ Adc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	Both Types Both Types MPSA92 MPSA93 h_{FE}	25 40	— —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	MPSA92 MPSA93 $V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, $f = 100$ MHz)	f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	MPSA92 MPSA93 C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

FIGURE 1 - DC CURRENT GAIN

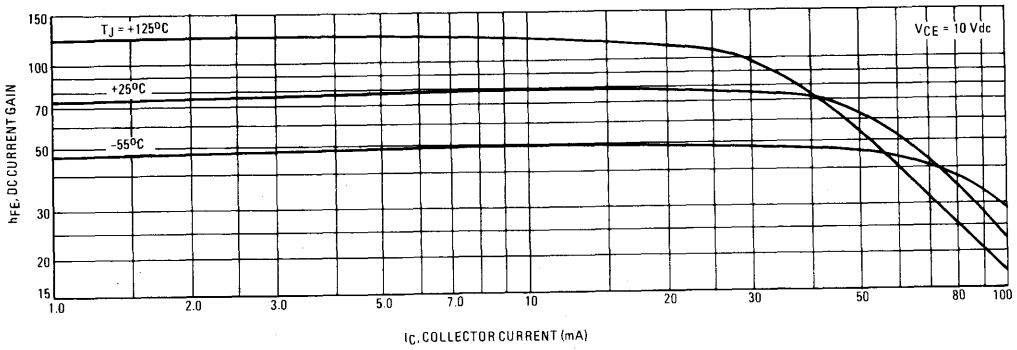


FIGURE 2 - CAPACITANCES

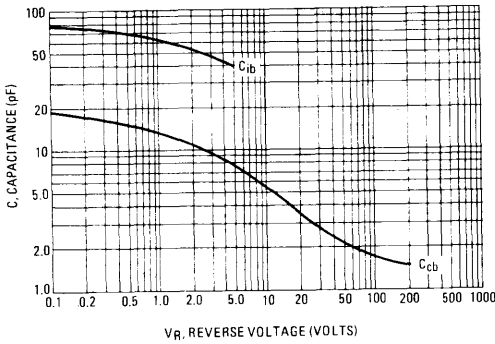


FIGURE 3 - CURRENT-GAIN-BANDWIDTH PRODUCT

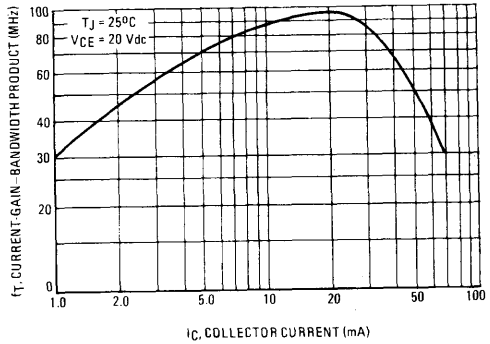


FIGURE 4 - "ON" VOLTAGES

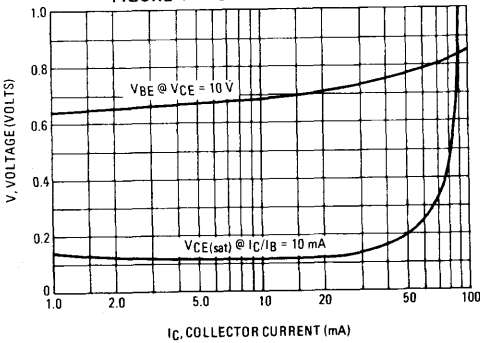
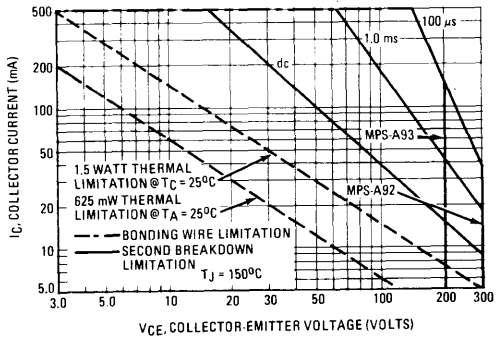


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



MPSH04 MPSH05

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAcd
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$	200	$^\circ\text{C/W}$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAcd, $I_B = 0$)	$V_{(BR)CEO}$	80	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Acd, $I_E = 0$)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Acd, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAcd
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAcd

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.5$ mAcd, $V_{CE} = 10$ Vdc)	MPSH04 MPSH05	h_{FE}	30 30	— —	120 150	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAcd, $I_B = 1.0$ mAcd)		$V_{CE(sat)}$	—	—	0.25	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 1.5$ mAcd, $V_{CE} = 10$ Vdc, $f = 100$ MHz)		f_T	80	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $f = 1.0$ MHz)		C_{cb}	—	—	1.6	pF
Output Admittance ($I_C = 1.5$ mAcd, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)		h_{oe}	—	—	5.0	μ mhos
Noise Figure ($I_C = 1.5$ mAcd, $V_{CE} = 10$ Vdc, $R_S = 50$ ohms, $f = 1.0$ MHz)	MPSH04	NF	—	—	2.0	dB

(2) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	25	Vdc
Collector-Base Voltage	V _{CBO}	30	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	357	°C/W

MPSH10

MPSH11

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF/UHF TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 1.0 mA _{dc} , I _B = 0)	V _{(BR)CEO}	25	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	3.0	—	Vdc
Collector Cutoff Current (V _{CB} = 25 Vdc, I _E = 0)	I _{CBO}	—	100	nA _{dc}
Emitter Cutoff Current (V _{BE} = 2.0 Vdc, I _C = 0)	I _{EBO}	—	100	nA _{dc}
ON CHARACTERISTICS				
DC Current Gain (I _C = 4.0 mA _{dc} , V _{CE} = 10 Vdc)	h _{FE}	60	—	—
Collector-Emitter Saturation Voltage (I _C = 4.0 mA _{dc} , I _B = 0.4 mA _{dc})	V _{CE(sat)}	—	0.5	Vdc
Base-Emitter On Voltage (I _C = 4.0 mA _{dc} , V _{CE} = 10 Vdc)	V _{BE}	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 4.0 mA _{dc} , V _{CE} = 10 Vdc, f = 100 MHz)	f _T	650	—	MHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	0.7	pF
Common-Base Feedback Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{rb}	0.35 0.6	0.65 0.9	pF
Collector Base Time Constant (I _C = 4.0 mA _{dc} , V _{CB} = 10 Vdc, f = 31.8 MHz)	rb'C _c	—	9.0	ps

COMMON-BASE y PARAMETERS versus FREQUENCY

($V_{CB} = 10 \text{ Vdc}$, $I_C = 4.0 \text{ mAdc}$, $T_A = 25^\circ\text{C}$)

y_{ib} , INPUT ADMITTANCE

FIGURE 1 – RECTANGULAR FORM

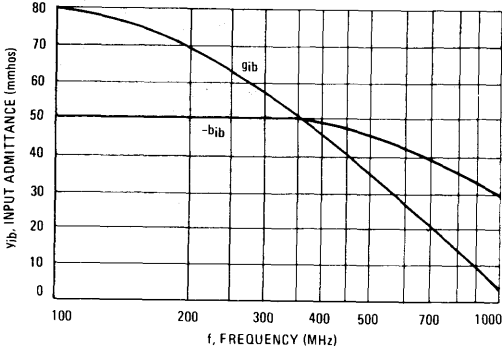
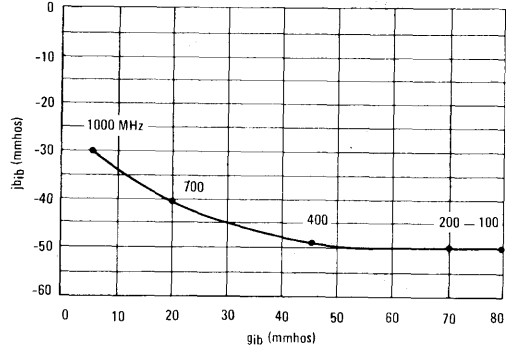


FIGURE 2 – POLAR FORM



COMMON-BASE y PARAMETERS versus FREQUENCY

($V_{CB} = 10 \text{ Vdc}$, $I_C = 4.0 \text{ mAdc}$, $T_A = 25^\circ\text{C}$)

y_{fb} , FORWARD TRANSFER ADMITTANCE

FIGURE 3 – RECTANGULAR FORM

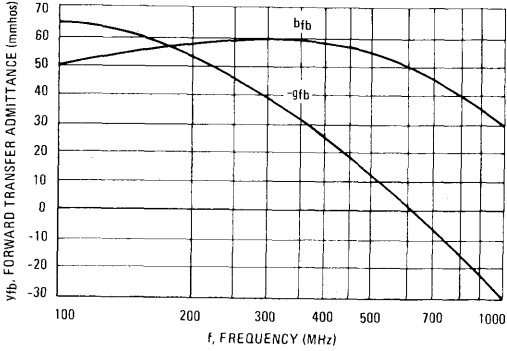
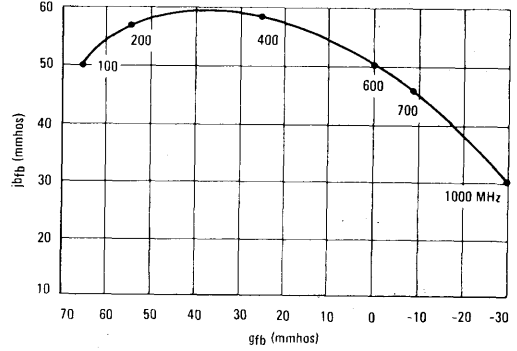


FIGURE 4 – POLAR FORM



y_{rb} , REVERSE TRANSFER ADMITTANCE

FIGURE 5 – RECTANGULAR FORM

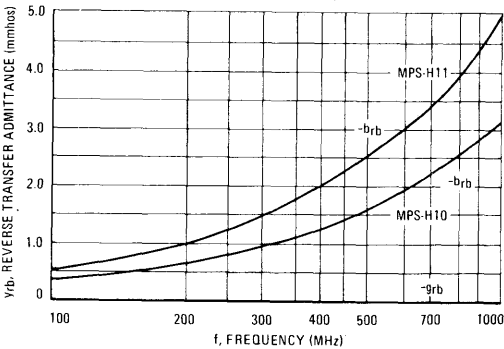
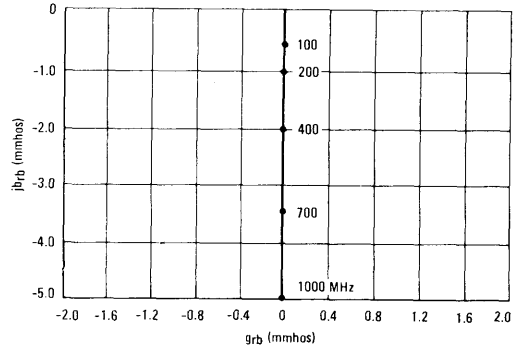


FIGURE 6 – POLAR FORM



Y_{ob} OUTPUT ADMITTANCE

FIGURE 7 – RECTANGULAR FORM

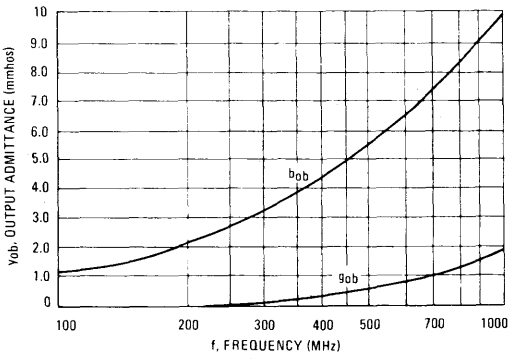
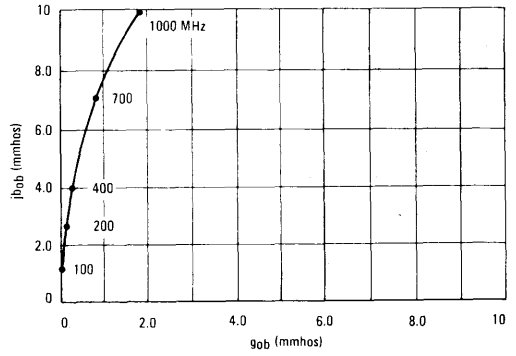


FIGURE 8 – POLAR FORM



MPSH17

**CASE 29-02, STYLE 2
TO-92 (TO-226AA)**

CATV TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	200	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mA}$, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}$, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	100	nA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	25	—	250	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 1.0 \text{ mA}$)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	800	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{cb}	0.3	—	0.9	pF
Small-Signal Current Gain ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	30	—	—	—
Noise Figure ($I_C = 5.0 \text{ mA}$, $V_{CC} = 12 \text{ Vdc}$, $R_S = 50 \text{ ohms}$, $f = 200 \text{ MHz}$)	NF	—	—	6.0	dB
FUNCTIONAL TEST					
Amplifier Power Gain ($I_C = 5.0 \text{ mA}$, $V_{CC} = 12 \text{ Vdc}$, $R_S = 50 \text{ ohms}$, $f = 200 \text{ MHz}$)	G_{pe}	—	24	—	dB

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	$^\circ\text{C}$

MPSH34

**CASE 29-02, STYLE 2
TO-92 (TO-226AA)**

IF TRANSISTOR

NPN SILICON

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

Refer to MPSH24 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 7.0 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}$) ($I_C = 20 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$)	h_{FE}	40 15	— —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 7.0 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}$)	$V_{BE(on)}$	—	—	0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 15 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	500	720	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{cb}	—	0.25	0.32	pF
Current-Gain — Bandwidth Ratio ($I_C = 15 \text{ mAdc}$ to $I_C = 20 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}$)	$\frac{f_{T15}}{f_{T20}}$	—	—	1.6	—

MPSH54 MPSH55

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	80	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}				
	MPSH54	30	—	120	—
	MPSH55	30	—	150	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	80	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $f = 1.0$ MHz)	C_{cb}	—	—	1.6	pF
Output Admittance ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{oe}	—	—	15	μ mhos
Noise Figure ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 50$ ohms, $f = 1.0$ MHz)	NF	—	—	2.0	dB

MPSH81

**CASE 29-02, STYLE 2
TO-92 (TO-226AA)
RF AMPLIFIER TRANSISTOR
PNP SILICON**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.81	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mAdc}, I_E = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	100	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 5.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 5.0 \text{ mAdc}, I_B = 0.5 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 5.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	$V_{BE(on)}$	—	—	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 5.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	600	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance ($I_B = 0, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ MHz}$)	C_{ce}	—	—	0.65	pF

TYPICAL COMMON-BASE y -PARAMETERS
 ($V_{CB} = 10$ Vdc, $T_A = 25^\circ\text{C}$, Frequency Points in MHz)

FIGURE 1 – INPUT ADMITTANCE

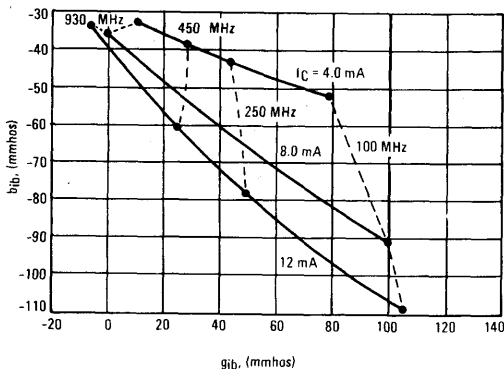


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

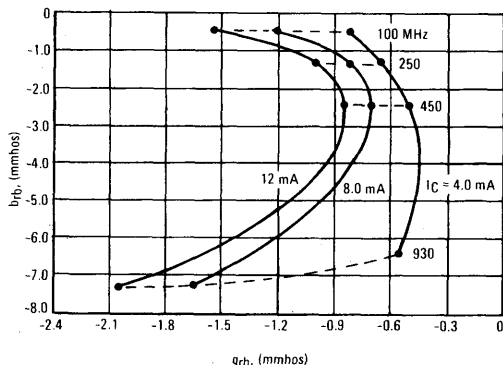


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

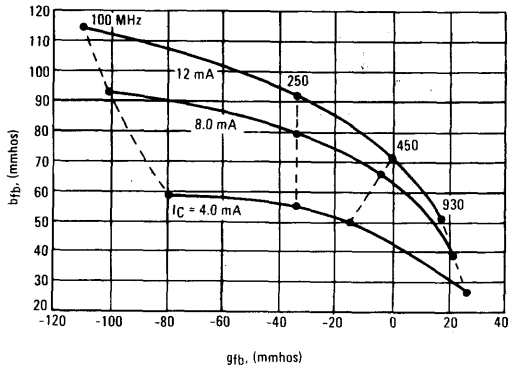


FIGURE 4 – OUTPUT ADMITTANCE

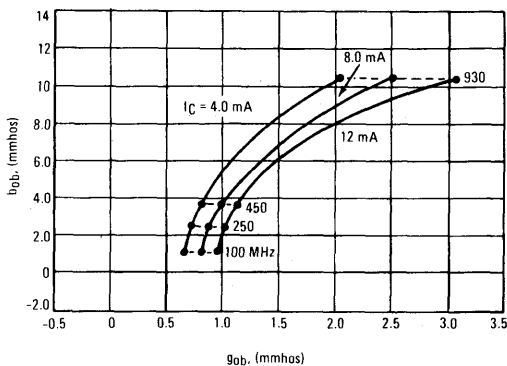
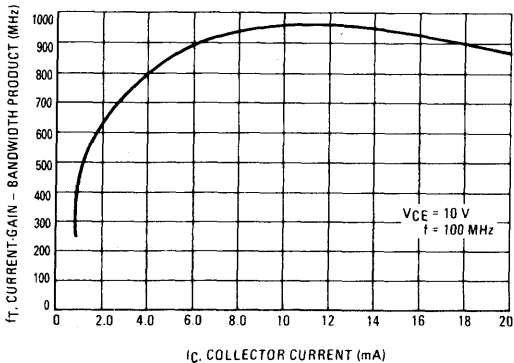


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	120	Vdc
Collector-Base Voltage	V_{CB0}	140	Vdc
Emitter-Base Voltage	V_{EB0}	5.0	Vdc
Collector Current — Continuous	I_C	150	mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C}/\text{W}$

MPSL01

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mA}_{dc}, I_E = 0$)	$V_{(BR)CEO}$	120	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}_{dc}, I_E = 0$)	$V_{(BR)CBO}$	140	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}_{dc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 75 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	1.0	μA_{dc}
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	100	nA _{dc}
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 10 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	50	300	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mA}_{dc}, I_B = 1.0 \text{ mA}_{dc}$) ($I_C = 50 \text{ mA}_{dc}, I_B = 5.0 \text{ mA}_{dc}$)	$V_{CE(sat)}$	— —	0.20 0.30	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mA}_{dc}, I_B = 1.0 \text{ mA}_{dc}$) ($I_C = 50 \text{ mA}_{dc}, I_B = 5.0 \text{ mA}_{dc}$)(1)	$V_{BE(sat)}$	— —	1.2 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) ($I_C = 10 \text{ mA}_{dc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	60	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{cb}	—	8.0	pF
Small-Signal Current Gain ($I_C = 1.0 \text{ mA}_{dc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	30	—	—

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2.0%.

MPSL51

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N5400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12.0	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	100	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc , $I_E = 0$)	$V_{(BR)CBO}$	100	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc , $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)	I_{CBO}	—	1.0	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain(1) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	40	250	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	— —	0.25 0.30	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	— —	1.2 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	8.0	pF
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{fe}	20	—	—

(1) Pulse Test: Pulse Test = 300 μs , Duty Cycle = 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPSW01 MPSW01A	V _{CEO}	30 40	V _{dc}
Collector-Base Voltage MPSW01 MPSW01A	V _{CBO}	40 50	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	V _{dc}
Collector Current — Continuous	I _C	1000	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

MPSW01 MPSW01A

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH CURRENT TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	30 40	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	40 50	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 40 Vdc, I _E = 0)	I _{CBO}	—	0.1 0.1	μAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 10 mAdc, V _{CE} = 1.0 Vdc) (I _C = 100 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1000 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	55 60 50	—	—
Collector-Emitter Saturation Voltage (I _C = 1000 mAdc, I _B = 100 mAdc)	V _{CE(sat)}	—	0.5	V _{dc}
Base-Emitter On Voltage (I _C = 1000 mAdc, V _{CE} = 1.0 Vdc)	V _{BE(on)}	—	1.2	V _{dc}
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	50	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSW01, MPSW01A

FIGURE 1 — DC CURRENT GAIN

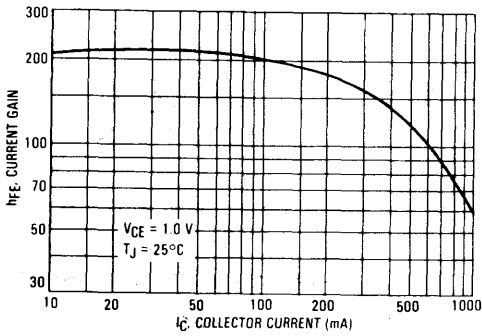


FIGURE 2 — COLLECTOR SATURATION REGION

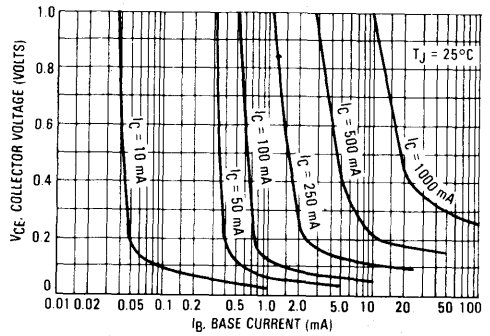


FIGURE 3 — ON VOLTAGES

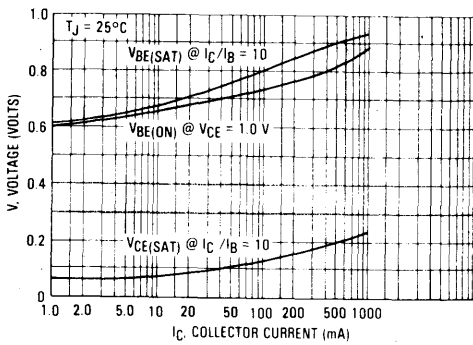


FIGURE 4 — TEMPERATURE COEFFICIENT

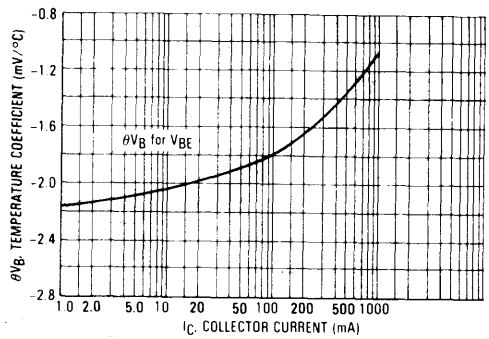


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

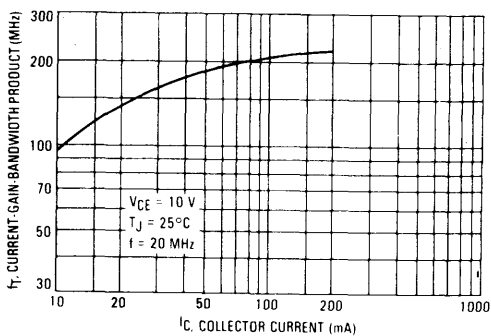
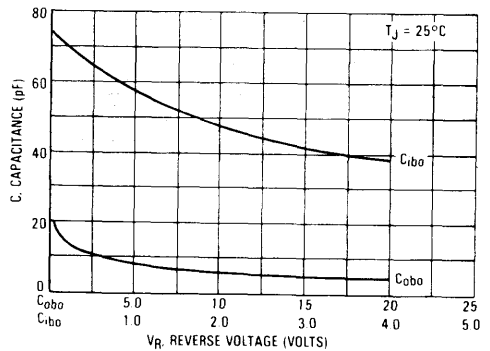
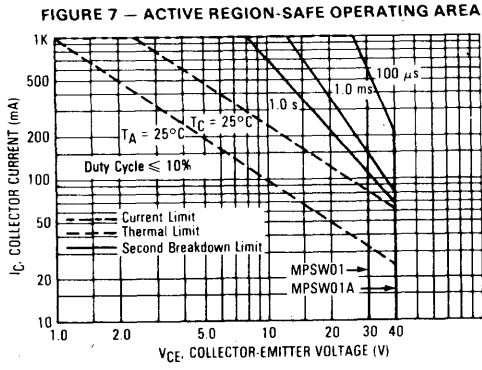


FIGURE 6 — CAPACITANCE





MPSW05 MPSW06

CASE 29-03, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW05	MPSW06	Unit
Collector-Emitter Voltage	V_{CE0}	60	80	Vdc
Collector-Base Voltage	V_{CB0}	60	80	Vdc
Emitter-Base Voltage	V_{EB0}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	8.0	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5	20	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	MPSW05 MPSW06	$V_{(BR)CE0}$	60 80	— — Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)		$V_{(BR)EB0}$	4.0	— Vdc
Collector Cutoff Current ($V_{CE} = 40 \text{ Vdc}, I_B = 0$) ($V_{CE} = 60 \text{ Vdc}, I_B = 0$)	MPSW05 MPSW06	I_{CE0}	— —	0.5 0.5 μAdc
Collector Cutoff Current ($V_{CB} = 40 \text{ Vdc}, I_E = 0$) ($V_{CB} = 60 \text{ Vdc}, I_E = 0$)	MPSW05 MPSW06	I_{CBO}	— —	0.1 0.1 μAdc
Emitter Cutoff Current ($V_{EB} = 3.0 \text{ Vdc}, I_C = 0$)		I_{EBO}	—	0.1 μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 50 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 250 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)		h_{FE}	80 60	— —
Collector-Emitter Saturation Voltage ($I_C = 250 \text{ mAdc}, I_B = 10 \text{ mAdc}$)		$V_{CE(sat)}$	—	0.40 Vdc
Base-Emitter Saturation Voltage ($I_C = 250 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)		$V_{BE(sat)}$	—	1.2 Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 200 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 20 \text{ MHz}$)		f_T	50	— MHz
Output Capacitance ($V_{CB} = 10 \text{ V}, f = 1.0 \text{ MHz}$)		C_{obo}	—	12 pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	300	Vdc
Collector-Base Voltage	V_{CB0}	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 20	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

MPSW10

**CASE 29-03, STYLE 1
TO-92 (TO-226AE)**

HIGH VOLTAGE TRANSISTOR

Refer to MPSW42 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	0.2	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 30 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	25 40 40	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 30 \text{ mAdc}, I_B = 3.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.75	Vdc
Base-Emitter On Voltage ($I_C = 30 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	45	—	MHz
Collector-Base Capacitance ($V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{cb}	—	3.0	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MPSW13 MPSW14

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}, V_{BE} = 0$)	$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}			
	MPSW13	5000	—	—
	MPSW14	10,000	—	—
($I_C = 100 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	MPSW13	10,000	—	—
	MPSW14	20,000	—	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 0.1 \text{ mAdc}$)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	125	—	MHz

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 1 — ACTIVE REGION SAFE OPERATING AREA

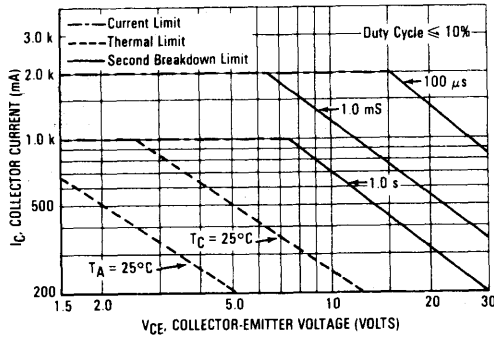


FIGURE 2 — DC CURRENT GAIN

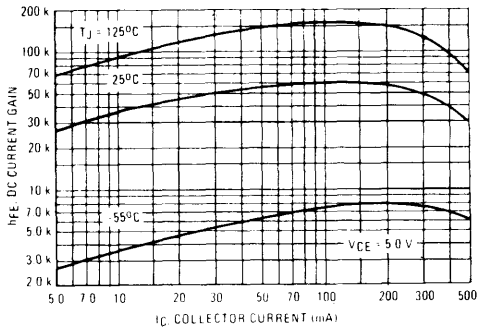


FIGURE 3 — COLLECTOR-SATURATION REGION

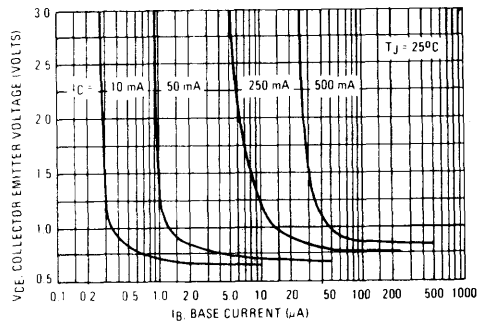


FIGURE 4 — ON VOLTAGES

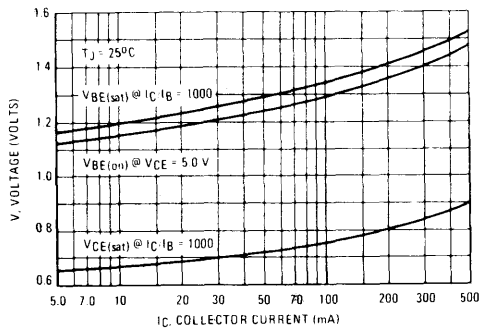


FIGURE 5 — TEMPERATURE COEFFICIENTS

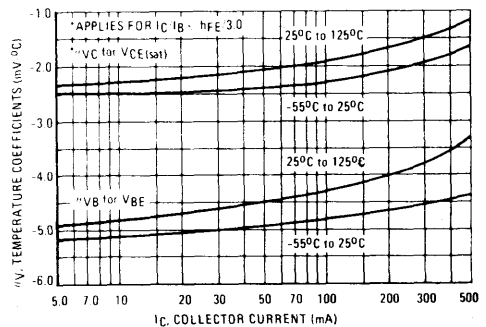


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN

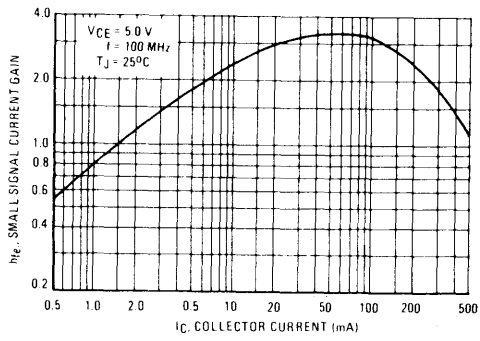
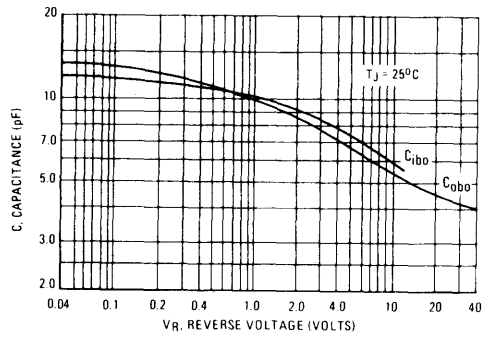


FIGURE 7 — CAPACITANCE



MPSW42 MPSW43

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE
TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW42	MPSW43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0		Watt
		8.0		mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5		Watts
		20		mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc , $I_E = 0$)	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc , $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0$ Vdc, $I_C = 0$) ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	Both Types Both Types MPSW42 MPSW43	h_{FE}	25 40 40 40	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	MPSW42 MPSW43	$V_{CE(sat)}$	— —	0.5 0.5
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, $f = 20$ MHz)		f_T	50	—
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	MPSW42 MPSW43	C_{cb}	— —	3.0 4.0

(1) Pulse Test: Pulse Width ≤ 300 μs , Duty Cycle $\leq 2.0\%$.

FIGURE 1 — D.C. CURRENT GAIN

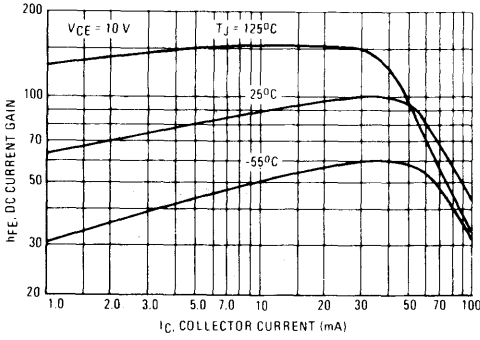


FIGURE 2 — COLLECTOR SATURATION REGION

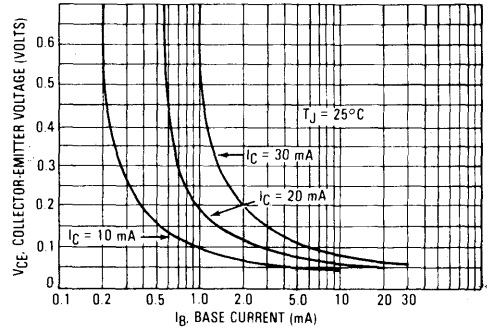


FIGURE 3 — ON VOLTAGES

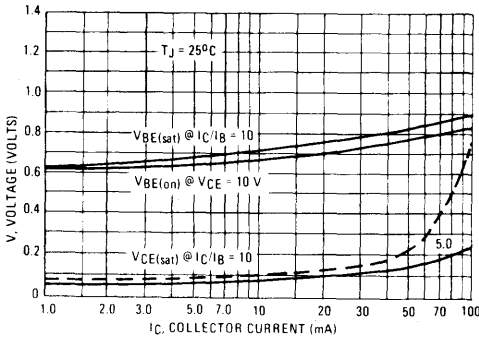


FIGURE 4 — TEMPERATURE COEFFICIENTS

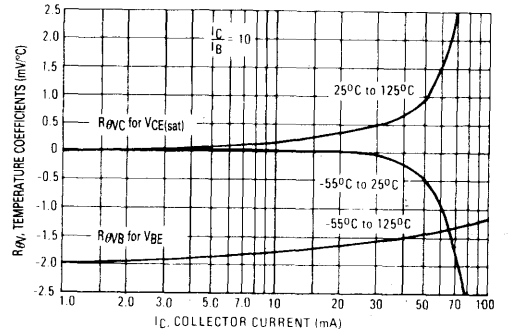


FIGURE 5 — CAPACITANCE

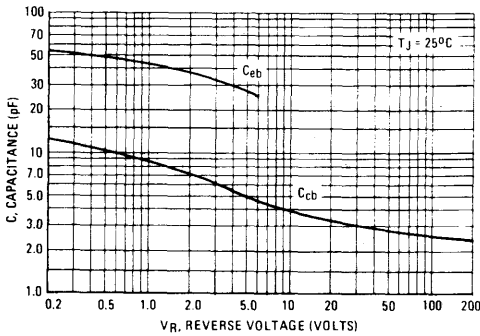


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

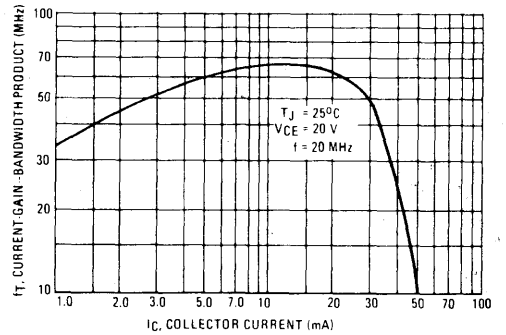
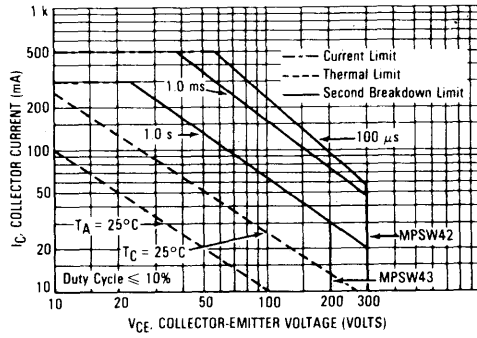


FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA



MPSW45CASE 29-03, STYLE 1
TO-92 (TO-226AE)**DARLINGTON TRANSISTOR**

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 20	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{Vdc}$, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10 \text{Vdc}$, $I_C = 0$)	I_{EBO}	—	100	nAdc

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 200 \text{mAdc}$, $V_{CE} = 5.0 \text{Vdc}$) ($I_C = 500 \text{mAdc}$, $V_{CE} = 5.0 \text{Vdc}$) ($I_C = 1.0 \text{Adc}$, $V_{CE} = 5.0 \text{Vdc}$)	h_{FE}	25,000 15,000 4,000	150,000 — —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{Adc}$, $I_B = 2.0 \text{mAdc}$)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{Adc}$, $I_B = 2.0 \text{mAdc}$)	$V_{BE(sat)}$	—	2.0	Vdc
Base-Emitter On Voltage ($I_C = 1.0 \text{Adc}$, $V_{CE} = 5.0 \text{Vdc}$)	$V_{BE(on)}$	—	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 200 \text{mAdc}$, $V_{CE} = 5.0 \text{Vdc}$, $f = 100 \text{MHz}$)	f_T	100	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{Vdc}$, $I_E = 0$, $f = 1.0 \text{MHz}$)	C_{cb}	—	6.0	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPSW51 MPSW51A	V _{CEO}	30 40	V _{dc}
Collector-Base Voltage MPSW51 MPSW51A	V _{CBO}	40 50	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	V _{dc}
Collector Current — Continuous	I _C	1000	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

MPSW51 MPSW51A

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH CURRENT TRANSISTOR

PNP SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	MPSW51 MPSW51A	V _{(BR)CEO}	30 40	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	MPSW51 MPSW51A	V _{(BR)CBO}	40 50	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)		V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 40 Vdc, I _E = 0)	MPSW51 MPSW51A	I _{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)		I _{EBO}	—	0.1	μAdc

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 10 mAdc, V _{CE} = 1.0 Vdc) (I _C = 100 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1000 mAdc, V _{CE} = 1.0 Vdc)		h _{FE}	55 60 50	— — —	—
Collector-Emitter Saturation Voltage (I _C = 1000 mAdc, I _B = 100 mAdc)		V _{CE(sat)}	—	0.7	V _{dc}
Base-Emitter On Voltage (I _C = 1000 mAdc, V _{CE} = 1.0 Vdc)		V _{BE(on)}	—	1.2	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)		f _T	50	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)		C _{obo}	—	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 — DC CURRENT GAIN

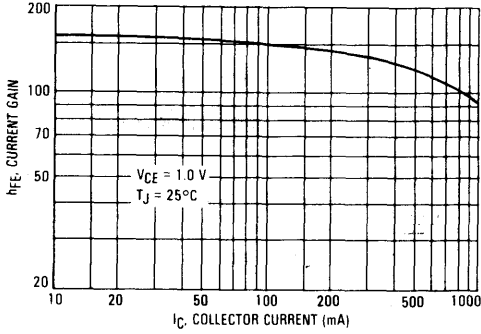


FIGURE 2 — COLLECTOR SATURATION REGION

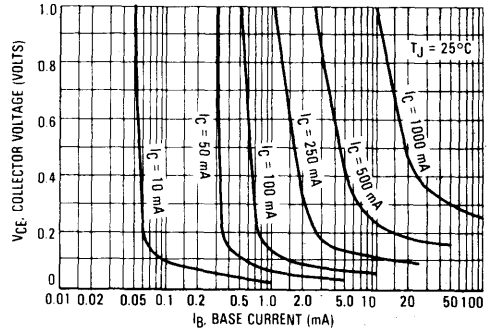


FIGURE 3 — ON VOLTAGES

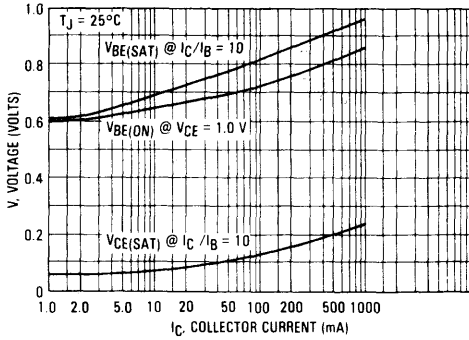


FIGURE 4 — TEMPERATURE COEFFICIENT

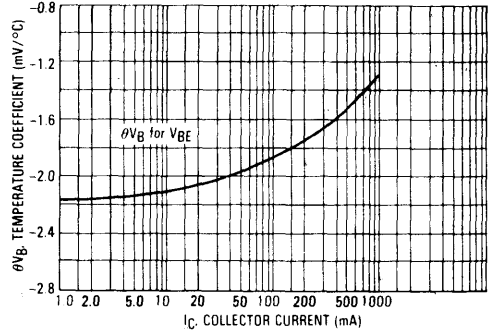


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

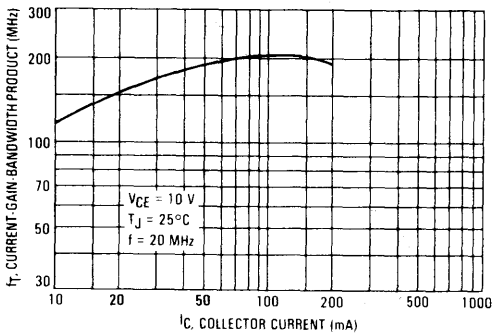
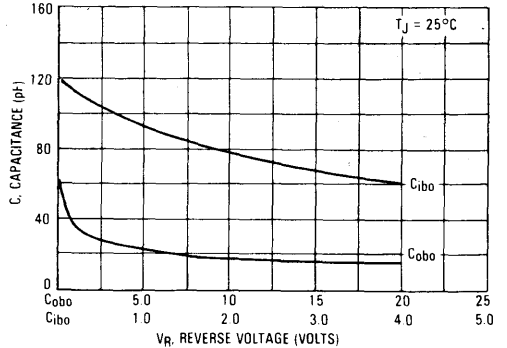
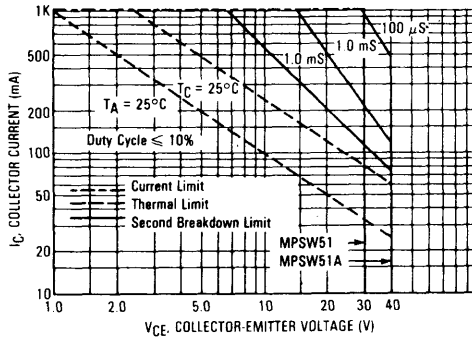


FIGURE 6 — CAPACITANCE



MPSW51, MPSW51A

FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



MPSW55 MPSW56

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW55	MPSW56	Unit
Collector-Emitter Voltage	V_{CE0}	60	80	Vdc
Collector-Base Voltage	V_{CB0}	60	80	Vdc
Emitter-Base Voltage	V_{EB0}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	8.0	Watt $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5	20	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	60 80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 40 \text{ Vdc}, I_B = 0$) ($V_{CE} = 60 \text{ Vdc}, I_B = 0$)	I_{CEO}	— —	0.5 0.5	μAdc
Collector Cutoff Current ($V_{CB} = 40 \text{ Vdc}, I_E = 0$) ($V_{CB} = 60 \text{ Vdc}, I_E = 0$)	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 50 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 250 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	80 50	—	—
Collector-Emitter Saturation Voltage ($I_C = 250 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 250 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 250 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ MHz}$)	C_{obo}	—	15	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 — D.C. CURRENT GAIN

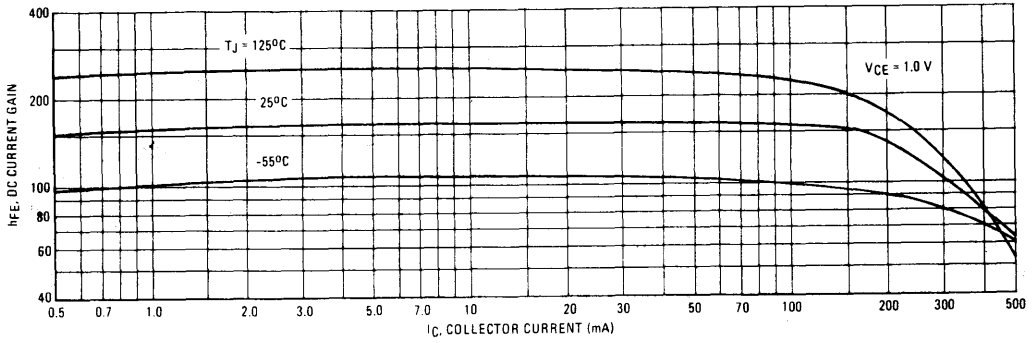


FIGURE 2 — COLLECTOR SATURATION REGION

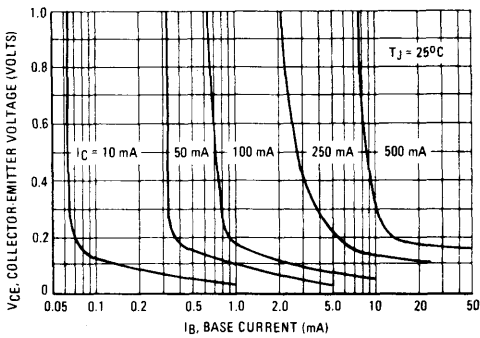


FIGURE 3 — ON VOLTAGES

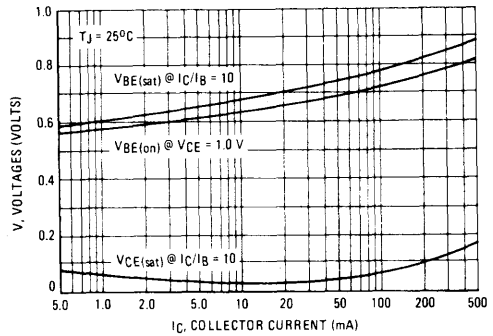


FIGURE 4 — BASE-EMITTER TEMPERATURE COEFFICIENT

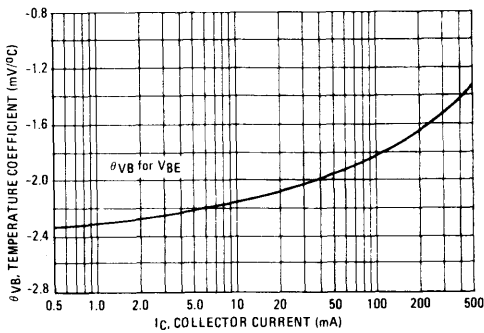
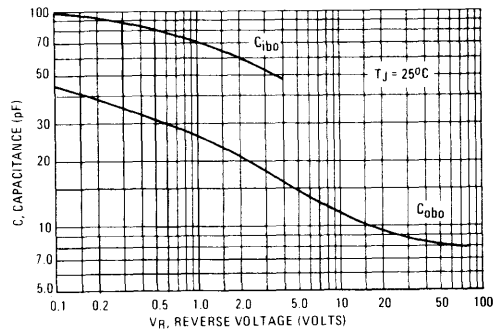


FIGURE 5 — CAPACITANCE



MPSW55, MPSW56

FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

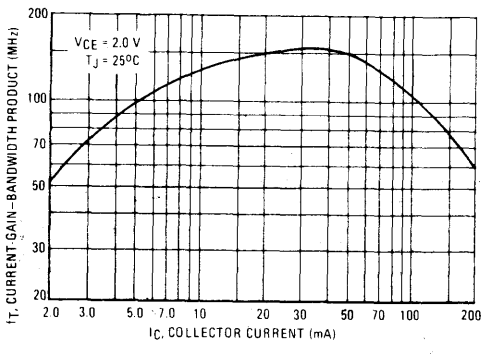
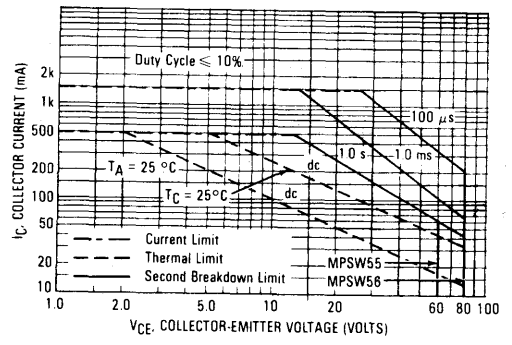


FIGURE 7 — ACTIVE REGION - SAFE OPERATING AREA



2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	300	Vdc
Collector-Base Voltage	V _{CBO}	300	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	500	mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

MPSW60

**CASE 29-03, STYLE 1
TO-92 (TO-226AE)**

**HIGH VOLTAGE
TRANSISTOR**

PNP SILICON

Refer to MPSW92 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mA _{dc} , I _B = 0)	V _{(BR)CEO}	300	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBO}	300	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10.0 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 200 Vdc, I _E = 0)	I _{CBO}	—	0.2	μA _{dc}
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	0.1	μA _{dc}
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 1.0 mA _{dc} , V _{CE} = 10 Vdc) (I _C = 10 mA _{dc} , V _{CE} = 10 Vdc) (I _C = 30 mA _{dc} , V _{CE} = 10 Vdc)	h _{FE}	25 30 25	— — —	—
Collector-Emitter Saturation Voltage (I _C = 20 mA _{dc} , I _B = 2.0 mA _{dc})	V _{CE(sat)}	—	0.75	Vdc
Base-Emitter On Voltage (I _C = 20 mA _{dc} , V _{CE} = 10 Vdc)	V _{BE(on)}	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mA _{dc} , V _{CE} = 20 Vdc, f = 20 MHz)	f _T	60	—	MHz
Collector-Base Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 10 MHz)	C _{cb}	—	8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSW63 MPSW64

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW63 MPSW64	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	500	mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 20	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}_{dc}, V_{BE} = 0$)	$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	100	nA _{dc}
Emitter Cutoff Current ($V_{EB} = 10 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	100	nA _{dc}
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 10 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	MPSW63 MPSW64	h_{FE}	5,000 10,000	— —
($I_C = 100 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	MPSW63 MPSW64		10,000 20,000	— —
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mA}_{dc}, I_B = 0.1 \text{ mA}_{dc}$)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) ($I_C = 10 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	125	—	MHz

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) $f_T = |h_{fe}| \cdot f_{test}$.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 - DC CURRENT GAIN

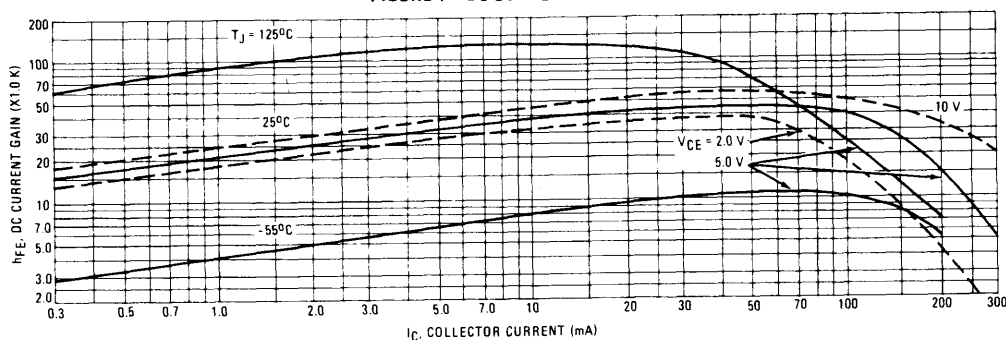


FIGURE 2 - "ON" VOLTAGE

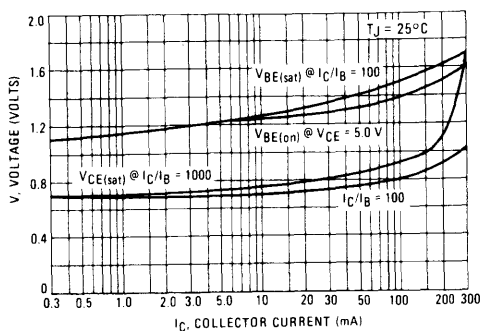


FIGURE 3 - COLLECTOR SATURATION REGION

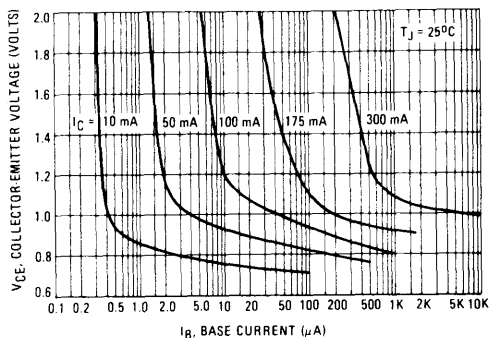


FIGURE 4 - TEMPERATURE COEFFICIENTS

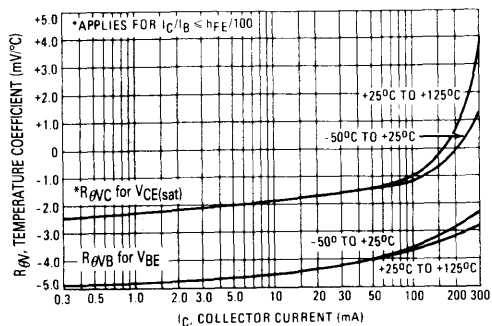
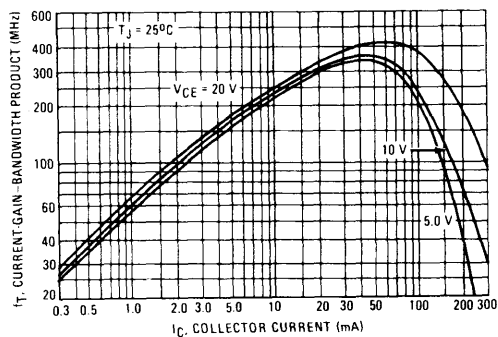


FIGURE 5 - CURRENT-GAIN-BANDWIDTH PRODUCT



MPSW63, MPSW64

2

FIGURE 6 — CAPACITANCE

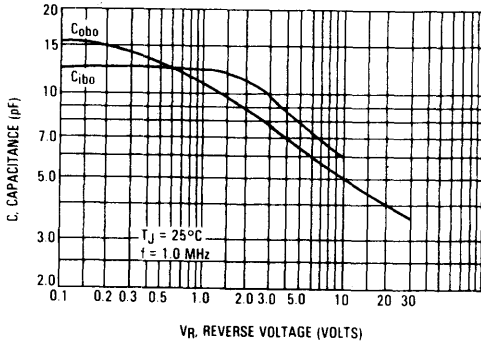
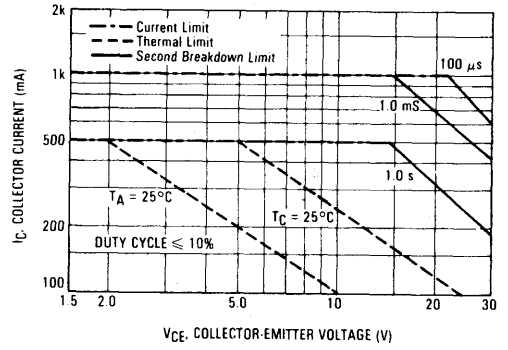


FIGURE 7 — ACTIVE REGION, SAFE OPERATING AREA



MPSW92
MPSW93

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE
TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW92	MPSW93	Unit
Collector-Emitter Voltage	V _{CEO}	300	200	V _{dc}
Collector-Base Voltage	V _{CBO}	300	200	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0		V _{dc}
Collector Current — Continuous	I _C	500		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0	8.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5	20	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to + 150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _E = 0)	MPSW92 MPSW93	V _{(BR)CEO}	300 200	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	MPSW92 MPSW93	V _{(BR)CBO}	300 200	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)		V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 200 Vdc, I _E = 0) (V _{CB} = 160 Vdc, I _E = 0)	MPSW92 MPSW93	I _{CBO}	— —	0.25 0.25	μAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)		I _{EBO}	—	0.1	μAdc

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 30 mAdc, V _{CE} = 10 Vdc)	Both Types Both Types MPSW92 MPSW93	h _{FE}	25 40 25 25	— — — —	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	MPSW92 MPSW93	V _{CE(sat)}	— —	0.5 0.5	V _{dc}
Base-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)		V _{BE(sat)}	—	0.9	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 20 MHz)		f _T	50	—	MHz
Collector-Base Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 1.0 MHz)	MPSW92 MPSW93	C _{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — D.C. CURRENT GAIN

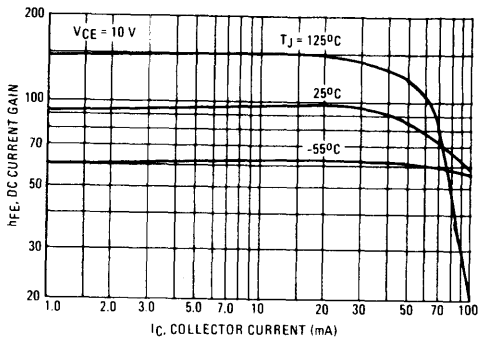


FIGURE 2 — COLLECTOR SATURATION REGION

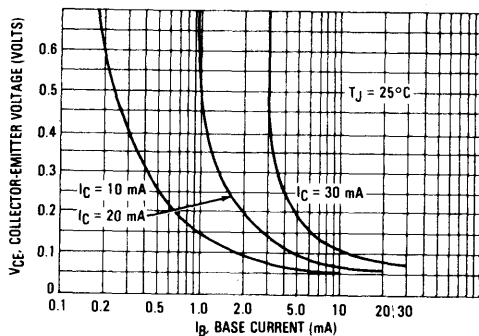


FIGURE 3 — ON VOLTAGES

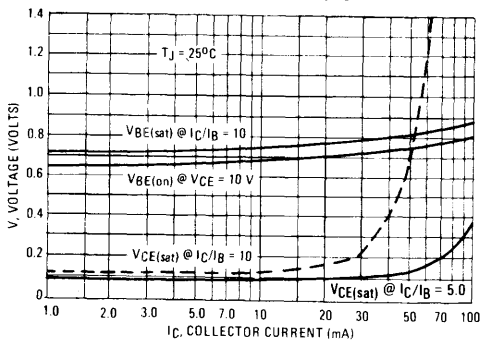


FIGURE 4 — TEMPERATURE COEFFICIENTS

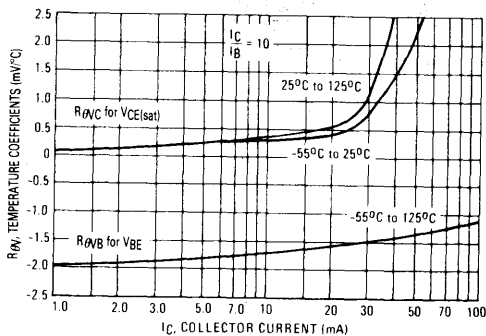


FIGURE 5 — CAPACITANCE

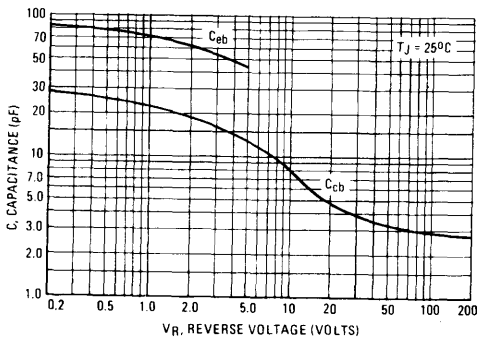


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

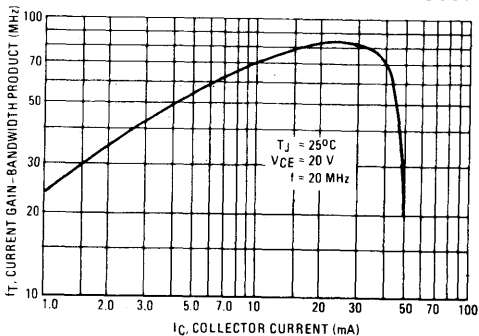
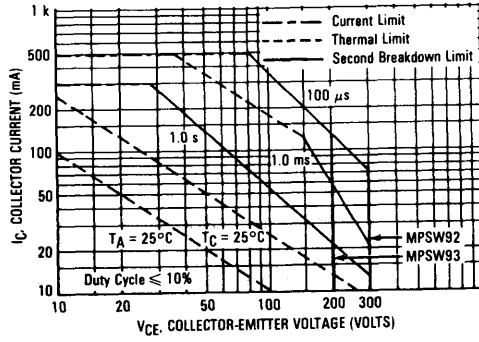


FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA



MSD6100

CASE 29-02, STYLE 3
TO-92 (TO-226AA)

DUAL SWITCHING DIODE
COMMON CATHODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μ sec)	$I_{FM}(\text{surge})$	500	mA
Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	$P_D(1)$	625 5.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	$T_J, T_{stg}(1)$	-55 to +135	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)} = 100 \mu\text{A}$)	$V_{(BR)}$	100	—	Vdc
Reverse Current ($V_R = 100 \text{ Vdc}$) ($V_R = 50 \text{ Vdc}$) ($V_R = 50 \text{ Vdc}, T_A = 125^\circ\text{C}$)	I_R	— — —	5.0 0.1 20	μA
Forward Voltage ($I_F = 1.0 \text{ mA}$) ($I_F = 10 \text{ mA}$) ($I_F = 100 \text{ mA}$)	V_F	0.55 0.67 0.75	0.7 0.82 1.1	Vdc
Capacitance ($V_R = 0$)	C	—	1.5	pF
Reverse Recovery Time ($I_F = I_R = 10 \text{ mA}$, $V_R = 5.0 \text{ Vdc}$, $i_{rr} = 1.0 \text{ mA}$)	t_{rr}	—	4.0	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0 \text{ W}$ @ $T_C = 25^\circ\text{C}$,
Derate above $25^\circ\text{C} - 8.0 \text{ mW}/^\circ\text{C}$, $T_J = -65$ to $+150^\circ\text{C}$, $\theta_{JC} = 125^\circ\text{C}/\text{W}$.

MSD6102

**CASE 29-02, STYLE 3
TO-92 (TO-226AA)**

**DUAL DIODE
COMMON CATHODE**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μ s)	$I_{FM}(\text{surge})$	500	mA
Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	$P_D(1)$	625 5.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	$T_J, T_{stg}(1)$	-55 to +135	$^\circ\text{C}$

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0 \text{ W}$ @ $T_C = 25^\circ\text{C}$, Derate above 25°C — 8.0 mW/ $^\circ\text{C}$, $T_J = -65$ to $+150^\circ\text{C}$, $\theta_{JC} = 125^\circ\text{C/W}$.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)} = 100 \mu\text{Adc}$)	$V_{(BR)}$	70	—	Vdc
Reverse Current ($V_R = 50 \text{ Vdc}$)	I_R	—	0.1	μAdc
Forward Voltage ($I_F = 10 \text{ mAdc}$)	V_F	—	1.0	Vdc
Capacitance ($V_R = 0$)	C	—	3.0	pF
Reverse Recovery Time ($I_F = I_R = 10 \text{ mAdc}$, $V_R = 5.0 \text{ Vdc}$, $i_{rr} = 1.0 \text{ mAdc}$)	t_{rr}	—	100	ns

MSD6150

**CASE 29-02, STYLE 4
TO-92 (TO-226AA)**

**DUAL DIODE
COMMON ANODE**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μ s)	$I_{FM}(\text{surge})$	500	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	$P_D(1)$	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	$T_J, T_{stg}(1)$	-55 to +135	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)} = 100 \mu\text{Adc}$)	$V_{(BR)}$	70	—	—	Vdc
Reverse Current ($V_R = 50 \text{Vdc}$)	I_R	—	—	0.1	μAdc
Forward Voltage ($I_F = 10 \text{mAdc}$)	V_F	—	0.80	1.0	Vdc
Capacitance ($V_R = 0$)	C	—	5.0	8.0	pF
Reverse Recovery Time ($I_F = I_R = 10 \text{mAdc}, V_R = 5.0 \text{Vdc}, i_{rr} = 1.0 \text{mAdc}$)	t_{rr}	—	—	100	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0 \text{ W}$ @ $T_C = 25^\circ\text{C}$, Derate above $8.0 \text{ mW}/^\circ\text{C}$, $P_D = 10 \text{ W}$ @ $T_C = 25^\circ\text{C}$, Derate above $80 \text{ mW}/^\circ\text{C}$, $T_J, T_{stg} = -55 \text{ to } +150^\circ$, $\theta_{JC} = 12.5^\circ\text{C}/\text{W}$, $\theta_{JA} = 125^\circ\text{C}$.

MVS240

CASE 182-03, STYLE 1
TO-92 (TO-226AA)

24 V STABILIZER

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Operating Current for 24 Vz	I _Z	26	mA
Power Dissipation @ T _A = 25°C	P _D	625	mW
Operating Junction Temperature	T _J	150	°C
Storage Temperature Range	T _{stg}	-40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	0.083	°C/mW
Thermal Resistance, Junction to Ambient	R _{θJA}	0.200	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Operating Voltage (I _Z T = 5.0 mA)	V _Z	23	24	25	Volts
Operating Voltage Change (I _Z T = 5.0 mA, 0 to 70°C)	$\frac{\Delta V_Z}{\Delta T}$	-1.55	-0.20	+1.55	mV/°C
Operating Dynamic Impedance (I _Z = 5.0 mA)	Z _z	—	9.0	25	Ohms

FIGURE 1 – POWER DERATING

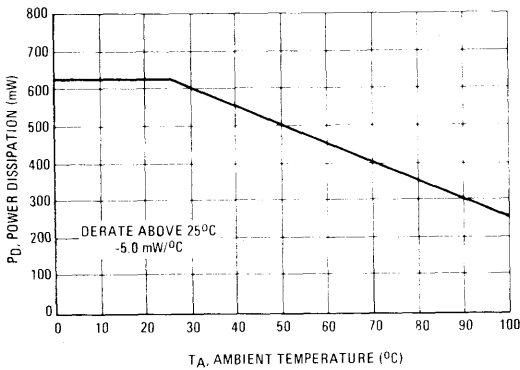


FIGURE 2 – CURRENT DERATING

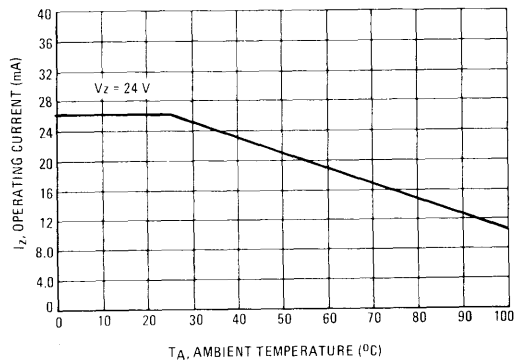


FIGURE 3 - OPERATING VOLTAGE CHANGE

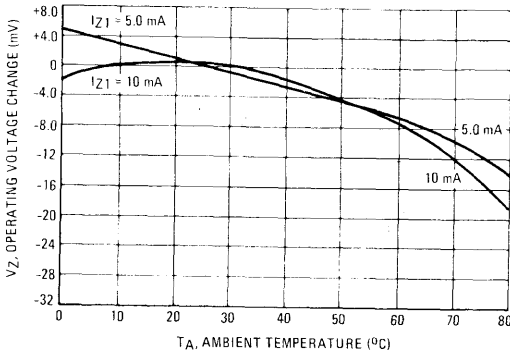


FIGURE 4 - OPERATING VOLTAGE CHANGE TEST CIRCUIT

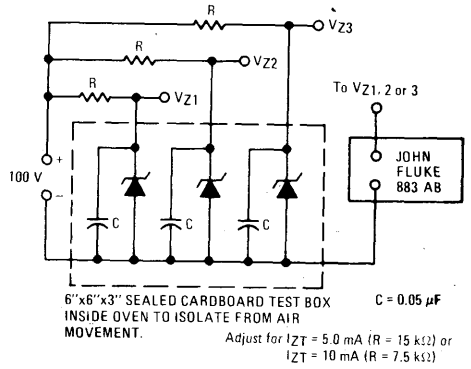


FIGURE 5 - OPERATING IMPEDANCE TEST CIRCUIT

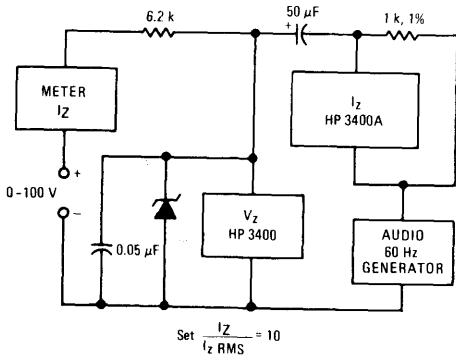
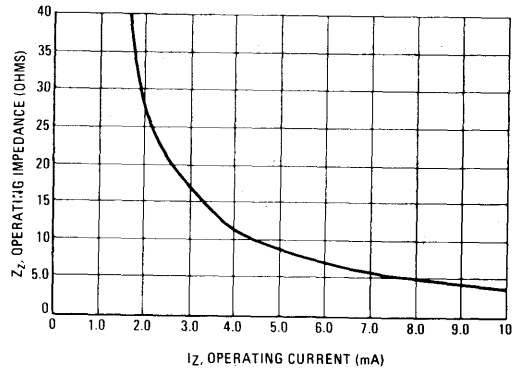


FIGURE 6 - OPERATING IMPEDANCE



MVS460

CASE 182-01, STYLE 1
TO-92 (TO-226AA)
TUNING DIODE REGULATOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Operating Current for 33 Vz	I _Z	18	mA
Power Dissipation @ T _A = 25°C	P _D	625	mW
Operating Junction Temperature	T _J	150	°C
Storage Temperature Range	T _{stg}	-40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	0.083	°C/mW
Thermal Resistance, Junction to Ambient	R _{θJA}	0.200	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Operating Voltage (I _{ZT} = 5.0 mA)	V _Z	31	33	35	Volts
Operating Voltage Change (I _{ZT} = 5.0 mA, 0 to 70°C)	$\frac{\Delta V_Z}{\Delta T}$	-3.1	-2.3	+1.55	mV/°C
Operating Dynamic Impedance (I _Z = 5.0 mA)	Z _Z	—	9.0	25	Ohms

FIGURE 1 - POWER DERATING

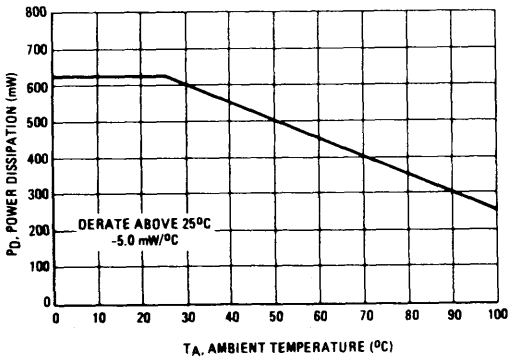
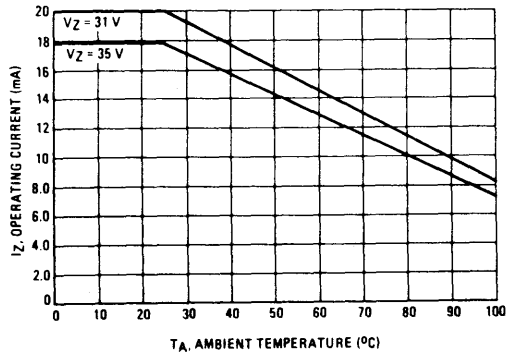


FIGURE 2 - CURRENT DERATING



2

FIGURE 3 - OPERATING VOLTAGE CHANGE

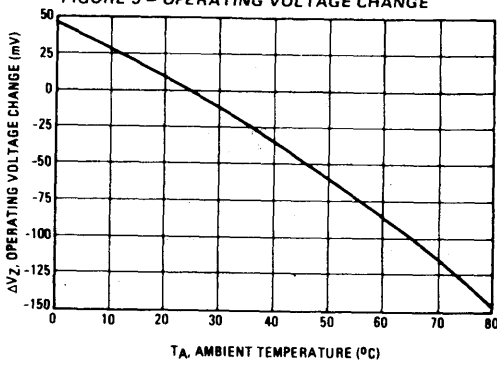


FIGURE 4 - OPERATING VOLTAGE CHANGE TEST CIRCUIT

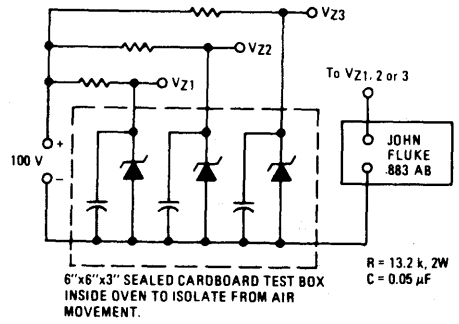


FIGURE 5 - OPERATING IMPEDANCE TEST CIRCUIT

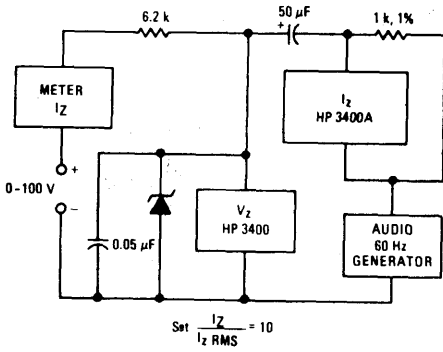
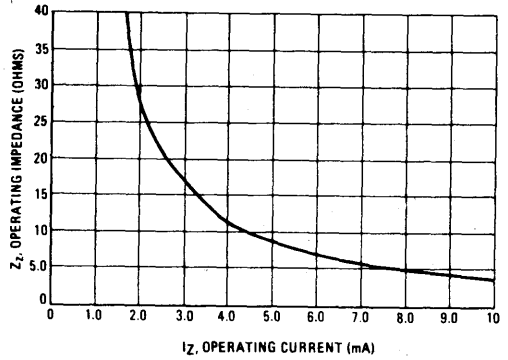


FIGURE 6 - OPERATING IMPEDANCE



MAXIMUM RATINGS

Rating	Symbol	PBF259, S	Unit
Collector-Emitter Voltage	V _{CEO}	300	Vdc
Collector-Base Voltage	V _{CBO}	300	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current - Continuous	I _C	500	mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	200	°C/W

PBF259

PBF259S

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mA _{dc} , I _B = 0)	V _{(BR)CEO}	300	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{(BR)CBO}	300	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 250 Vdc, I _E = 0)	I _{CBO}	—	50	nA _{dc}
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 20 mA _{dc} , V _{CE} = 10 Vdc) (I _C = 1.0 mA _{dc} , V _{CE} = 10 Vdc) (I _C = 30 mA _{dc} , V _{CE} = 10 Vdc)	h _{FE}	60 25 25	— — —	—
Collector-Emitter Saturation Voltage (I _C = 30 mA _{dc} , I _B = 1.5 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 60 mA _{dc})	V _{CE(sat)}	— —	0.5 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mA _{dc} , V _{CE} = 10 Vdc, f = 20 MHz)	f _T	40	—	MHz
Output Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	3.0	pF

PBF259R PBF259RS

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	PBF259R,RS	Unit
Collector-Emitter Voltage	V _{CEO}	300	Vdc
Collector-Base Voltage	V _{CBO}	300	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current - Continuous	I _C	500	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJC}	200	°C/W

Refer to MPSA42 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 3.0 mAdc, I _B = 0)	V _{(BR)CEO}	300	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	300	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 250 Vdc, I _E = 0)	I _{CBO}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 20 mAdc, V _{CE} = 10 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 30 mAdc, V _{CE} = 10 Vdc)	PBF259RS All Types All Types	h _{FE}	60 25 25	—
Collector-Emitter Saturation Voltage (I _C = 30 mAdc, I _B = 1.5 mAdc) (I _C = 30 mAdc, I _B = 6.0 mAdc)	V _{CE(sat)}	—	0.5 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	40	—	MHz
Output Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	3.0	pF

MAXIMUM RATINGS

Rating	Symbol	PBF493, S	Unit
Collector-Emitter Voltage	V _{CEO}	300	Vdc
Collector-Base Voltage	V _{CBO}	300	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	500	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**PBF493
PBF493S**

**CASE 29-02, STYLE 1
TO-92 (TO-226AA)**

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	300	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	300	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 200 Vdc, I _E = 0)	I _{CBO}	—	0.25	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc)	h _{FE}	40 40 25	—	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{CE(sat)}	—	0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{BE(sat)}	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 20 MHz)	f _T	50	—	MHz
Output Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	6.0	pF

PBF493R PBF493RS

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	PBF493R,RS	Unit
Collector-Emitter Voltage	V _{CEO}	300	Vdc
Collector-Base Voltage	V _{CBO}	300	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current - Continuous	I _C	500	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.0	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	300	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	300	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 200 Vdc, I _E = 0)	I _{CBO}	—	0.25	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc)	h _{FE}	40 40 25	—	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{CE(sat)}	—	0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{BE(sat)}	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 20 MHz)	f _T	50	—	MHz
Output Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	6.0	pF

MAXIMUM RATINGS

Rating	Symbol	P2N2222	P2N2222A	Unit
Collector-Emitter Voltage	V _{CEO}	30	40	Vdc
Collector-Base Voltage	V _{CBO}	60	75	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	6.0	Vdc
Collector Current - Continuous	I _C	600		mAdc
Total Device Dissipation Derate above 25°C	P _D	625	5.0	mW mW/°C
Total Device Dissipation Derate above 25°C	P _D	1.5	12	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**P2N2222
P2N2222A**

**CASE 29-02, STYLE 17
TO-39 (TO-226AA)
AMPLIFIER TRANSISTORS
NPN SILICON**

Refer to MPS2222 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	30 40	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60 75	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0 6.0	— —	Vdc
Collector Cutoff Current (V _{CE} = 60 Vdc, V _{EB(off)} = 3.0 Vdc)	I _{CEX}	—	10	nAdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0, T _A = 150°C) (V _{CB} = 60 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	— — — —	0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	10	nAdc
Base Cutoff Current (V _{CE} = 60 Vdc, V _{EB(off)} = 3.0 Vdc)	I _{BEX}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 10 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc, T _A = -55°C) (I _C = 150 mAdc, V _{CE} = 10 Vdc) (1) (I _C = 150 mAdc, V _{CE} = 1.0 Vdc) (1) (I _C = 500 mAdc, V _{CE} = 10 Vdc) (1)	h _{FE}	35 50 75 35 100 50 30 40	— — — — 300 — — —	—
Collector-Emitter Saturation Voltage (1) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	— — — —	0.4 0.3 1.6 1.0	Vdc

P2N2222, P2N2222A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage (1) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	—	1.3	Vdc
		0.6	1.2	
($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)		—	2.6	
		—	2.0	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain – Bandwidth Product (2) ($I_C = 20\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	P2N2222 P2N2222A	f_T	250 300	— —	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)		C_{obo}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	P2N2222 P2N2222A	C_{ibo}	— —	30 25	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	P2N2222A P2N2222A	h_{ie}	2.0 0.25	8.0 1.25	k Ω
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	P2N2222A P2N2222A	h_{re}	— —	8.0 4.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	P2N2222A P2N2222A	h_{fe}	50 75	300 375	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	P2N2222A P2N2222A	h_{oe}	5.0 25	35 200	μmhos
Collector Base Time Constant ($I_E = 20\text{ mAdc}$, $V_{CB} = 20\text{ Vdc}$, $f = 31.8\text{ MHz}$)	P2N2222A	$r_b' C_c$	—	150	ps
Noise Figure ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 1.0\text{ k}\Omega$, $f = 1.0\text{ kHz}$)	P2N2222A	NF	—	4.0	dB

SWITCHING CHARACTERISTICS MPS2222A only

Delay Time	(V _{CC} = 30 Vdc, V _{BE(off)} = 0.5 Vdc, I _C = 150 mAdc, I _{B1} = 15 mAdc) (Figure 1)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time		t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$. (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON TIME

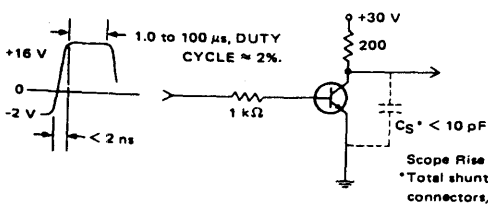
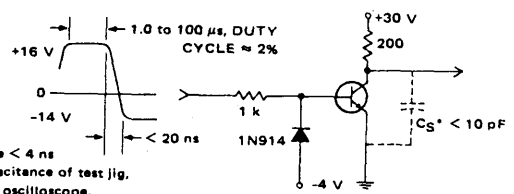


FIGURE 2 – TURN-OFF TIME



MAXIMUM RATINGS

Rating	Symbol	P2N2907	P2N2907A	Unit
Collector-Emitter Voltage	V _{CEO}	40	60	Vdc
Collector-Base Voltage	V _{CBO}	60		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current - Continuous	I _C	600		mAdc
Total Device Dissipation Derate above 25°C	P _D	625	5.0	mW mW/°C
Total Device Dissipation Derate above 25°C	P _D	1.5	12	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**P2N2907
P2N2907A**

**CASE 29-02, STYLE 17
TO-92 (TO-226AA)**

AMPLIFIER TRANSISTORS

PNP SILICON

Refer to MPS2907 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40 60	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CE} = 30 Vdc, V _{EB(off)} = 0.5 Vdc)	I _{CEX}	—	50	nAdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0)	I _{CBO}	—	0.020 0.010	μAdc
(V _{CB} = 50 Vdc, I _E = 0, T _A = 125 °C)		—	20 10	
Base Current (V _{CE} = 30 Vdc, V _{EB(off)} = 0.5 Vdc)	I _B	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 10 Vdc)	h _{FE}	35 75	—	—
(I _C = 1.0 mAdc, V _{CE} = 10 Vdc)		50 100	—	
(I _C = 10 mAdc, V _{CE} = 10 Vdc)		75 100	—	
(I _C = 150 mAdc, V _{CE} = 10 Vdc) (1)		100	300	
(I _C = 500 mAdc, V _{CE} = 10 Vdc) (1)		30 50	—	
Collector-Emitter Saturation Voltage (1) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	—	0.4 1.6	Vdc
Base-Emitter Saturation Voltage (1) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{BE(sat)}	—	1.3 2.6	Vdc

P2N2907, P2N2907A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain - Bandwidth Product (1), (2) ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	—	MHz	
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	8.0	pF	
Input Capacitance ($V_{BE} = 2.0\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	30	pF	
SWITCHING CHARACTERISTICS					
Turn-On Time	($V_{CC} = 30\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = 15\text{ mAdc}$) (Figures 1 and 5)	t_{on}	—	50	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-Off Time	($V_{CC} = 6.0\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = I_{B2} = 15\text{ mAdc}$) (Figure 2)	t_{off}	—	110	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	ns

FIGURE 1 - DELAY AND RISE TIME TEST CIRCUIT

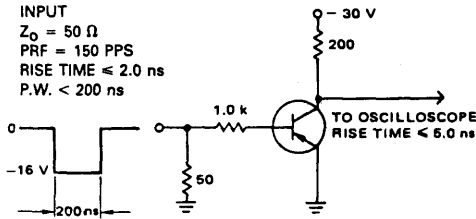
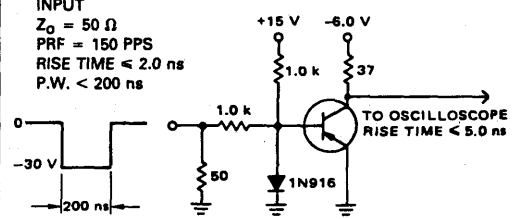


FIGURE 2 - STORAGE AND FALL TIME TEST CIRCUIT



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	80	Vdc
Collector-Base Voltage	V _{CBO}	120	Vdc
Emitter-Base Voltage	V _{EBO}	7.0	Vdc
Collector Current - Continuous	I _C	1.0	Adc
Total Device Dissipation Derate above 25°C	P _D	1.0 8.0	Watts mW/°C
Total Device Dissipation Derate above 25°C	P _D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

P2N3019
P2N3020

CASE 29-3, STYLE 1
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTORS

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I _C = 30 mAdc, I _B = 0)	V _{(BR)CEO}	80	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	120	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	7.0	—	Vdc
Collector Cutoff Current (V _{CB} = 90 Vdc, I _E = 0) (V _{CB} = 90 Vdc, I _E = 0, T _A = +150°C)	I _{CBO}	—	0.01 10	μAdc
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	0.010	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I _C = 0.1 mAdc, V _{CE} = 10 Vdc)	h _{FE}	P2N3020	50	—
		P2N3019	30	100
(I _C = 10 mAdc, V _{CE} = 10 Vdc)		P2N3019	90	—
		P2N3020	40	120
(I _C = 150 mAdc, V _{CE} = 10 Vdc)		P2N3019	100	300
		P2N3020	40	120
(I _C = 150 mAdc, V _{CE} = 10 Vdc, T _C = -55°C)		P2N3019	40	—
(I _C = 500 mAdc, V _{CE} = 10 Vdc)		P2N3019	50	—
	P2N3020	30	100	
(I _C = 1.0 Adc, V _{CE} = 10 Vdc)	All Types	15	—	
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	—	0.2 0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{BE(sat)}	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain - Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	80 100	—	MHz

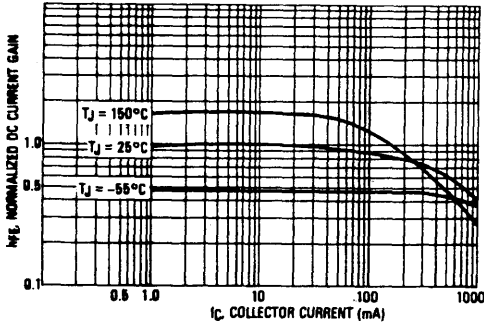
P2N3019, P2N3020

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

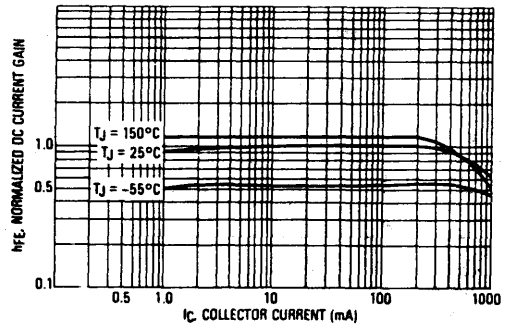
Characteristic	Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	12	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	60	pF
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	80 30	400 200	—
Collector Base Time Constant ($I_E = 10\text{ mA}$, $V_{CB} = 10\text{ Vdc}$, $f = 4.0\text{ MHz}$)	$rb'C_c$	— 15	400 400	ps
Noise Figure ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 1.0\text{ kohms}$, $f = 1.0\text{ kHz}$)	NF	—	4	dB

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 1.0\%$.

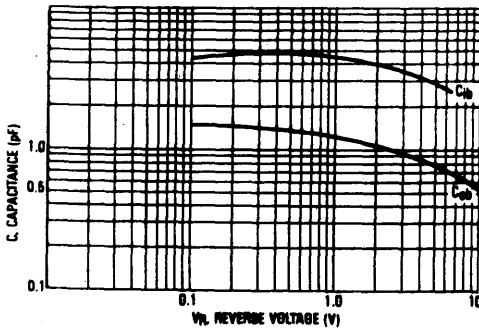
DC CURRENT GAIN
P2N3019



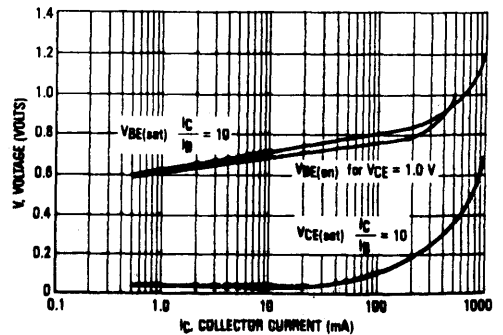
DC CURRENT GAIN
P2N3020



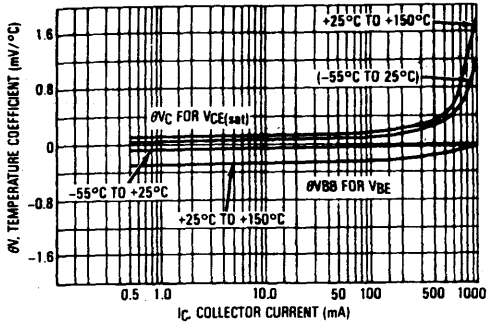
CAPACITANCE



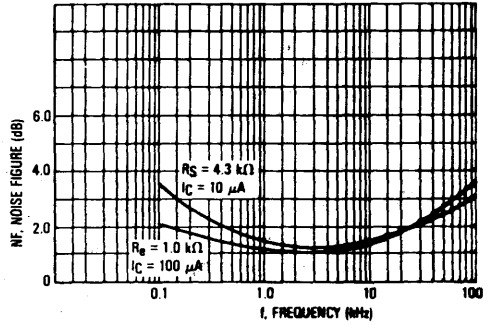
"ON" VOLTAGES



TEMPERATURE COEFFICIENTS

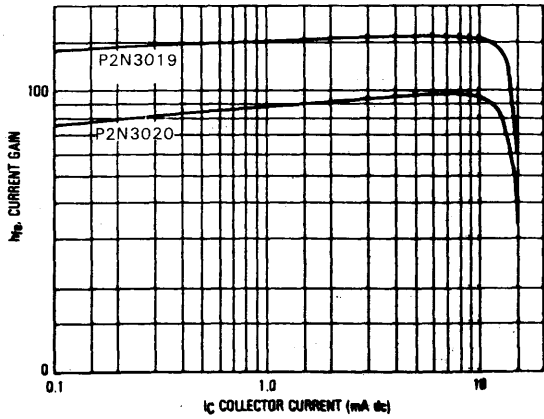


FREQUENCY EFFECTS

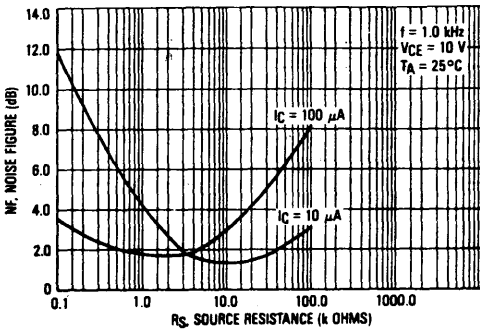


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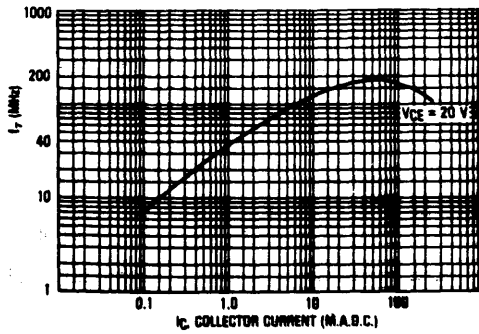
CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT — 1 kHz f_{β}



SOURCE RESISTANCE EFFECTS



CURRENT GAIN — BANDWIDTH PRODUCT



P2N4031 P2N4033

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	80	Vdc
Collector-Base Voltage	V _{CBO}	80	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current - Continuous	I _C	1.0	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	W mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 20	W mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	50	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA)	V _{(BR)CEO}	80	—	V
Collector-Base Breakdown Voltage (I _C = 10 μA)	V _{(BR)CBO}	80	—	V
Emitter-Base Breakdown Voltage (I _E = 10 μA)	V _{(BR)EBO}	5.0	—	V
Collector Cutoff Current (V _{CB} = 60 V) (V _{CB} = 60 V, T _A = 150°C)	I _{CBO}	—	5.0 50	nA μA
Emitter Cutoff Current (V _{EB} = 5.0 V)	I _{EBO}	—	10	nA
ON CHARACTERISTICS				
DC Current Gain (I _C = 100 mA, V _{CE} = 5.0 V, -55°C)	h _{FE}	P2N4031	15	—
		P2N4033	40	—
(I _C = 100 μA, V _{CE} = 5.0 V)	h _{FE}	P2N4031	30	—
		P2N4033	75	—
(I _C = 100 mA, V _{CE} = 5.0 V)	h _{FE}	P2N4031	40	120
		P2N4033	100	300
(I _C = 500 mA, V _{CE} = 5.0 V)	h _{FE}	P2N4031	25	—
		P2N4033	70	—
(I _C = 1.0 A, V _{CE} = 5.0 V)	h _{FE}	P2N4031	10	—
		P2N4033	25	—
Collector-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA) (I _C = 500 mA, I _B = 50 mA)	V _{CE(sat)}	—	0.15 0.50	V
Base-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA) (I _C = 500 mA, I _B = 50 mA)	V _{BE(sat)}	—	0.9 1.1	V

P2N4027, P2N4029, P2N4031, P2N4033

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CE} = 10\text{ V}, f = 1.0\text{ MHz}$)	C_{obo}	—	25	pF
Input Capacitance ($V_{EB} = 0.5\text{ V}, f = 1.0\text{ MHz}$)	C_{ibo}	—	150	pF
Current Gain — Bandwidth Product ($I_C = 50\text{ mA}, V_{CC} = 10\text{ V}, f = 100\text{ MHz}$)	f_T	150		MHz
SWITCHING CHARACTERISTICS				
Turn-On Time (see Figure 1) ($I_C = 500\text{ mA}, I_{B1} = 50\text{ mA}$)	t_{on}	—	100	ns
Turn-Off Time (see Figure 1) ($I_C = 500\text{ mA}, I_{B1} = I_{B2} = 50\text{ mA}$)	t_{off}	—	400	ns

(1) Pulse Width = 300 μs , Duty Cycle 1.0%.

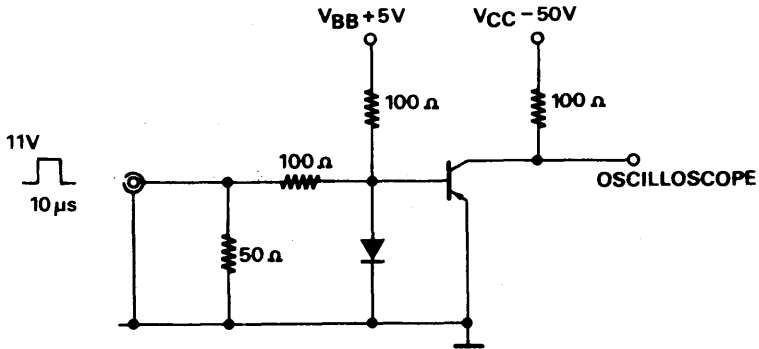


FIGURE 1: SWITCHING TIMES TEST CIRCUIT

2

P2N5550 P2N5551

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N 5550	2N 5551	Unit
Collector-Emitter Voltage	V_{CE0}	140	160	Vdc
Collector-Base Voltage	V_{CBO}	160	180	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current - Continuous	I_C	600		mAdc
Total Device Dissipation Derate above 25°C	$T_A = 25^\circ\text{C}$ P_D	625 5.0		mW mW/°C
Total Device Dissipation Derate above 25°C	$T_C = 25^\circ\text{C}$ P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

Refer to 2N5550 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (2) ($I_C = 1.0$ mAdc, $I_B = 0$)	P2N5550 P2N5551	$V_{(BR)CEO}$	140 160	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	P2N5550 P2N5551	$V_{(BR)CBO}$	160 180	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 100^\circ\text{C}$) ($V_{CB} = 120$ Vdc, $I_E = 0$, $T_A = 100^\circ\text{C}$)	P2N5550 P2N5551 P2N5550 P2N5551	I_{CBO}	— — — —	100 50 100 50	nAdc μ Adc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc

ON CHARACTERISTICS (2)

DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	P2N5550 P2N5551	h_{FE}	60 80	— —	—
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	P2N5550 P2N5551		60 80	250 250	
($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	P2N5550 P2N5551		20 30	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	Both Types P2N5550 P2N5551	$V_{CE(sat)}$	— — —	0.15 0.25 0.20	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	Both Types P2N5550 P2N5551	$V_{BE(sat)}$	— — —	1.0 1.2 1.0	Vdc

P2N5550, P2N5551

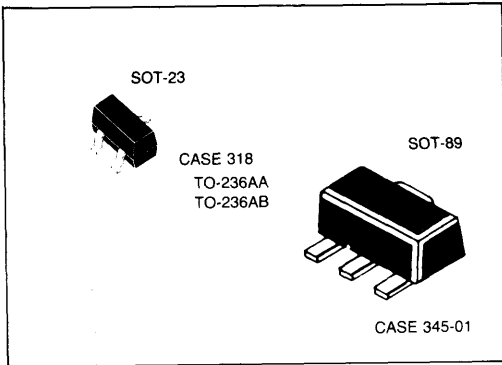
ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain – Bandwidth Product ($I_C = 10\text{ mA dc}$, $V_{CE} = 10\text{ V dc}$, $f = 100\text{ MHz}$)	f_T	100	300	MHz
Output Capacitance ($V_{CB} = 10\text{ V dc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ V dc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	30 20	pF
				P2N5550 P2N5551
Small-Signal Current Gain ($I_C = 1.0\text{ mA dc}$, $V_{CE} = 10\text{ V dc}$, $f = 1.0\text{ kHz}$)	h_{fe}	50	200	—
Noise Figure ($I_C = 250\text{ }\mu\text{A dc}$, $V_{CE} = 5.0\text{ V dc}$, $R_S = 1.0\text{ kohms}$, $f = 10\text{ Hz to }15.7\text{ kHz}$)	N_F	—	10 8.0	dB
				P2N5550 P2N5551

(2) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2.0%.

2





A wide variety of discrete components from Motorola's repertoire of reliability-proven semiconductor processes and geometries are available in the SOT-23 and SOT-89 packages. Products include Bipolar and Field-Effect Transistors, Switching, Zener and Varactor Diodes.

As an additional service to our customers SOT-23's are available in:

- 8 mm tape and reel
- reverse pinout
- standard profile (TO-236AA) or low profile (TO-236AB)

Contact your Motorola representative for ordering information.

Microminature Products

3

BAL99

CASE 318-02/03, STYLE 17
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	70	Vdc
Peak Forward Current	I_F	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current ($V_R = 70\text{ V}$) ($V_R = 25\text{ V}$, $T_J = 150^\circ\text{C}$) ($V_R = 70\text{ V}$, $T_J = 150^\circ\text{C}$)	I_R	— — —	2.5 30 50	μA
Reverse Breakdown Voltage ($I_R = 100\ \mu\text{A}$)	$V_{(BR)}$	70	—	V
Forward Voltage ($I_F = 1.0\text{ mA}$) ($I_F = 10\text{ mA}$) ($I_F = 50\text{ mA}$) ($I_F = 100\text{ mA}$)	V_F	— — — —	715 855 1100 1300	mV
Recovery Current ($I_F = 10\text{ mA}$, $V_R = 5.0\text{ V}$, $R_L = 500\ \Omega$)	Q_S	—	45	pC
Diode Capacitance ($V_R = 0$, $f = 1.0\text{ MHz}$)	C_D	—	1.5	pF
Reverse Recovery Time ($I_F = I_R = 10\text{ mA}$, $R_L = 100\ \Omega$, measured at $I_R = 1.0\text{ mA}$)	t_{rr}	—	6.0	ns
Forward Recovery Voltage ($I_F = 10\text{ mA}$, $t_r = 20\text{ ns}$)	V_{FR}	—	1.75	V

BAS16

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	75	V_{CC}
Peak Forward Current	I_F	200	mA
Peak Forward Surge Current	$I_{FM}(\text{surge})$	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current ($V_R = 75\text{ V}$) ($V_R = 75\text{ V}, T_J = 150^\circ\text{C}$) ($V_R = 25\text{ V}, T_J = 150^\circ\text{C}$)	I_R	— — —	1.0 50 30	μA
Reverse Breakdown Voltage ($I_{BR} = 100\ \mu\text{A}$)	$V_{(BR)}$	75	—	V
Forward Voltage ($I_F = 1.0\text{ mA}$) ($I_F = 10\text{ mA}$) ($I_F = 50\text{ mA}$) ($I_F = 100\text{ mA}$)	V_F	— — — —	715 855 1100 1300	mV
Diode Capacitance ($V_R = 0, f = 1.0\text{ MHz}$)	C_D	—	2.0	pF
Forward Recovery Voltage ($I_F = 10\text{ mA}, t_r = 20\text{ ns}$)	V_{FR}	—	1.75	V
Reverse Recovery Time ($I_F = I_R = 10\text{ mA}, R_L = 100\ \Omega$)	t_{rr}	—	6.0	ns
Stored Charge ($I_F = 10\text{ mA}$ to $V_R = 5.0\text{ V}, R_L = 500\ \Omega$)	Q_S	—	45	pC

BAV70

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM}(\text{surge})$	500	mAdc

THERMAL CHARACTERISTICS

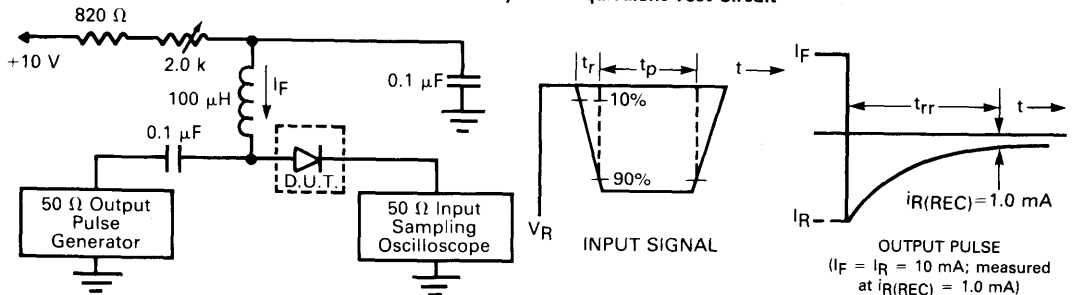
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)} = 100 \mu\text{Adc}$)	$V_{(BR)}$	>70	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25 \text{ Vdc}, T_J = 150^\circ\text{C}$) ($V_R = 70 \text{ Vdc}$) ($V_R = 70 \text{ Vdc}, T_J = 150^\circ\text{C}$)	I_R	— — —	60 5.0 100	μAdc
Diode Capacitance ($V_R = 0, f = 1.0 \text{ MHz}$)	C_T	—	1.5	pF
Forward Voltage ($I_F = 1.0 \text{ mAdc}$) ($I_F = 10 \text{ mAdc}$) ($I_F = 50 \text{ mAdc}$) ($I_F = 100 \text{ mAdc}$)	V_F	— — — —	715 855 1100 1300	mVdc
Reverse Recovery Time ($I_F = I_R = 10 \text{ mAdc}, V_R = 5.0 \text{ Vdc}$, $I_{R(REC)} = 1.0 \text{ mAdc}$) (Figure 1)	t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



- Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(\text{peak})}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM}(\text{surge})$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

BAV74

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Reverse Breakdown Voltage ($I_{BR} = 5.0 \mu\text{Adc}$)	$V_{(BR)}$	50	—	Vdc
Reverse Voltage Leakage Current ($V_R = 50 \text{ Vdc}$, $T_J = 125^\circ\text{C}$) ($V_R = 50 \text{ Vdc}$)	I_R	—	100 0.1	μAdc
Diode Capacitance ($V_R = 0$, $f = 1.0 \text{ MHz}$)	C_T	—	2.0	pF
Forward Voltage ($I_F = 100 \text{ mAdc}$)	V_F	—	1.0	Vdc
Reverse Recovery Time ($I_F = I_R = 10 \text{ mAdc}$, $I_{R(REC)} = 1.0 \text{ mAdc}$, measured at $I_R = 1.0 \text{ mA}$, $R_L = 100 \Omega$)	t_{rr}	—	4.0	ns

BAV99

CASE 318-02/03, STYLE 11
SOT-23 (TO-236AA/AB)

DUAL SERIES
SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	100	mAdc
Peak Forward Surge Current	$I_{FM}(\text{surge})$	500	mAdc

THERMAL CHARACTERISTICS

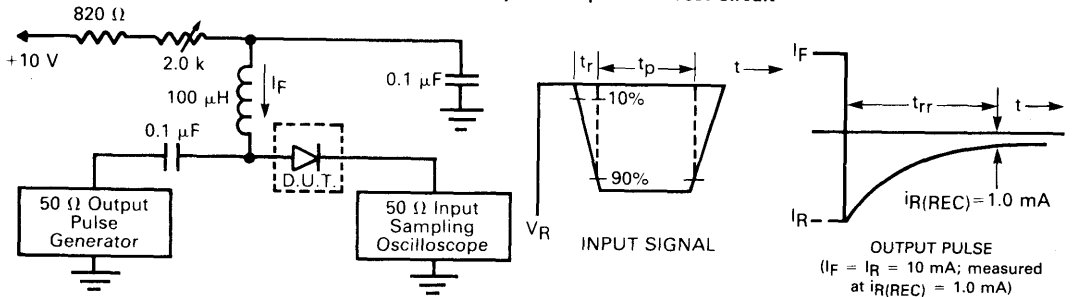
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)} = 100 \mu\text{A}$)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25 \text{ Vdc}, T_J = 150^\circ\text{C}$) ($V_R = 70 \text{ Vdc}$) ($V_R = 70 \text{ Vdc}, T_J = 150^\circ\text{C}$)	I_R	—	30 2.5 50	μAdc
Diode Capacitance ($V_R = 0, f = 1.0 \text{ MHz}$)	C_T	—	1.5	pF
Forward Voltage ($I_F = 1.0 \text{ mAdc}$) ($I_F = 10 \text{ mAdc}$) ($I_F = 50 \text{ mAdc}$) ($I_F = 100 \text{ mAdc}$)	V_F	—	715 855 1100 1300	mVdc
Reverse Recovery Time ($I_F = I_R = 10 \text{ mAdc}, i_{R(REC)} = 1.0 \text{ mAdc}$) (Figure 1)	t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



- Notes: 1. A 2.0 k Ω variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_R(\text{peak})$ is equal to 10 mA.
3. $t_p \approx t_{rr}$

BAW56

CASE 318-02/03, STYLE 12
SOT-23 (TO-236AA/AB)

DUAL
SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM}(\text{surge})$	200	mAdc

THERMAL CHARACTERISTICS

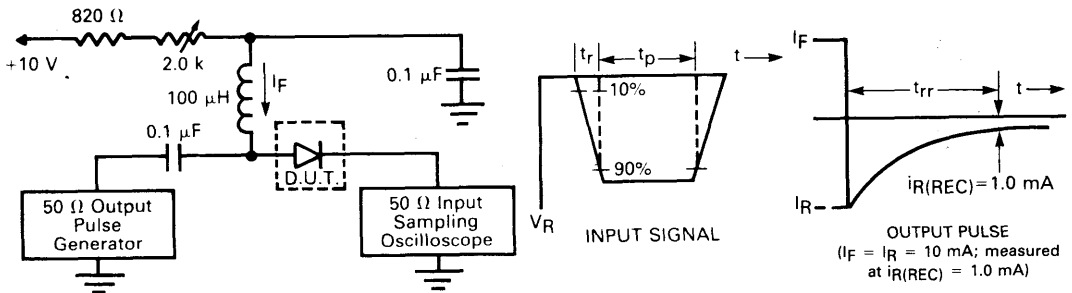
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{BR} = 100 \mu\text{Adc}$)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25 \text{ Vdc}, T_J = 150^\circ\text{C}$) ($V_R = 70 \text{ Vdc}$) ($V_R = 70 \text{ Vdc}, T_J = 150^\circ\text{C}$)	I_R	—	30 2.5 50	μAdc
Diode Capacitance ($V_R = 0, f = 1.0 \text{ MHz}$)	C_T	—	2.5	pF
Forward Voltage ($I_F = 1.0 \text{ mAdc}$) ($I_F = 10 \text{ mAdc}$) ($I_F = 50 \text{ mAdc}$) ($I_F = 100 \text{ mAdc}$)	V_F	—	715 855 1100 1300	mVdc
Reverse Recovery Time ($I_F = I_R = 10 \text{ mAdc}, I_R(\text{REC}) = 1.0 \text{ mAdc}$) (Figure 1)	t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



- Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_R(\text{peak})$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

BCW29,30

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	20	Vdc
Collector-Base Voltage	V_{CB0}	30	Vdc
Emitter-Base Voltage	V_{EB0}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mAdc, $I_E = 0$)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc , $V_{EB} = 0$)	$V_{(BR)CES}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc , $I_C = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc , $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	— —	100 10	nAdc μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)	BCW29 BCW30	h_{FE}	120 215	260 500	— —
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	0.6	0.75	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($I_E = 0$, $V_{CE} = 10$ Vdc, $f = 1.0$ MHz)		C_{obo}	—	7.0	pF
Noise Figure ($I_C = 0.2$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 2.0$ k Ω , $f = 1.0$ kHz, BW = 200 Hz)		NF	—	10	dB

BCW31,32,33

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350	mW
		2.8	mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 2.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_B = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBC}$	5.0	—	Vdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}			—
		BCW31	110	220
		BCW32	200	450
		BCW33	420	800
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0.5 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	0.55	0.70	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($I_E = 0$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	4.0	pF
Noise Figure ($I_C = 0.2 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 2.0 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$)	NF	—	10	dB

BCW60A,B,C,D

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	32	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mA _{dc}

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 2.0 \text{ mA}_{dc}$, $I_E = 0$)	$V_{(BR)CEO}$	32	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \mu\text{A}_{dc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 32 \text{ Vdc}$) ($V_{CE} = 32 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{CES}	— —	20 20	nA _{dc} μA_{dc}
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	20	nA _{dc}

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \mu\text{A}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$)	Symbol	Min	Max	Unit
BCW60A	h_{FE}	—	—	—
BCW60B		20	—	—
BCW60C		40	—	—
BCW60D		100	—	—
($I_C = 2.0 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$)	BCW60A	120	220	
	BCW60B	180	310	
	BCW60C	250	460	
	BCW60D	380	630	
($I_C = 50 \text{ mA}_{dc}$, $V_{CE} = 1.0 \text{ Vdc}$)	BCW60A	60	—	
	BCW60B	70	—	
	BCW60C	90	—	
	BCW60D	100	—	
($I_C = 2.0 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	BCW60A	125	250	
	BCW60B	175	350	
	BCW60C	250	500	
	BCW60D	350	700	
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mA}_{dc}$, $I_B = 1.25 \text{ mA}_{dc}$) ($I_C = 10 \text{ mA}_{dc}$, $I_B = 0.25 \text{ mA}_{dc}$)	$V_{CE(sat)}$	— —	0.55 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 50 \text{ mA}_{dc}$, $I_B = 1.25 \text{ mA}_{dc}$) ($I_C = 50 \text{ mA}_{dc}$, $I_B = 0.25 \text{ mA}_{dc}$)	$V_{BE(sat)}$	0.7 0.6	1.05 0.85	Vdc
Base-Emitter On Voltage ($I_C = 2.0 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	0.55	0.75	Vdc

BCW60A,B,C,D

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $f = 1.0 \text{ MHz}$)	f_T	125	—	MHz
Output Capacitance ($V_{CE} = 10 \text{ V dc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	4.5	pF
Noise Figure ($I_C = 0.2 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $R_S = 2.0 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time ($I_C = 10 \text{ mA dc}$, $I_{B1} = 1.0 \text{ mA dc}$)	t_{on}	—	150	ns
Turn-Off Time ($I_{B2} = 1.0 \text{ mA dc}$, $V_{BB} = 3.6 \text{ V dc}$, $R_1 = R_2 = 5.0 \text{ k}\Omega$, $R_L = 990 \Omega$)	t_{off}	—	800	ns

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BCW61A,B,C,D

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	32	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mA _{dc}

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 2.0 \text{ mA}_{dc}$, $I_B = 0$)	$V_{(BR)CEO}$	32	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \text{ mA}_{dc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 32 \text{ Vdc}$) ($V_{CE} = 32 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{CES}	— —	20 20	nA _{dc} μA_{dc}

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$)	BCW61A BCW61B BCW61C BCW61D	h_{FE}	— 20 40 100	— — — —	—
($I_C = 2.0 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$)	BCW61A BCW61B BCW61C BCW61D		120 140 250 380	220 310 460 630	
($I_C = 50 \text{ mA}_{dc}$, $V_{CE} = 1.0 \text{ Vdc}$)	BCW61A BCW61B BCW61C BCW61D		60 80 100 100	— — — —	
($I_C = 2.0 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	BCW61A BCW61B BCW61C BCW61D		125 175 250 350	250 350 500 700	
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mA}_{dc}$, $I_B = 1.25 \text{ mA}_{dc}$) ($I_C = 10 \text{ mA}_{dc}$, $I_B = 0.25 \text{ mA}_{dc}$)		$V_{CE(sat)}$	— —	0.55 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 50 \text{ mA}_{dc}$, $I_B = 1.25 \text{ mA}_{dc}$) ($I_C = 10 \text{ mA}_{dc}$, $I_B = 0.25 \text{ mA}_{dc}$)		$V_{BE(sat)}$	0.68 0.6	1.05 0.85	Vdc
Base-Emitter On Voltage ($I_C = 2.0 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$)		$V_{BE(on)}$	0.6	0.75	Vdc

BCW61A,B,C,D

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CE} = 10\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	6.0	pF
Noise Figure ($I_C = 0.2\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 2.0\text{ k}\Omega$, $f = 1.0\text{ kHz}$, $BW = 200\text{ Hz}$)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time ($I_C = 10\text{ mAdc}$, $I_{B1} = 1.0\text{ mAdc}$)	t_{on}	—	150	ns
Turn-Off Time ($I_{B2} = 1.0\text{ mAdc}$, $V_{BB} = 3.6\text{ Vdc}$, $R_1 = R_2 = 5.0\text{ k}\Omega$, $R_L = 990\ \Omega$)	t_{off}	—	800	ns

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BCW65A,B,C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	32	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μ Adc, $V_{EB} = 0$)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 32$ Vdc, $I_E = 0$) ($V_{CE} = 32$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CES}	—	—	20 20	nAdc μ Adc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 100$ μ Adc, $V_{CE} = 10$ Vdc)	A	—	—	—	—
	B	35	—	—	—
	C	50	—	—	—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	A	80	—	—	—
	B	75	—	—	—
	C	110	—	—	—
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	A	180	—	—	—
	B	100	—	250	—
	C	160	—	400	—
($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)		250	—	630	—
		35	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	—	—	0.7 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{BE(sat)}$	—	—	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	100	—	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	—	12	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{ibo}	—	—	80	pF
Noise Figure ($I_C = 0.2 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 1.0 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$)	NF	—	—	10	dB

SWITCHING CHARACTERISTICS

Turn-On Time ($I_{B1} = I_{B2} = 15 \text{ mAdc}$, $I_C = 150 \text{ mAdc}$, $R_L = 150 \Omega$)	t_{on}	—	—	100	ns
Turn-Off Time ($I_{B1} = I_{B2} = 15 \text{ mAdc}$, $I_C = 150 \text{ mAdc}$, $R_L = 150 \Omega$)	t_{off}	—	—	400	ns

BCW66F,G

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μ Adc, $V_{EB} = 0$)	$V_{(BR)CES}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 45$ Vdc, $I_C = 0$) ($V_{CE} = 45$ Vdc, $I_C = 0$, $T_A = 150^\circ\text{C}$)	I_{CES}	—	—	20 20	nAdc μ Adc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 100$ μ Adc, $V_{CE} = 1.0$ Vdc)	F G F G F G	h_{FE}	—	—	—	—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)			35	—	—	—
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)			50	—	—	—
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)			75	—	—	—
($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)			110	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	—	0.7 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	—	—	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	100	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	—	12	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 1.0$ MHz)	C_{ibo}	—	—	80	pF
Noise Figure ($I_C = 0.2$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ k Ω , $f = 1.0$ kHz, BW = 200 Hz)	NF	—	—	10	dB

SWITCHING CHARACTERISTICS

Turn-On Time ($I_{B1} = I_{B2} = 15$ mAdc, $I_C = 150$ mAdc, $R_L = 150$ Ω)	t_{on}	—	—	100	ns
Turn-Off Time ($I_{B1} = I_{B2} = 15$ mAdc, $I_C = 150$ mAdc, $R_L = 150$ Ω)	t_{off}	—	—	400	ns

BCW67,A,B,C BCW68,F,G

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BCW67	BCW68	Unit
Collector-Emitter Voltage	V _{CEO}	32	45	Vdc
Collector-Base Voltage	V _{CBO}	45	60	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	800		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	BCW67 Series BCW68 Series	V _{(BR)CEO}	32 45	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I _C = 10 μAdc, V _{EB} = 0)	BCW67 Series BCW68 Series	V _{(BR)CES}	45 60	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)		V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CE} = 32 Vdc, I _E = 0) (V _{CE} = 45 Vdc, I _E = 0) (V _{CE} = 32 Vdc, I _B = 0, T _A = 150°C) (V _{CE} = 45 Vdc, I _B = 0, T _A = 150°C)	BCW67 Series BCW68 Series BCW67 Series BCW68 Series	I _{CES}	— — — —	— — — —	20 20 10 10	nAdc μAdc
Emitter Cutoff Current (V _{EB} = 4.0 Vdc, I _C = 0)		I _{EBO}	—	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 10 mAdc, V _{CE} = 1.0 Vdc)	BCW67,A,68,F BCW67B,68G BCW67C	h _{FE}	75 120 180	— — —	— — —	—
(I _C = 100 mAdc, V _{CE} = 1.0 Vdc)	BCW67,A,68,F BCW67B,68G BCW67C		100 160 250	— — —	250 400 630	
(I _C = 500 mAdc, V _{CE} = 1.0 Vdc)	BCW67,A,68,F BCW67B,68G BCW67C		35 60 100	— — —	— — —	
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 10 mAdc)		V _{CE(sat)}	—	—	0.3	Vdc
Base-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc)		V _{BE(sat)}	—	—	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	100	—	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	—	18	pF
Input Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	—	80	pF
Noise Figure (I _C = 0.2 mAdc, V _{CE} = 5.0 Vdc, R _S = 1.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	—	10	dB

BCW69,70

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	PD	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 2.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $V_{EB} = 0$)	$V_{(BR)CES}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	— —	100 10	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_E = 0$, $V_{CE} = 5.0 \text{ Vdc}$)	BCW69 BCW70 h_{FE}	120 215	260 500	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0.5 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	0.6	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($I_E = 0$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	7.0	pF
Noise Figure ($I_C = 0.2 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 2.0 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$)	NF	—	10	dB

BCW71,72

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	45	Vdc
Collector-Base Voltage	V _{CBO}	50	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 2.0 mAdc, V _{EB} = 0)	V _{(BR)CEO}	45	—	—	Vdc
Collector-Emitter Breakdown Voltage (I _C = 2.0 mAdc, V _{EB} = 0)	V _{(BR)CES}	45	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0) (V _{CB} = 20 Vdc, I _E = 0, T _A = 100°C)	I _{CBO}	— —	— —	100 10	nAdc μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 2.0 mAdc, V _{CE} = 5.0 Vdc)	BCW71 BCW72	h _{FE}	110 200	— —	220 450	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 50 mAdc, I _B = 2.5 mAdc)		V _{CE(sat)}	— —	— 0.21	0.25 —	Vdc
Base-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 2.5 mAdc)		V _{BE(sat)}	—	0.85	—	Vdc
Base-Emitter On Voltage (I _C = 2.0 mAdc, V _{CE} = 5.0 Vdc)		V _{BE(on)}	0.6	—	0.75	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 5.0 Vdc, f = 35 MHz)		f _T	—	300	—	MHz
Output Capacitance (I _E = 0, V _{CE} = 10 Vdc, f = 1.0 MHz)		C _{obo}	—	—	4.0	pF
Input Capacitance (I _C = 0, V _{EB} = 0.5 Vdc, f = 1.0 MHz)		C _{ibo}	—	9.0	—	pF
Noise Figure (I _C = 0.2 mAdc, V _{CE} = 5.0 Vdc, R _S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	—	10	dB

BCX17,18

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		BCX17	BCX18	
Collector-Emitter Voltage	V _{CEO}	45	25	V _{dc}
Collector-Base Voltage	V _{CBO}	50	30	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0		V _{dc}
Collector Current — Continuous	I _C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	BCX17 BCX18	V _{(BR)CEO}	45 25	— —	V _{dc}
Collector-Emitter Breakdown Voltage (I _C = 10 μAdc, I _C = 0)	BCX17 BCX18	V _{(BR)CES}	50 30	— —	V _{dc}
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0) (V _{CB} = 20 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	— —	— —	100 5.0	nAdc μAdc
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 100 mAdc, V _{CE} = 1.0 Vdc) (I _C = 300 mAdc, V _{CE} = 1.0 Vdc) (I _C = 500 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	100 70 40	— — —	600 — —	—
Collector-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	—	—	0.62	V _{dc}
Base-Emitter On Voltage (I _C = 500 mAdc, V _{CE} = 1.0 Vdc)	V _{BE(on)}	—	—	1.2	V _{dc}

BCX19,20

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		BCX19	BCX20	
Collector-Emitter Voltage	V _{CEO}	45	25	V _{dc}
Collector-Base Voltage	V _{CBO}	50	30	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0		V _{dc}
Collector Current — Continuous	I _C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	45 25	— —	— —	V _{dc}
Collector-Emitter Breakdown Voltage (I _C = 10 μAdc, I _C = 0)	V _{(BR)CES}	50 30	— —	— —	V _{dc}
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0) (V _{CB} = 20 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	— —	— —	100 5.0	nAdc μAdc
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 100 mAdc, V _{CE} = 1.0 Vdc) (I _C = 300 mAdc, V _{CE} = 1.0 Vdc) (I _C = 500 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	100 70 40	— — —	600 — —	—
Collector-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	—	—	0.62	V _{dc}
Base-Emitter On Voltage (I _C = 500 mAdc, V _{CE} = 1.0 Vdc)	V _{BE(on)}	—	—	1.2	V _{dc}

**BCX51
BCX52
BCX53**

**CASE 345-01, STYLE 1
SOT-89**

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BCX51	BCX52	BCX53	Unit
Collector-Emitter Voltage	V _{CEO}	45	60	80	V
Collector-Emitter Voltage	V _{CER}	45	60	100	V
Collector-Base Voltage	V _{CBO}	45	60	100	V
Emitter-Base Voltage	V _{EBO}	5.0	5.0	5.0	V
Base Current	I _B	0.1	0.1	0.1	A
Collector Current — Continuous	I _C	1.0	1.0	1.0	A
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to + 150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA) (I _C = 10 mA) (I _C = 10 mA)	BCX51 BCX52 BCX53	V _{(BR)CEO}	45 60 80	— — — V
Collector-Base Breakdown Voltage (I _C = 10 μA) (I _C = 10 μA) (I _C = 10 μA)	BCX51 BCX52 BCX53	V _{(BR)CBO}	45 60 100	— — — V
Emitter-Base Breakdown Voltage (I _E = 10 μA)		V _{(BR)EBO}	5.0	— — V
Collector Cutoff Current (V _{CB} = 30 V) (V _{CB} = 30 V, T _J = 125°C)		I _{CBO}	— —	100 10 nA μA
Emitter Cutoff Current (V _{EB} = 3.0 V)		I _{EBO}	—	100 nA
ON CHARACTERISTICS				
DC Current Gain (I _C = 5.0 mA, V _{CE} = 2.0 V) (I _C = 150 mA, V _{CE} = 2.0 V) (I _C = 150 mA, V _{CE} = 2.0 V) (I _C = 500 mA, V _{CE} = 2.0 V)	BCX51 BCX52,53	h _{FE}	25 40 40 25	— — 250 160 —
Collector-Emitter Saturation Voltage (I _C = 500 mA, I _B = 50 mA)		V _{CE(sat)}	—	0.5 V
Base-Emitter On Voltage (I _C = 500 mA, V _{CE} = 2.0 V)		V _{BE(on)}	—	1.0 V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V _{CE} = 5.0 V, I _C = 10 mA, f = 35 MHz)		f _T	50	— MHz

MAXIMUM RATINGS

Rating	Symbol	BCX54	BCX55	BCX56	Unit
Collector-Emitter Voltage	V _{CEO}	45	60	80	V
Collector-Emitter Voltage	V _{CER}	45	60	100	V
Collector-Base Voltage	V _{CBO}	45	60	100	V
Emitter-Base Voltage	V _{EBO}	5.0	5.0	5.0	V
Base Current	I _B	0.1	0.1	0.1	A
Collector Current — Continuous	I _C	1.0	1.0	1.0	A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

BCX54
BCX55
BCX56

CASE 345-01, STYLE 1
SOT-89

GENERAL PURPOSE TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA) (I _C = 10 mA) (I _C = 10 mA)	V _{(BR)CEO}	45 60 80	— — —	V
Collector-Base Breakdown Voltage (I _C = 10 μA) (I _C = 10 μA) (I _C = 10 μA)	V _{(BR)CBO}	45 60 100	— — —	V
Emitter-Base Breakdown Voltage (I _E = 500 mA, I _B = 50 mA) (I _E = 10 μA) (I _E = 10 μA)	V _{(BR)EBO}	5.0 5.0 5.0	— — —	V
Collector Cutoff Current (V _{CB} = 30 V) (V _{CB} = 30 V, T _J = 125°C)	I _{CBO}	— —	100 10	nA μA
Emitter Cutoff Current (V _{EB} = 3.0 V)	I _{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain (I _C = 5.0 mA, V _{CE} = 2.0 V) (I _C = 150 mA, V _{CE} = 2.0 V) (I _C = 500 mA, V _{CE} = 2.0 V)	h _{FE}	25 40 25	— 250 —	—
Collector-Emitter Saturation Voltage (I _C = 500 mA, I _B = 50 mA)	V _{CE(sat)}	—	0.5	V
Base-Emitter On Voltage (I _C = 500 mA, V _{CE} = 2.0 V)	V _{BE(on)}	—	1.0	V
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V _{CE} = 5.0 V, I _C = 10 mA, f = 35 MHz)	f _T	50	—	MHz

BCX68

CASE 345-01, STYLE 1
SOT-89

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	V
Collector-Emitter Voltage	V _{CES}	25	V
Emitter-Base Voltage	V _{EBO}	5.0	V
Base Current	I _B	100	mA
Base Current — Maximum	I _{BM}	200	mA
Collector Current — Continuous	I _C	1.0	A
Collector Current — Maximum	I _{CM}	2.0	A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA)	V _{(BR)CEO}	20	—	V
Collector Cutoff Current (V _{CB} = 25 V)	I _{CBO}	—	100	nA
Emitter Cutoff Current (V _{EB} = 5.0 V)	I _{EBO}	—	10	μA
ON CHARACTERISTICS				
DC Current Gain (V _{CE} = 10 V, I _C = 5.0 mA) (V _{CE} = 1.0 V, I _C = 0.5 A) (V _{CE} = 1.0 V, I _C = 1.0 A)	h _{FE}	50 85 60	— 375 —	—
Collector-Emitter Saturation Voltage (I _C = 1.0 A, I _B = 100 mA)	V _{CE(sat)}	—	0.5	V
Base-Emitter On Voltage (V _{CE} = 10 V, I _C = 5.0 mA) (V _{CE} = 1.0 V, I _C = 1.0 A)	V _{BE(on)}	— —	0.6 1.0	V _{dc}
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V _{CE} = 5.0 V, I _C = 10 mA, f = 20 MHz)	f _T	65	—	MHz

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	V
Collector-Emitter Voltage	V _{CES}	25	V
Emitter-Base Voltage	V _{EBO}	5.0	V
Base Current	I _B	100	mA
Base Current — Maximum	I _{BM}	200	mA
Collector Current — Continuous	I _C	1.0	A
Collector Current — Maximum	I _{CM}	2.0	A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

BCX69

**CASE 345-01, STYLE 1
SOT-89**

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3**ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA)	V _{(BR)CEO}	20	—	V
Collector Cutoff Current (V _{CB} = 25 V)	I _{CBO}	—	100	nA
Emitter Cutoff Current (V _{EB} = 5.0 V)	I _{EBO}	—	10	μA
ON CHARACTERISTICS				
DC Current Gain (V _{CE} = 10 V, I _C = 5.0 mA) (V _{CE} = 1.0 V, I _C = 0.5 A) (V _{CE} = 1.0 V, I _C = 1.0 A)	h _{FE}	50 85 60	— 375 —	—
Collector-Emitter Saturation Voltage (I _C = 1.0 A, I _B = 100 mA)	V _{CE(sat)}	—	0.5	V
Base-Emitter On Voltage (V _{CE} = 10 V, I _C = 5.0 mA) (V _{CE} = 1.0 V, I _C = 1.0 A)	V _{BE(on)}	— —	0.6 1.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V _{CE} = 5.0 V, I _C = 10 mA, f = 20 MHz)	f _T	65	—	MHz

BCX70G,H,J,K

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	45	Vdc
Collector-Base Voltage	V_{CB0}	45	Vdc
Emitter-Base Voltage	V_{EB0}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 2.0 \text{ mAdc}$, $I_E = 0$)	$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 32 \text{ Vdc}$) ($V_{CE} = 32 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{CES}	— —	20 20	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	—	—	—
BCX70G				
BCX70H				
BCX70K				
($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	—	—	—	—
BCX70G				
BCX70H				
BCX70K				
($I_C = 50 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	—	—	—	—
BCX70G				
BCX70H				
BCX70K				
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 1.25 \text{ mAdc}$) ($I_C = 10 \text{ mAdc}$, $I_B = 0.25 \text{ mAdc}$)	$V_{CE(sat)}$	— —	0.55 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 1.25 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 0.25 \text{ mAdc}$)	$V_{BE(sat)}$	0.7 0.6	1.05 0.85	Vdc
Base-Emitter On Voltage ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	0.55	0.75	Vdc

BCX70G,H,J,K

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	125	—	MHz
Output Capacitance ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	4.5	pF
Small-Signal Current Gain ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	125 175 250 350	250 350 500 700	—
Noise Figure ($I_C = 0.2 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 2.0 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time ($I_C = 10 \text{ mAdc}$, $I_{B1} = 1.0 \text{ mAdc}$)	t_{on}	—	150	ns
Turn-Off Time ($I_{B2} = 1.0 \text{ mAdc}$, $V_{BB} = 3.6 \text{ Vdc}$, $R1 = R2 = 5.0 \text{ k}\Omega$, $R_L = 990 \Omega$)	t_{off}	—	800	ns

BCX71G,H,J,KCASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**GENERAL PURPOSE TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	45	Vdc
Collector-Base Voltage	V_{CB0}	45	Vdc
Emitter-Base Voltage	V_{EB0}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 2.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 32 \text{ Vdc}$) ($V_{CE} = 32 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{CES}	— —	20 20	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$)	BCX71G BCX71H BCX71J BCX71K	h_{FE}	— 30 40 100	— — — —
($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	BCX71G BCX71H BCX71J BCX71K		120 140 250 380	220 310 460 630
($I_C = 50 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	BCX71G BCX71H BCX71J BCX71K		60 80 100 110	— — — —
($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	BCX71G BCX71H BCX71J BCX71K		125 175 250 350	250 350 500 700
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0.25 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 1.25 \text{ mAdc}$)	$V_{CE(sat)}$	— —	0.25 0.55	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0.25 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 1.25 \text{ mAdc}$)	$V_{BE(sat)}$	0.6 0.68	0.85 1.05	Vdc
Base-Emitter On Voltage ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	0.6	0.75	Vdc
Output Capacitance ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	6.0	pF

BCX71G,H,J,K**ELECTRICAL CHARACTERISTICS** (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Noise Figure ($I_C = 0.2 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$, $R_S = 2.0 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$)	NF	—	6.0	dB

SWITCHING CHARACTERISTICS

Turn-On Time ($I_C = 10 \text{ mA}$, $I_{B1} = 1.0 \text{ mA}$)	t_{on}	—	150	ns
Turn-Off Time ($I_{B2} = 1.0 \text{ mA}$, $V_{BB} = 3.6 \text{ V}$, $R1 = R2 = 5.0 \text{ k}\Omega$, $R_L = 990 \Omega$)	t_{off}	—	800	ns

BFQ17

CASE 345-01, STYLE 1
SOT-89

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	V
Collector-Emitter Voltage ($R_{BE} \leq 50 \Omega$)	V_{CER}	40	V
Collector-Base Voltage	V_{CBO}	40	V
Emitter-Base Voltage	V_{EBO}	2.0	V
Collector Current — Continuous	I_C	300	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina $10 \times 12 \times 0.6 \text{ mm}$.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mA}$)	$V_{(BR)CEO}$	25	—	V
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}$)	$V_{(BR)CBO}$	40	—	V
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}$)	$V_{(BR)EBO}$	2.0	—	V
Collector Cutoff Current ($V_{CB} = 20 \text{ V}$) ($V_{CB} = 20 \text{ V}, T_A = 150^\circ\text{C}$)	I_{CBO}	— —	100 20	nA
Emitter Cutoff Current ($V_{EB} = 1.0 \text{ V}$)	I_{EBO}	—	100	nA

ON CHARACTERISTICS

DC Current Gain ($I_C = 50 \text{ mA}, V_{CE} = 5.0 \text{ V}$) ($I_C = 150 \text{ mA}, V_{CE} = 5.0 \text{ V}$)	h_{FE}	25 25	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$)	$V_{CE(sat)}$	—	0.5	V

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($V_{CE} = 15 \text{ V}, I_C = 150 \text{ mA}, f = 500 \text{ MHz}$)	f_T	1200(1)	—	MHz
Collector-Base Capacitance ($V_{CB} = 15 \text{ V}, f = 1.0 \text{ MHz}$)	C_{cb}	—	4.0	pF
Reverse Transfer Capacitance Common-Emitter ($V_{CE} = 15 \text{ V}, I_C = 10 \text{ mA}, f = 1.0 \text{ MHz}$)	C_{re}	—	1.9	pF

(1) Typical only

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	V
Collector-Base Voltage	V_{CBO}	25	V
Emitter-Base Voltage	V_{EBO}	12	V
Collector Current — Continuous	I_C	150	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

BFQ18A

CASE 354-01, STYLE 1
SOT-89

RF TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ mA}$)	$V_{(BR)CEO}$	15	—	V
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{A}$)	$V_{(BR)CBO}$	25	—	V
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{A}$)	$V_{(BR)EBO}$	2.0	—	V
Collector Cutoff Current ($V_{CB} = 10\text{ V}$)	I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{EB} = 1.0\text{ V}$)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 50\text{ mA}, V_{CE} = 10\text{ V}$) ($I_C = 100\text{ mA}, V_{CE} = 10\text{ V}$)	h_{FE}	25 25	— —	—
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($V_{CE} = 10\text{ V}, I_C = 50\text{ mA}, f = 500\text{ MHz}$)	f_T	3200(1)	—	MHz

(1) Typical only

BFQ19

CASE 345-01, STYLE 1
SOT-89

RFP TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	V
Collector-Base Voltage	V_{CBO}	20	V
Emitter-Base Voltage	V_{EBO}	3.0	V
Collector Current Max ($f > 1.0$ MHz)	I_{CM}	150	mA
Collector Current — Average	I_{CAV}	75	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	15	—	V
Collector-Base Breakdown Voltage ($I_C = 10$ μA)	$V_{(BR)CBO}$	20	—	V
Emitter-Base Breakdown Voltage ($I_E = 10$ μA)	$V_{(BR)EBO}$	3.0	—	V
Collector Cutoff Current ($V_{CB} = 10$ V)	I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{EB} = 1.0$ V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 50$ mA, $V_{CE} = 10$ V) ($I_C = 75$ mA, $V_{CE} = 10$ V)	h_{FE}	25 25	— —	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mA, $V_{CE} = 10$ V, $f = 500$ MHz) ($I_C = 75$ mA, $V_{CE} = 10$ V, $f = 500$ MHz)	f_T	4.0 4.4	— —	GHz
Collector-Base Capacitance ($V_{CB} = 10$ V, $f = 1.0$ MHz)	C_{cb}	—	1.6	pF
Capacitance Emitter-to-Base ($V_{EB} = 0.5$ V, $f = 1.0$ MHz)	C_{eb}	—	5.0	pF
Reverse Transfer Capacitance Common Emitter ($V_{CE} = 10$ V, $I_C = 10$ mA, $f = 1.0$ MHz)	C_{re}	—	1.3	pF
Noise Figure ($I_C = 50$ mA, $V_{CE} = 10$ V, $f = 500$ MHz)	NF	—	3.3	dB

BFR30,31

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

JFET
AMPLIFIER

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate Reverse Current ($V_{GS} = 10 \text{ Vdc}, V_{DS} = 0$)		I_{GSS}	—	0.2	nAdc
Gate Source Cutoff Voltage ($I_D = 0.5 \text{ nAdc}, V_{DS} = 10 \text{ Vdc}$)	BFR30 BFR31	$V_{GS(off)}$	— —	5.0 2.5	Vdc
Gate Source Voltage ($I_D = 1.0 \text{ mAdc}, V_{DS} = 10 \text{ Vdc}$)	BFR30 BFR31	V_{GS}	0.7 —	3.0 1.3	Vdc
($I_D = 50 \mu\text{Adc}, V_{DS} = 10 \text{ Vdc}$)	BFR30 BFR31		— —	4.0 2.0	

ON CHARACTERISTICS

Zero-Gate-Voltage Drain ($V_{DS} = 10 \text{ Vdc}, V_{GS} = 0$)	BFR30 BFR31	I_{DSS}	4.0 1.0	10 5.0	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($I_D = 1.0 \text{ mAdc}, V_{DS} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	BFR30 BFR31	$ Y_{fs} $	1.0 1.5	4.0 4.5	mAdc
($I_D = 200 \mu\text{Adc}, V_{DS} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	BFR30 BFR31		0.5 0.75	— —	
Output Admittance ($I_D = 1.0 \text{ mAdc}, V_{DS} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_D = 200 \mu\text{Adc}, V_{DS} = 10 \text{ Vdc}$)	BFR31 BFR31	$ Y_{os} $	40 20	25 15	μAdc
Input Capacitance ($I_D = 1.0 \text{ mAdc}, V_{DS} = 10 \text{ Vdc}, f = 1.0 \text{ MHz}$) ($I_D = 200 \mu\text{Adc}, V_{DS} = 10 \text{ Vdc}, f = 1.0 \text{ MHz}$)		C_{iss}	— —	5.0 4.0	pF
Reverse Transfer Capacitance ($I_D = 1.0 \text{ mAdc}, V_{DS} = 10 \text{ Vdc}, f = 1.0 \text{ MHz}$) ($I_D = 200 \mu\text{Adc}, V_{DS} = 10 \text{ Vdc}, f = 1.0 \text{ MHz}$)		C_{rss}	— —	1.5 1.5	pF

BFR92,S

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	25	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mA)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μA)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μA)	$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ V)	I_{CEO}	—	50	nA
Collector Cutoff Current ($V_{CB} = 10$ V)	I_{CBO}	—	50	nA
Emitter Cutoff Current ($V_{EB} = 1.0$ V)	I_{EBO}	—	10	nA

ON CHARACTERISTICS

DC Current Gain ($I_C = 500$ μA , $V_{CE} = 10$ V) ($I_C = 3.0$ mA, $V_{CE} = 1.5$ V) ($I_C = 14$ mA, $V_{CE} = 10$ V)(1)	BFR92S	h_{FE}	25 30 25	— 100 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 25$ mA, $I_B = 5.0$ mA)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 25$ mA, $I_B = 5.0$ mA)		$V_{BE(sat)}$	—	1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 14$ mA, $V_{CE} = 10$ V, $f = 500$ MHz)		f_T	4.5	—	MHz
Noise Figure ($V_{CE} = 1.5$ V, $I_C = 3.0$ mA, $R_S = 50$ Ω , $f = 30$ MHz)	BFR92S	NF	—	3.0	dB

(1) Pulse Width ≤ 300 μs , Duty Cycle $\leq 2.0\%$.

BFR93,S

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	12	Vdc
Collector-Base Voltage	V _{CBO}	15	Vdc
Emitter-Base Voltage	V _{EBO}	2.0	Vdc
Collector Current — Continuous	I _C	25	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mA)	V _{(BR)CEO}	12	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA)	V _{(BR)CBO}	15	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μA)	V _{(BR)EBO}	2.0	—	Vdc
Collector Cutoff Current (V _{CE} = 10 V)	I _{CEO}	—	50	nA
Collector Cutoff Current (V _{CB} = 10 V)	I _{CBO}	—	50	nA
Emitter Cutoff Current (V _{EB} = 1.0 V)	I _{EBO}	—	10	nA

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mA, V _{CE} = 5.0 V) (I _C = 20 mA, V _{CE} = 4.0 V) (I _C = 30 mA, V _{CE} = 5.0 V)	h _{FE} BFR93S	25 30 25	— 100 —	—
Collector-Emitter Saturation Voltage (I _C = 35 mA, I _B = 7.0 mA)	V _{CE(sat)}	—	0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 35 mA, I _B = 7.0 mA)	V _{BE(sat)}	—	1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 30 mA, V _{CE} = 5.0 V, f = 500 MHz)	f _T	4.5	—	GHz
Noise Figure (V _{CE} = 5.0 V, I _C = 2.0 mA, R _S = 50 Ω, f = 30 MHz)	NF	—	3.0	dB

BFS17,S

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μA)	$V_{(BR)CBO}$	25	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ V)	I_{CEO}	—	25	nA
Collector Cutoff Current ($V_{CB} = 15$ V)	I_{CBO}	—	25	nA
Emitter Cutoff Current ($V_{EB} = 1.0$ V)	I_{EBO}	—	10	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 2.0$ mA, $V_{CE} = 1.0$ V) ($I_C = 2.0$ mA, $V_{CE} = 1.0$ V) ($I_C = 25$ mA, $V_{CE} = 1.0$ V)	BFS17 BFS17S	h_{FE} 20 50 20	150 150 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{CE(sat)}$	—	0.4	V
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{BE(sat)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 2.0$ mA, $V_{CE} = 5.0$ V, $f = 500$ MHz) ($I_C = 25$ mA, $V_{CE} = 5.0$ V, $f = 500$ MHz)	f_T	1.0 1.3	— —	GHz
Output Capacitance ($V_{CB} = 10$ V, $f = 1.0$ MHz)	C_{obo}	—	1.5	pF
Noise Figure ($I_C = 2.0$ mA, $V_{CE} = 5.0$ V, $R_S = 50$ Ω , $f = 30$ MHz)	NF	—	5.0	dB

BSS63

**CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**

HIGH VOLTAGE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	100	V _{dc}
Collector-Emitter Voltage R _{BE} = 10 kΩ	V _{CER}	110	V _{dc}
Collector Current — Continuous	I _C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 100 μAdc)	V _{(BR)CEO}	100	—	—	V _{dc}
Collector-Emitter Breakdown Voltage (I _C = 10 μAdc, I _E = 0, R _{BE} = 10 kΩ)	V _{(BR)CER}	110	—	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	110	—	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μAdc)	V _{(BR)EBO}	6.0	—	—	V _{dc}
Collector Cutoff Current (V _{CB} = 90 Vdc, I _E = 0)	I _{CBO}	—	—	100	nAdc
Collector Cutoff Current (V _{CE} = 110 Vdc, R _{BE} = 10 kΩ)	I _{CER}	—	—	10	μAdc
Emitter Cutoff Current (V _{EB} = 6.0 Vdc, I _C = 0)	I _{EBO}	—	—	200	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 10 mAdc, V _{CE} = 1.0 Vdc) (I _C = 25 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	30 30	— —	— —	—
Collector-Emitter Saturation Voltage (I _C = 25 mAdc, I _B = 2.5 mAdc)	V _{CE(sat)}	—	—	250	mVdc
Base-Emitter Saturation Voltage (I _C = 25 mAdc, I _B = 2.5 mAdc)	V _{BE(sat)}	—	—	900	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 25 mAdc, V _{CE} = 5.0 Vdc, f = 35 MHz)	f _T	50	95	—	MHz
Case Capacitance (I _E = I _C = 0, V _{CB} = 10 Vdc)	C _C	—	—	5.0	pF

BSS64

CASE 318-03, STYLE 6
SOT-23 (TO-236AA/AB)

DRIVER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 4.0\text{ mA}$)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{A}$)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{A}$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 80\text{ V}$, $T_A = 70^\circ\text{C}$)	I_{CES}	—	20	μA
Emitter Cutoff Current ($V_{BE} = 4.0\text{ V}$)	I_{EBO}	—	200	nA
ON CHARACTERISTICS				
DC Current Gain ($V_{CE} = 1.0\text{ V}$, $I_C = 10\text{ mA}$)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage ($I_C = 4.0\text{ mA}$, $I_B = 400\ \mu\text{A}$) ($I_C = 50\text{ mA}$, $I_B = 15\text{ mA}$)	$V_{CE(sat)}$	— —	0.7 3.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 35\text{ MHz}$)	f_T	50	—	MHz

BSS79B,C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc)	$V_{(BR)CBO}$	75	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc) ($V_{CB} = 60$ Vdc, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	10 10	nAdc μ Adc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc)	I_{EBO}	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	B C	h_{FE}	40 100	120 300	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	— —	0.3 1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($V_{CE} = 20$ Vdc, $I_C = 20$ mAdc, $f = 100$ MHz)		f_T	250	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $f = 1.0$ MHz)		C_{obo}	—	8.0	pF

SWITCHING CHARACTERISTICS

Delay Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc) ($I_{B1} = I_{B2} = 15$ mAdc)		t_d	—	10	ns
Rise Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc) ($I_{B1} = I_{B2} = 15$ mAdc)		t_r	—	10	ns
Storage Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc) ($I_{B1} = I_{B2} = 15$ mAdc)		t_s	—	225	ns
Fall Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc) ($I_{B1} = I_{B2} = 15$ mAdc)		t_f	—	60	ns

BSS80B,C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	40	—	Vdc	
Collector-Base Breakdown Voltage ($I_C = 10$ μA)	$V_{(BR)CBO}$	60	—	Vdc	
Emitter-Base Breakdown Voltage ($I_E = 10$ μA)	$V_{(BR)EBO}$	5.0	—	Vdc	
Collector Cutoff Current ($V_{CB} = 50$ Vdc) ($V_{CB} = 50$ Vdc, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	10 10	nA μA	
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc)	I_{EBO}	—	10	nA	
ON CHARACTERISTICS					
DC Current Gain ($I_C = 150$ mA, $V_{CE} = 10$ Vdc)	B C	h_{FE}	40 100	120 300	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA) ($I_C = 500$ mA, $I_B = 50$ mA)		$V_{CE(sat)}$	— —	0.4 1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mA, $V_{CE} = 20$ Vdc, $f = 100$ MHz)		f_T	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $f = 1.0$ MHz)		C_{obo}	—	8.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	($I_{B1} = I_{B2} \approx 15$ mA, $V_{CC} = 30$ V, $I_C = 150$ mA)	t_d	—	10	ns
Rise Time		t_r	—	40	ns
Storage Time	($I_{B1} = I_{B2} \approx 15$ mA, $V_{CC} = 30$ V, $I_C = 150$ mA)	t_s	—	80	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs , Duty Cycle $\leq 2.0\%$.

BSS82C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	60	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA)	V _{(BR)CEO}	60	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 50 V) (V _{CB} = 50 V, T _A = 150°C)	I _{CBO}	—	10 10	nA μA
Emitter Cutoff Current (V _{EB} = 3.0 V)	I _{EBO}	—	10	nA
ON CHARACTERISTICS				
DC Current Gain (I _C = 150 mA, V _{CE} = 10 V)	h _{FE}	100	300	—
Collector-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA) (I _C = 500 mA, I _B = 50 mA)	V _{CE(sat)}	—	0.4 1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 50 mA, V _{CE} = 20 V, f = 200 MHz)	f _T	100	—	MHz

BSV52

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	20	Vdc
Collector Current — Continuous	I_C	200	mA _{dc}

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mA _{dc})	$V_{(BR)CEO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$) ($V_{CB} = 10$ Vdc, $I_E = 0$, $T_A = 125^\circ\text{C}$)	I_{CBO}	—	100 5.0	nA _{dc} $\mu\text{A}dc$
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mA _{dc} , $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mA _{dc} , $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mA _{dc} , $V_{CE} = 1.0$ Vdc)	h_{FE}	25 40 25	— 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA _{dc} , $I_B = 300$ μA) ($I_C = 10$ mA _{dc} , $I_B = 1.0$ mA _{dc}) ($I_C = 50$ mA _{dc} , $I_B = 5.0$ mA _{dc})	$V_{CE(sat)}$	—	300 250 400	mVdc
Base-Emitter Saturation Voltage ($I_C = 10$ mA _{dc} , $I_B = 1.0$ mA _{dc}) ($I_C = 50$ mA _{dc} , $I_B = 5.0$ mA _{dc})	$V_{BE(sat)}$	700 —	850 1200	mVdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mA _{dc} , $V_{CE} = 10$ Vdc)	f_T	400	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{EB} = 1.0$ Vdc, $I_C = 0$)	C_{ibo}	—	4.5	pF
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = I_B = I_{BM} = 10$ mA _{dc})	t_s	—	13	ns
Turn-On Time ($V_{BE} = 1.5$ Vdc, $I_C = 10$ mA _{dc} , $I_B = 3.0$ mA _{dc})	t_{on}	—	12	ns
Turn-Off Time ($I_C = 10$ mA _{dc} , $I_B = 3.0$ mA _{dc})	t_{off}	—	18	ns

BSX39

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	14	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm:

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 2.0\text{ mA}$)	$V_{(BR)CEO}$	14	—	Vdc
Collector Cutoff Current ($V_{CB} = 12\text{ V}$)	I_{CBO}	—	100	nA
Collector Cutoff Current ($V_{CE} = 12\text{ V}$) ($V_{CE} = 12\text{ V}, T_J = 125^\circ\text{C}$)	I_{CES}	— —	100 5.0	nA μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0\text{ mA}, V_{CE} = 1.0\text{ V}$) ($I_C = 10\text{ mA}, V_{CE} = 1.0\text{ V}$) ($I_C = 50\text{ mA}, V_{CE} = 1.0\text{ V}$)	h_{FE}	25 40 25	— 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}, I_B = 1.0\text{ mA}$) ($I_C = 50\text{ mA}, I_B = 5.0\text{ mA}$)	$V_{CE(sat)}$	— —	250 400	mV
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}, I_B = 1.0\text{ mA}$) ($I_C = 50\text{ mA}, I_B = 5.0\text{ mA}$)	$V_{BE(sat)}$	700 —	850 1.2	mV V
SWITCHING CHARACTERISTICS				
Turn-On Time ($I_C = 10\text{ mA}, I_B = 3.0\text{ mA}$)	t_{on}	—	12	ns
Turn-Off Time ($I_C = 10\text{ mA}, I_{B1} = I_{B2} = 3.0\text{ mA}$)	t_{off}	—	18	ns

MMBD101

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

HOT-CARRIER
UHF MIXER DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10 \mu\text{Adc}$)	$V_{(BR)}$	4.0	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 3.0 \text{ Vdc}$)	I_R	—	—	0.25	μAdc
Series Inductance ($f = 250 \text{ MHz}$)	L_S	—	6.0	—	nH
Case Capacitance ($f = 1.0 \text{ MHz}$)	C_C	—	0.18	—	pF
Diode Capacitance ($V_R = 0, f = 1.0 \text{ MHz}$)	C_T	—	—	1.0	pF
Forward Voltage ($I_F = 10 \text{ mAdc}$)	V_F	—	—	0.60	Vdc
Noise Figure ($f = 1.0 \text{ GHz}$)	NF	—	—	7.0	dB

MMBD352

CASE 318-02/03 STYLE 11
SOT-23 (TO-236AA/AB)

DUAL HOT CARRIER
MIXER DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	4	V_{CC}

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Forward Voltage ($I_F = 10$ mA)	V_F	—	0.60	V
Reverse Voltage Leakage Current ($V_R = 3.0$ V) ($V_R = 4.0$ V)	I_R	— —	0.25 10	μA
Capacitance ($V_R = 0$ V, $f = 1.0$ MHz)	C	—	1.0	pF

MMBD501

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

HOT-CARRIER DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10 \mu\text{Adc}$)	$V_{(BR)}$	50	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25 \text{Vdc}$)	I_R	—	—	200	μAdc
Diode Capacitance ($V_R = 20 \text{Vdc}$, $f = 1.0 \text{MHz}$)	C_T	—	—	1.0	pF
Forward Voltage ($I_F = 10 \text{mAdc}$)	V_F	—	—	1.2	Vdc

MMBD914

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

HIGH-SPEED SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM}(\text{surge})$	500	mAdc

THERMAL CHARACTERISTICS

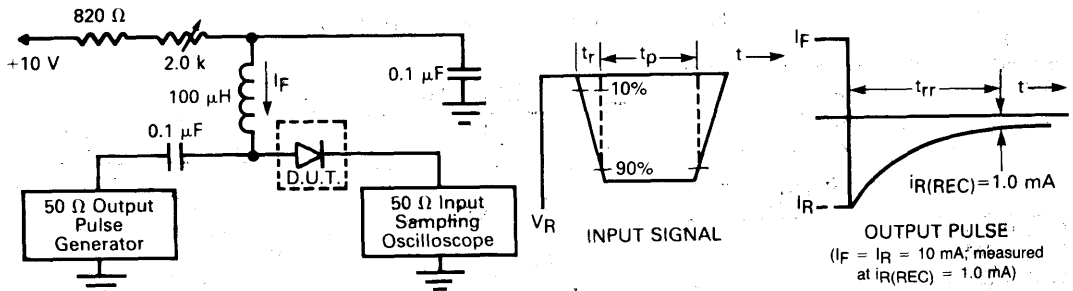
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_R = 100 \mu\text{Adc}$)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current ($V_R = 20$ Vdc) ($V_R = 75$ Vdc)	I_R	—	25 5.0	nAdc μAdc
Diode Capacitance ($V_R = 0$ Vdc, $f = 1.0$ MHz)	C_T	—	4.0	pF
Forward Voltage ($I_F = 10$ mAdc)	V_F	—	1.0	Vdc
Reverse Recovery Time ($I_F = I_R = 10$ mAdc) (Figure 1)	t_{rr}	—	4.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



- Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(\text{peak})}$ is equal to 10 mA.
3. $t_p = t_{rr}$

MMBD2835,36

CASE 318-02/03, STYLE 12
SOT-23 (TO-236AA/AB)

DUAL
SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	100	mAdc

THERMAL CHARACTERISTICS

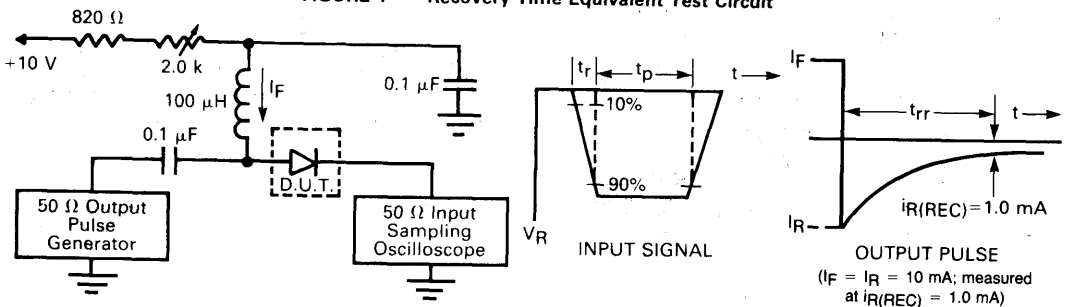
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_R = 100 \mu\text{Adc}$)	MMBD2835 MMBD2836	$V_{(BR)}$	35 75	Vdc
Reverse Voltage Leakage Current ($V_R = 30$ Vdc) ($V_R = 50$ Vdc)	MMBD2835 MMBD2836	I_R	— 100 100	nAdc
Diode Capacitance ($V_R = 0$, $f = 1.0$ MHz)		C_T	—	4.0 pF
Forward Voltage ($I_F = 10$ mAdc) ($I_F = 50$ mAdc) ($I_F = 100$ mAdc)		V_F	— — —	1.0 1.0 1.2 Vdc
Reverse Recovery Time ($I_F = I_R = 10$ mAdc, $i_{R(REC)} = 1.0$ mAdc) (Figure 1)		t_{rr}	—	6.0 ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Voltage	V_{RM}	75	Vdc
D.C. Reverse Voltage	V_R	30 50	Vdc
Peak Forward Current	I_{FM}	450 300	mAdc
Average Rectified Current	I_O	150 100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

MMBD2837
MMBD2838

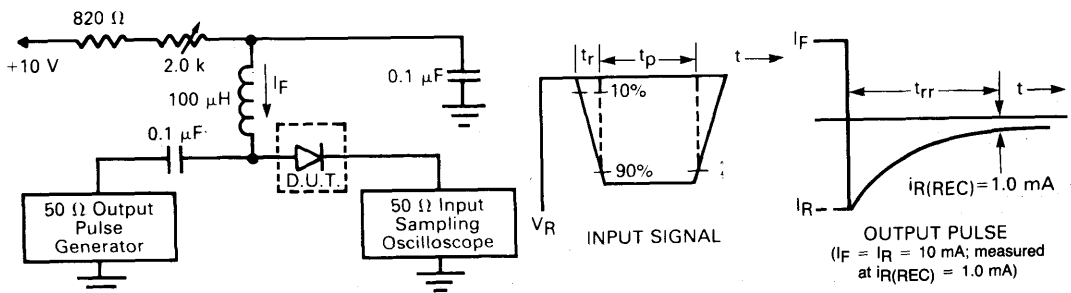
CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

DUAL
SWITCHING DIODE

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{BR} = 100 \mu\text{Adc}$)	$V_{(BR)}$	35 75	— —	Vdc
Reverse Voltage Leakage Current ($V_R = 30 \text{ Vdc}$) ($V_R = 50 \text{ Vdc}$)	I_R	— —	0.1 0.1	μAdc
Diode Capacitance ($V_R = 0, f = 1.0 \text{ MHz}$)	C_T	—	4.0	pF
Forward Voltage ($I_F = 10 \text{ mAdc}$) ($I_F = 50 \text{ mAdc}$) ($I_F = 100 \text{ mAdc}$)	V_F	— — —	1.0 1.0 1.2	Vdc
Reverse Recovery Time ($I_F = I_R = 10 \text{ mAdc}, i_{R(REC)} = 1.0 \text{ mAdc}$) (Figure 1)	t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



- Notes: 1. A 2.0 k Ω variable resistor adjusted for a Forward Current (I_F) of 10 mA.
- 2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
- 3. $t_p \approx t_{rr}$

MMBD6050

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM}(\text{surge})$	500	mAdc

THERMAL CHARACTERISTICS

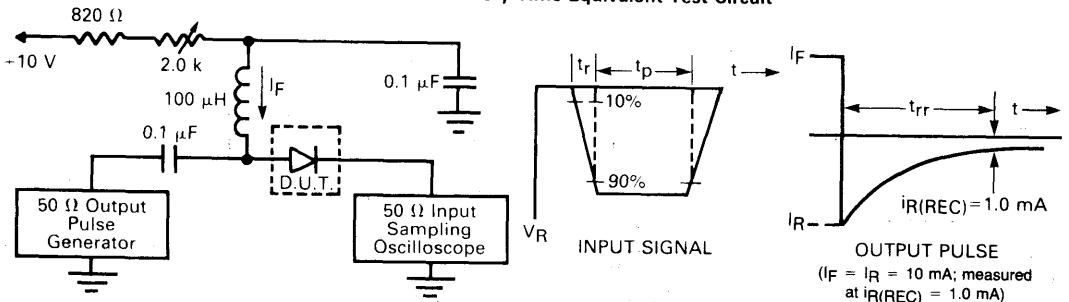
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW, mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{BR} = 100 \mu\text{Adc}$)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current ($V_R = 50$ Vdc)	I_R	—	0.1	μAdc
Forward Voltage ($I_F = 1.0$ mAdc) ($I_F = 100$ mAdc)	V_F	0.55 0.85	0.7 1.1	Vdc
Reverse Recovery Time ($I_F = I_R = 10$ mAdc, $i_{R(REC)} = 1.0$ mAdc) (Figure 1)	t_{rr}	—	10	ns
Capacitance ($V_R = 0$)	C	—	2.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



- Notes: 1. A 2.0 k Ω variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(\text{peak})}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MMBD6100

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

DUAL
SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM}(\text{surge})$	500	mAdc

THERMAL CHARACTERISTICS

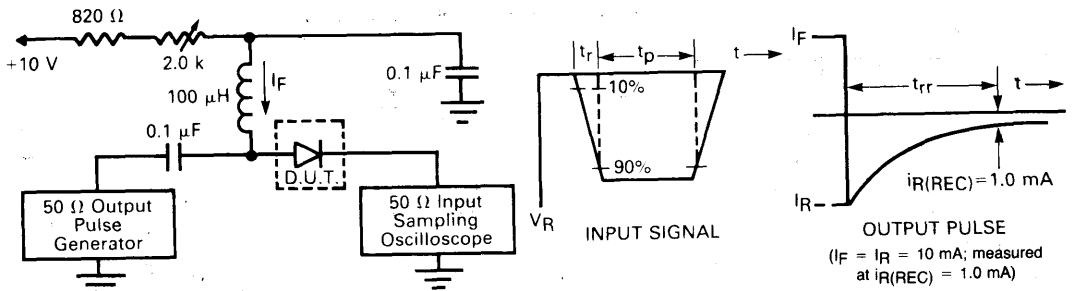
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)} = 100 \mu\text{Adc}$)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current ($V_R = 50 \text{ Vdc}$)	I_R	—	0.1	μAdc
Forward Voltage ($I_F = 1.0 \text{ mAdc}$) ($I_F = 100 \text{ mAdc}$)	V_F	0.55 0.85	0.7 1.1	Vdc
Reverse Recovery Time ($I_F = I_R = 10 \text{ mAdc}$, $i_{R(REC)} = 1.0 \text{ mAdc}$) (Figure 1)	t_{rr}	—	15	ns
Capacitance ($V_R = 0$)	C	—	2.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



- Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(\text{peak})}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MMBD7000

CASE 318-02/03, STYLE 11
SOT-23 (TO-236AA/AB)

DUAL
SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Forward Current	I_F	200	mAdc
Peak-Forward Surge Current	$I_{FM}(\text{surge})$	500	mAdc

THERMAL CHARACTERISTICS

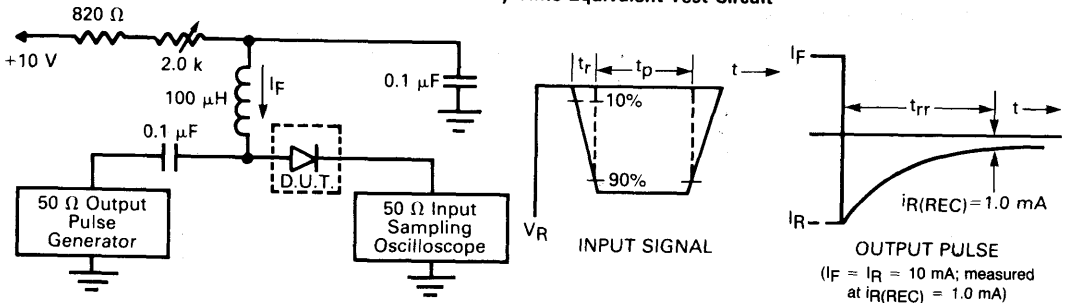
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)} = 100 \mu\text{Adc}$)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current ($V_R = 50 \text{ Vdc}$) ($V_R = 100 \text{ Vdc}$) ($V_R = 50 \text{ Vdc}, 125^\circ\text{C}$)	I_R I_{R2} I_{R3}	— — —	0.30 0.5 100	μAdc
Forward Voltage ($I_F = 1.0 \text{ mAdc}$) ($I_F = 10 \text{ mAdc}$) ($I_F = 100 \text{ mAdc}$)	V_F	0.55 0.67 0.75	0.7 0.82 1.1	Vdc
Reverse Recovery Time ($I_F = I_R = 10 \text{ mAdc}$) (Figure 1)	t_{rr}	—	15	ns
Capacitance ($V_R = 0$)	C	—	1.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



- Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_R(\text{peak})$ is equal to 10 mA.
3. $t_p = t_{rr}$

MMBF4391 thru MMBF4393

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

JFET
SWITCHING TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	30	Vdc
Drain-Gate Voltage	V _{DG}	30	Vdc
Gate-Source Voltage	V _{GS}	30	Vdc
Forward Gate Current	I _{G(f)}	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I _G = 1.0 μAdc, V _{DS} = 0)	V _{(BR)GSS}	30	—	Vdc
Gate Reverse Current (V _{GS} = 15 Vdc, V _{DS} = 0, T _A = 25°C) (V _{GS} = 15 Vdc, V _{DS} = 0, T _A = 100°C)	I _{GSS}	— —	1.0 0.20	nAdc μAdc
Gate Source Cutoff Voltage (V _{DS} = 15 Vdc, I _D = 10 nAdc)	V _{GS(off)}	4.0 2.0 0.5	10 5.0 3.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain (V _{DS} = 15 V, V _{GS} = 0)	I _{DSS}	50 25 5.0	150 75 30	mAdc
Drain Current (V _{DS} = 15 Vdc, V _{GS} = 12 Vdc) (V _{DS} = 15, V _{GS} = 12 Vdc, T _A = 100°C)	I _D	— —	1.0 1.0	nAdc μAdc
Drain-Source On-Voltage (I _D = 12 mAdc, V _{GS} = 0) (I _D = 6.0 mAdc, V _{GS} = 0) (I _D = 3.0 mAdc, V _{GS} = 0)	V _{DS(on)}	— — —	0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance (I _D = 1.0 mAdc, V _{GS} = 0)	r _{DS(on)}	— — —	30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	—	14	pF
Reverse Transfer Capacitance (V _{DS} = 0, V _{GS} = 12 Vdc, f = 1.0 MHz)	C _{rss}	—	3.5	pF

MMBF4416

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
VHF/UHF AMPLIFIER TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	—	100 200	pAdc nAdc
Gate Source Cutoff Voltage ($I_D = 1.0 \text{ nAdc}$, $V_{DS} = 15 \text{ Vdc}$)	$V_{GS(off)}$	—	6.0	Vdc
Gate Source Voltage ($I_D = 0.5 \text{ mAdc}$, $V_{DS} = 15 \text{ Vdc}$)	V_{GS}	1.0	5.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain ($V_{GS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	5.0	15	mAdc
Gate-Source Forward Voltage ($I_G = 1.0 \text{ mAdc}$, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ Y_{fs} $	4500	7500	μmhos
Output Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ Y_{os} $	—	50	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	0.8	pF
Output Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 15 \text{ Vdc}$, $I_D = 5.0 \text{ mAdc}$, $R_g \approx 1000 \Omega$, $f = 100 \text{ MHz}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 5.0 \text{ mAdc}$, $R_g \approx 1000 \Omega$, $f = 400 \text{ MHz}$)	NF	—	2.0 4.0	dB
Common Source Power Gain ($V_{DS} = 15 \text{ Vdc}$, $I_D = 5.0 \text{ mAdc}$, $f = 100 \text{ MHz}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 5.0 \text{ mAdc}$, $f = 400 \text{ MHz}$)	G_{ps}	18 10	—	dB

MMBF4860

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
SWITCHING TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	30	V _{dc}
Drain-Gate Voltage	V _{DG}	30	V _{dc}
Reverse Gate-Source Voltage	V _{GS(r)}	30	V _{dc}
Forward Gate Current	I _{G(f)}	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage (I _G = 1.0 μAdc, V _{DS} = 0)	V _{(BR)GSS}	30	—	V _{dc}
Gate Reverse Current (V _{GS} = 15 V _{dc} , V _{DS} = 0) (V _{GS} = 15 V _{dc} , V _{DS} = 0, T _A = 150°C)	I _{GSS}	—	0.5 2.0	nAdc μAdc
Gate Source Cutoff Voltage (V _{DS} = 15 V _{dc} , I _D = 0.5 nAdc)	V _{GS(off)}	2.0	6.0	V _{dc}

ON CHARACTERISTICS

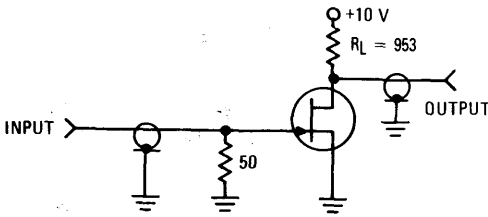
Zero-Gate-Voltage Drain(1) (V _{DS} = 15 V _{dc} , V _{GS} = 0)	I _{DSS}	20	100	mAdc
Drain Cutoff Current (V _{DS} = 15 V _{dc} , V _{GS} = 10 V _{dc}) (V _{DS} = 15 V _{dc} , V _{GS} = 10 V _{dc} , T _A = 150°C)	I _{D(off)}	—	0.25 0.5	nAdc μAdc
Drain-Source On-Voltage (I _D = 10 mAdc, V _{GS} = 0)	V _{DS(on)}	—	0.5	V _{dc}
Static Drain-Source On Resistance (V _{GS} = 0, I _D = 0, f = 1.0 kHz)	r _{DS(on)}	—	40	Ohms
Input Capacitance (V _{DS} = 0, V _{GS} = 10 V _{dc} , f = 1.0 MHz)	C _{iss}	—	18	pF
Reverse Transfer Capacitance (V _{DS} = 0, V _{GS} = 10 V _{dc} , f = 1.0 MHz)	C _{rss}	—	8.0	pF

SWITCHING CHARACTERISTICS

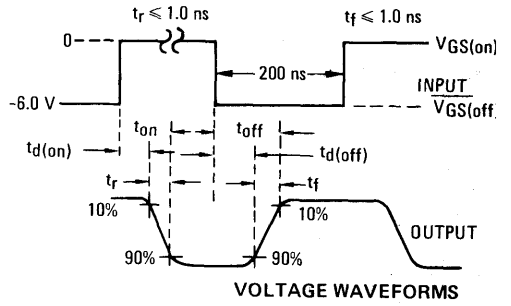
Delay Time (V _{DD} = 10 V _{dc} , I _{D(on)} = 20 mAdc) (V _{G(on)} = 0, V _{GS(off)} = 10 V _{dc})	t _d	—	6.0	ns
Rise Time (V _{DD} = 10 V _{dc} , I _{D(on)} = 10 mAdc) (V _{GS(on)} = 0, V _{GS(off)} = 6.0 V _{dc}) (Figure 1)	t _r	—	4.0	ns
Turn-Off Time (V _{DD} = 10 V _{dc} , I _{D(on)} = 5.0 mAdc) (V _{GS(on)} = 0, V _{GS(off)} = 4.0 V _{dc}) (Figure 1)	t _{off}	—	50	ns

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



TEST CIRCUIT



- NOTES: 1. The input waveforms are supplied by a generator with the following characteristics:
 $Z_{out} = 50$ ohms, Duty Cycle $\approx 2.0\%$
2. Waveforms are monitored on an oscilloscope with the following characteristics:
 $t_r \leq 0.75$ ns, $R_{in} \geq 1.0$ megohm, $C_{in} \leq 2.5$ pF.

MMBF5457

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
GENERAL PURPOSE TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)IGSS}$	25	—	—	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = 15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	—	—	1.0 200	nAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 10 \text{ nAdc}$)	$V_{GS(off)}$	0.5	—	6.0	Vdc
Gate Source Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 100 \mu\text{Adc}$)	V_{GS}	—	2.5	—	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	1.0	—	5.0	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ Y_{fs} $	1000	—	5000	μmhos
Reverse Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ Y_{rs} $	—	10	50	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	1.5	3.0	pF

(1) Pulse test: Pulse Width ≤ 630 ms; Duty Cycle $\leq 10\%$.

MMBF5459CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)**FET
TRANSISTOR****N-CHANNEL****MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	-25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -10 \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Gate 1 Leakage Current ($V_{GS} = -15 \text{ V}$, $V_{DS} = 0$)	I_{G1SS}	—	1.0	nA
Gate 2 Leakage Current ($V_{GS} = -15 \text{ V}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{G2SS}	—	200	nA
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ V}$, $I_D = 10 \text{ nA}$)	$V_{GS(off)}$	2.0	8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$)	I_{DSS}	4.0	16	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ Y_{fs} $	2000	6000	μmhos
Output Admittance ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ Y_{os} $	—	50	μmhos
Input Capacitance ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	3.0	pF

MMBF5460

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
GENERAL PURPOSE
TRANSISTOR

P-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V _{DG}	40	V _{dc}
Reverse Gate-Source Voltage	V _{GSR}	40	V _{dc}
Forward Gate Current	I _{GF}	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I _G = 10 μAdc, V _{DS} = 0)	V _{(BR)GSS}	40	—	—	V _{dc}
Gate Reverse Current (V _{GS} = 20 V _{dc} , V _{DS} = 0) (V _{GS} = 20 V _{dc} , V _{DS} = 0, T _A = 100°C)	I _{GSS}	—	—	5.0 1.0	nAdc μAdc
Gate Source Cutoff Voltage (V _{DS} = 15 V _{dc} , I _D = 1.0 μAdc)	V _{GS(off)}	0.75	—	6.0	V _{dc}
Gate Source Voltage (V _{DS} = 15 V _{dc} , I _D = 0.1 mAdc)	V _{GS}	0.5	—	4.0	V _{dc}
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V _{DS} = 15 V _{dc} , V _{GS} = 0)	I _{DSS}	1.0	—	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 kHz)	Y _{fs}	1000	—	4000	μmhos
Output Admittance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 kHz)	Y _{os}	—	—	75	μmhos
Input Capacitance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 MHz)	C _{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 MHz)	C _{rss}	—	1.0	2.0	pF
Equivalent Short-Circuit Input Noise Voltage (V _{DS} = 15 V _{dc} , V _{GS} = 0, R _G = 1.0 MΩ, f = 100 Hz, BW = 1.0 Hz)	\bar{e}_n	—	20	—	nV/√Hz

MMBF5484CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)**FET
TRANSISTOR**

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V _{DG}	25	V _{dc}
Reverse Gate-Source Voltage	V _{GS(r)}	25	V _{dc}
Forward Gate Current	I _{G(f)}	10	mA
Continuous Device Dissipation at or Below T _C = 25°C	P _D	200	mW
Linear Derating Factor		2.80	mW/°C
Storage Channel Temperature Range	T _{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I _G = -1.0 μA, V _{DS} = 0)	V _{(BR)GSS}	-25	—	V _{dc}
Gate Reverse Current (V _{GS} = -20 V, V _{DS} = 0) (V _{GS} = -20 V, V _{DS} = 0, T _A = 100°C)	I _{GSS}	—	-1.0 -0.2	nA μA
Gate Source Cutoff Voltage (V _{DS} = 15 V, I _D = 10 nA)	V _{GS(off)}	-0.3	-3.0	V _{dc}
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain (V _{DS} = 15 V, V _{GS} = 0)	I _{DSS}	1.0	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V _{DS} = 15 V, V _{GS} = 0, f = 1.0 kHz)	Y _{fs}	3000	6000	μmhos
Output Admittance (V _{DS} = 15 V, V _{GS} = 0, f = 1.0 kHz)	Y _{os}	—	50	μmhos
Input Capacitance (V _{DS} = 15 V, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	—	5.0	pF
Reverse Transfer Capacitance (V _{DS} = 15 V, V _{GS} = 0, f = 1.0 MHz)	C _{rss}	—	1.0	pF
Output Capacitance (V _{DS} = 15 V, V _{GS} = 0, f = 1.0 MHz)	C _{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V _{DS} = 15 V, I _D = 1.0 mA, YG' = 1.0 mmhos) (R _G = 1.0 kΩ, f = 100 MHz) (V _{DS} = 15 V, V _{GS} = 0, YG' = 1.0 μmho) (R _G = 1.0 MΩ, f = 1.0 kHz)	NF	—	3.0 2.5	dB
Common Source Power Gain (V _{DS} = 15 V _{dc} , I _D = 1.0 mA _{dc} , f = 100 MHz)	G _{ps}	16	25	dB

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CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($V_{DS} = 0$, $I_G = -1.0 \mu\text{A}$)	$V_{(BR)GSS}$	-25	—	Vdc
Gate 1 Leakage Current ($V_{GS} = -20 \text{ V}$, $V_{DS} = 0$)	I_{G1SS}	—	-1.0	nA
Gate 2 Leakage Current ($V_{GS} = -20 \text{ V}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{G2SS}	—	-0.2	μA
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ V}$, $I_D = 10 \text{ nA}$)	$V_{GS(off)}$	-2.0	-6.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$)	I_{DSS}	8.0	20	mA
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	4000	8000	μmhos
Input Admittance ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$, $f = 400 \text{ MHz}$)	$\text{Re}(y_{is})$	—	1000	μmhos
Output Admittance ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	—	75	μmhos
Output Conductance ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$, $f = 400 \text{ MHz}$)	$\text{Re}(y_{os})$	—	100	μmhos
Forward Transconductance ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$, $f = 400 \text{ MHz}$)	$\text{Re}(y_{fs})$	3500	—	μmhos
Input Capacitance ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	1.0	pF
Output Capacitance ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{oss}	—	2.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 15 \text{ V}$, $I_D = 4.0 \text{ mA}$, $f = 100 \text{ MHz}$, $Y_G = 1.0 \mu\text{mhos}$) ($V_{DS} = 15 \text{ V}$, $I_D = 4.0 \text{ mA}$, $R_G = 1.0 \text{ k}\Omega$, $f = 400 \text{ MHz}$, $Y_G = 1.0 \mu\text{mhos}$) ($V_{GS} = 0$, $V_{DS} = 15 \text{ V}$, $R_G = 1.0 \text{ m}\Omega$, $f = 1.0 \text{ kHz}$, $Y_G = 1.0 \mu\text{mhos}$)	NF	—	—	2.0 4.0 2.5	dB
Common Source Power Gain ($V_{DS} = 15 \text{ V}$, $I_D = 4.0 \text{ mA}$, $f = 100 \text{ MHz}$) ($V_{DS} = 15 \text{ V}$, $I_D = 4.0 \text{ mA}$, $f = 400 \text{ MHz}$)	G_{ps}	18 10	30 20	—	dB

MMBFJ310CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)**FET**
VHF/UHF AMPLIFIER
TRANSISTOR**N-CHANNEL****MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-25	—	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ V}$) ($V_{GS} = -15 \text{ V}$, $T_A = 125^\circ\text{C}$)	I_{GSS}	—	—	-1.0 -1.0	nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 10 \text{ Vdc}$, $I_D = 1.0 \text{ nAdc}$)	$V_{GS(off)}$	-2.0	—	-6.5	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain ($V_{DS} = 10 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	24	—	60	mAdc
Gate-Source Forward Voltage ($I_G = 1.0 \text{ mAdc}$, $V_{DS} = 0$)	$V_{GS(f)}$	—	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 10 \text{ Vdc}$, $I_D = 10 \text{ mAdc}$, $f = 1.0 \text{ kHz}$)	$ Y_{fs} $	8.0	—	18	mmhos
Output Admittance ($V_{DS} = 10 \text{ Vdc}$, $I_D = 10 \text{ mAdc}$, $f = 1.0 \text{ kHz}$)	$ Y_{os} $	—	—	200	μmhos
Input Capacitance ($V_{GS} = -10 \text{ Vdc}$, $V_{DS} = 0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance ($V_{GS} = -10 \text{ Vdc}$, $V_{DS} = 0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	—	2.5	pF
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = 10 \text{ Vdc}$, $I_D = 10 \text{ mAdc}$, $f = 100 \text{ Hz}$)	\bar{e}_n	—	10	—	nV/ $\sqrt{\text{Hz}}$

MMBFU310

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-25	—	Vdc
Gate 1 Leakage Current ($V_{GS} = -15 \text{ V}$, $V_{DS} = 0$)	I_{G1SS}	—	-150	pA
Gate 2 Leakage Current ($V_{GS} = -15 \text{ V}$, $V_{DS} = 0$, $T_A = 125^\circ\text{C}$)	I_{G2SS}	—	-150	nA
Gate Source Cutoff Voltage ($V_{DS} = 10 \text{ V}$, $I_D = 1.0 \text{ nA}$)	$V_{GS(off)}$	-2.5	-6.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain ($V_{DS} = 10 \text{ V}$, $V_{GS} = 0$)	I_{DSS}	24	60	mA
Gate-Source Forward Voltage ($I_G = 10 \text{ mA}$, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 10 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 1.0 \text{ kHz}$)	$ Y_{fs} $	10	18	mmhos
Output Admittance ($V_{DS} = 10 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 1.0 \text{ kHz}$)	$ Y_{os} $	—	150	μmhos
Input Capacitance ($V_{GS} = -10 \text{ V}$, $V_{DS} = 10 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{GS} = -10 \text{ V}$, $V_{DS} = 10 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	2.5	pF

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**CASE 318-02/03, STYLE 14
SOT-23 (TO-236AA/AB)**

UNIUNCTION TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation Derate Above 25°C	P_D $R_{\theta JA}$	350 2.8	mW mW/°C
DC Gate Current	I_G	±20	mA
Repetitive Peak Forward Current 100 μ s Pulse Width, 1.0% Duty Cycle	I_{TRM}	1.0	Amp
20 μ s Pulse Width, 1.0% Duty Cycle		1.0	
Non-Repetitive Peak Forward Current 10 μ s Pulse Width	I_{TSM}	1.0	Amp
Gate to Cathode Forward Voltage	V_{GKF}	40	Volt
Gate to Cathode Reverse Voltage	V_{GKR}	5.0	Volt
Gate to Anode Reverse Voltage	V_{GAR}	40	Volt
Anode to Cathode Voltage	V_{AK}	±40	Volt

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Peak-Point Current ($V_S = 10$ Vdc, $R_G = 1.0$ M Ω) ($V_S = 10$ Vdc, $R_G = 10$ k Ω)	I_P	— —	2.0 5.0	μ A
On-State Voltage ($V_S = 10$ Vdc, $R_G = 1.0$ M Ω)	V_T	0.2	1.6	Volts
Luminous Intensity ($V_S = 10$ Vdc, $R_G = 1.0$ M Ω) ($V_S = 10$ Vdc, $R_G = 10$ k Ω)	I_V	— 70	50 —	μ A
Anode to Cathode On-State Voltage ($I_F = 50$ mA Peak)	V_F	—	1.5	Volts
Output Voltage ($V_B = 20$ Vdc, $C_C = 0.2$ μ F)	V_O	6.0	—	Volts
Rise Time ($V_B = 20$ Vdc, $C_C = 0.2$ μ F)	t_r	—	80	ns

MMBR901

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	15	Vdc
Collector-Base Voltage	V _{CBO}	25	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Continuous	I _C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	15	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0)	V _{(BR)CBO}	25	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	V _{(BR)EBO}	2.0	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 5.0 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	30	200	—
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SMALL-SIGNAL CHARACTERISTICS

Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	1.0	pF
Common-Emitter Amplifier Power Gain (V _{CC} = 6.0 Vdc, I _C = 5.0 mAdc, f = 1.0 GHz)	G _{pe(1)}	16 (Typ)	—	dB
Noise Figure (I _C = 5.0 mAdc, V _{CE} = 6.0 Vdc, f = 1.0 GHz)	NF(1)	—	1.9 (Typ)	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50Ω system.

MMBR920CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**RF AMPLIFIER/SWITCHING
TRANSISTOR**

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	35	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_E = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 14$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 14$ mAdc, $V_{CE} = 10$ Vdc, $f = 0.5$ GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	—	1.0	pF
Noise Figure ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 0.5$ GHz) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ GHz)	NF(1)	—	2.4 3.0	—	dB
Common-Emitter Amplifier Power Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 0.5$ GHz) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ GHz)	$G_{pe}(1)$	—	15 10	—	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBR930**CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)****AMPLIFIER/SWITCHING
TRANSISTOR****NPN SILICON****MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	35	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}$, $I_E = 0$)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 30 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	25	—	250	—
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SMALL-SIGNAL CHARACTERISTICS

Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{cb}	—	—	1.0	pF
Noise Figure ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 0.5 \text{ GHz}$) ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ GHz}$)	NF(1)	—	1.9 2.5	—	dB
Common-Emitter Amplifier Power Gain ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 0.5 \text{ GHz}$) ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 0.5 \text{ GHz}$)	$G_{pe}(1)$	—	11 8.0	—	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBR931

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	5.0	Vdc
Collector-Base Voltage	V_{CBO}	10	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	5.0	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 0.1$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	5.0	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	10	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 5.0$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	30	—	150	—
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 1.0$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	—	0.5	pF
Noise Figure ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, $f = 1.0$ GHz)	NF(1)	—	4.3	—	dB
Gate Power Dissipation ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, $f = 1.0$ GHz)	PG(1)	—	10	—	—

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	30	Vdc
Collector-Base Voltage	V _{CBO}	14	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	Vdc
Collector Current — Continuous	I _C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	14	—	Vdc
Collector Cutoff Current (V _{CB} = 10 Vdc, I _E = 0)	I _{CBO}	—	50	nAdc
Emitter Cutoff Current (V _{EB} = 4.0, I _C = 0)	I _{EBO}	—	100	μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 5.0 mAdc, V _{CE} = 5.0 Vdc) (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 500 MHz)	h _{FE}	20 2.0	— —	—
Collector-Emitter Saturation Voltage (I _C = 80 mAdc, I _B = 8.0 mAdc)	V _{CE(sat)}	—	0.38	Vdc
Base-Emitter Saturation Voltage (I _C = 40 mAdc, I _B = 20 mAdc)	V _{BE(sat)}	—	0.98	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 20 mAdc, V _{CE} = 1.0 Vdc, f = 100 MHz)	f _T	—	1.0	GHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0)	C _{cb}	—	1.0	pF
Emitter-Base Capacitance (V _{EB} = 0.5 Vdc, I _C = 0)	C _{eb}	—	3.0	pF
Noise Figure (V _{CE} = 10 Vdc, I _E = 1.5 mAdc, f = 450 MHz)	NF(1)	—	3.5	dB
Common-Emitter Amplifier Power Gain (V _{CE} = 10 Vdc, I _E = 1.5 mAdc, f = 450 MHz)	G _{pe(1)}	12.5	—	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBR2060

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MMBR2857CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**RF TRANSISTOR**

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	40	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 3.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	0.05	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 3.0 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	1000	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 0.1 \text{ MHz}$)	C_{cb}	—	1.0	pF
Small-Signal Current Gain ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	50	—	—
Noise Figure ($I_C = 1.5 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $R_S = 50 \Omega$, $f = 450 \text{ MHz}$)	NF	—	4.5	dB
Common-Emitter Amplifier Power Gain ($I_C = 1.5 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 450 \text{ MHz}$)	GPE	12.5	—	dB

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	30	Vdc
Collector-Base Voltage	V _{CBO}	30	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Continuous	I _C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

MMBR4957

**CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**

RF AMPLIFIER TRANSISTOR

PNP SILICON

3

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	30	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	Vdc
Collector Cutoff Current (V _{CB} = 10 Vdc, I _C = 0)	I _{CBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 2.0 mAdc, V _{CE} = 10 Vdc)	h _{FE}	20	150	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _E = 2.0 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	1,200	—	MHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	0.8	pF
Common-Emitter Amplifier Power Gain(1) (V _{CE} = 10 Vdc, I _C = 2.0 mAdc, f = 450 MHz)	G _{pe}	17 (Typ)	—	dB
Noise Figure(1) (I _C = 2.0 mAdc, V _{CE} = 10 Vdc, f = 450 MHz)	NF	—	3.0 (Typ)	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBR5031

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	20	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	10	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01 \text{ mAdc}$, $I_E = 0$)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.01 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 6.0 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$)	h_{FE}	25	300	—
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SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	1,000	—	MHz
Collector-Base Capacitance ($V_{CE} = 6.0 \text{ Vdc}$, $I_E = 0$, $f = 0.1 \text{ MHz}$)	C_{cb}	—	1.5	pF
Noise Figure ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 450 \text{ MHz}$)	$NF(1)$	—	2.5	dB
Common-Emitter Amplifier Power Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 450 \text{ MHz}$)	$G_{pe}(1)$	14	25	dB

(1) Noise figure and power gain measure on Ailtech 7380 50 Ω system.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	12	Vdc
Collector-Base Voltage	V _{CBO}	20	Vdc
Emitter-Base Voltage	V _{EBO}	2.5	Vdc
Collector Current — Continuous	I _C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

MMBR5179

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 3.0 mAdc, I _B = 0)	V _{(BR)CEO}	12	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.01 mAdc, I _E = 0)	V _{(BR)CBO}	20	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.01 mAdc, I _C = 0)	V _{(BR)EBO}	2.5	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	0.02	μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 3.0 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	25	—	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	0.4	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	—	1.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 5.0 mAdc, V _{CE} = 6.0 Vdc, f = 100 MHz)	f _T	900	—	MHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 0.1 to 1.0 MHz)	C _{cb}	—	1.0	pF
Small Signal Current Gain (I _C = 2.0 mAdc, V _{CE} = 6.0 Vdc, f = 1.0 kHz)	h _{fe}	25	—	—
Noise Figure (I _C = 1.5 mAdc, V _{CE} = 6.0 Vdc, R _S = 50 Ω, f = 200 Mhz)	NF(1)	—	4.5	dB
Common-Emitter Amplifier Power Gain (V _{CE} = 6.0 Vdc, I _C = 5.0 mAdc, f = 200 MHz)	G _{pe(1)}	15	—	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBS5060,61,62

CASE 318-02/03, STYLE 14
SOT-23 (TO-236AA/AB)

SILICON CONTROLLED RECTIFIER

PNPN DEVICE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Forward Current Avg. ($T_C = +67^\circ\text{C}$)	I_F	510	mA
Peak Forward Gate Voltage	V_{GFM}	5.0	V
Peak Forward Blocking Voltage; RG = 1.0 k	V_{FXM}	30 60 100	V
		MMBS5060	
		MMBS5061	
		MMBS5062	

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate Trigger Voltage ($R_L = 100 \Omega$, $R_{GC} = 1.0 \text{ k}\Omega$, $T_C = 125^\circ\text{C}$)	Anode Voltage = MMBS5060 = 30 V MMBS5061 = 60 V MMBS5062 = 100 V	V_{GNT}	0.1	— V
Peak Forward Blocking Current ($R_{GC} = 1.0 \text{ k}\Omega$, $T_C = 125^\circ\text{C}$)	$V_{FXM} =$ MMBS5060 = 30 V MMBS5061 = 60 V MMBS5062 = 100 V	I_{FXM}	— 50	μA
Peak Reverse Blocking Current ($R_{GC} = 1.0 \text{ k}\Omega$, $T_C = 125^\circ\text{C}$)	$V_{RXM} =$ MMBS5060 = 30 V MMBS5061 = 60 V MMBS5062 = 100 V	I_{RXM}	— 50	μA
Forward Voltage* ($I_F = 1.2 \text{ A Peak}$)		V_F	— 1.7	V
Gate Trigger Current** ($R_{GC} = 1.0 \text{ k}\Omega$, $V_{AC} = 7.0 \text{ V}$, $R_L = 100 \Omega$)		I_{GT}	— 200	μA
Gate Trigger Voltage ($R_{GC} = 1.0 \text{ k}\Omega$, $V_{AC} = 7.0 \text{ V}$, $R_L = 100 \Omega$)		V_{GT}	— 0.8	V
Holding Current ($V_{AC} = 7.0 \text{ V}$, $R_{GC} = 1.0 \text{ k}\Omega$)		I_H	— 5.0	mA

*PW $\leq 1.0 \text{ ms}$, D.C. $\leq 1.0\%$.

**RGC current not included in measurement.

MMBT404,A

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

CHOPPER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		404	404A	
Collector-Emitter Voltage	V _{CEO}	24	35	V _{dc}
Collector-Base Voltage	V _{CBO}	25	40	V _{dc}
Emitter-Base Voltage	V _{EBO}	12	25	V _{dc}
Collector Current — Continuous	I _C	150		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	MMBT404 MMBT404A	V _{(BR)CEO}	24 35	— —	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	MMBT404 MMBT404A	V _{(BR)CBO}	25 40	— —	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	MMBT404 MMBT404A	V _{(BR)EBO}	12 25	— —	— —	V _{dc}
Collector Cutoff Current (V _{CB} = 10 Vdc, I _E = 0)		I _{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V _{BE} = 10 Vdc, I _C = 0)		I _{EBO}	—	—	100	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 12 mAdc, V _{CE} = 0.15 Vdc)		h _{FE}	30	—	400	—
Collector-Emitter Saturation Voltage (I _C = 12 mAdc, I _B = 0.4 mAdc) (I _C = 24 mAdc, I _B = 1.0 mAdc)		V _{CE(sat)}	— —	— —	0.15 0.20	V _{dc}
Base-Emitter Saturation Voltage (I _C = 12 mAdc, I _B = 0.4 mAdc) (I _C = 24 mAdc, I _B = 1.0 mAdc)		V _{BE(sat)}	— —	— —	0.85 1.0	V _{dc}

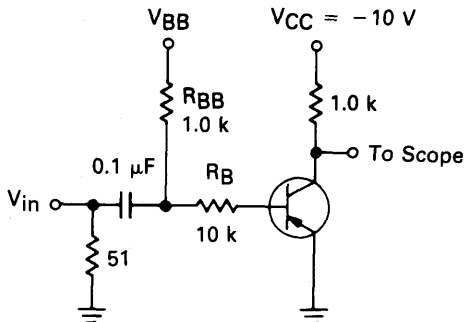
SMALL-SIGNAL CHARACTERISTICS

Output Capacitance (V _{CB} = 6.0 Vdc, I _E = 0)		C _{obo}	—	—	20	pF
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SWITCHING CHARACTERISTICS

Delay Time (V _{CC} = 10 Vdc, I _C = 10 mAdc) (Figure 1)		t _d	—	43	—	ns
Rise Time (I _{B1} = 1.0 mAdc, V _{BE(off)} = 14 Vdc)		t _r	—	180	—	ns
Storage Time (V _{CC} = 10 Vdc, I _C = 10 mAdc)		t _s	—	675	—	ns
Fall Time (I _{B1} = I _{B2} = 1.0 mAdc) (Figure 1)		t _f	—	160	—	ns

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



	V_{in} (Volts)	V_{BB} (Volts)
t_{on}, t_d, t_r	- 12	+ 1.4
t_{off}, t_s and t_f	+ 20.6	- 11.6

Voltages and resistor values shown are for $I_C = 10$ mA, $I_C/I_B = 10$ and $I_{B1} = I_{B2}$

MMBT918

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

VHF/UHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	15	Vdc
Collector-Base Voltage	V_{CB0}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	350	mAdc

THERMAL CHARACTERISTICS

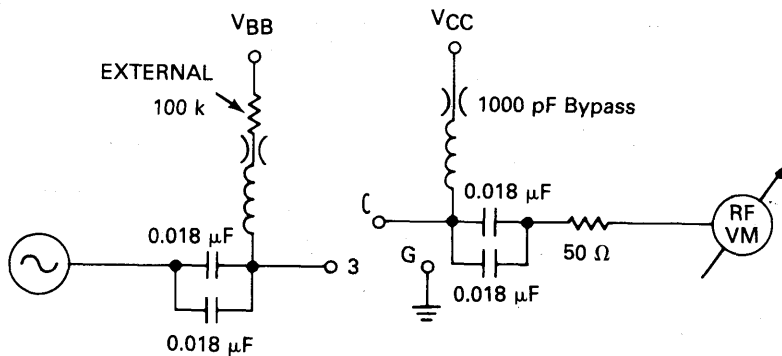
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc , $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc , $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	600	—	MHz
Output Capacitance ($V_{CB} = 0$ Vdc, $I_E = 0$, $f = 1.0$ MHz) ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	— —	3.0 1.7	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 1.0$ MHz)	C_{ibo}	—	2.0	pF
Noise Figure ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50$ Ω , $f = 60$ MHz) (Figure 1)	NF	—	6.0	dB
Power Output ($I_C = 8.0$ mAdc, $V_{CB} = 15$ Vdc, $f = 500$ MHz)	P_{out}	30	—	mW
Common-Emitter Amplifier Power Gain ($I_C = 6.0$ mAdc, $V_{CB} = 12$ Vdc, $f = 200$ MHz)	G_{pe}	11	—	dB

FIGURE 1 — NF, G_{pe} MEASUREMENT CIRCUIT 20-200



NF Test Conditions

- I_C = 1.0 Amp
- V_{CE} = 6.0 Volts
- R_S = 50 Ω
- f = 60 MHz

G_{pe} Test Conditions

- I_C = 6.0 mA
- V_{CE} = 12 Volts
- f = 200 MHz

3

MMBT930

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 5.0 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	10	nAdc
Collector Cutoff Current ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	10	nAdc
Collector Cutoff Current ($V_{CE} = 45 \text{ Vdc}$, $V_{BE} = 0$)	I_{CES}	—	10	nAdc
Emitter Cutoff Current ($V_{EB} = 5.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 500 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	100 150 —	300 — 600	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0.5 \text{ mAdc}$)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0.5 \text{ mAdc}$)	$V_{BE(sat)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 500 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 30 \text{ MHz}$)	f_T	30	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	8.0	pF
Noise Figure ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 10 \text{ k}\Omega$, $f = 10 \text{ Hz to } 15.7 \text{ kHz}$)	NF	—	3.0	dB

MMBT2222,A

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MMBT2222	MMBT2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	600		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

Refer to MPS2222 for graphs.

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	MMBT2222 MMBT2222A	$V_{(BR)CEO}$	30 40	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc, $I_E = 0$)	MMBT2222 MMBT2222A	$V_{(BR)CBO}$	60 75	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	MMBT2222 MMBT2222A	$V_{(BR)EBO}$	5.0 6.0	— —	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	MMBT2222A	I_{CEX}	—	10	nAdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)	MMBT2222	I_{CBO}	—	0.01	μ Adc
($V_{CB} = 60$ Vdc, $I_E = 0$)	MMBT2222A		—	0.01	
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 125^\circ\text{C}$)	MMBT2222		—	10	
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 125^\circ\text{C}$)	MMBT2222A		—	10	
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	MMBT2222A	I_{EBO}	—	10	nAdc
Base Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	MMBT2222A	I_{BL}	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55^\circ\text{C}$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)(1) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	MMBT2222A only MMBT2222 MMBT2222A	h_{FE}	35 50 75 35 100 50 30 40	— — — — 300 — — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	MMBT2222 MMBT2222A	$V_{CE(sat)}$	— —	0.4 0.3	Vdc
($I_C = 500$ mAdc, $I_B = 50$ mAdc)	MMBT2222 MMBT2222A		— —	1.6 1.0	

MMBT2222,A
ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1) ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)	MMBT2222	—	1.3	Vdc
	MMBT2222A	0.6	1.2	
($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)	MMBT2222	—	2.6	
	MMBT2222A	—	2.0	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 20\text{ mA}$, $V_{CE} = 20\text{ V}$, $f = 100\text{ MHz}$)	MMBT2222 MMBT2222A	f_T	250 300	— —	MHz
Output Capacitance ($V_{CB} = 10\text{ V}$, $I_E = 0$, $f = 1.0\text{ MHz}$)		C_{obo}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5\text{ V}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	MMBT2222 MMBT2222A	C_{ibo}	—	30 25	pF
Input Impedance ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$)	MMBT2222A MMBT2222A	h_{ie}	2.0 0.25	8.0 1.25	k Ω
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$)	MMBT2222A MMBT2222A	h_{re}	— —	8.0 4.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$)	MMBT2222A MMBT2222A	h_{fe}	50 75	300 375	—
Output Admittance ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$)	MMBT2222A MMBT2222A	h_{oe}	5.0 25	35 200	μmhos
Collector Base Time Constant ($I_E = 20\text{ mA}$, $V_{CB} = 20\text{ V}$, $f = 31.8\text{ MHz}$)	MMBT2222A	$r_b C_C$	—	150	ps
Noise Figure ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 10\text{ V}$, $R_S = 1.0\text{ k}\Omega$, $f = 1.0\text{ kHz}$)	MMBT2222A	NF	4.0	4.0	dB

SWITCHING CHARACTERISTICS MMBT2222A only

Delay Time	$(V_{CC} = 30\text{ V}$, $V_{BE(\text{off})} = 0.5\text{ V}$, $I_C = 150\text{ mA}$, $I_{B1} = 15\text{ mA}$)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	$(V_{CC} = 30\text{ V}$, $I_C = 150\text{ mA}$, $I_{B1} = I_{B2} = 15\text{ mA}$)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

 (1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

 (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MMBT2369

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

Refer to MPS2369 for graphs.

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $T_A = 125^\circ\text{C}$)	I_{CBO}	—	—	0.4 30	μAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 100 \text{ mAdc}$, $V_{CE} = 2.0 \text{ Vdc}$)	h_{FE}	40 20 20	— — —	120 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$)	$V_{BE(sat)}$	0.70	—	0.85	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	—	4.0	pF
Small Signal Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	h_{fe}	5.0	—	—	—

SWITCHING CHARACTERISTICS

Storage Time ($I_{B1} = I_{B2} = I_C = 10 \text{ mAdc}$)	t_s	—	5.0	13	ns
Turn-On Time ($V_{CC} = 3.0 \text{ Vdc}$, $I_C = 10 \text{ mAdc}$, $I_{B1} = 3.0 \text{ mAdc}$)	t_{on}	—	8.0	12	ns
Turn-Off Time ($V_{CC} = 3.0 \text{ Vdc}$, $I_C = 10 \text{ mAdc}$, $I_{B1} = 3.0 \text{ mAdc}$, $I_{B2} = 1.5 \text{ mAdc}$)	t_{off}	—	10	18	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MMBT2484

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

LOW NOISE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	60	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current — Continuous	I _C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to MPSA18 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	60	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 45 Vdc, I _E = 0) (V _{CB} = 45 Vdc, I _E = 0, T _A 150°C)	I _{CBO}	—	10 10	nAdc μAdc
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	250 —	— 800	—
Collector-Emitter Saturation Voltage (I _C = 1.0 mAdc, I _B = 0.1 mAdc)	V _{CE(sat)}	—	0.35	Vdc
Base-Emitter On Voltage (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)	V _{BE(on)}	—	0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	6.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 140 kHz)	C _{ibo}	—	6.0	pF
Noise Figure (I _C = 10 μAdc, V _{CE} = 5.0 Vdc, R _S = 10 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	3.0	dB

MMBT2907,ACASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**GENERAL PURPOSE TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS2907	MPS2907A	Unit
Collector-Emitter Voltage	V_{CE0}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

Refer to MPS2907 for graphs.

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10\text{ mAdc}$, $I_E = 0$)	$V_{(BR)CEO}$	40 60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE(off)} = 0.5\text{ Vdc}$)	I_{CEX}	—	50	nAdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	0.020 0.010	μAdc
($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = 125^\circ\text{C}$)		—	20 10	
Base Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE(off)} = 0.5\text{ Vdc}$)	I_B	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	MMBT2907 MMBT2907A	h_{FE}	35 75	—	—
($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	MMBT2907 MMBT2907A		50 100	—	—
($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	MMBT2907 MMBT2907A		75 100	—	—
($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)(1)	MMBT2907, MMBT2907A		100	300	
($I_C = 500\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)(1)	MMBT2907 MMBT2907A		30 50	—	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)		$V_{CE(sat)}$	—	0.4 1.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)		$V_{BE(sat)}$	—	1.3 2.6	Vdc

MMBT2907,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1),(2) ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 2.0\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	30	pF

SWITCHING CHARACTERISTICS

Turn-On Time	$(V_{CC} = 30\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = 15\text{ mAdc}$)	t_{on}	—	45	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-Off Time	$(V_{CC} = 6.0\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = I_{B2} = 15\text{ mAdc}$)	t_{off}	—	100	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

3

MMBT3640

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	80	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

Refer to MPS3640 for graphs.

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	12	—	Vdc	
Collector-Emitter Sustaining Voltage(1) ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	$V_{CEO(sus)}$	12	—	Vdc	
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	12	—	Vdc	
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc	
Collector Cutoff Current ($V_{CE} = 6.0 \text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 6.0 \text{ Vdc}$, $V_{BE} = 0$, $T_A = 65^\circ\text{C}$)	I_{CES}	—	0.01 1.0	μAdc	
Base Current ($V_{CE} = 6.0 \text{ Vdc}$, $V_{BE} = 0$)	I_B	—	10	nAdc	
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 0.3 \text{ Vdc}$) ($I_C = 50 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30 20	120 —	—	
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$) ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$, $T_A = 65^\circ\text{C}$)	$V_{CE(sat)}$	—	0.2 0.6 0.25	Vdc	
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0.5 \text{ mAdc}$) ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)	$V_{BE(sat)}$	0.75 0.8 —	0.95 1.0 1.5	Vdc	
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	500	—	MHz	
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	3.5	pF	
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{ibo}	—	3.5	pF	
SWITCHING CHARACTERISTICS					
Delay Time	($V_{CC} = 6.0 \text{ Vdc}$, $I_C = 50 \text{ mAdc}$, $V_{BE(off)} = 1.9 \text{ Vdc}$, $I_{B1} = 5.0 \text{ mAdc}$)	t_d	—	10	ns
Rise Time		t_r	—	30	ns
Storage Time	($V_{CC} = 6.0 \text{ Vdc}$, $I_C = 50 \text{ mAdc}$, $I_{B1} = I_{B2} = 5.0 \text{ mAdc}$)	t_s	—	20	ns
Fall Time		t_f	—	12	ns
Turn-On Time	($V_{CC} = 6.0 \text{ Vdc}$, $I_C = 50 \text{ mAdc}$, $V_{BE(off)} = 1.9 \text{ Vdc}$, $I_{B1} = 5.0 \text{ mAdc}$) ($V_{CC} = 1.5 \text{ Vdc}$, $I_C = 10 \text{ mAdc}$, $I_{B1} = 0.5 \text{ mAdc}$)	t_{on}	—	25 60	ns
Turn-Off Time	($V_{CC} = 6.0 \text{ Vdc}$, $I_C = 50 \text{ mAdc}$, $V_{BE(off)} = 1.9 \text{ V}$, $I_{B1} = I_{B2} = 5.0 \text{ mAdc}$) ($V_{CC} = 1.5 \text{ Vdc}$, $I_C = 10 \text{ mAdc}$, $I_{B1} = I_{B2} = 0.5 \text{ mAdc}$)	t_{off}	—	35 75	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MMBT3903 MMBT3904

CASE 318-03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current — Continuous	I _C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to 2N3903 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	Vdc
Base Cutoff Current (V _{CE} = 30 Vdc, V _{EB} = 3.0 Vdc)	I _{BL}	—	50	nAdc
Collector Cutoff Current (V _{CE} = 30 Vdc, V _{EB} = 3.0 Vdc)	I _{CEX}	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc)	MMBT3903 MMBT3904	h _{FE}	20 40	—	—
(I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc)	MMBT3903 MMBT3904		35 70	—	—
(I _C = 10 mAdc, V _{CE} = 1.0 Vdc)	MMBT3903 MMBT3904		50 100	150 300	
(I _C = 50 mAdc, V _{CE} = 1.0 Vdc)	MMBT3903 MMBT3904		30 60	—	—
(I _C = 100 mAdc, V _{CE} = 1.0 Vdc)	MMBT3903 MMBT3904		15 30	—	—
Collector-Emitter Saturation Voltage(1) (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)		V _{CE(sat)}	— —	0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)		V _{BE(sat)}	0.65 —	0.85 0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	MMBT3903 MMBT3904	f _T	250 300	— —	MHz
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MMBT3903

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)		C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)		C_{ibo}	—	8.0	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	MMBT3903 MMBT3904	h_{ie}	1.0 1.0	8.0 10	k ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	MMBT3903 MMBT3904	h_{re}	0.1 0.5	5.0 8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	MMBT3903 MMBT3904	h_{fe}	50 100	200 400	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{oe}	1.0	40	μmhos
Noise Figure ($I_C = 100\ \mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 1.0\text{ k ohms}$, $f = 10\text{ Hz to }15.7\text{ kHz}$)	MMBT3903 MMBT3904	NF	— —	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 3.0\text{ Vdc}$, $V_{BE} = 0.5\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 1.0\text{ mAdc}$)		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	$(V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = I_{B2} = 1.0\text{ mAdc}$)	MMBT3903 MMBT3904	t_s	—	175	ns
Fall Time			t_f	—	50	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

MMBT3906

**CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3905 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Base Cutoff Current (V _{CE} = 30 Vdc, V _{BE} = 3.0 Vdc)	I _{BL}	—	50	nAdc
Collector Cutoff Current (V _{CE} = 30 Vdc, V _{BE} = 3.0 Vdc)	I _{CEX}	—	50	nAdc

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc) (I _C = 10 mAdc, V _{CE} = 1.0 Vdc) (I _C = 50 mAdc, V _{CE} = 1.0 Vdc) (I _C = 100 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	60 80 100 60 30	— — 300 — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)	V _{CE(sat)}	— —	0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc)	V _{BE(sat)}	0.65 —	0.85 0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	250	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	4.5	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	10.0	pF
Input Impedance (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{ie}	2.0	12	k ohms
Voltage Feedback Ratio (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{re}	0.1	10	X 10 ⁻⁴
Small-Signal Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	100	400	—

MMBT3906

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	3.0	60	μmhos
Noise Figure ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 1.0 \text{ k ohm}$, $f = 10 \text{ Hz to } 15.7 \text{ kHz}$)	NF	—	4.0	dB

SWITCHING CHARACTERISTICS

Delay Time	($V_{CC} = 3.0 \text{ Vdc}$, $V_{BE} = 0.5 \text{ Vdc}$ $I_C = 10 \text{ mA}$, $I_{B1} = 1.0 \text{ mA}$)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	($V_{CC} = 3.0 \text{ Vdc}$, $I_C = 10 \text{ mA}$, $I_{B1} = I_{B2} = 1.0 \text{ mA}$)	t_s	—	225	ns
Fall Time		t_f	—	75	ns

(1) Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

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MMBT4124

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N4123 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N4124	Unit
Collector-Emitter Voltage	V_{CE0}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}$, $I_E = 0$)	$V_{(BR)CE0}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 50 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	120 60	360 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	8.0	pF
Collector-Base Capacitance ($I_E = 0$, $V_{CB} = 5.0 \text{ V}$, $f = 100 \text{ kHz}$)	C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	120	480	—
Current Gain — High Frequency ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$) ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 10 \text{ V}$, $f = 1.0 \text{ kHz}$)	$ h_{fe} $	3.0 120	— 480	—
Noise Figure ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 1.0 \text{ kohm}$, Noise Bandwidth = 10 Hz to 15.7 kHz)	NF	—	5.0	dB

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2.0%.

MMBT4125

**CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N4125 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V _{CEO}	30	25	Vdc
Collector-Base Voltage	V _{CBO}	30	25	Vdc
Emitter-Base Voltage	V _{EBO}	4.0		Vdc
Collector Current — Continuous	I _C	200		mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350	2.8	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0	8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mA _{dc} , I _E = 0)	V _{(BR)CEO}	30	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{(BR)CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	4.0	—	Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0)	I _{CBO}	—	50	nA _{dc}
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	50	nA _{dc}
ON CHARACTERISTICS				
DC Current Gain(1) (I _C = 2.0 mA _{dc} , V _{CE} = 1.0 Vdc) (I _C = 50 mA _{dc} , V _{CE} = 1.0 Vdc)	h _{FE}	50 25	150 —	—
Collector-Emitter Saturation Voltage(1) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})	V _{CE(sat)}	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})	V _{BE(sat)}	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mA _{dc} , V _{CE} = 20 Vdc, f = 100 MHz)	f _T	200	—	MHz
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	10	pF
Collector-Base Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 100 kHz)	C _{cb}	—	4.5	pF
Small-Signal Current Gain (I _C = 2.0 mA _{dc} , V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	50	200	—
Current Gain — High Frequency (I _C = 10 mA _{dc} , V _{CE} = 20 Vdc, f = 100 MHz)	h _{fe}	2.0	—	—
Noise Figure (I _C = 100 μA _{dc} , V _{CE} = 5.0 Vdc, R _S = 1.0 kohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	NF	—	5.0	dB

(1) Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2.0%.

MMBT4401

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to 2N4401 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 35 \text{ Vdc}, V_{EB} = 0.4 \text{ Vdc}$)	I_{BEV}	—	0.1	μAdc
Collector Cutoff Current ($V_{CE} = 35 \text{ Vdc}, V_{EB} = 0.4 \text{ Vdc}$)	I_{CEX}	—	0.1	μAdc

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 0.1 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$)	h_{FE}	20 40 80 100 40	— — — 300 —	—
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$)	$V_{CE(sat)}$	— —	0.4 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$)	$V_{BE(sat)}$	0.75 —	0.95 1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	250	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{cb}	—	6.5	pF
Emitter-Base Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{eb}	—	30	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ie}	1.0	15	k ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{re}	0.1	8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	40	500	—
Output Admittance ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{oe}	1.0	30	μmhos

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30 \text{ Vdc}, V_{EB} = 2.0 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = 15 \text{ mAdc})$	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	$(V_{CC} = 30 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = I_{B2} = 15 \text{ mAdc})$	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MMBT4403

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current ($V_{CE} = 35$ Vdc, $V_{BE} = 0.4$ Vdc)	I_{BEV}	—	0.1	μAdc
Collector Cutoff Current ($V_{CE} = 35$ Vdc, $V_{BE} = 0.4$ Vdc)	I_{CEX}	—	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 2.0$ Vdc)(1) ($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)(1)	h_{FE}	30 60 100 100 20	— — — 300 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{CE(sat)}$	—	0.4 0.75	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{BE(sat)}$	0.75 —	0.95 1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	200	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 140$ kHz)	C_{cb}	—	8.5	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 140$ kHz)	C_{eb}	—	30	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{ie}	1.5k	15k	ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{re}	0.1	8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{fe}	60	500	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{oe}	1.0	100	μmhos

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30$ Vdc, $V_{BE} = 2.0$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	$(V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs , Duty Cycle $\leq 2.0\%$.

MMBT5086,87

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

LOW NOISE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	50	Vdc
Collector-Base Voltage	V _{CBO}	50	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Continuous	I _C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	50	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	50	—	Vdc
Collector Cutoff Current (V _{CB} = 10 Vdc, I _E = 0) (V _{CB} = 35 Vdc, I _E = 0)	I _{CBO}	— —	10 50	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 100 μAdc, V _{CE} = 5.0 Vdc)	MMBT5086 MMBT5087	h _{FE}	150 250	500 800	—
(I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)	MMBT5086 MMBT5087		150 250	—	
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	MMBT5086 MMBT5087		150 250	—	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)		V _{CE(sat)}	—	0.3	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)		V _{BE(sat)}	—	0.85	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 500 μAdc, V _{CE} = 5.0 Vdc, f = 20 MHz)		f _T	40	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 100 kHz)		C _{obo}	—	4.0	pF
Small-Signal Current Gain (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz) (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz)	MMBT5086 MMBT5087	h _{fe}	150 250	600 900	—
Noise Figure (I _C = 20 mAdc, V _{CE} = 5.0 Vdc, R _S = 10 kΩ, f = 10 Hz to 15.7 kHz)	MMBT5086 MMBT5087	NF	— —	3.0 2.0	dB
(I _C = 100 μAdc, V _{CE} = 5.0 Vdc, R _S = 3.0 kΩ, f = 1.0 kHz)	MMBT5086 MMBT5087		— —	3.0 2.0	

MMBT5088,89CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**LOW NOISE TRANSISTOR**

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MMBT5088	MMBT5089	
Collector-Emitter Voltage	V_{CE0}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	35	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0\text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	30 25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	35 30	—	Vdc
Collector Cutoff Current ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)} = 3.0\text{ Vdc}$, $I_C = 0$) ($V_{EB(off)} = 4.5\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	50 100	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 100\ \mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	300 400	900 1200	—
($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)		350 450	—	—
($I_C = 10\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)		300 400	—	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	—	0.8	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 500\ \mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$ emitter guarded)	C_{cb}	—	4.0	pF
Emitter-Base Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$ collector guarded)	C_{eb}	—	10	pF
Small Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	350 450	1400 1800	—
Noise Figure ($I_C = 100\ \mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k}\Omega$, $f = 10\text{ Hz}$ to 15.7 Hz)	NF	—	3.0 2.0	dB

MMBT5401

**CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**

HIGH VOLTAGE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	150	Vdc
Collector-Base Voltage	V_{CB0}	160	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

Refer to 2N5401 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	150	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc , $I_E = 0$)	$V_{(BR)CBO}$	160	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc , $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	50 50	nAdc μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	50 60 50	— 240 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	— —	0.20 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	— —	1.0 1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	100	300	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	6.0	pF
Small Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{fe}	40	200	—
Noise Figure ($I_C = 200$ μAdc , $V_{CE} = 5.0$ Vdc, $R_S = 10$ ohms, $f = 10$ Hz to 15.7 kHz)	NF	—	8.0	dB

MMBT5550CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**HIGH VOLTAGE TRANSISTOR**

NPN SILICON

Refer to 2N5550 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	140	Vdc
Collector-Base Voltage	V_{CBO}	160	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	140	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc, $I_C = 0$)	$V_{(BR)CBO}$	160	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	— —	100 100	nAdc μ Adc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	60 60 20	— 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	— —	0.15 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	— —	1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	100	300	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 1.0$ MHz)	C_{ibo}	—	30	pF

MMBT6427

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	12	Vdc
Collector Current — Continuous	I _C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to 2N6426 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I _C = 10 μAdc, I _C = 0)	V _{(BR)EBO}	12	—	Vdc
Collector Cutoff Current (V _{CE} = 25 Vdc, I _B = 0)	I _{CEO}	—	1.0	μAdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	50	nAdc
Emitter Cutoff Current (V _{BE} = 10 Vdc, I _C = 0)	I _{EBO}	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 10 mAdc, V _{CE} = 5.0 Vdc) (I _C = 100 mAdc, V _{CE} = 5.0 Vdc) (I _C = 500 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	10,000 20,000 14,000	100,000 200,000 140,000	—
Collector-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 0.5 mAdc) (I _C = 500 mAdc, I _B = 0.5 mAdc)	V _{CE(sat)}	— —	1.2 1.5	Vdc
Base-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 0.5 mAdc)	V _{BE(sat)}	—	2.0	Vdc
Base-Emitter On Voltage (I _C = 50 mAdc, V _{CE} = 5.0 Vdc)	V _{BE(on)}	—	1.75	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	7.0	pF
Input Capacitance (V _{BE} = 0.5, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	15	pF
Current Gain — High Frequency (I _C = 10 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)	h _{fe}	1.3	—	Vdc
Noise Figure (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, R _S = 100 kΩ, f = 1.0 kHz to 15.7 kHz)	NF	—	10	dB

MMBT6428,29

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MMBT6428	MMBT6429	
Collector-Emitter Voltage	V _{CEO}	50	45	Vdc
Collector-Base Voltage	V _{CBO}	60	55	Vdc
Emitter-Base Voltage	V _{EBO}	6.0		Vdc
Collector Current — Continuous	I _C	200		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

Refer to MPSA18 for graphs.

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0) (I _C = 1.0 mAdc, I _B = 0)	MMBT6428 MMBT6429	V _{(BR)CEO}	50 45	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0) (I _C = 0.1 mAdc, I _E = 0)	MMBT6428 MMBT6429	V _{(BR)CBO}	60 55	— —	Vdc
Collector Cutoff Current (V _{CE} = 30 Vdc)		I _{CEO}	—	0.1	μAdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)		I _{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V _{EB} = 5.0 Vdc, I _C = 0)		I _{EBO}	—	0.01	μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 0.01 mAdc, V _{CE} = 5.0 Vdc)	MMBT6428 MMBT6429	h _{FE}	250 500	— —	—
(I _C = 0.1 mAdc, V _{CE} = 5.0 Vdc)	MMBT6428 MMBT6429		250 500	650 1250	
(I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)	MMBT6428 MMBT6429		250 500	— —	
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	MMBT6428 MMBT6429		250 500	— —	
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc) (I _C = 100 mAdc, I _B = 5.0 mAdc)		V _{CE(sat)}	— —	0.2 0.6	Vdc
Base-Emitter On Voltage (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)		V _{BE(on)}	0.56	0.66	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)		f _T	100	700	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)		C _{obo}	—	3.0	pF
Input Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)		C _{ibo}	—	8.0	pF

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CBO}	350	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	250	mA
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

MMBT6517

**CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**

HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to 2N6517 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0\text{ mA}$)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{A}$)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{A}$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 250\text{ V}$)	I_{CBO}	—	50	nA
Emitter Cutoff Current ($V_{EB} = 5.0\text{ V}$)	I_{EBO}	—	50	nA

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ V}$) ($I_C = 30\text{ mA}$, $V_{CE} = 10\text{ V}$) ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ V}$) ($I_C = 100\text{ mA}$, $V_{CE} = 10\text{ V}$)	h_{FE}	20 30 30 20 15	— — 200 100 —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 20\text{ mA}$, $I_B = 2.0\text{ mA}$) ($I_C = 30\text{ mA}$, $I_B = 3.0\text{ mA}$) ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)	$V_{CE(sat)}$	— — — —	0.30 0.35 0.50 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 20\text{ mA}$, $I_B = 2.0\text{ mA}$) ($I_C = 30\text{ mA}$, $I_B = 3.0\text{ mA}$)	$V_{BE(sat)}$	— — —	0.75 0.85 0.90	Vdc
Base-Emitter On Voltage ($I_C = 100\text{ mA}$, $V_{CE} = 10\text{ V}$)	$V_{BE(on)}$	—	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 20\text{ V}$, $f = 20\text{ MHz}$)	f_T	40	200	MHz
Collector-Base Capacitance ($V_{CB} = 20\text{ V}$, $f = 1.0\text{ MHz}$)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5\text{ V}$, $f = 1.0\text{ MHz}$)	C_{eb}	—	80	pF

MMBT6520

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to 2N6520 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	350	Vdc
Collector-Base Voltage	V_{CBO}	350	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	250	mA
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0\text{ mA}$)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{A}$)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{A}$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 250\text{ V}$)	I_{CBO}	—	50	nA
Emitter Cutoff Current ($V_{EB} = 4.0\text{ V}$)	I_{EBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ V}$) ($I_C = 30\text{ mA}$, $V_{CE} = 10\text{ V}$) ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ V}$) ($I_C = 100\text{ mA}$, $V_{CE} = 10\text{ V}$)	h_{FE}	20 30 30 20 15	— — 200 100 —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 20\text{ mA}$, $I_B = 2.0\text{ mA}$) ($I_C = 30\text{ mA}$, $I_B = 3.0\text{ mA}$) ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)	$V_{CE(sat)}$	— — — —	0.30 0.35 0.50 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 20\text{ mA}$, $I_B = 2.0\text{ mA}$) ($I_C = 30\text{ mA}$, $I_B = 3.0\text{ mA}$)	$V_{BE(sat)}$	— — —	0.75 0.85 0.90	Vdc
Base-Emitter On Voltage ($I_C = 100\text{ mA}$, $V_{CE} = 10\text{ V}$)	$V_{BE(on)}$	—	—	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 20\text{ V}$, $f = 20\text{ MHz}$)	f_T	40	200	MHz
Collector-Base Capacitance ($V_{CB} = 20\text{ V}$, $f = 1.0\text{ MHz}$)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5\text{ V}$, $f = 1.0\text{ MHz}$)	C_{eb}	—	100	pF

MMBT6543

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	25	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 25 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 2.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 4.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	25	60	—	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	200	350	mVdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	750	950	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0 \text{ mAdc}, V_{CE} = 12 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	750	1100	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	0.8	1.0	pF
Collector Base Time Constant ($I_E = 4.0 \text{ mAdc}, V_{CE} = 12 \text{ Vdc}, f = 31.8 \text{ MHz}$)	$r_b' C_C$	—	—	9.5	ps

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MMBTA05,06CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)**DRIVER TRANSISTOR**

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MMBTA05	MMBTA06	
Collector-Emitter Voltage	V_{CE0}	60	80	Vdc
Collector-Base Voltage	V_{CB0}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	60 80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 60 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	50 50	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}$, $I_B = 10 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) ($I_C = 10 \text{ mA}$, $V_{CE} = 2.0 \text{ V}$, $f = 100 \text{ MHz}$)	f_T	100	—	MHz

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MMBTA13,14

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DARLINGTON AMPLIFIER
TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CES}	30	Vdc
Collector-Base Voltage	V _{CBO}	30	Vdc
Emitter-Base Voltage	V _{EBO}	10	Vdc
Collector Current — Continuous	I _C	300	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to 2N6426 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 100 μAdc, I _B = 0)	V _{(BR)CES}	30	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	100	nAdc
Emitter Cutoff Current (V _{BE} = 10 Vdc, I _C = 0)	I _{EBO}	—	100	nAdc

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	MMBTA13	h _{FE}	5000	—	—
	MMBTA14		10,000	—	—
(I _C = 100 mAdc, V _{CE} = 5.0 Vdc)	MMBTA13		10,000	—	
	MMBTA14		20,000	—	
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 0.1 mAdc)	V _{CE(sat)}	—	1.5		Vdc
Base-Emitter On Voltage (I _C = 100 mAdc, V _{CE} = 5.0 Vdc)	V _{BE}	—	2.0		Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)	f _T	125	—	MHz
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(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) f_T = |h_{fe}| • f_{test}.

MMBTA20

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE AMPLIFIER

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	125	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{obo}	—	4.0	pF

MMBTA42,43

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MMBTA42	MMBTA43	
Collector-Emitter Voltage	V _{CEO}	300	200	V _{dc}
Collector-Base Voltage	V _{CBO}	300	200	V _{dc}
Emitter-Base Voltage	V _{EBO}	6.0	6.0	V _{dc}
Collector Current — Continuous	I _C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to MPSA42 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	MMBTA42 MMBTA43 V _{(BR)CEO}	300 200	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	MMBTA42 MMBTA43 V _{(BR)CBO}	300 200	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 200 Vdc, I _E = 0) (V _{CB} = 160 Vdc, I _E = 0)	MMBTA42 MMBTA43 I _{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current (V _{BE} = 6.0 Vdc, I _C = 0) (V _{BE} = 4.0 Vdc, I _C = 0)	MMBTA42 MMBTA43 I _{EBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 30 mAdc, V _{CE} = 10 Vdc)	Both Types Both Types MMBTA42 MMBTA43 h _{FE}	25 40 40 40	— — —	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	MMBTA42 MMBTA43 V _{CE(sat)}	— —	0.5 0.5	V _{dc}
Base-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{BE(sat)}	—	0.9	V _{dc}
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	50	—	MHz
Collector-Base Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 1.0 MHz)	MMBTA42 MMBTA43 C _{cb}	— —	3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBTA55,56

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DRIVER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MMBTA55	MMBTA56	Unit
Collector-Emitter Voltage	V _{CEO}	60	80	Vdc
Collector-Base Voltage	V _{CBO}	60	80	Vdc
Emitter-Base Voltage	V _{EBO}	4.0		Vdc
Collector Current — Continuous	I _C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	MMBTA55 MMBTA56	V _{(BR)CEO}	60 80	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)		V _{(BR)EBO}	4.0	—	Vdc
Collector Cutoff Current (V _{CE} = 60 Vdc, I _B = 0)		I _{CEO}	—	0.1	μAdc
Collector Cutoff Current (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 80 Vdc, I _E = 0)	MMBTA55 MMBTA56	I _{CBO}	— —	0.1 0.1	μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 10 mAdc, V _{CE} = 1.0 Vdc) (I _C = 100 mAdc, V _{CE} = 1.0 Vdc)		h _{FE}	50 50	—	—
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 10 mAdc)		V _{CE(sat)}	—	0.25	Vdc
Base-Emitter On Voltage (I _C = 100 mAdc, V _{CE} = 1.0 Vdc)		V _{BE(on)}	—	1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) (I _C = 100 mAdc, V _{CE} = 1.0 Vdc, f = 100 MHz)		f _T	50	—	MHz
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(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) f_T is defined as the frequency at which |h_{fe}| extrapolates to unity.

MMBTA63 MMBTA64

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DARLINGTON TRANSISTOR

PNP SILICON

Refer to MPSA75 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}$)	$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}$)	I_{EBO}	—	100	nAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1000 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	MMBTA63 MMBTA64 MMBTA63 MMBTA64	h_{FE}	5,000 10,000 10,000 20,000	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}$, $I_B = 0.1 \text{ mAdc}$)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)		$V_{BE(on)}$	—	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 50 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	125	—	MHz
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(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MMBTA70

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	125	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{obo}	—	4.0	pF

MMBTA92,93

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

**HIGH VOLTAGE
TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MMBTA92	MMBTA93	Unit
Collector-Emitter Voltage	V _{CEO}	300	200	V _{dc}
Collector-Base Voltage	V _{CBO}	300	200	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	5.0	V _{dc}
Collector Current — Continuous	I _C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to MPSA92 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	300 200	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	300 200	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 200 Vdc, I _E = 0) (V _{CB} = 160 Vdc, I _E = 0)	I _{CBO}	—	0.25 0.25	μAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 30 mAdc, V _{CE} = 10 Vdc)	h _{FE}	25 40	—	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{CE(sat)}	—	0.5 0.5	V _{dc}
Base-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{BE(sat)}	—	0.9	V _{dc}
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	50	—	MHz
Collector-Base Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBTH10

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

VHF/UHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

Refer to MPSH10 for graphs.

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	60	—	—
Collector-Emitter Saturation Voltage ($I_C = 4.0$ mAdc, $I_B = 0.4$ mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	V_{BE}	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	650	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	0.7	pF
Common-Base Feedback Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{rb}	0.35	0.65	pF
Collector Base Time Constant ($I_C = 4.0$ mAdc, $V_{CB} = 10$ Vdc, $f = 31.8$ MHz)	$rb'C_c$	—	9.0	ps

MMBTH24

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

VHF MIXER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina $10 \times 8 \times 0.6$ mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_E = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 8.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 8.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	400	620	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	0.25	0.36	pF
Conversion Gain (213 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms) (60 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)	— C_G	19 24	24 29	—	dB

(1) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

MMBTH81

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

UHF/VHF TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mA}$, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}$, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}$, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 5.0 \text{ mA}$, $I_B = 0.5 \text{ mA}$)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$)	$V_{BE(on)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	600	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance ($I_B = 0$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{ce}	—	—	0.65	pF

MMBV105G

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

VOLTAGE VARIABLE
CAPACITANCE DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10 \mu\text{Adc}$)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 28 \text{Vdc}$)	I_R	—	—	50	nAdc
Series Inductance ($f = 250 \text{MHz}$)	L_S	—	3.0	—	nH
Diode Capacitance Temperature Coefficient ($V_R = 3.0 \text{Vdc}$, $f = 1.0 \text{MHz}$)	T_{CC}	—	280	—	ppm/ $^\circ\text{C}$
Diode Capacitance ($V_R = 25 \text{Vdc}$)	C_T	1.8	—	2.8	pF
Capacitance ($V_{R1} = 3.0 \text{Vdc}$, $V_{R2} = 25 \text{Vdc}$, $f = 1.0 \text{MHz}$)	$C3/C25$	4.0	—	6.0	pF

MMBV109CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)**VOLTAGE VARIABLE
CAPACITANCE DIODE****MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10 \mu\text{Adc}$)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 28 \text{ Vdc}$)	I_R	—	—	0.1	μAdc
Series Inductance ($f = 250 \text{ MHz}$)	L_S	—	3.0	—	nH
Case Capacitance ($f = 1.0 \text{ MHz}$)	C_C	—	0.1	—	pF
Diode Capacitance Temperature Coefficient ($V_R = 3.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	T_{CC}	—	280	—	ppm/ $^\circ\text{C}$
Figure of Merit ($V_R = 3.0 \text{ Vdc}$, $f = 50 \text{ MHz}$)	Q	280	—	—	—
Diode Capacitance ($V_R = 3.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_T	26	—	32	pF

MMBV2097 thru MMBV2109

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

TUNING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V _R	30	Vdc
Forward Current	I _F	20	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Reverse Breakdown Voltage (I _R = 10 μAdc)	V(BR)	30	—	—	Vdc
Reverse Voltage Leakage Current (V _R = 25 Vdc)	I _R	—	—	20	nAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L _S	—	3.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length = 1/16")	C _C	—	0.15	—	pF
Diode Capacitance Temperature Coefficient (V _R = 4.0 Vdc, f = 1.0 MHz)	T _{CC}	—	280	400	ppm/°C

Device	C _T , Diode Capacitance V _R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V _R = 4.0 Vdc f = 50 MHz	TR, Tuning Ratio C ₂ /C ₃₀ f = 1.0 MHz		Marking Top
	Min	Nom	Max		Min	Max	
MMBV-2101	6.1	6.8	7.5	450	2.5	3.3	4G
MMBV-2102	7.3	8.2	9.0	275	2.6	3.3	4S
MMBV-2103	9.0	10	11	400	2.6	3.3	4H
MMBV2104	10.8	12	13.2	275	2.6	3.3	4T
MMBV-2105	13.5	15	16.5	275	2.6	3.3	4U
MMBV-2106	16.2	18	19.8	250	2.7	3.3	4V
MMBV-2107	19.8	22	24.2	200	2.7	3.3	4W
MMBV-2108	24.3	27	29.7	300	2.7	3.3	4X
MMBV-2109	29.7	33	36.3	200	2.7	3.3	4J

MMBV3102

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

VOLTAGE VARIABLE
CAPACITANCE DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10 \mu\text{Adc}$)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25 \text{ Vdc}$)	I_R	—	—	0.1	μAdc
Series Inductance ($f = 250 \text{ MHz}$)	L_S	—	3.0	—	nH
Case Capacitance ($f = 1.0 \text{ MHz}$)	C_C	—	0.1	—	pF
Diode Capacitance Temperature Coefficient ($V_R = 3.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	T_{CC}	—	280	—	ppm/ $^\circ\text{C}$
Figure of Merit ($V_R = 3.0 \text{ Vdc}$, $f = 50 \text{ MHz}$)	Q	300	—	—	—
Diode Capacitance ($V_R = 3.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_T	20	—	25	pF

MMBV3401

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

SILICON PIN
SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10 \mu\text{Adc}$)	$V_{(BR)}$	35	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25 \text{Vdc}$)	I_R	—	—	0.1	μAdc
Series Inductance ($f = 250 \text{MHz}$)	L_S	—	3.0	—	nH
Series Resistance ($I_F = 10 \text{mAdc}$)	R_S	—	—	0.7	Ohms
Case Capacitance ($f = 1.0 \text{MHz}$)	C_C	—	0.1	—	pF
Diode Capacitance ($V_R = 20 \text{Vdc}$, $f = 1.0 \text{MHz}$)	C_T	—	—	1.0	pF

MXR3866

CASE 345-01, STYLE 1
SOT-89

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Base Voltage	V_{CBO}	55	V
Emitter-Base Voltage	V_{EBO}	3.5	V
Collector Current — Continuous	I_C	0.4	A
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 5.0\text{ mA}$, $R_{BE} = 10\ \Omega$)	$V_{(BR)CER}$	55	—	V
Collector-Emitter Sustaining Voltage ($I_C = 5.0\text{ mA}$)	$V_{CEO(sus)}$	30	—	V
Collector-Base Breakdown Voltage ($I_C = 0.1\text{ mA}$)	$V_{(BR)CBO}$	55	—	V
Emitter-Base Breakdown Voltage ($I_E = 0.1\text{ mA}$)	$V_{(BR)EBO}$	3.5	—	V
Collector Cutoff Current ($V_{CE} = 28\text{ V}$)	I_{CEO}	—	20	μA
Collector Cutoff Current ($V_{CE} = 55\text{ V}$, $V_{BE} = 1.5\text{ V}$)	I_{CEX}	—	100	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.36\text{ A}$, $V_{CE} = 5.0\text{ V}$) ($I_C = 0.05\text{ A}$, $V_{CE} = 5.0\text{ V}$)	h_{FE}	5.0 10	— 200	—
Collector-Emitter Saturation Voltage ($I_C = 100\text{ mA}$, $I_B = 20\text{ mA}$)	$V_{CE(sat)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 15\text{ V}$, $f = 200\text{ MHz}$)	f_T	500	—	MHz
Output Capacitance ($V_{CB} = 30\text{ V}$, $f = 1.0\text{ MHz}$)	C_{obo}	—	3.0	pF

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	V
Collector-Base Voltage	V_{CBO}	60	V
Emitter-Base Voltage	V_{EBO}	4.0	V
Collector Current — Continuous	I_C	0.4	A
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 5.0 \text{ mA}$)	$V_{CEO(sus)}$	40	—	V
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mA}$)	$V_{(BR)EBO}$	4.0	—	V
Collector Cutoff Current ($V_{CB} = 28 \text{ V}$)	I_{CBO}	—	1.0	μA
Collector Cutoff Current ($V_{CE} = 60 \text{ V}$)	I_{CES}	—	0.1	mA
Emitter Cutoff Current ($V_{CE} = 28 \text{ V}$)	I_{CEO}	—	20	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 50 \text{ mA}, V_{CE} = 5.0 \text{ V}$)	h_{FE}	10	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mA}, V_{CE} = 15 \text{ V}, f = 200 \text{ MHz}$)	f_T	500	—	MHz

MXR5160**CASE 345-01, STYLE 1
SOT-89****RF TRANSISTOR****PNP SILICON**

MXR5583CASE 345-01, STYLE 1
SOT-89**HIGH FREQUENCY RF TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Base Voltage	V_{CBO}	30	V
Emitter-Base Voltage	V_{EBO}	3.0	V
Collector Current — Continuous	I_C	500	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10\text{ mA}$)	$V_{(BR)CEO}$	30	—	V
Collector-Base Breakdown Voltage(1) ($I_C = 10\text{ }\mu\text{A}$)	$V_{(BR)CBO}$	30	—	V
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$)	$V_{(BR)EBO}$	3.0	—	V
Collector Cutoff Current ($V_{CB} = 20\text{ V}$)	I_{CBO}	—	50	nA
Emitter Cutoff Current ($V_{EB} = 2.0\text{ V}$)	I_{EBO}	—	0.5	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 40\text{ mA}, V_{CE} = 2.0\text{ V}$) ($I_C = 100\text{ mA}, V_{CE} = 2.0\text{ V}$) ($I_C = 300\text{ mA}, V_{CE} = 5.0\text{ V}$)	h_{FE}	20 25 15	— 100 —	—
Collector-Emitter Saturation Voltage ($I_C = 100\text{ mA}, I_B = 10\text{ mA}$)	$V_{CE(sat)}$	—	0.8	V
Base-Emitter On Voltage ($I_C = 100\text{ mA}, V_{CE} = 2.0\text{ V}$)	$V_{BE(on)}$	—	1.8	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 40\text{ mA}, V_{CE} = 10\text{ V}, f = 100\text{ MHz}$) ($I_C = 100\text{ mA}, V_{CE} = 10\text{ V}, f = 100\text{ MHz}$)	f_T	1000 1300	— —	MHz

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	30	V
Collector-Base Voltage	V _{CBO}	40	V
Emitter-Base Voltage	V _{EBO}	3.5	V
Collector Current — Continuous	I _C	400	mA
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T _A = 25°C Derate above 25°C	P _D	1.0 8.0	Watt mW/°C
Storage Temperature	T _{stg}	150	°C
*Thermal Resistance Junction to Ambient	R _{θJA}	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

MXR5943**CASE 345-01, STYLE 1
SOT-89****RF TRANSISTOR****NPN SILICON****3****ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 5.0 mA)	V _{(BR)CEO}	30	—	V
Collector-Base Breakdown Voltage (I _C = 100 μA)	V _{(BR)CBO}	40	—	V
Emitter-Base Breakdown Voltage (I _E = 100 μA)	V _{(BR)EBO}	3.5	—	V
Collector Cutoff Current (V _{CE} = 20 V)	I _{CEO}	—	50	μA
Collector Cutoff Current (V _{CB} = 15 V)	I _{CBO}	—	10	μA

ON CHARACTERISTICS

DC Current Gain (I _C = 50 mA, V _{CE} = 15 V)	h _{FE}	25	300	—
Collector-Emitter Saturation Voltage (I _C = 100 mA, I _B = 10 mA)	V _{CE(sat)}	—	0.2	V
Base-Emitter Saturation Voltage (I _C = 100 mA, I _B = 10 mA)	V _{BE(sat)}	—	1.0	V

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 25 mA, V _{CE} = 15 V, f = 200 MHz) (I _C = 50 mA, V _{CE} = 15 V, f = 200 MHz) (I _C = 100 mA, V _{CE} = 15 V, f = 200 MHz)	f _T	1000 1200 1000	— — —	MHz
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MXT3904CASE 345-01, STYLE 1
SOT-89**GENERAL PURPOSE TRANSISTOR**

NPN SILICON

Refer to 2N3904 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0\text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{EB} = 3.0\text{ Vdc}$)	I_{BL}	—	50	nAdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{EB} = 3.0\text{ Vdc}$)	I_{CEX}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 50\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	40 70 100 60 30	— — 300 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5.0\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5.0\text{ mAdc}$)	$V_{BE(sat)}$	0.65 —	0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	8.0	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	1.0	10	k ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	0.5	8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	100	400	—

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

MXT3904

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	1.0	40	μmhos	
Noise Figure ($I_C = 100 \mu\text{A}$ dc, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 1.0 \text{ k ohms}$, $f = 10 \text{ Hz to } 15.7 \text{ kHz}$)	NF	—	5.0	dB	
SWITCHING CHARACTERISTICS					
Delay Time	($V_{CC} = 3.0 \text{ Vdc}$, $V_{BE} = 0.5 \text{ Vdc}$, $I_C = 10 \text{ mAdc}$, $I_{B1} = 1.0 \text{ mAdc}$)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time		t_s	—	200	ns
Fall Time		t_f	—	50	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MXT3906CASE 345-01, STYLE 1
SOT-89**GENERAL PURPOSE TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina $10 \times 12 \times 0.6 \text{ mm}$.

Refer to 2N3905 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE} = 3.0 \text{ Vdc}$)	I_{BL}	—	50	nAdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE} = 3.0 \text{ Vdc}$)	I_{CEX}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 0.1 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 50 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	60 80 100 60 30	— — 300 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)	$V_{CE(sat)}$	— —	0.25 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)	$V_{BE(sat)}$	0.65 —	0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	250	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	4.5	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	10.0	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ie}	2.0	12	k ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{re}	0.1	10	$\times 10^{-4}$
Small Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	100	400	—

MXT3906

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	3.0	60	μmhos
Noise Figure ($I_C = 100 \mu\text{A}$ dc, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 1.0 \text{ k ohm}$, $f = 10 \text{ Hz to } 15.7 \text{ kHz}$)	NF	—	4.0	dB

SWITCHING CHARACTERISTICS

Delay Time	(V _{CC} = 3.0 Vdc, V _{BE} = 0.5 Vdc I _C = 10 mAdc, I _{B1} = 1.0 mAdc)	t _d	—	35	ns
Rise Time		t _r	—	35	ns
Storage Time	(V _{CC} = 3.0 Vdc, I _C = 10 mAdc, I _{B1} = I _{B2} = 1.0 mAdc)	t _s	—	225	ns
Fall Time		t _f	—	75	ns

(1) Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.



MXTA14CASE 345-01, STYLE 1
SOT-89**DARLINGTON TRANSISTOR**

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Emitter Voltage	V_{CES}	30	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$)	$V_{(BR)CES}$	30	—	V
Collector Cutoff Current ($V_{CB} = 30$)	I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{BE} = 10 \text{ V}$)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$) ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$)	h_{FE}	10 K 20 K	— —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 100 \text{ mA}$, $I_B = 0.1 \text{ mA}$)	$V_{CE(sat)}$	—	1.5	V
Base-Emitter On Voltage ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$)	$V_{BE(on)}$	—	2.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($V_{CE} = 5.0 \text{ V}$, $I_C = 10 \text{ mA}$, $f = 100 \text{ MHz}$)	f_T	125	—	MHz

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0 \%$.

MXTA27

CASE 345-01, STYLE 1
SOT-89

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

Refer to MPSA25 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$)	$V_{(BR)CES}$	60	—	V
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$)	$V_{(BR)CBO}$	60	—	V
Collector Cutoff Current ($V_{CB} = 50 \text{ V}$)	I_{CBO}	—	100	nA
Collector Cutoff Current ($V_{CE} = 50 \text{ V}$)	I_{CES}	—	500	nA
Emitter Cutoff Current ($V_{BE} = 10 \text{ V}$)	I_{EBO}	—	100	nA

ON CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100 \text{ mA}$, $I_B = 0.1 \text{ A}$)	V_{CES}	—	1.5	V
Base-Emitter On Voltage ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$)	$V_{BE(on)}$	—	2.0	V

SMALL-SIGNAL CHARACTERISTICS

Current Gain ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$) ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$)	h_{FE}	10 K 10 K	—	—
Current Gain — High Frequency ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$, $f = 100 \text{ MHz}$)	$ h_{fe} $	1.25	—	—

MXTA42 MXTA43

CASE 345-01, STYLE 1
SOT-89

HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPSA42	MPSA43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina $10 \times 12 \times 0.6 \text{ mm}$.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}$, $I_B = 0$)	MXTA42 MXTA43 $V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	MXTA42 MXTA43 $V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 160 \text{ Vdc}$, $I_E = 0$)	MXTA42 MXTA43 I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 6.0 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = 4.0 \text{ Vdc}$, $I_C = 0$)	MXTA42 MXTA43 I_{EBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 30 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	Both Types Both Types MXTA42 MXTA43	h_{FE}	25 40 40 40	— — — —
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}$, $I_B = 2.0 \text{ mAdc}$)	MXTA42 MXTA43 $V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}$, $I_B = 2.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	MXTA42 MXTA43 C_{cb}	— —	3.0 4.0	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MXTA44

CASE 345-01, STYLE 1
SOT-89

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	400	V
Collector-Base Voltage	V_{CBO}	500	V
Emitter-Base Voltage	V_{EBO}	6.0	V
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C/W}$

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

Refer to MPSA44 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0\text{ mA}, I_B = 0$)	$V_{(BR)CEO}$	400	—	V
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu\text{A}, V_{BE} = 0$)	$V_{(BR)CES}$	500	—	V
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{A}, I_B = 0$)	$V_{(BR)CBO}$	500	—	V
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{A}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	V

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 1.0\text{ mA}, V_{CE} = 10$) ($I_C = 10\text{ mA}, V_{CE} = 10$) ($I_C = 50\text{ mA}, V_{CE} = 10$) ($I_C = 100\text{ mA}, V_{CE} = 10$)	h_{FE}	40 50 45 40	— 200 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 1.0\text{ mA}, I_B = 0.1\text{ mA}$) ($I_C = 10\text{ mA}, I_B = 1.0\text{ mA}$) ($I_C = 50\text{ mA}, I_B = 5.0\text{ mA}$)	$V_{CE(sat)}$	— — —	0.4 0.5 0.75	V
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}, I_B = 1.0\text{ mA}$)	$V_{BE(sat)}$	—	0.75	V

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 20\text{ V}, I_E = 0, f = 1.0\text{ MHz}$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5\text{ V}, I_C = 0, f = 1.0\text{ MHz}$)	C_{ibo}	—	110	pF
Current Gain — High Frequency ($I_C = 10\text{ mA}, V_{CE} = 10\text{ V}, f = 10\text{ MHz}$)	$ h_{fe} $	2.0	—	—

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MXTA64

CASE 345-01, STYLE 1
SOT-89

DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW°C
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$)	$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$)	I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}$)	I_{EBO}	—	100	nAc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$)(1) ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$)(1)	h_{FE}	10000 20000	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mA}$, $I_B = 0.1 \text{ mA}$)(1)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$)(1)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($V_{CE} = 5.0 \text{ Vdc}$, $I_C = 100 \text{ mA}$, $f = 100 \text{ MHz}$)	f_T	125	—	MHz

(1) Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MXA77

CASE 345-01, STYLE 1
SOT-89

DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

Refer to MPSA75 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$)	$V_{(BR)CES}$	60	—	V
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$)	$V_{(BR)CBO}$	60	—	V
Collector Cutoff Current ($V_{CB} = 50 \text{ V}$)	I_{CBO}	—	100	nA
Collector Cutoff Current ($V_{CE} = 50 \text{ V}$)	I_{CES}	—	500	nA
Emitter Cutoff Current ($V_{BE} = 10 \text{ V}$)	I_{EBO}	—	100	nA

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$) ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$)	h_{FE}	10 K 10 K	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mA}$, $I_B = 0.1 \text{ mA}$)	$V_{CE(sat)}$	—	1.5	V
Base-Emitter On Voltage ($I_C = 100 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$)	$V_{BE(on)}$	—	2.0	V
Current Gain — High Frequency ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$, $f = 100 \text{ MHz}$)	$ h_{fe} $	1.25	—	—

MXTA92 MXTA93

CASE 345-01, STYLE 1
SOT-89

HIGH VOLTAGE
TRANSISTOR

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS-A92	MPS-A93	Unit
Collector-Emitter Voltage	V_{CE0}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

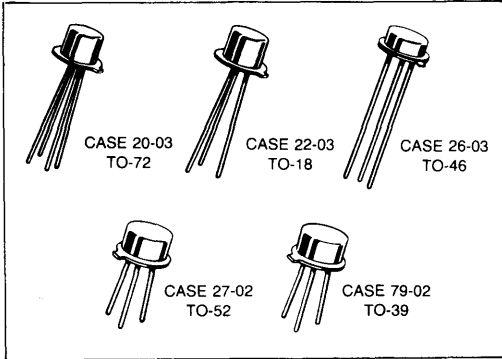
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	$^\circ\text{C}/\text{W}$

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	MXTA92 MXTA93 $V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc , $I_E = 0$)	MXTA92 MXTA93 $V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc , $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	MXTA92 MXTA93 I_{CBO}	— —	0.25 0.25	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	Both Types Both Types MXTA92 MXTA93 h_{FE}	25 40 25 25	— — — 150	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	MXTA92 MXTA93 $V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, $f = 100$ MHz)	f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	MXTA92 MXTA93 C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs , Duty Cycle $\leq 2.0\%$.



Motorola's metal-can transistor product offering includes: general purpose, switching, high voltage, choppers, Darlingtons, low noise amplifiers and RF amplifiers.

A variety of package options are available: TO-18, TO-46, TO-52, TO-72, and TO-39.

Many devices contained in this section are also available with high reliability MIL-S-19500 processing. JAN, JANTX, JANTXV, and JANS qualified devices are so noted on the following data sheets.

Metal Transistors

2N697

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

Refer to 2N2218 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 100\text{ mAdc}, R_{BE} = 10\text{ ohms}$)	$V_{(BR)CER}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30\text{ Vdc}, I_E = 0$) ($V_{CB} = 30\text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	— —	1.0 100	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 150\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	h_{FE}	40	120	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0$)	C_{obo}	—	35	pF
Small-Signal Current Gain ($I_C = 50\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 20\text{ MHz}$)	h_{fe}	2.5	—	MHz

(1) Pulse Test: Pulse Length $\leq 12\text{ ms}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CER}	80	Vdc
Collector-Base Voltage	V _{CBO}	120	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.6 4.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.0 13.3	Watts mW/°C
Operating and Storage Temperature Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	75	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	250	°C/W

2N699

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) (I _C = 100 mA _{dc} , R _{BE} ≤ 10 ohms)	V _{(BR)CER}	80	—	Vdc
Collector Cutoff Current (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	2.0 200	μA _{dc}
Emitter Cutoff Current (V _{EB} = 2.0 Vdc, I _C = 0)	I _{EBO}	—	100	μA _{dc}

ON CHARACTERISTICS

DC Current Gain (1) (I _C = 150 mA _{dc} , V _{CE} = 10 Vdc)	h _{FE}	40	120	—
Collector-Emitter Saturation Voltage (1) (I _C = 150 mA _{dc} , I _B = 15 mA _{dc})	V _{CE(sat)}	—	5.0	Vdc
Base-Emitter Saturation Voltage (1) (I _C = 150 mA _{dc} , I _B = 15 mA _{dc})	V _{BE(sat)}	—	1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mA _{dc} , V _{CE} = 10 Vdc, f = 20 MHz)	f _T	50	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	20	pF
Input Impedance (I _C = 1.0 mA _{dc} , V _{CB} = 5.0 Vdc, f = 1.0 kHz) (I _C = 5.0 mA _{dc} , V _{CB} = 10 Vdc, f = 1.0 kHz)	h _{ib}	20 —	30 10	Ohms
Voltage Feedback Ratio (I _C = 1.0 mA _{dc} , V _{CB} = 5.0 Vdc, f = 1.0 kHz) (I _C = 5.0 mA _{dc} , V _{CB} = 10 Vdc, f = 1.0 kHz)	h _{rb}	— —	2.5 3.0	X 10 ⁻⁴
Small Signal Current Gain (I _C = 1.0 mA _{dc} , V _{CE} = 5.0 Vdc, f = 1.0 kHz) (I _C = 5.0 mA _{dc} , V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	35 45	100 —	—
Output Admittance (I _C = 1.0 mA _{dc} , V _{CB} = 5.0 Vdc, f = 1.0 kHz) (I _C = 5.0 mA _{dc} , V _{CB} = 10 Vdc, f = 1.0 kHz)	h _{ob}	0.05 —	0.5 1.0	μmhos

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N706,A,B

(2N706 JAN AVAILABLE)
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	2N706A,B V_{CE0}	15	Vdc
Collector-Emitter Voltage(1)	V_{CER}	20	Volts
Collector-Base Voltage	V_{CBO}	25	Volts
Emitter-Base Voltage	2N706 2N706A 2N706B V_{EBO}	3.0 5.0 5.0	Volts
Collector Current	2N706,A,B I_C	50	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.3 2.0	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 6.67	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 100^\circ\text{C}$ Derate above 100°C	P_D	0.5	Watt
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	150	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) ($I_C = 10\text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Emitter Breakdown Voltage(2) ($R = 10\text{ ohms}, I_C = 10\text{ mAdc}$)	$V_{(BR)CER}$	20	—	Vdc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}, I_E = 0$) ($V_{CB} = 15\text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$) ($V_{CB} = 25\text{ Vdc}, I_E = 0$)	I_{CBO}	— — —	0.5 30 10	μAdc
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}, R_{BE} = 100\text{k}$)	I_{CER}	—	10	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0\text{ Vdc}, I_C = 0$) ($V_{EB} = 5.0\text{ Vdc}, I_C = 0$)	I_{EBO}	— —	10 10	μAdc

ON CHARACTERISTICS

DC Current Gain(2) ($I_C = 10\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	20 20	— 60	—
Collector-Emitter Saturation Voltage(2) ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.6 0.4	Vdc
Base-Emitter Saturation Voltage(2) ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	— 0.7	0.9 0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($V_{CE} = 15\text{ Vdc}, I_E = 10\text{ mAdc}, f = 100\text{ MHz}$)	f_T	200	—	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}, I_E = 0$) ($V_{CB} = 10\text{ Vdc}, I_E = 0$)	C_{obo}	— —	5.0 6.0	pF
Magnitude of Forward Current Transfer Ratio, Common-Emitter ($V_{CE} = 15\text{ Vdc}, I_E = 10\text{ mAdc}, f = 100\text{ MHz}$) ($V_{CE} = 10\text{ Vdc}, I_E = 10\text{ mAdc}, f = 100\text{ MHz}$)	$ h_{fe} $	2.0 2.0	— —	—

2N706,A,B

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

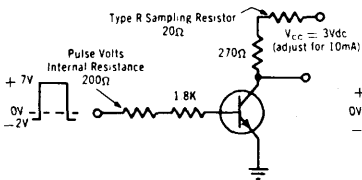
Characteristic	Symbol	Min	Max	Unit
Collector Base Time Constant ($V_{CE} = 15\text{ Vdc}$, $I_E = 10\text{ mAdc}$, $f = 300\text{ MHz}$)	r_b	—	50	ohms
Storage Time 2N706B	t_s	—	25	ns
Turn-On Time ($I_{B1} = 3.0\text{ mA}$, $I_{B2} = 1.0\text{ mA}$)	t_{on}	—	40	ns
Turn-Off Time ($I_{B1} = 3.0\text{ mA}$, $I_{B2} = 1.0\text{ mA}$)	t_{off}	—	75	ns
Charge Storage Time Constant(2) 2N706 2N706A,B	τ_s	—	60 25	ns

(1) Refers to collector breakdown voltage in the high current region when $R_{BE} = 10\ \Omega$

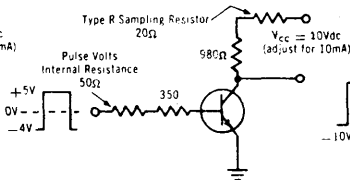
(2) Pulse Test: Pulse Width $\leq 12\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(3) Switching Times Measured with Tektronix Type R Plug-In (50 Ω Internal Impedance).

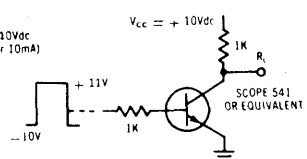
SWITCHING TIME TEST CIRCUIT



STORAGE TIME TEST CIRCUIT



MEASUREMENT CIRCUIT



2N708

JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	limited by P_D only	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.1	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C Derate above 100°C	P_D	1.2 680 6.9 6.9	Watts mW mW/°C mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	145	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 30 \text{ mAdc}, R_{BE} \leq 10 \text{ ohms}$)	$V_{CER(sus)}$	20	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 30 \text{ mAdc}, I_B = 0$)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}, V_{BE} = 0.25 \text{ Vdc}, T_A = +125^\circ\text{C}$)	I_{CEX}	—	10	μAdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}, I_E = 0$) ($V_{CB} = 20 \text{ Vdc}, I_C = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	—	0.025 15	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.08	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.5 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$)(1)	h_{FE}	15 30 15	— 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 7.0 \text{ mAdc}, I_B = 0.7 \text{ mAdc}, T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$)	$V_{CE(sat)}$	— —	0.4 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 7.0 \text{ mAdc}, I_B = 0.7 \text{ mAdc}, T_A = -55^\circ\text{C}$)	$V_{BE(sat)}$	0.72 —	0.80 0.90	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, 100 \text{ kHz} \leq f \leq 1.0 \text{ MHz}$)	C_{obo}	—	6.0	pF
Extrinsic Base Resistance ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 300 \text{ MHz}$)	r_b'	—	50	ohms
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = I_{B1} = I_{B2} = 10 \text{ mAdc}$)	t_s	—	25	ns
Turn-On Time	t_{on}	—	40	ns
Turn-Off Time	t_{off}	—	70	ns

2N718A 2N956, 2N1711

**2N718A JAN, JTX,
JTXV AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)**

**GENERAL PURPOSE
TRANSISTOR**

NPN SILICON

2N718A: See 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N718A 2N956	2N1711	Unit
Collector-Emitter Voltage	V _{CE}	50		V _{dc}
Collector-Base Voltage	V _{CBO}	75		V _{dc}
Emitter-Base Voltage	V _{EBO}	7.0		V _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	500 2.86	800 4.57	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.8 10.3	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 100 mA _{dc} , pulsed; R _{BE} ≤ 10 ohms)	V _{CE(sus)}	50	—	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBO}	75	—	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μA _{dc} , I _C = 0)	V _{(BR)EBO}	7.0	—	—	V _{dc}
Collector Cutoff Current (V _{CB} = 60 V _{dc} , I _E = 0) (V _{CB} = 60 V _{dc} , I _E = 0, T _A = 150°C)	I _{CBO}	—	0.001	0.01	μA _{dc}
Emitter Cutoff Current (V _{BE} = 5.0 V _{dc} , I _C = 0)	I _{EBO}	—	—	0.010	μA _{dc}
		2N718A, 2N956, 2N1711	—	0.005	

ON CHARACTERISTICS

DC Current Gain (I _C = 0.01 mA _{dc} , V _{CE} = 10 V _{dc})	h _{FE}	2N956, 2N1711	20	—	—	—
(I _C = 0.1 mA _{dc} , V _{CE} = 10 V _{dc})		2N718A, 2N956, 2N1711	20 35	—	—	—
(I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc})		2N718A, 2N956, 2N1711	35 75	—	—	—
(I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc} , T _A = -55°C)		2N718A, 2N956, 2N1711	20 35	—	—	—
(I _C = 150 mA _{dc} , V _{CE} = 10 V _{dc})		2N718A, 2N956, 2N1711	40 100	—	120 300	—
(I _C = 500 mA _{dc} , V _{CE} = 10 V _{dc})		2N718A, 2N956, 2N1711	20 40	—	—	—
Collector-Emitter Saturation Voltage(1) (I _C = 150 mA _{dc} , I _B = 15 mA _{dc})		V _{CE(sat)}	—	0.24	1.5	V _{dc}
Base-Emitter Saturation Voltage(1) (I _C = 150 mA _{dc} , I _B = 15 mA _{dc})	V _{BE(sat)}	—	1.0	1.3	V _{dc}	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N718A, 2N956, 2N1711

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	f_T	60 70	300 300	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	4.0	25	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	20	80	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ib}	24 4.0	— —	34 8.0	ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{rb}	— —	— —	3.0 5.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	30 50	— —	100 200	—
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ob}	0.05 0.05	— —	0.5 0.5	μmhos
Noise Figure ($I_C = 300 \mu\text{Adc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	NF	— —	— —	12 8.0	dB

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 2.86	Watt $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10.3	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	$^\circ\text{C}/\text{W}$

2N720A

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 100 \text{ mAdc}, R_{BE} \leq 10 \text{ ohms}$)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 30 \text{ mAdc}, I_B = 0$)	$V_{CE0(sus)}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \text{ } \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \text{ } \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 90 \text{ Vdc}, I_E = 0$) ($V_{CB} = 90 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	—	.010 15	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	.010	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)(1)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{CE(sat)}$	— —	1.2 5.0	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{BE(sat)}$	— —	0.9 1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	15	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	85	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{rb}	— —	1.25 1.50	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	30 45	100 —	—
Output Admittance ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ob}	— —	0.5 0.5	μmhos

(1) Pulse Test: Pulse Width $\leq 300 \text{ } \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N869A 2N4453

JAN, JTX, JTXV AVAILABLE

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

2N4453
CASE 26-03, STYLE 1
TO-46 (TO-206AB)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N869A	2N4453	Unit
Collector-Emitter Voltage	V _{CEO}	18	18	Vdc
Collector-Emitter Voltage	V _{CES}	25		Vdc
Collector-Base Voltage	V _{CBO}	25*	25	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	200		mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	360 2.06	400 2.29	mW mW/°C
Total Device Dissipation @ T _C = 25°C TC = 100°C Derate above 25°C	P _D	1.2 0.686 6.86	2.0 1.03 11.3	Watts Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N869A	2N4453	Unit
Thermal Resistance, Junction to Case	R _{θJC}	146	97.5	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	486	585	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mA _{dc} , I _B = 0)	V _{(BR)CEO}	18	—	Vdc
Collector-Emitter Breakdown Voltage (I _C = 10 μA _{dc} , V _{BE} = 0)	V _{(BR)CES}	25	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I _C = 10 mA _{dc} , I _B = 0)	V _{CEO(sus)}	18	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{(BR)CBO}	25	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	25	μA _{dc}
Collector Cutoff Current (V _{CE} = 15 Vdc, V _{BE} = 0)	I _{CES}	—	10	nA _{dc}
Emitter Cutoff Current (V _{EB} = 4.5 Vdc, I _C = 0)	I _{EBO}	—	10	nA _{dc}
Base Current (V _{CE} = 15 Vdc, V _{BE} = 0)	I _B	—	10	nA _{dc}

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 10 mA _{dc} , V _{CE} = 0.3 Vdc) (I _C = 10 mA _{dc} , V _{CE} = 5.0 Vdc) (I _C = 30 mA _{dc} , V _{CE} = 0.5 Vdc) (I _C = 30 mA _{dc} , V _{CE} = 0.5 Vdc, T _A = -55°C) (I _C = 100 mA _{dc} , V _{CE} = 1.0 Vdc)	h _{FE}	30 40 40 17 25	— 120 120 — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 1.5 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 3.0 mA _{dc}) (I _C = 100 mA _{dc} , I _B = 10 mA _{dc})	V _{CE(sat)}	— — — —	0.15 0.25 0.2 0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 1.5 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 3.0 mA _{dc}) (I _C = 100 mA _{dc} , I _B = 10 mA _{dc})	V _{BE(sat)}	0.78 0.8 0.85 —	0.98 1.1 1.2 1.7	Vdc

2N869A, 2N4453

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1)(2) (I _C = 10 mA, V _{CE} = 15 Vdc, f = 100 MHz)		f _T	400	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 140 kHz)		C _{obo}	—	6.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 150 kHz)		C _{ibo}	—	6.0	pF
Collector-Base Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz)		C _{cb}	—	6.0	pF
Emitter-Base Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)		C _{eb}	—	6.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	I _C = 30 mA, I _{B1} = 1.5 mA V _{CC} = 2.0 Vdc, 2N869A V _{CC} = 3.0 Vdc, 2N4453	t _{on}	—	50	ns
Delay Time		t _d	—	35	ns
Rise Time		t _r	—	20	ns
Turn-Off Time		t _{off}	—	80	ns
Storage Time		t _s	—	65	ns
Fall Time	t _f	—	20	ns	

- (1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 1.0%.
- (2) f_T is defined as the frequency at which |h_{fe}| extrapolates to unity.

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 — SWITCHING TEST CIRCUIT VALUES

		V _{in} Volts	V _{BB} Volts	V _{CC} Volts	R _L Ohms	I _C mA	I _{B1} ⁽⁴⁾ mA	I _{B2} ⁽⁴⁾ mA
t _{on} , t _r , t _d	2N869A	-7.0	3.0	2.0	62	30	1.5	—
	2N4453	-7.0	3.0	3.0	91	30	1.5	—
t _{off} , t _s , t _f	2N869A	+6.0	-4.0	2.0	62	30	1.5	1.5
	2N4453	+6.0	-4.0	3.0	91	30	1.5	1.5

- (3) I_C/I_B = 10. Switching is shown to reflect current industry practices. Compare the values shown in Figures 1 and 2 @ I_C = 30 mA to the typical values in the Electrical Characteristics table @ I_C/I_B = 20.
- (4) I_{B1} = I_{B2} = 3.0 mA @ I_C/I_B = 10

FIGURE 2 — DC CURRENT GAIN

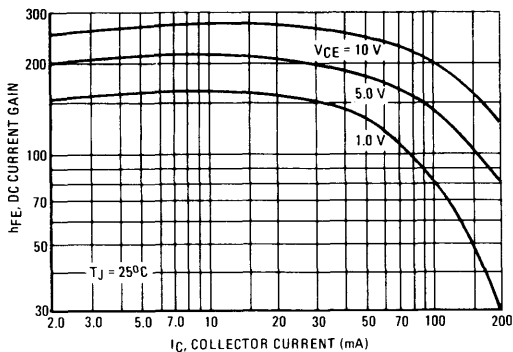
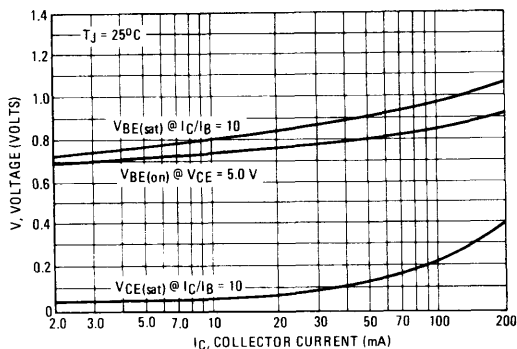


FIGURE 3 — "ON" VOLTAGES



2N869A, 2N4453

FIGURE 4 — CURRENT-GAIN — BANDWIDTH PRODUCT

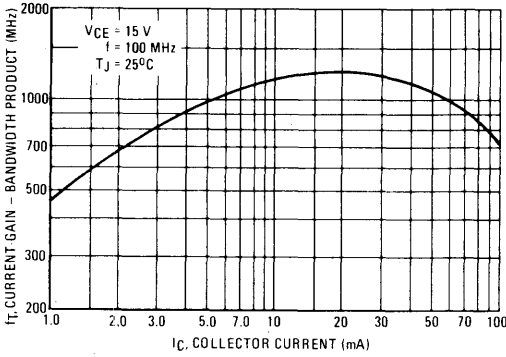


FIGURE 5 — TURN-ON TIME

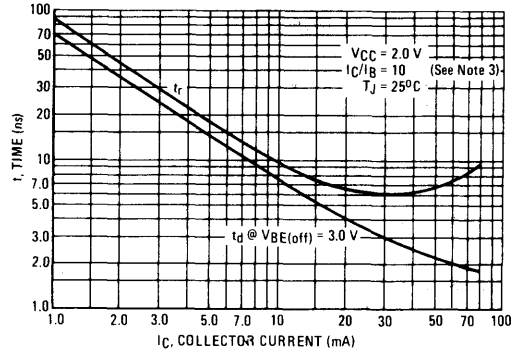


FIGURE 6 — TURN-OFF TIME

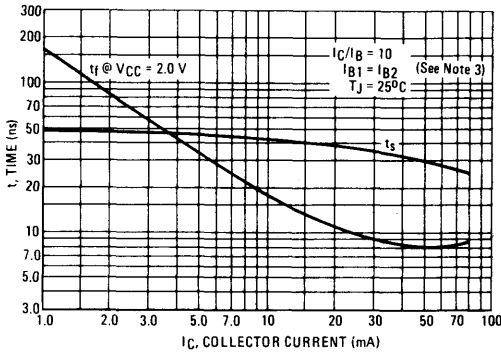


FIGURE 7 — SWITCHING TIME TEST CIRCUIT

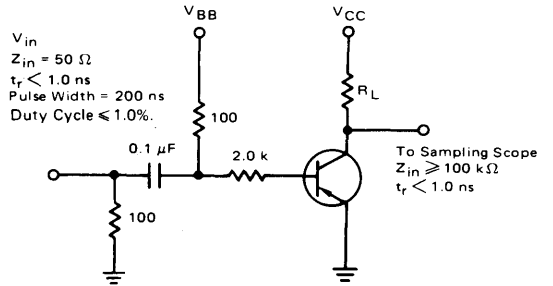
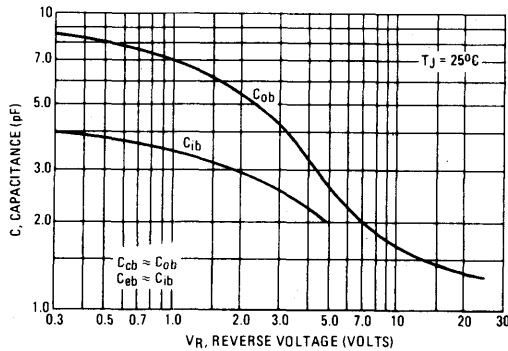


FIGURE 8 — CAPACITANCE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	15	Vdc
Collector-Emitter Voltage (R _{BE} ≤ 10 ohms)	V _{CER}	20	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous(1)	I _C	150	mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	360 2.06	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.2 6.8	Watts mW/°C
Total Device Dissipation @ T _C = 100°C Derate above 100°C	P _D	0.68	Watt
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

2N914

**JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)**

SWITCHING TRANSISTOR

NPN SILICON

4

Refer to 2N2368 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) (I _C = 30 mA _{dc} , R _{BE} ≤ 10 ohms)	V _{CER(sus)}	20	—	Vdc
Collector-Emitter Sustaining Voltage(2) (I _C = 30 mA _{dc} , I _B = 0)	V _{CEO(sus)}	15	—	Vdc
Collector-Base Breakdown Voltage (I _C = 1.0 μA _{dc} , I _E = 0)	V _{(BR)CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CE} = 20 Vdc, V _{BE} = 0.25 Vdc, T _A = 125°C)	I _{CEX}	—	10	μA _{dc}
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0) (V _{CB} = 20 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	0.025 15	μA _{dc}
Emitter Cutoff Current (V _{BE} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	0.1	μA _{dc}

ON CHARACTERISTICS

DC Current Gain(2) (I _C = 10 mA _{dc} , V _{CE} = 1.0 Vdc) (I _C = 10 mA _{dc} , V _{CE} = 1.0 Vdc, T _A = -55°C) (I _C = 500 mA _{dc} , V _{CE} = 5.0 Vdc)	h _{FE}	30 12 10	120 — —	—
Collector-Emitter Saturation Voltage(2) (I _C = 200 mA _{dc} , I _B = 20 mA _{dc}) (I _C = 10 mA _{dc} , I _B = 1.0 thru 20 mA _{dc} , T _A = -55 to +125°C)	V _{CE(sat)}	—	0.70 0.25	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc})	V _{BE(sat)}	0.70	0.80	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 20 mA _{dc} , V _{CE} = 10 Vdc, f = 100 MHz)	f _T	300	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	6.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	9.0	pF

SWITCHING CHARACTERISTICS

Storage Time(3) (I _C = I _{B1} = I _{B2} = 20 mA _{dc})	t _s	—	20	ns
Turn-On Time(3) (I _C = 200 mA _{dc} , I _{B1} = 40 mA _{dc} , I _{B2} = 20 mA _{dc})	t _{on}	—	40	ns
Turn-Off Time(3) (I _C = 200 mA _{dc} , I _{B1} = 40 mA _{dc} , I _{B2} = 20 mA _{dc})	t _{off}	—	40	ns

(1) Limited by Power Dissipation.

(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 1.0%.

(3) Measured on Sampling Scope: Pulse Width ≥ 200 ns.

2N915

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	50	Vdc
Collector-Base Voltage	V_{CBO}	70	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.05	Watts $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.81	Watts $\text{mW}/^\circ\text{C}$
Total Power Dissipation @ + 100°C Case	P_D	0.68	W
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

Refer to 2N3946 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 10 \text{ mA}, I_B = 0$)	$V_{CE0(sus)}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}, I_E = 0$)	$V_{(BR)CBO}$	70	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ V}, I_E = 0$)	I_{CBO}	—	0.010	μA
Collector Cutoff Current ($V_{CB} = 60 \text{ V}, I_E = 0$) ($V_{CB} = 60 \text{ V}, I_E = 0, T_A = +150^\circ\text{C}$)	I_{CBO}	— —	0.010 30	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10 \text{ mA}, V_{CE} = 5.0 \text{ V}$)	h_{FE}	50	200	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA}$)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA}$)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($I_E = 0, V_{CB} = 10 \text{ V}, f = 100 \text{ kHz}$)	C_{obo}	—	3.5	pF
Emitter Transition Capacitance ($I_C = 0, V_{EB} = 0.5 \text{ V}, f = 100 \text{ kHz}$)	C_{TE}	—	10	pF
Input Impedance ($I_C = 1.0 \text{ mA}, V_{CE} = 5.0 \text{ V}$) ($I_C = 5.0 \text{ mA}, V_{CE} = 5.0 \text{ V}$)	h_{ie}	— —	6000 2000	ohms
High Frequency Current Gain $f = 100 \text{ MHz}$ ($I_C = 10 \text{ mA}, V_{CE} = 15 \text{ V}$)	h_{fe}	2.5	—	—
Small-Signal Current Gain $f = 1 \text{ kHz}$ ($I_C = 1.0 \text{ mA}, V_{CE} = 5.0 \text{ V}$) ($I_C = 5.0 \text{ mA}, V_{CE} = 5.0 \text{ V}$)	h_{fe}	40 50	200 250	—
Output Admittance ($I_C = 1.0 \text{ mA}, V_{CE} = 5.0 \text{ V}$) ($I_C = 5.0 \text{ mA}, V_{CE} = 5.0 \text{ V}$)	h_{oe}	— —	75 125	μhos μmho
Collector Base Time Constant ($I_C = 10 \text{ mA}, V_{CB} = 10 \text{ V}, f = 40 \text{ mHz}$)	$rb'C_c$	—	300	ps

(1) Pulse Test: $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 1.0\%$.

2N916

JAN AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	25	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watts $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.9	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

Refer to 2N3946 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) ($I_C = 30\text{ mA}, I_B = 0$)	$V_{CE0(sus)}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{A}, I_E = 0$)	$V_{(BR)CBO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{A}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30\text{ V}, I_E = 0$)	I_{CBO}	—	10	nAdc
Collector Cutoff Current @ 150°C ($V_{CB} = 30\text{ V}, I_E = 0$)	I_{CBO}	—	10	μAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10\text{ mA}, V_{CE} = 1.0\text{ V}$) ($I_C = 10\text{ mA}, V_{CE} = 1.0\text{ V}, -55^\circ\text{C}$)	h_{FE}	50 15	200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}, I_B = 1.0\text{ mA}$)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}, I_B = 1.0\text{ mA}$)	$V_{BE(sat)}$	—	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 5.0\text{ V}, I_E = 0$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5\text{ V}, I_C = 0$)	C_{ibo}	—	10	pF
Input Impedance, $f = 1.0\text{ kHz}$ ($I_C = 1.0\text{ mA}, V_{CE} = 5.0\text{ V}$) ($I_C = 5.0\text{ mA}, V_{CE} = 5.0\text{ V}$)	h_{ie}	— —	6000 2000	ohms ohms
Small-Signal Current Gain, $f = 1.0\text{ kHz}$ ($I_C = 1.0\text{ mA}, V_{CE} = 5.0\text{ V}$) ($I_C = 5.0\text{ mA}, V_{CE} = 5.0\text{ V}$)	h_{fe}	40 50	200 250	—
Magnitude of Forward Circuit Transfer Ratio, Common-Emitter ($I_C = 10\text{ mA}, V_{CE} = 15\text{ V}$)	$ h_{fe} $	3.0	—	—
Output Admittance, $f = 1.0\text{ kHz}$ ($I_C = 1.0\text{ mA}, V_{CE} = 5.0\text{ V}$) ($I_C = 5.0\text{ mA}, V_{CE} = 5.0\text{ V}$)	h_{oe}	— —	75 125	μmho μmho
Collector Base Time Constant ($I_C = 10\text{ mA}, V_{CB} = 10\text{ V}, f = 40\text{ MHz}$)	$rb'C_c$	—	300	ps

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 1.0\%$.

2N918

JAN, JTX, JTXV AVAILABLE
CASE 20-03, STYLE 10
(TO-72 (TO-206AF))

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.71	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	.010 1.0	μ Adc μ Adc

ON CHARACTERISTICS

DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	600	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 140$ kHz) ($V_{CB} = 0$, $I_E = 0$, $f = 140$ kHz)	C_{obo}	— —	1.7 3.0	μF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 140$ kHz)	C_{ibo}	—	2.0	μF
Noise Figure ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, $R_G = 400$ Ohms, $f = 60$ MHz)	NF	—	6.0	dB

FUNCTIONAL TEST

Amplifier Power Gain ($V_{CB} = 12$ Vdc, $I_C = 6.0$ mAdc, $f = 200$ MHz)	G_{pe}	15	—	dB
Power Output ($V_{CB} = 15$ Vdc, $I_C = 8.0$ mAdc, $f = 500$ MHz)	P_O	30	—	mW
Collector Efficiency ($V_{CB} = 15$ Vdc, $I_C = 8.0$ mAdc, $f = 500$ MHz)	η	25	—	%

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N930,A

JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N930	2N930A	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current	I_C	30		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 3.33		W mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 12		Watt mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	-65 to +175		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	2N930A	—	—
		2N930 2N930A	5.0 6.0	— —
Collector Cutoff Current ($V_{CE} = 5.0 \text{ Vdc}, I_B = 0$)	I_{CEO}	—	2.0	nAdc
Collector Cutoff Current ($V_{CB} = 45 \text{ Vdc}, I_E = 0$)	I_{CBO}	2N930	—	10
		2N930A	—	2.0
Collector Cutoff Current ($V_{CE} = 45 \text{ Vdc}, V_{BE} = 0$)	I_{CES}	2N930	—	10
		2N930A	—	2.0
		2N930 2N930A	— —	10 2.0
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	2N930	—	10
		2N930A	—	2.0

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0 \text{ } \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	2N930A	60	—	—
($I_C = 10 \text{ } \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)		2N930 2N930A	100	300	—
($I_C = 10 \text{ } \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}, T_A = -55^\circ\text{C}$)		2N930	20	—	—
		2N930A	30	—	—
($I_C = 500 \text{ } \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)		2N930	150	—	—
		2N930A	—	—	—
($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$) (1)		2N930	—	600	—
		2N930A	—	600	—

2N930,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage (1) ($I_C = 10 \text{ mA}$, $I_B = 0.5 \text{ mA}$)	2N930 2N930A	$V_{CE(sat)}$	— —	1.0 0.5	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 10 \text{ mA}$, $I_B = 0.5 \text{ mA}$)	2N930 2N930A	$V_{BE(sat)}$	0.7	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 500 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 30 \text{ MHz}$)	2N930 2N930A	f_T	30 45	— —	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	2N930 2N930A	C_{obo}	— —	8.0 6.0	pF
Input Impedance ($I_E = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)		h_{ib}	25	32	ohms
Voltage Feedback Ratio ($I_E = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)		h_{rb}	—	600	$\times 10^{-6}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N930 2N930A	h_{fe}	150	600	—
Output Admittance ($I_E = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)		h_{ob}	—	1.0	μmhos
Noise Figure ($I_C = 10 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 10 \text{ k ohms}$, $f = 10 \text{ Hz to } 15.7 \text{ kHz}$)	2N930, 2N930A	NF	—	3.0	dB

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N956

For Specifications, See 2N718A Data.

MAXIMUM RATINGS

Rating	Symbol	2N1132	2N1132A	Unit
Collector-Emitter Voltage	V_{CE0}	35	40	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ Ohms)	V_{CER}	← 50 →		Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	← 5.0 →		Vdc
Collector Current — Continuous	I_C	← 600 →		mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	← 600 → ← 3.43 →		mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	← 2.0 → ← 11.43 →		Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 100^\circ\text{C}$ 2N1132A	P_D	← 1.0 →		Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 65 to + 200		$^\circ\text{C}$

2N1132A

JAN AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

4

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.49	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	291.55	$^\circ\text{C}/\text{W}$

Refer to 2N2904 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	2N1132A 2N1132	$V_{(BR)CEO}$	40 35	— — Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc , $I_E = 0$)	2N1132, 2N1132A	$V_{(BR)CBO}$	50 60	— — Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc , $I_C = 0$) ($I_E = 1.0$ mA, $I_C = 0$)	2N1132, 2N1132A	$V_{(BR)EBO}$	5.0 5.0	— — Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$) ($V_{CB} = 45$ Vdc, $I_E = 0$) ($V_{CB} = 45$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	2N1132 2N1132 2N1132 2N1132A 2N1132A	I_{CBO}	— — — — —	1.0 100 100 0.5 50 μAdc
Collector Cutoff Current ($V_{CE} = 50$ V, $R_{BE} \leq 10$ Ohms)	2N1132 2N1132A	I_{CER}	— —	10 10 mA mA
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$) ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	2N1132A 2N1132	I_{EBO}	— —	100 100 μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25 30	— 90 —
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{CE(sat)}$	—	1.5 Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	1.3 Vdc

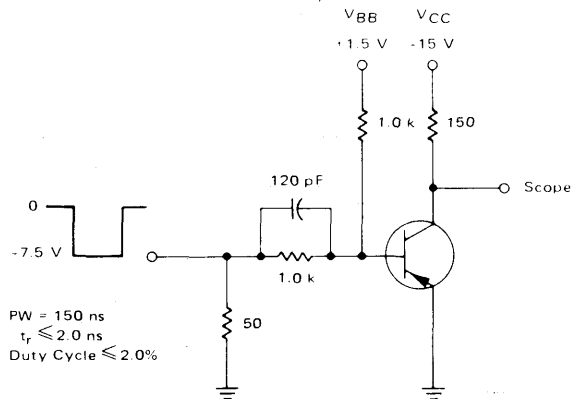
2N1132,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	60	—	MHz	
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$) ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	45 30	pF	
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ kHz}$) ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	80 80	pF	
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	25 —	35 10	Ohms	
Voltage Feedback Ratio ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	—	8.0 8.0	$\times 10^{-4}$	
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	25 25	100 75	—	
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	—	1.0 5.0	μhos	
SWITCHING CHARACTERISTICS					
Turn-On Time	2N1132A	t_{on}	—	45	ns
Turn-Off Time	2N1132A	t_{off}	—	35	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 SWITCHING TIMES TEST CIRCUIT



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage ($R_{BE} \leq 10 \text{ Ohms}$)	V_{CER}	50	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8 4.57	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.15	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	$^\circ\text{C/W}$

2N1613

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

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ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 100 \text{ mAdc}, R_{BE} \leq 10 \text{ Ohms}$)	$V_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$) ($V_{CB} = 60 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	—	—	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 100 \mu\text{Adc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20 35 20 40 20	35 50 — 80 30	— — — 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.3	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.78	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	60	—	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	10	25	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	50	80	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{rb}	— —	— —	3.0 3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	30 35	— —	100 150	—
Output Admittance ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ob}	0.05 0.05	— —	0.5 0.5	μmhos
Noise Figure ($I_C = 0.3 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, R_S = 510 \text{ Ohms}, f = 1.0 \text{ kHz}$, Bandwidth = 1.0 Hz)	NF	—	—	12	dB
SWITCHING CHARACTERISTICS					
Switching Time	$t_d + t_r + t_f$	—	—	30	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N1711

For Specifications, See 2N718A Data.

2N1893

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8 4.57	Watt $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.2	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	$^\circ\text{C}/\text{W}$

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100 \text{ mAdc}, R_{BE} = 10 \text{ ohms}$)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 30 \text{ mAdc}, I_B = 0$)	$V_{CEO(sus)}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \text{ }\mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \text{ }\mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 90 \text{ Vdc}, I_E = 0$) ($V_{CB} = 90 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	—	0.01 15	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.01	μAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 0.1 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{CE(sat)}$	—	1.2 5.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.9 1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, 100 \text{ kHz} \leq f \leq 1.0 \text{ MHz}$)	C_{obo}	—	15	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, 100 \text{ kHz} \leq f \leq 1.0 \text{ MHz}$)	C_{ibo}	—	85	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{rb}	—	1.25 1.5	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	30 45	100 —	—
Output Admittance ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ob}	—	0.5 0.5	μmho

(1) Pulse Test: Pulse Width $\leq 300 \text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	65	Vdc
Collector-Emitter Voltage, $R_{BE} \leq 10$ Ohms	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	175	°C/W

2N2102

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

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Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, $R_{BE} \leq 10$ ohms)	$V_{CER(sus)}$	80	—	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 100$ mAdc, $I_B = 0$)	$V_{CE0(sus)}$	65	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μ Adc, $V_{EB} = 1.5$ Vdc)	$V_{(BR)CEX}$	120	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	120	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	—	2.0 2.0	nAdc μ Adc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	2.0	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55^\circ\text{C}$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(2) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(2) ($I_C = 1.0$ Adc, $V_{CE} = 10$ Vdc)(2)	h_{FE}	20 35 20 40 25 10	— — — — — —	— — — 120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.15	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.88	1.1	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, $f = 20$ MHz)	f_T	60	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{obo}	—	6.0	15	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 100$ kHz)	C_{ibo}	—	50	80	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{rb}	—	—	3.0 3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{fe}	30 35	—	100 150	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{ob}	0.01 0.01	—	0.5 1.0	μ mho
Noise Figure ($I_C = 300$ μ Adc, $V_{CE} = 10$ Vdc, $R_S = 1.0$ k Ohm, $f = 1.0$ kHz, Bandwidth = 1.0 Hz)	NF	—	4.0	6.0	dB

SWITCHING CHARACTERISTICS

Switching Time	$t_d + t_r + t_f$	—	—	30	ns
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(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board. (2) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

2N2193A

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	8.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8 4.6	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.8 16	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ 100°C Case Derate above 100°C	P_D	1.6 16	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 25\text{ mA}, I_B = 0$)	$V_{CEO(sus)}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	8.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}, I_E = 0$) ($V_{CB} = 60\text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.010 25	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.050	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 0.1\text{ mAdc}, V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 150\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)(1) ($I_C = 150\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$)(1) ($I_C = 500\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)(1) ($I_C = 1.0\text{ Adc}, V_{CE} = 10\text{ Vdc}$)(1)	h_{FE}	15 30 20 40 30 20 15	— — — 120 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$)	C_{obo}	—	20	pF
Small-Signal Current Gain ($I_C = 50\text{ mA}, V_{CE} = 10\text{ V}, f = 20\text{ MHz}$)	h_{fe}	2.5	—	—
SWITCHING CHARACTERISTICS				
Rise Time	t_r	—	70	ns
Storage Time	t_s	—	150	ns
Fall Time	t_f	—	50	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	2N2218	2N2218A	2N5581	Unit
		2N2219 2N2221 2N2222	2N2219A 2N2221A 2N2222A		
Collector-Emitter Voltage	V _{CEO}	30	40	40	Vdc
Collector-Base Voltage	V _{CBO}	60	75	75	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	6.0	6.0	Vdc
Collector Current → Continuous	I _C	800	800	800	mAdc
		2N2218,A 2N2219,A	2N2221,A 2N2222,A	2N5581 2N5582	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.8 4.57	0.4 2.28	0.6 3.33	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	3.0 17.1	1.2 6.85	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200			°C

2N2218,A/2N2219,A 2N2221,A/2N2222,A 2N5581/82

JAN, JTX, JTXV AVAILABLE

2N2218,A
2N2219,A
CASE 79-02
TO-39 (TO-205AD)
2N2221,A
2N2222,A
CASE 22-03
TO-18 (TO-206AA)

2N5581
2N5582
CASE 26-03
TO-46 (TO-206AB)

GENERAL PURPOSE TRANSISTOR
NPN SILICON

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	Non-A Suffix A-Suffix, 2N5581, 2N5582	V _{(BR)CEO}	30 40	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	Non-A Suffix A-Suffix, 2N5581, 2N5582	V _{(BR)CBO}	60 75	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	Non-A Suffix A-Suffix, 2N5581, 2N5582	V _{(BR)EBO}	5.0 6.0	— —	Vdc
Collector Cutoff Current (V _{CE} = 60 Vdc, V _{EB(off)} = 3.0 Vdc)	A-Suffix, 2N5581, 2N5582	I _{CEX}	—	10	nAdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0, T _A = 150°C) (V _{CB} = 60 Vdc, I _E = 0, T _A = 150°C)	Non-A Suffix A-Suffix, 2N5581, 2N5582 Non-A Suffix A-Suffix, 2N5581, 2N5582	I _{CBO}	— — — —	0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	A-Suffix, 2N5581, 2N5582	I _{EBO}	—	10	nAdc
Base Cutoff Current (V _{CE} = 60 Vdc, V _{EB(off)} = 3.0 Vdc)	A-Suffix	I _{BL}	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 10 Vdc)	2N2218,A, 2N2221,A, 2N5581(1) 2N2219,A, 2N2222,A, 2N5582(1)	h _{FE}	20 35	— —	—
(I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	2N2218,A, 2N2221,A, 2N5581 2N2219,A, 2N2222,A, 2N5582		25 50	— —	
(I _C = 10 mAdc, V _{CE} = 10 Vdc)	2N2218,A, 2N2221,A, 2N5581(1) 2N2219,A, 2N2222,A, 2N5582(1)		35 75	— —	
(I _C = 10 mAdc, V _{CE} = 10 Vdc, T _A = - 55°C)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582		15 35	— —	
(I _C = 150 mAdc, V _{CE} = 10 Vdc)(1)	2N2218,A, 2N2221,A, 2N5581 2N2219,A, 2N2222,A, 2N5582		40 100	120 300	

2N2218/19/21/22, A SERIES, 2N5581/82

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
($I_C = 150\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)(1)	2N2218,A, 2N2221,A, 2N5581 2N2219,A, 2N2222,A, 2N5582		20 50	— —	
($I_C = 500\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)(1)	2N2218, 2N2221 2N2219, 2N2222 2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582		20 30 25 40	— — — —	
Collector-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{CE(sat)}$	— —	0.4 0.3	Vdc
($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)	Non-A Suffix A-Suffix, 2N5581, 2N5582		— —	1.6 1.0	
Base-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{BE(sat)}$	0.6 0.6	1.3 1.2	Vdc
($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)	Non-A Suffix A-Suffix, 2N5581, 2N5582		— —	2.6 2.0	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 20\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	All Types, Except 2N2219A, 2N2222A, 2N5582	f_T	250 300	— —	MHz
Output Capacitance(3) ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)		C_{obo}	—	8.0	pF
Input Capacitance(3) ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	Non-A Suffix A-Suffix, 2N5581, 2N5582	C_{ibo}	— —	30 25	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2218A, 2N2221A 2N2219A, 2N2222A	h_{ie}	1.0 2.0	3.5 8.0	kohms
($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2218A, 2N2221A 2N2219A, 2N2222A		0.2 0.25	1.0 1.25	
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2218A, 2N2221A 2N2219A, 2N2222A	h_{re}	— —	5.0 8.0	$\times 10^{-4}$
($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2218A, 2N2221A 2N2219A, 2N2222A		— —	2.5 4.0	
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2218A, 2N2221A 2N2219A, 2N2222A	h_{fe}	30 50	150 300	—
($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2218A, 2N2221A 2N2219A, 2N2222A		50 75	300 375	
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2218A, 2N2221A 2N2219A, 2N2222A	h_{oe}	3.0 5.0	15 35	μmhos
($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2218A, 2N2221A 2N2219A, 2N2222A		10 25	100 200	
Collector Base Time Constant ($I_E = 20\text{ mAdc}$, $V_{CB} = 20\text{ Vdc}$, $f = 31.8\text{ MHz}$)	A-Suffix	$r_b' C_C$	—	150	ps
Noise Figure ($I_C = 100\ \mu\text{Adc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 1.0\text{ kohm}$, $f = 1.0\text{ kHz}$)	2N2219A, 2N2222A	NF	—	4.0	dB
Real Part of Common-Emitter High Frequency Input Impedance ($I_C = 20\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 300\text{ MHz}$)	2N2218A, 2N2221A 2N2221A, 2N2222A	$\text{Re}(h_{ie})$	—	60	Ohms

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

(3) 2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Delay Time	t_d	—	10	ns
Rise Time				
Storage Time	t_s	—	225	ns
Fall Time				
Active Region Time Constant ($I_C = 150\text{ mAdc}$, $V_{CE} = 30\text{ Vdc}$) (See Figure 14 for 2N2218A, 2N2219A, 2N2221A, 2N2222A)	T_A	—	2.5	ns

FIGURE 1 – NORMALIZED DC CURRENT GAIN

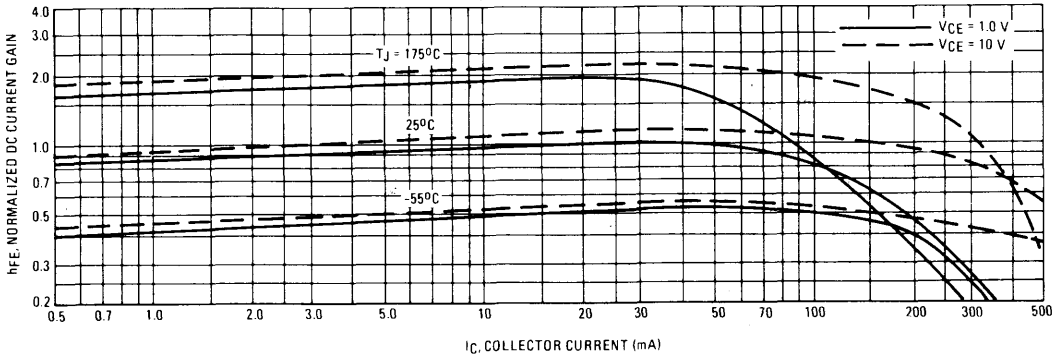
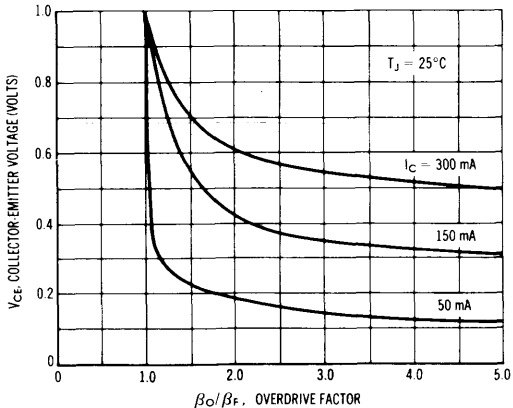


FIGURE 2 – COLLECTOR CHARACTERISTICS IN SATURATION REGION



This graph shows the effect of base current on collector current. β_o (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_r (forced gain) is the ratio of I_C/I_B in a circuit.

EXAMPLE: For type 2N2219, estimate a base current (I_B) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at $I_C = 150\text{ mA}$ an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.62 of h_{FE} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, $\beta_o = 62$ and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_r} = \frac{h_{FE} @ 1.0\text{ V}}{I_C/I_B} \quad 2.5 = \frac{62}{150/I_B} \quad I_B \approx 6.0\text{ mA}$$

FIGURE 3 - "ON" VOLTAGES

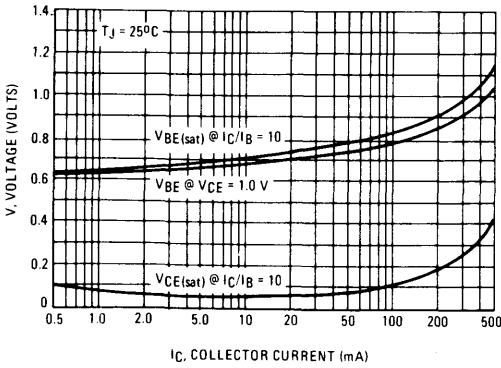
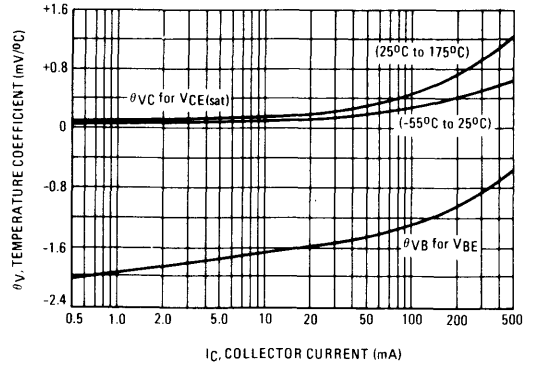


FIGURE 4 - TEMPERATURE COEFFICIENTS



h PARAMETERS

$V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 5 - INPUT IMPEDANCE

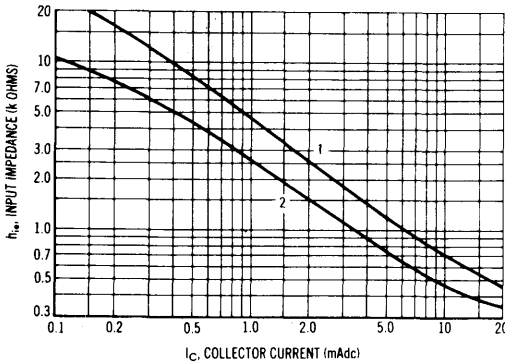


FIGURE 6 - VOLTAGE FEEDBACK RATIO

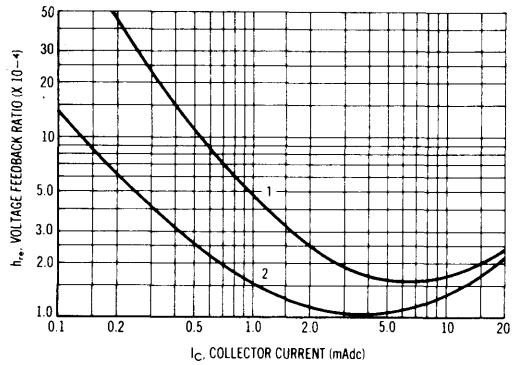


FIGURE 7 - CURRENT GAIN

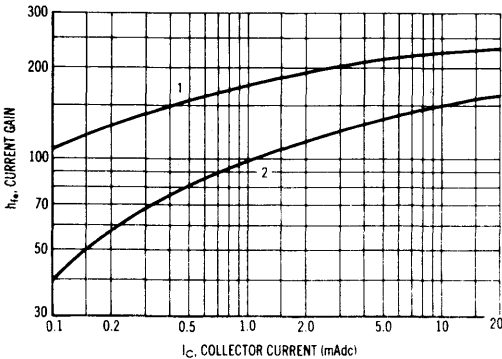
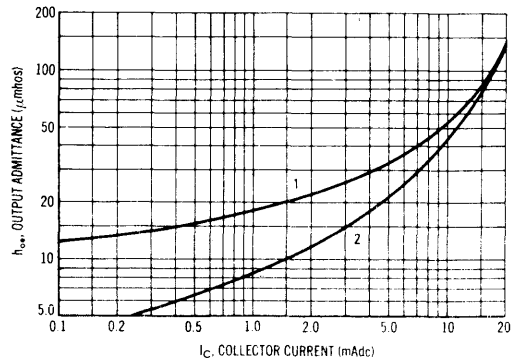


FIGURE 8 - OUTPUT ADMITTANCE



SWITCHING TIME CHARACTERISTICS

FIGURE 9 — TURN-ON TIME

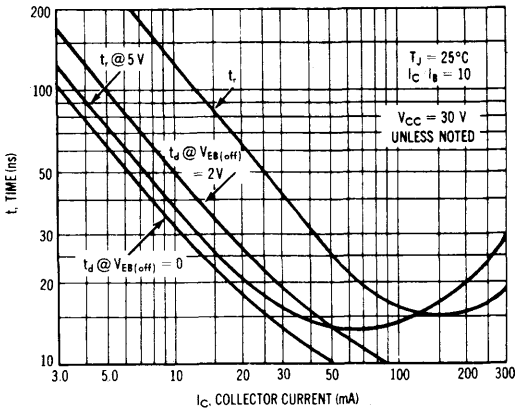


FIGURE 10 — CHARGE DATA

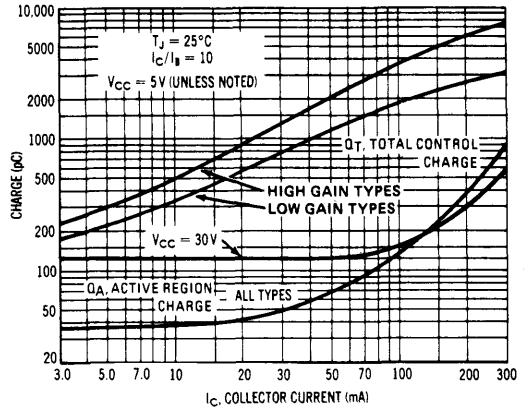


FIGURE 11 — TURN-OFF BEHAVIOR

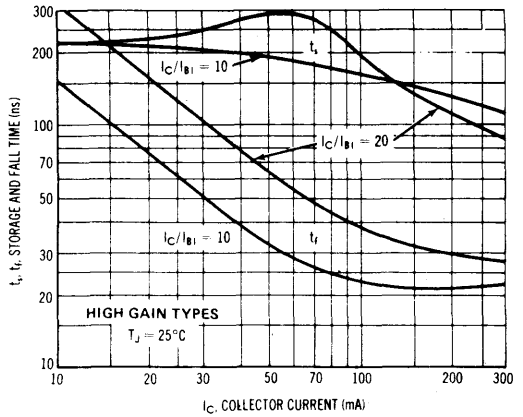
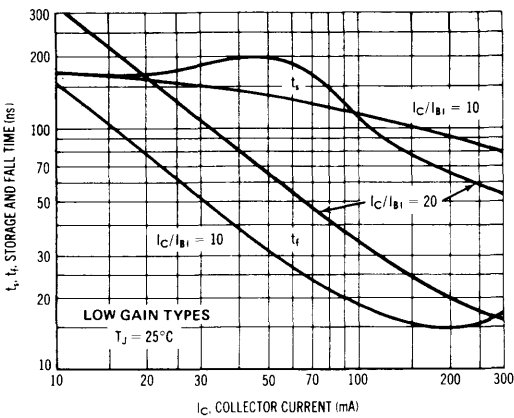


FIGURE 12 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

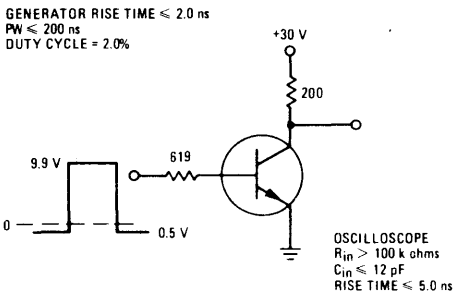
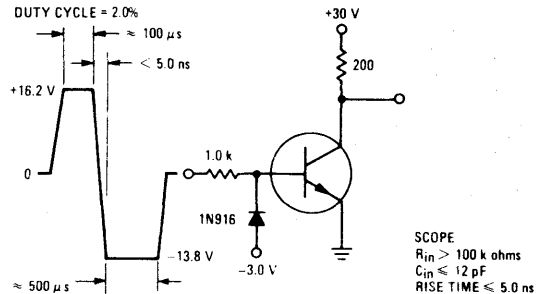


FIGURE 13 — STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



2N2270

CASE 79-02, STYLE
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Emitter Voltage, $R_{BE} \leq 10$ Ohms	V_{CER}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	A dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	175	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 100$ mAdc, $R_{BE} \leq 10$ Ohms)	$V_{(BR)CER}$	60	—	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 100$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.05$ μAdc , $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_C = 25^\circ\text{C}$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_C = 150^\circ\text{C}$)	I_{CBO}	—	—	0.05 100	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30 50	90 135	— 200	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.15	0.9	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.88	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, $f = 20$ MHz)	f_T	100	250	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{obo}	—	10	15	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 100$ kHz)	C_{ibo}	—	60	80	pF
Small-Signal Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	h_{fe}	50	—	275	—
Noise Figure ($I_C = 0.3$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 1.0$ k Ohm, $f = 1.0$ kHz, B.W. = 1.0 Hz)	NF	—	7.0	10	dB
SWITCHING CHARACTERISTICS					
Total Switching Time	$t_{on} + t_{off}$	—	—	30	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

(2) Pulse Test: Pulse Width ≤ 300 μs , Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	800 4.56	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	219	°C/W
Lead Temperature, 1/16" from Case for 10 seconds	T_L	300	°C

2N2297

**CASE 79-02, STYLE 1
TO-39 (TO-205AD)
AMPLIFIER TRANSISTOR**

NPN SILICON

4

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(2) ($I_C = 30 \text{ mAdc}, I_B = 0$)	$V_{CEO(sus)}$	35	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$) ($V_{CB} = 60 \text{ Vdc}, I_E = 0, T_A = +150^\circ\text{C}$)	I_{CBO}	—	—	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	10	nAdc

ON CHARACTERISTICS(2)

DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	30 40 15	60 80 40	— 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.1 0.6	0.2 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.8	1.6	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	60	100	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	8.0	12	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	60	80	pF
Collector Base Time Constant ($I_C = 10 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 4.0 \text{ MHz}$)	rb^*C_c	—	—	800	ps

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N2368 2N2369,A 2N3227

**2N2369A JAN, JTX,
JTXV AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)**

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage 2N2368,9,A 2N3227	V_{CE0}	15 20	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage 2N2368,9,A 2N3227	V_{EBO}	4.5 6.0	Vdc
Collector Current (10 μ sec pulse)	$I_C(\text{Peak})$	500	mA
Collector Current — Continuous 2N2369A, 2N3227	I_C	200	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.85	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 100^\circ\text{C}$ Derate above 100°C	P_D	.68 6.85	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, V_{BE} = 0$)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{A}, V_{BE} = 0$)	$V_{(BR)CES}$	40	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{CE0(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}, I_B = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)EBO}$	4.5 6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}, V_{BE} = 3.0 \text{ Vdc}$)	I_{CEX}	—	0.2	μAdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	0.4 0.2	μAdc
($V_{CB} = 20 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)		—	30 50	
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}, V_{BE} = 0$)	I_{CES}	—	0.4	μAdc
Base Current ($V_{CE} = 20 \text{ Vdc}, V_{BE} = 0$)	I_B	—	0.4	μAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	2N2368 2N2369 2N2369A 2N3227	h_{FE}	20 40 — 100	60 120 120 300	—
($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$)	2N2368 2N2369 2N3227		10 20 40	— — —	
($I_C = 10 \text{ mAdc}, V_{CE} = 0.35 \text{ Vdc}, T_A = -55^\circ\text{C}$)	2N2369A		20	—	
($I_C = 30 \text{ mAdc}, V_{CE} = 0.4 \text{ Vdc}$)	2N2369A		30	—	

2N2368, 2N2369,A, 2N3227

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
($I_C = 100\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$) 2N2369A 2N3227		20 30	— —	
($I_C = 100\text{ mA}$, $V_{CE} = 2.0\text{ Vdc}$) 2N2368 2N2369		10 20	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) 2N2368, 2N2369, 2N3227 2N2369A	$V_{CE(sat)}$	— —	0.25 0.20	Vdc
($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$, $T_A = +125^\circ\text{C}$) ($I_C = 30\text{ mA}$, $I_B = 3.0\text{ mA}$) 2N2369A 2N2369A		— —	0.30 0.25	
($I_C = 100\text{ mA}$, $I_B = 10\text{ mA}$) 2N2369A 2N3227		— —	0.50 .45	
Base-Emitter Saturation Voltage(1) ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$, $T_A = +125^\circ\text{C}$) ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$, $T_A = -55^\circ\text{C}$) ($I_C = 30\text{ mA}$, $I_B = 3.0\text{ mA}$) 2N2368 2N2369A 2N2369A 2N2369A 2N2369A	$V_{BE(sat)}$	0.70 0.59 — —	0.85 — 1.02 1.15	Vdc
($I_C = 100\text{ mA}$, $I_B = 10\text{ mA}$) 2N2369A 2N3227		— 0.8	1.60 1.4	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$) 2N2368 2N2369, 2N2369A, 2N3227	f_T	400 500	— —	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$) All Types	C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 1.0\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$) 2N3227	C_{ibo}	—	4.0	pF

SWITCHING CHARACTERISTICS

Delay Time ($V_{CC} = 10\text{ V}$, $V_{EB} = 2.0\text{ Vdc}$, 100 mA, $I_{B1} = 10\text{ mA}$) 2N3227	t_d	—	5.0	ns
Rise Time ($V_{CC} = 10\text{ V}$, $V_{EB} = 2.0\text{ Vdc}$, 100 mA, $I_{B1} = 10\text{ mA}$) 2N3227	t_r	—	18	ns
Storage Time ($I_C = I_{B1} = 10\text{ mA}$, $I_{B2} = -10\text{ mA}$) ($I_C = 100\text{ mA}$, $I_{B1} = I_{B2} = 10\text{ mA}$, $V_{CC} = 10\text{ V}$) 2N2368 2N2369,A 2N3227	t_s	— — —	10 13 13	ns
Fall Time ($V_{CC} = 10\text{ V}$, $I_C = 100\text{ mA}$, $I_{B1} = I_{B2} = 10\text{ mA}$) 2N3227	t_f	—	15	ns
Turn-On Time ($I_C = 10\text{ mA}$, $I_{B1} = 3.0\text{ mA}$, $I_{B2} = -1.5\text{ mA}$, $V_{CC} = 3.0\text{ Vdc}$) All Types	t_{on}	—	12	ns
Turn-Off Time ($I_C = 10\text{ mA}$, $I_{B1} = 3.0\text{ mA}$, $I_{B2} = -1.5\text{ mA}$, $V_{CC} = 3.0\text{ Vdc}$) 2N2368 2N2369 2N2369A 2N3227	t_{off}	— — — —	— 18 15 18	ns
Total Control Charge ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$, $V_{CC} = 3.0\text{ V}$) 2N3227	Q_T	—	50	pC

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

SWITCHING TIME EQUIVALENT TEST CIRCUITS FOR 2N2369, 2N3227

FIGURE 1 — t_{on} CIRCUIT — 10 mA

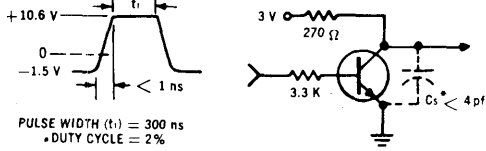


FIGURE 3 — t_{off} CIRCUIT — 10 mA

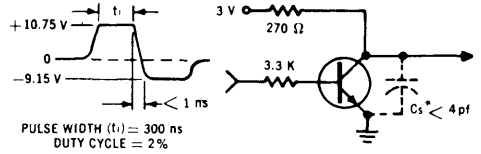


FIGURE 2 — t_{on} CIRCUIT — 100 mA

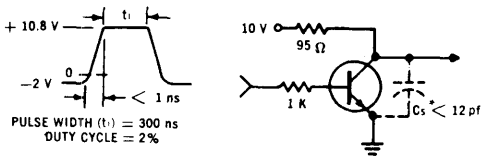
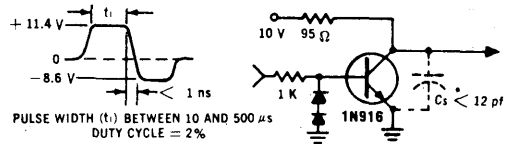


FIGURE 4 — t_{off} CIRCUIT — 100 mA



* Total shunt capacitance of test jig and connectors.

FIGURE 5 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

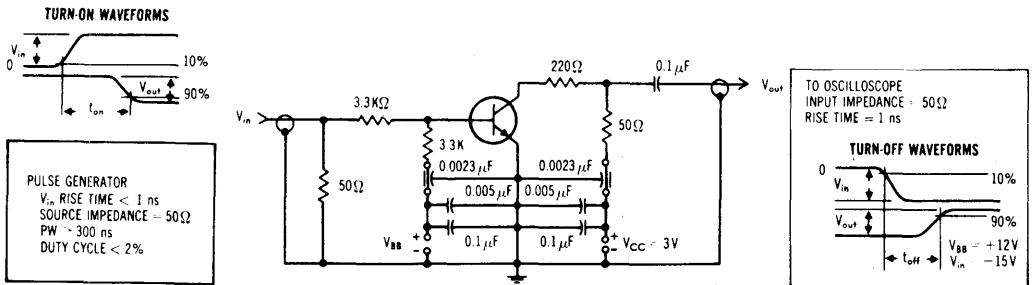


FIGURE 6 — JUNCTION CAPACITANCE VARIATIONS

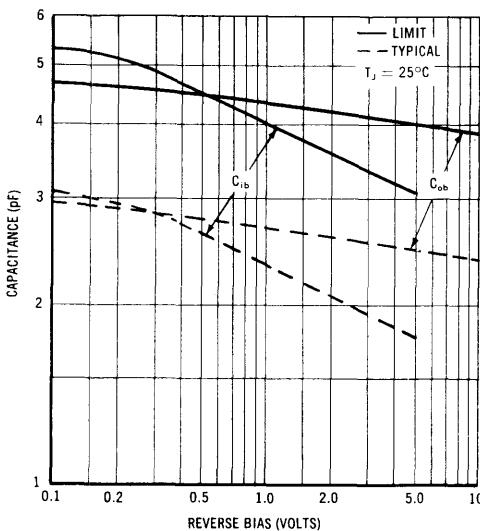


FIGURE 7 — TYPICAL SWITCHING TIMES

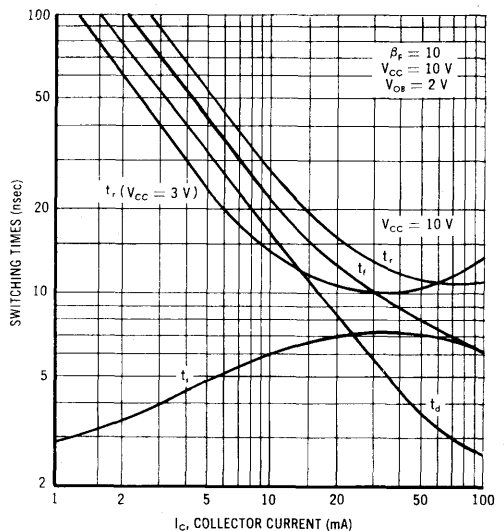


FIGURE 8 — MAXIMUM CHARGE DATA

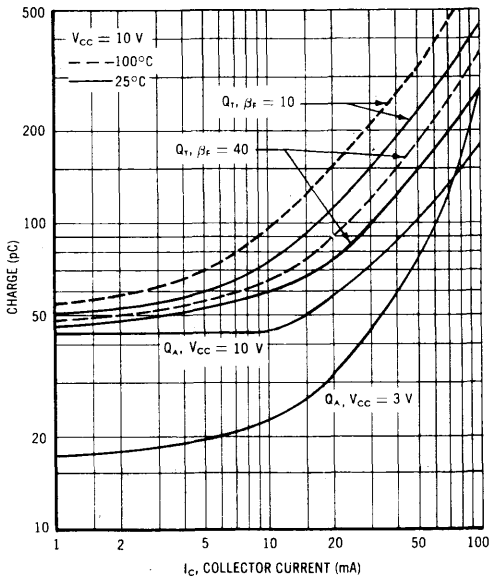


FIGURE 9 — Q_T TEST CIRCUIT

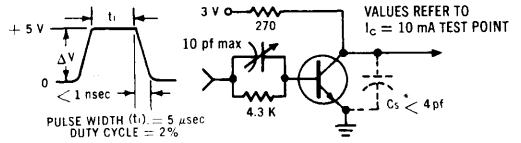


FIGURE 10 — TURN-OFF WAVE FORM

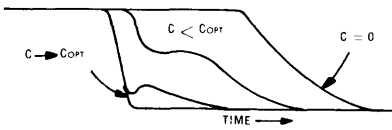


FIGURE 11 — STORAGE TIME EQUIVALENT TEST CIRCUIT

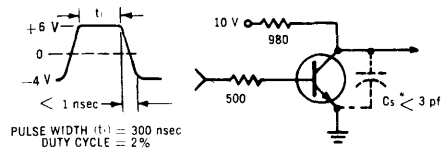


FIGURE 12 — MAXIMUM COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

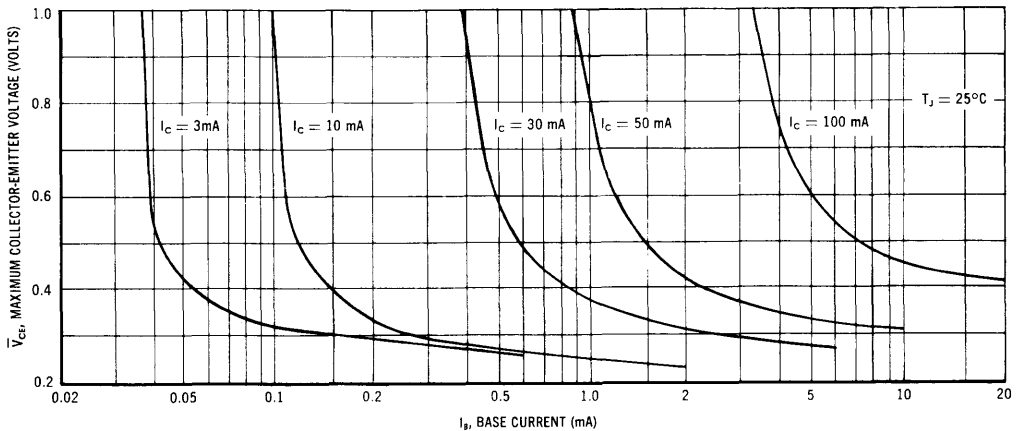


FIGURE 13 — MINIMUM CURRENT GAIN CHARACTERISTICS

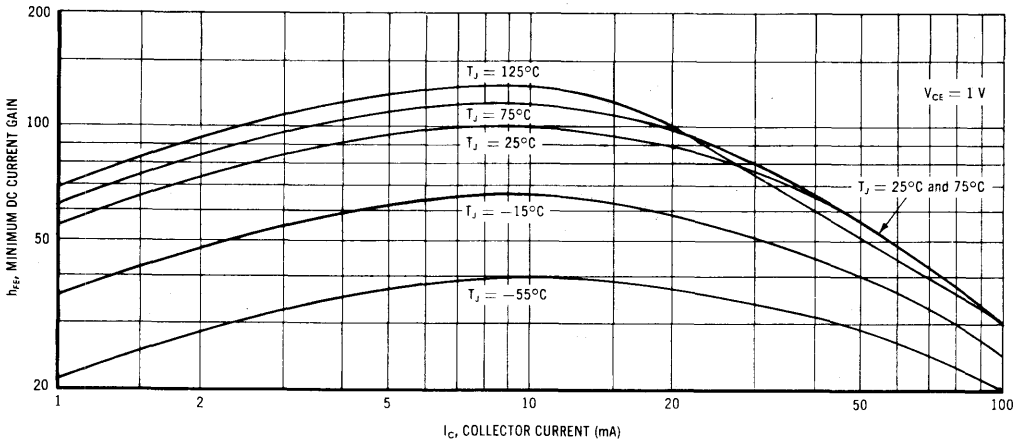


FIGURE 14 — SATURATION VOLTAGE LIMITS

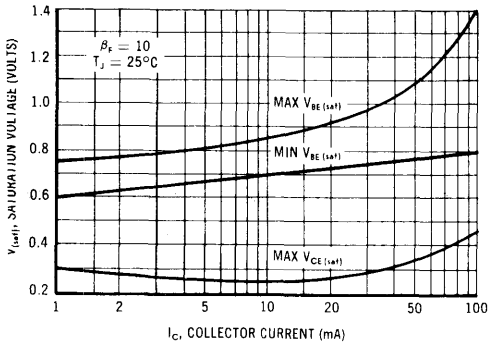
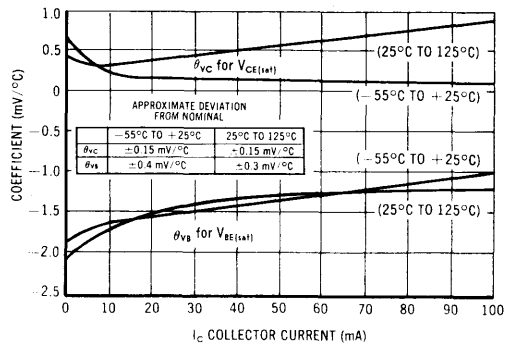


FIGURE 15 — TYPICAL TEMPERATURE COEFFICIENTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	60	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current — Continuous	I _C	50	mA _{dc}
Total Device Dissipation (@ T _A = 25°C Derate above 25°C	P _D	360 2.06	mW mW/°C
Total Device Dissipation (@ T _C = 25°C Derate above 25°C	P _D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

2N2484

JAN, JTX, JTXV AVAILABLE
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

NPN SILICON

4

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	146	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	485	°C/W
Lead Temperature 1/16" from Case for 10 Seconds	T _L	300	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) (I _C = 10 mA _{dc} , I _B = 0)	V _{(BR)CEO}	60	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{(BR)CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	6.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 45 Vdc, I _E = 0) (V _{CB} = 45 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	—	10 10	nA _{dc} μA _{dc}
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	—	10	nA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 μA _{dc} , V _{CE} = 5.0 Vdc) (I _C = 10 μA _{dc} , V _{CE} = 5.0 Vdc) (I _C = 10 μA _{dc} , V _{CE} = 5.0 Vdc, T _A = 55°C) (I _C = 100 μA _{dc} , V _{CE} = 5.0 Vdc) (I _C = 500 μA _{dc} , V _{CE} = 5.0 Vdc) (I _C = 1.0 mA _{dc} , V _{CE} = 5.0 Vdc) (I _C = 10 mA _{dc} , V _{CE} = 5.0 Vdc)(1)	h _{FE}	30 100 20 175 200 250 —	190 250 40 275 300 350 400	— 500 — — — — 800	— — — — — — —
Collector-Emitter Saturation Voltage (I _C = 1.0 mA _{dc} , I _B = 0.1 mA _{dc})	V _{CE(sat)}	—	0.25	0.35	Vdc
Base-Emitter On Voltage (I _C = 0.1 mA _{dc} , V _{CE} = 5.0 Vdc)	V _{BE(on)}	0.5	0.65	0.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 0.05 mA _{dc} , V _{CE} = 5.0 Vdc, f = 5.0 MHz) (I _C = 0.5 mA _{dc} , V _{CE} = 5.0 Vdc, f = 30 MHz)	f _T	15 60	50 100	— —	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	3.0	6.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 140 kHz)	C _{ibo}	—	4.0	6.0	pF
Input Impedance (I _C = 1.0 mA _{dc} , V _{CE} = 5.0 Vdc, f = 1.0 kHz)	h _{ie}	3.5	—	24	kΩ
Voltage Feedback Ratio (I _C = 1.0 mA _{dc} , V _{CE} = 5.0 Vdc, f = 1.0 kHz)	h _{re}	—	—	800	X 10 ⁻⁶
Small-Signal Current Gain (I _C = 1.0 mA _{dc} , V _{CE} = 5.0 Vdc, f = 1.0 kHz)	h _{fe}	150	—	900	—
Output Admittance (I _C = 1.0 mA _{dc} , V _{CE} = 5.0 Vdc, f = 1.0 kHz)	h _{oe}	—	—	40	μmhos
Noise Figure (I _C = 10 μA _{dc} , V _{CE} = 5.0 Vdc, R _S = 10 kΩ, f = 100 Hz, BW = 20 Hz) (I _C = 10 μA _{dc} , V _{CE} = 5.0 Vdc, R _S = 10 kΩ, f = 1.0 kHz, BW = 200 Hz) (I _C = 10 μA _{dc} , V _{CE} = 5.0 Vdc, R _S = 10 kΩ, f = 10 kHz, BW = 2.0 kHz) (I _C = 10 μA _{dc} , V _{CE} = 5.0 Vdc, R _S = 10 kΩ, f = 10 Hz to 15.7 kHz, BW = 15.7 kHz)	NF	— — — —	8.0 — — —	10 3.0 2.0 3.0	dB

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2501

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Total Device Dissipation (α $T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	0.36 2.1	Watt mW/ $^\circ\text{C}$
Total Device Dissipation (α $T_C = 25^\circ\text{C}$ Derate above 25°C)	P_D	1.2 6.9	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 30$ mAdc, $I_B = 0$, Pulsed)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 3.0$ Vdc)	I_{CEX}	—	25	nAdc
Base Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 3.0$ Vdc) ($V_{CE} = 20$ Vdc, $V_{BE} = 3.0$ Vdc, $T_A = 150^\circ\text{C}$)	I_{BL}	—	0.025 50	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 100$ μ Adc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55^\circ\text{C}$) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20 30 50 20 40 30 10	— — 150 — — — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	— — —	0.2 0.3 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{BE(sat)}$	— — —	0.85 1.0 1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($V_{CE} = 20$ Vdc, $I_C = 10$ mAdc, $f = 100$ MHz)	f_T	350	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 100$ kHz)	C_{ibo}	—	7.0	pF
Small-Signal Current Gain ($V_{CE} = 20$ Vdc, $I_C = 10$ mAdc, $f = 100$ MHz)	h_{fe}	3.5	—	—

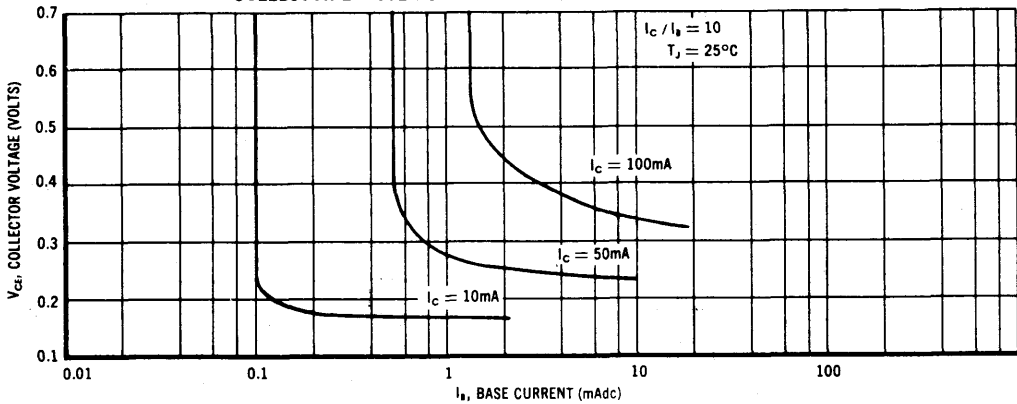
2N2501

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

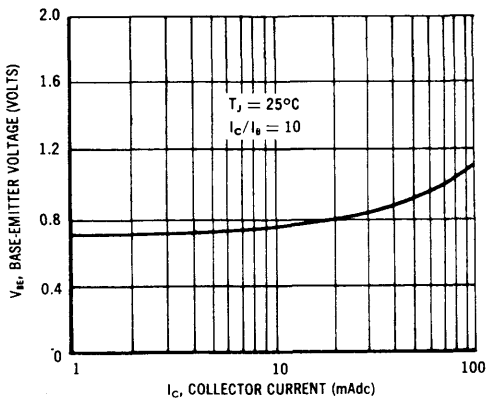
Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Charge Storage Time Constant ($I_C = I_{B1} = I_{B2} = 10 \text{ mAdc}$)	τ_S	—	15	ns
Total Control Charge ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	Q_τ	—	60	pC
Active Region Time Constant ($I_C = 10 \text{ mAdc}$)	τ_A	—	2.5	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

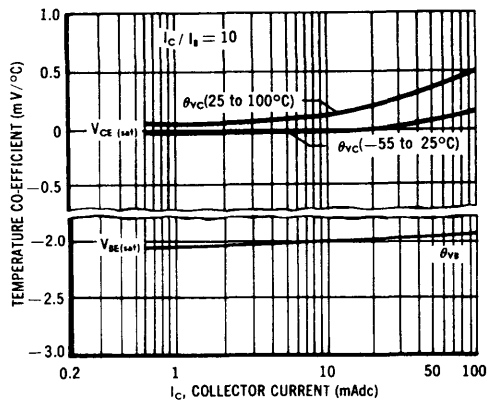
COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT



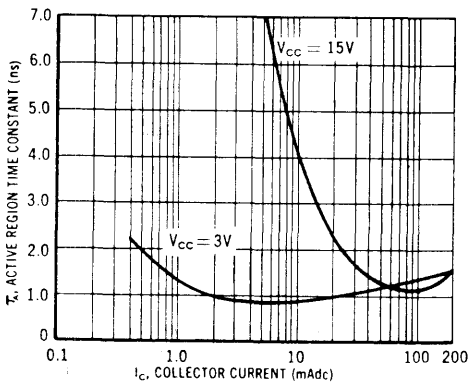
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT



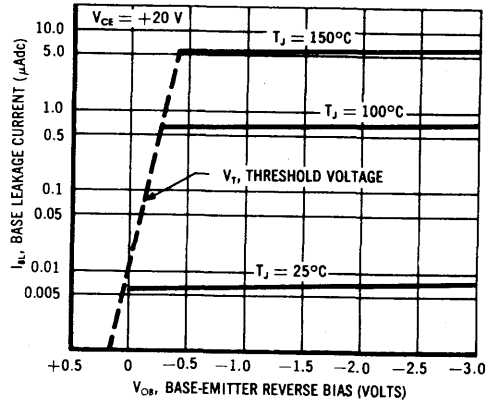
TEMPERATURE COEFFICIENTS



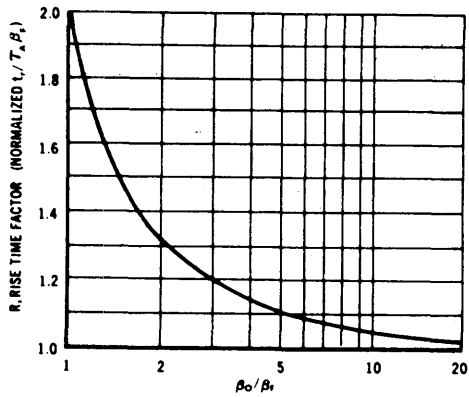
ACTIVE REGION TIME CONSTANT



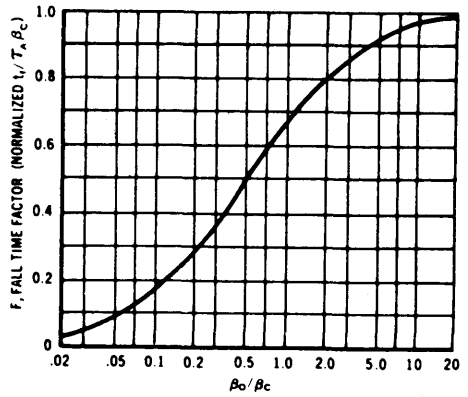
COMMON EMITTER DC LEAKAGE CHARACTERISTICS



RISE TIME FACTOR



FALL TIME FACTOR



2N2540

CASE 22, STYLE 1
TO-18

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100 \text{ mAdc}$, pulsed, $I_B = 0$)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \text{ mAdc}$, pulsed, $R_{BE} \leq 10 \Omega$)	$V_{(BR)CER}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{BE} = 0.2 \text{ Vdc}$, $V_{CE} = 20 \text{ Vdc}$)	I_{CEX}	—	0.250	μAdc
Collector Cutoff Current ($V_{CB} = 40 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 40 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	0.250 200	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.05	μAdc
Base Cutoff Current ($V_{BE} = 0.2 \text{ Vdc}$, $V_{CE} = 20 \text{ Vdc}$) ($V_{BE} = 0.2 \text{ Vdc}$, $V_{CE} = 20 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{BL}	—	0.250 200	μAdc
ON CHARACTERISTICS(1)				
DC Forward Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)(1) ($I_C = 500 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)(1)	h_{FE}	35 50 100 30	— — 300 —	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	25	pF
Small-Signal Current Gain ($V_{CE} = 20 \text{ Vdc}$, $I_C = 20 \text{ mAdc}$, $f = 100 \text{ MHz}$)	h_{fe}	2.5	—	—
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = I_{B1} = I_{B2} = 20 \text{ mAdc}$, $V_{CC} = 5.0 \text{ V}$)	τ_S	—	20	ns
Active Region Time Constant	τ_A	—	2.0	ns
Turn-On Time ($I_{B1} = I_{B2} = 15 \text{ mAdc}$, $I_C = 150 \text{ mAdc}$, $V_{CC} = 7.0 \text{ Vdc}$, $R_L = 40 \Omega$)	t_{on}	—	40	ns
Turn-Off Time ($I_{B1} = I_{B2} = 15 \text{ mAdc}$, $I_C = 150 \text{ mAdc}$, $V_{CC} = 7.0 \text{ Vdc}$, $R_L = 40 \Omega$)	t_{off}	—	40	ns
Total Control Charge	Q_T	—	750	pC

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N2605

JAN, JTX AVAILABLE
CASE 26-03, STYLE 1
TO-46 (TO-206AB)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	V
Collector-Base Voltage	V_{CBO}	60	V
Emitter-Base Voltage	V_{EBO}	6	V
Collector Current — Continuous	I_C	30	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	400 2.28	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

Refer to 2N3962 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) $I_C = 10\text{ mA}$ (Pulse)	$V_{(BR)CEO}$	45	—	V
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{A}$)	$V_{(BR)CBO}$	60	—	V
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{A}$)	$V_{(BR)EBO}$	6	—	V
Collector Cutoff Current ($V_{CB} = 45\text{ V}$)	I_{CBO}	—	10	nA
Base-Emitter Short Circuit Current ($V_{CE} = 45\text{ V}$) ($V_{CE} = 45\text{ V}, T_A = 170^\circ\text{C}$)	I_{CES}	—	10 10	nA μA
Emitter Cutoff Current ($V_{BE} = 5.0\text{ V}$)	I_{EBO}	—	2	nA

ON CHARACTERISTICS

DC Current Gain(1) ($V_{CE} = 5.0\text{ V}, I_C = 10\ \mu\text{A}$) ($V_{CE} = 5.0\text{ V}, I_C = 500\ \mu\text{A}$) ($V_{CE} = 5.0\text{ V}, I_C = 10\text{ mA}$) ($V_{CE} = 5.0\text{ V}, I_C = 10\ \mu\text{A}, T_A = -55^\circ\text{C}$)	h_{FE}	100 150 — 20	300 — 600 —	— — — —
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}, I_B = 500\ \mu\text{A}$)	$V_{CE(sat)}$	—	0.5	V
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}, I_B = 500\ \mu\text{A}$)	$V_{BE(sat)}$	0.7	0.9	V

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 5.0\text{ V}, I_E = 0, f = 1.0\text{ MHz}$)	C_{obo}	—	6	pF
Input Impedance ($V_{CE} = 5.0\text{ V}, I_C = 1.0\text{ mA}, f = 100\text{ MHz}$)	h_{ie}	—	200	Ω
Input Impedance ($V_{CB} = 5.0\text{ V}, I_E = 1.0\text{ mA}, f = 1.0\text{ kHz}$)	h_{ib}	25	35	Ω
Voltage Feedback Ratio ($V_{CB} = 5.0\text{ V}, I_E = 1.0\text{ mA}, f = 1.0\text{ kHz}$)	h_{rb}	—	10	10^{-4}
Small-Signal Current Gain ($V_{CB} = 5.0\text{ V}, I_E = 1.0\text{ mA}, f = 1.0\text{ kHz}$) ($V_{CB} = 5.0\text{ V}, I_C = 500\ \mu\text{A}, f = 30\text{ MHz}$)	h_{fe}	150 1.0	600 —	— —
Output Admittance ($V_{CB} = 5.0\text{ V}, I_E = 1.0\text{ mA}, f = 1.0\text{ kHz}$)	h_{ob}	—	1	μmho
Noise Figure(2) ($V_{CB} = 5.0\text{ V}, I_C = 10\ \mu\text{A}, R_g = 10\text{ k}\ \Omega, \text{BW} = 15.7\text{ kHz}$)	NF	—	3	dB

(1) Pulse Width $< 300\ \mu\text{sec}$, Duty Cycle $\leq 2.0\%$.

(2) Measured in amplifier with response down 3 db at 10 Hz.

2N2894

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

Refer to 2N869A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAcd
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.06	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1200 6.85	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{Acd}, V_{BE} = 0$)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 10 \text{ mAcd}, I_B = 0$)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Acd}, I_E = 0$)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Acd}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 6.0 \text{ Vdc}, I_E = 0, T_A = 125^\circ\text{C}$)	I_{CBO}	—	10	μAcd
Collector Cutoff Current ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0$)	I_{CES}	—	80	nAcd
Base Current ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0$)	I_B	—	80	nAcd

ON CHARACTERISTICS

DC Current Gain(2) ($I_C = 10 \text{ mAcd}, V_{CE} = 0.3 \text{ Vdc}$) ($I_C = 30 \text{ mAcd}, V_{CE} = 0.5 \text{ Vdc}$) ($I_C = 30 \text{ mAcd}, V_{CE} = 0.5 \text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 100 \text{ mAcd}, V_{CE} = 1.0 \text{ Vdc}(2)$)	h_{FE}	30 40 17 25	— 150 — —	—
Collector-Emitter Saturation Voltage(2) ($I_C = 10 \text{ mAcd}, I_B = 1.0 \text{ mAcd}$) ($I_C = 30 \text{ mAcd}, I_B = 3.0 \text{ mAcd}$) ($I_C = 100 \text{ mAcd}, I_B = 10 \text{ mAcd}$)	$V_{CE(sat)}$	— — —	0.15 0.2 0.5	Vdc
Base-Emitter Saturation Voltage(2) ($I_C = 10 \text{ mAcd}, I_B = 1.0 \text{ mAcd}$) ($I_C = 30 \text{ mAcd}, I_B = 3.0 \text{ mAcd}$) ($I_C = 100 \text{ mAcd}, I_B = 10 \text{ mAcd}$)	$V_{BE(sat)}$	0.78 0.85 —	0.98 1.2 1.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 30 \text{ mAcd}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	400	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = -0.5 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{ibo}	—	6.0	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 2.0 \text{ Vdc}, V_{BE} = 3.0 \text{ Vdc}, I_C = 30 \text{ mAcd}, I_{B1} = 1.5 \text{ mAcd}$)	t_{on}	—	60	ns
Turn-Off Time ($V_{CC} = 2.0 \text{ Vdc}, I_C = 30 \text{ mAcd}, I_{B1} = I_{B2} = 1.5 \text{ mAcd}$)	t_{off}	—	90	ns

(1) Applicable from 0.01 to 10 mAcd.

(2) Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2.0\%$.

**2N2895
2N2896
2N2897**

**CASE 22, STYLE 1
TO-18 (TO-206AA)**

**GENERAL PURPOSE
TRANSISTOR**

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N2895	2N2896	2N2897	Unit
Collector-Emitter Voltage	V _{CEO}	65	90	45	V _{dc}
Collector-Emitter Voltage	V _{CER}	80	140	60	V _{dc}
Collector-Base Voltage	V _{CBO}	120	140	60	V _{dc}
Emitter-Base Voltage	V _{EBO}	7.0			V _{dc}
Collector Current — Continuous	I _C	1.0			A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.5 2.86			Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.8 10.3			Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 100 mA _{dc} , R _{BE} = 10 ohms)	2N2895 2N2896 2N2897	V _{(BR)ICER}	80 140 60	— — —	V _{dc}
Collector-Emitter Sustaining Voltage(1) (I _C = 100 mA _{dc} , I _B = 0)	2N2895 2N2896 2N2897	V _{CEO(sus)}	65 90 45	— — —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 0.1 mA _{dc} , I _E = 0)	2N2895 2N2896 2N2897	V _{(BR)CBO}	120 140 60	— — —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 0.1 mA _{dc} , I _C = 0)		V _{(BR)EBO}	7.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 60 V _{dc} , I _C = 0)	2N2895 2N2896 2N2897	I _{CBO}	— — —	0.002 0.01 0.05	μA _{dc}
(V _{CB} = 60 V _{dc} , I _E = 0, T _A = +150°C)	2N2895 2N2897		— —	2.0 50	
(V _{CB} = 90 V _{dc} , I _E = 0) (V _{CB} = 90 V _{dc} , I _E = 0, T _A = +150°C)	2N2896 2N2896		— —	0.01 10	
Emitter Cutoff Current (V _{BE} = 5.0 V _{dc} , I _C = 0)	2N2895 2N2896 2N2897	I _{EBO}	— — —	0.005 0.01 0.05	μA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 100 μA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 1.0 mA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc} , T _A = -55°C)	2N2895 2N2895 2N2896, 2N2897 2N2895 2N2895, 2N2896	h _{FE}	10 20 35 35 20	— — — — —	—
(I _C = 150 mA _{dc} , V _{CE} = 10 V _{dc})(1)	2N2895 2N2896 2N2897		40 60 50	120 200 200	
(I _C = 500 mA _{dc} , V _{CE} = 10 V _{dc})(1)	2N2895		25	—	

2N2895, 2N2896, 2N2897

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	2N2895, 2N2896 2N2897	$V_{CE(sat)}$	— —	0.6 1.0	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	2N2895, 2N2896 2N2897	$V_{BE(sat)}$	— —	1.2 1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	2N2895, 2N2896 2N2897	f_T	120 100	— —	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)		C_{obo}	—	15	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)		C_{ibo}	—	80	pF
Small-Signal Current Gain ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N2895 2N2896, 2N2897	h_{fe}	50 50	200 275	—
Noise Figure ($I_C = 0.3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 500 \text{ ohms}$, $f = 1.0 \text{ kHz}$, $BW = 15 \text{ kHz}$)	2N2895	NF	—	8.0	dB

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 1.8\%$.

**2N2904,A, 2N2905,A,
2N2906,A, 2N2907,A,
2N3485,A, 2N3486,A**

JAN, JTX, JTXV AVAILABLE*

CASE 79-02, STYLE 1
2N2904/2905 TO-39 (TO-205AD)
CASE 22-03, STYLE 1
2N2906/2907 TO-18 (TO-206AA)
CASE 26-03, STYLE 1
2N3485/3486 TO-46 (TO-206AB)

**GENERAL PURPOSE
TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Non-A Suffix	A-Suffix	Unit	
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc	
Collector-Base Voltage	V_{CBO}	60		Vdc	
Emitter-Base Voltage	V_{EBO}	5.0		Vdc	
Collector Current — Continuous	I_C	600		mAdc	
		2N2904,A 2N2905,A	2N2906,A 2N2907,A	2N3485,A 2N3486,A	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	600 3.43	400 2.28	400 2.28	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.2	1.8 10.3	2.0 11.43	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$	

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10\text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Non-A Suffix A-Suffix		60	—	—	
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}, V_{BE} = 0.5\text{ Vdc}$)	I_{CEX}	—	—	50	nAdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	0.020	μAdc
Non-A Suffix A-Suffix		—	—	0.010	
($V_{CB} = 50\text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)		—	—	20	
Base Current ($V_{CE} = 30\text{ Vdc}, V_{BE} = 0.5\text{ Vdc}$)	I_B	—	—	50	nAdc

ON CHARACTERISTICS						
DC Current Gain ($I_C = 0.1\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A	h_{FE}	20	—	—	—
(1)			35	—	—	—
			40	—	—	—
			75	—	—	—
			($I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	25	—	—
(1)	50	—	—	—		
	40	—	—	—		
	100	—	—	—		
	($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	35	—	—	—	
(1)	75	—	—	—		
	40	—	—	—		
	100	—	—	—		
	($I_C = 150\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)(1)	2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A	40	—	120	—
		100	—	300	—	

*ALSO AVAILABLE 2N2905ALJANS AND 2N2907AJANS

2N2904,A, 2N2905,A, 2N2906,A, 2N2907,A, 2N3485,A, 2N3486,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
$(I_C = 500 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})(1)$ 2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A		20	—	—	Vdc
		30	—	—	
		40	—	—	
		50	—	—	
Collector-Emitter Saturation Voltage(1) $(I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc})$ $(I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc})$	$V_{CE(sat)}$	—	—	0.4 1.6	Vdc
Base-Emitter Saturation Voltage $(I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc})(1)$ $(I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc})$	$V_{BE(sat)}$	—	—	1.3 2.6	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) $(I_C = 50 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz})$	f_T	200	—	—	MHz
Output Capacitance $(V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz})$	C_{obo}	—	—	8.0	pF
Input Capacitance $(V_{BE} = 2.0 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz})$	C_{ibo}	—	—	30	pF

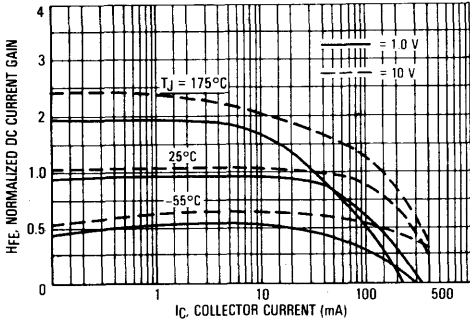
SWITCHING CHARACTERISTICS

Turn-On Time	$(V_{CC} = 30 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = 15 \text{ mAdc})$	t_{on}	—	26	45	ns
Delay Time		t_d	—	6.0	10	ns
Rise Time		t_r	—	20	40	ns
Turn-Off Time	$(V_{CC} = 6.0 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = I_{B2} = 15 \text{ mAdc})$	t_{off}	—	70	100	ns
Storage Time		t_s	—	50	80	ns
Fall Time		t_f	—	20	30	ns

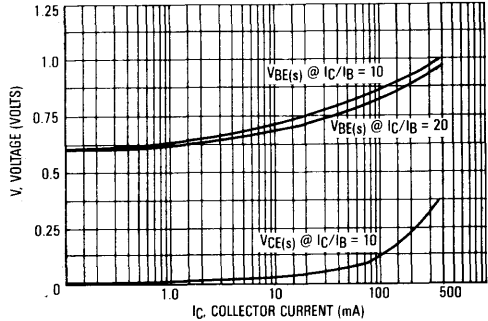
(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

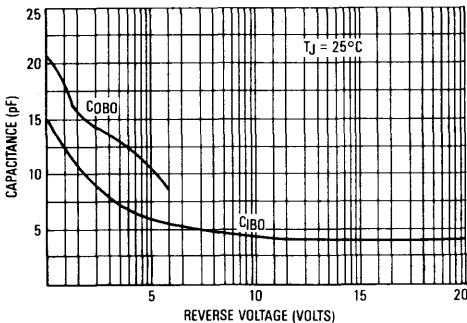
NORMALIZED DC CURRENT GAIN



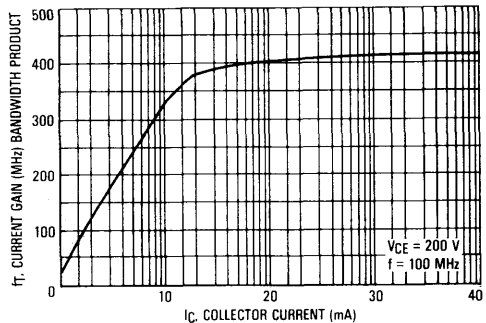
CURRENT GAIN—BANDWIDTH PRODUCT



"ON" VOLTAGES

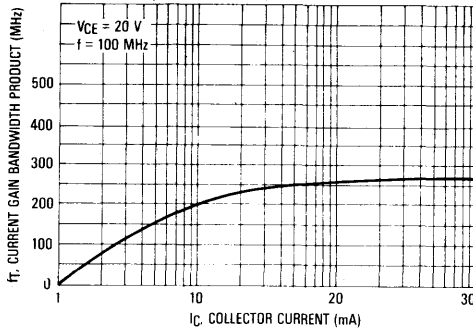


CURRENT GAIN—BANDWIDTH PRODUCT

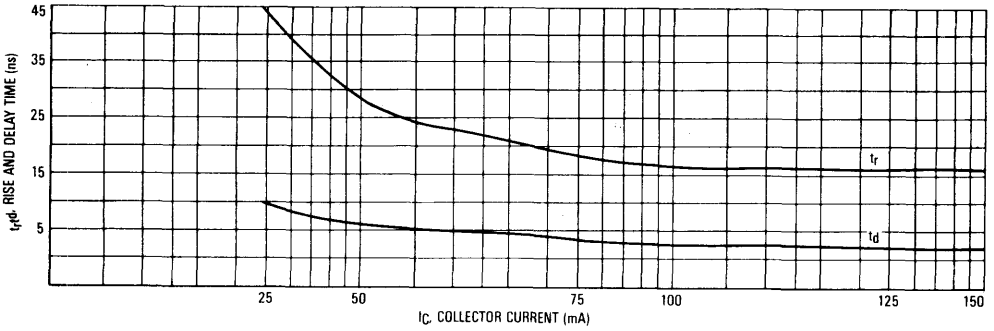


2N2904,A, 2N2905,A, 2N2906,A, 2N2907,A, 2N3485,A, 2N3486,A

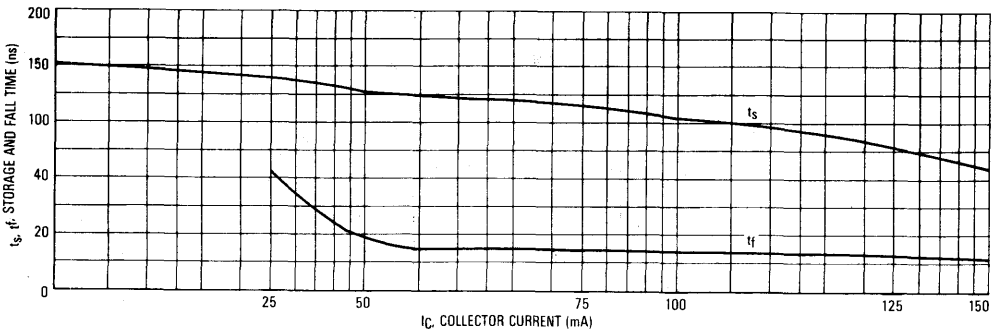
CAPACITANCES



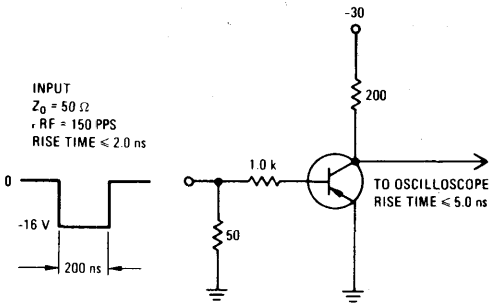
TURN ON BEHAVIOR



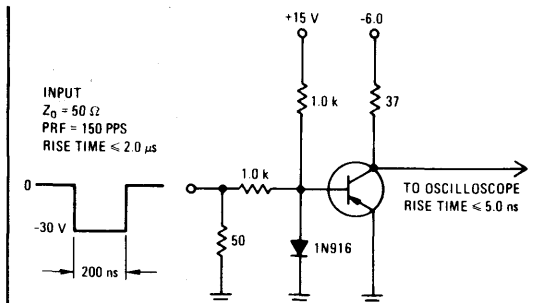
TURN OFF BEHAVIOR



DELAY AND RISE TIME TEST CIRCUIT



STORAGE AND FALL TIME TEST CIRCUIT



MAXIMUM RATINGS

Rating	Symbol	2N2944	2N2945	2N2946	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	35	Vdc
Collector-Base Voltage	V_{CBO}	15	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	15	25	40	Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	400			mW
Derate above 25°C		2.3			mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	2.0			Watts
Derate above 25°C		11.43			mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.5	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	435	$^\circ\text{C/W}$

**2N2944
thru
2N2946**

**CASE 26-03, STYLE 1
TO-46 (TO-206AB)**

TRANSISTOR

PNP SILICON

4

Refer to 2N2944A for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	0.1	nAdc
($V_{CB} = 25\text{ Vdc}, I_E = 0$)		—	—	0.2	
($V_{CB} = 40\text{ Vdc}, I_E = 0$)		—	—	0.5	
Emitter Cutoff Current ($V_{EB} = 15\text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	0.1	nAdc
($V_{EB} = 25\text{ Vdc}, I_C = 0$)		—	—	0.2	
($V_{EB} = 40\text{ Vdc}, I_C = 0$)		—	—	0.5	

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0\text{ mAdc}, V_{CE} = 0.5\text{ Vdc}$)	h_{FE}	80	180	—	—
		40	160	—	
		30	130	—	
*DC Current Gain (inverted connection) ($I_B = 200\ \mu\text{Adc}, V_{EC} = 0.5\text{ Vdc}$)	$h_{FE(inv)}$	6.0	20	—	—
		4.0	17	—	
		3.0	15	—	
Offset Voltage ($I_B = 200\ \mu\text{Adc}, I_E = 0$)	$V_{EC(ofs)}$	—	0.18	0.3	mVdc
		—	0.23	0.5	
		—	0.27	0.8	
($I_B = 1.0\text{ mAdc}, I_E = 0$)		—	0.4	0.6	
		—	0.5	1.0	
		—	0.6	2.0	
($I_B = 2.0\text{ mAdc}, I_E = 0$)		—	0.8	1.0	
		—	0.9	1.6	
		—	1.0	2.5	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 1.0\text{ mAdc}, V_{CE} = 6.0\text{ Vdc}, f = 1.0\text{ MHz}$)	f_T	10	15	—	MHz
		5.0	13	—	
		3.0	12	—	
Output Capacitance ($V_{CB} = 6.0\text{ Vdc}, I_E = 0, f = 500\text{ kHz}$)	C_{obo}	—	3.2	10	pF
Input Capacitance ($V_{EB} = 6.0\text{ Vdc}, I_C = 0, f = 500\text{ kHz}$)	C_{ibo}	—	1.9	6.0	pF
"ON" Series Resistance ($I_B = 1.0\text{ mAdc}, I_E = 0, I_C = 100\ \mu\text{Arms}, f = 1.0\text{ kHz}$)	r_{ec}	—	4.0	20	Ohms
		—	4.5	35	
		—	5.0	45	

*Indicates Data in addition to JEDEC Requirements.

2N2944A
2N2945A
2N2946A

JAN, JTX, JTXV AVAILABLE
CASE 26-03, STYLE 1
TO-46 (TO-205AB)

CHOPPER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N2944A	2N2945A	2N2946A	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	35	Vdc
Collector-Base Voltage	V_{CBO}	15	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	15	25	40	Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	400 2.3			mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0 11.43			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C
Lead Temperature 1/16" from Case for 10 seconds	T_L	240			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	435	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	87.5	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Emitter-Collector Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_B = 0$)	$V_{(BR)ECO}$	10 20 35	— — —	— — —	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}, I_E = 0$) ($V_{CB} = 25 \text{ Vdc}, I_E = 0$) ($V_{CB} = 40 \text{ Vdc}, I_E = 0$) ($V_{CB} = 15 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$) ($V_{CB} = 25 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$) ($V_{CB} = 40 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$)	I_{CBO}	— — — — —	— — — — —	0.1 0.2 0.5 10 20 25	nAdc
Emitter Cutoff Current ($V_{EB} = 25 \text{ Vdc}, I_C = 0$) ($V_{EB} = 40 \text{ Vdc}, I_C = 0$) ($V_{EB} = 25 \text{ Vdc}, I_C = 0, T_A = 100^\circ\text{C}$) ($V_{EB} = 40 \text{ Vdc}, I_C = 0, T_A = 100^\circ\text{C}$)	I_{EBO}	— — — —	— — — —	0.1 0.2 10 15 20	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 0.5 \text{ Vdc}$)	h_{FE}	100 70 50	— 200 200	— — —	—
DC Current Gain (Inverted Connection) ($I_B = 200 \mu\text{Adc}, V_{EC} = 0.5 \text{ Vdc}$)	$h_{FE(inv)}$	50 30 20	— 32 25	— — —	—
Offset Voltage ($I_B = 200 \mu\text{Adc}, I_E = 0$)	$V_{EC(ofs)}$	— — —	0.23 0.4 0.7	0.3 0.5 0.8	mVdc

2N2944A, 2N2945A, 2N2946A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
$(I_B = 1.0 \text{ mA}, I_E = 0)$	2N2944A	—	—	0.6	
	2N2945A	—	0.5	1.0	
	2N2946A	—	0.6	2.0	
$(I_B = 2.0 \text{ mA}, I_E = 0)$	2N2944A	—	—	1.0	
	2N2945A	—	0.9	1.6	
	2N2946A	—	1.0	2.5	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 1.0 \text{ mA}, V_{CE} = 6.0 \text{ Vdc}, f = 1.0 \text{ MHz}$)	f_T	— 10 5.0	— 15 8.0	— — —	MHz
Output Capacitance ($V_{CB} = 6.0 \text{ Vdc}, I_E = 0, f = 0.1 \text{ MHz to } 1.0 \text{ MHz}$)	C_{obo}	—	3.2	10	pF
Input Capacitance ($V_{EB} = 6.0 \text{ Vdc}, I_C = 0, f = 0.1 \text{ MHz to } 1.0 \text{ MHz}$)	C_{ibo}	—	1.9	6.0	pF
“ON” Series Resistance ($I_B = 1.0 \text{ mA}, I_E = 0, I_C = 100 \mu\text{Arms}, f = 1.0 \text{ kHz}$)	$r_{ec(on)}$	— — —	— 5.0 7.0	4.0 6.0 8.0	Ohms

FIGURE 1 — $V_{EC(on)}$

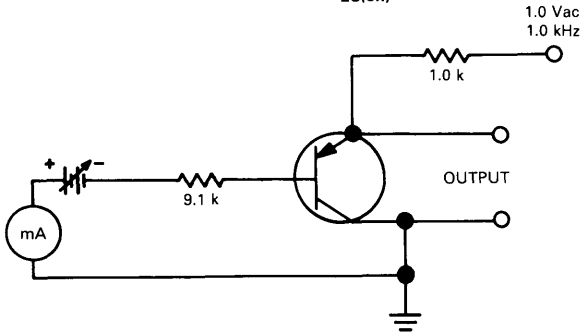
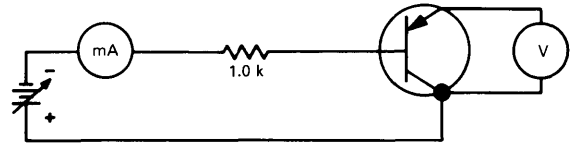
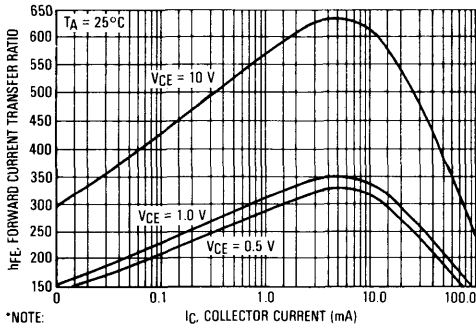


FIGURE 2 — $V_{EC(offset)}$



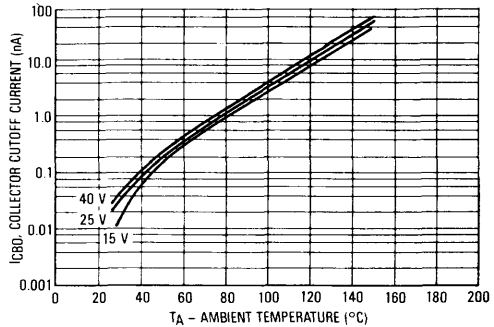
mA + + + + + - - - - - 9.1 k 2% 1.0 Vac
 10 k 2% Output Figure 1 — $r_{ec(on)}$ $r_{ec(on)}$ $r_{ec(on)}$
 mA 1.0k 2% V
 Output measured with H.P. 400D
 Ac VTVM or equivalent.
 1.0 mV = 1.0 Ω $r_{ec(on)}$

h_{FE} versus I_C

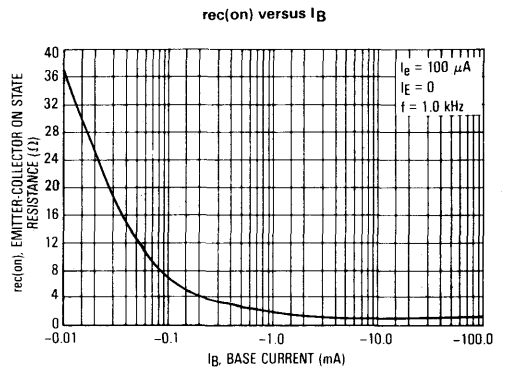
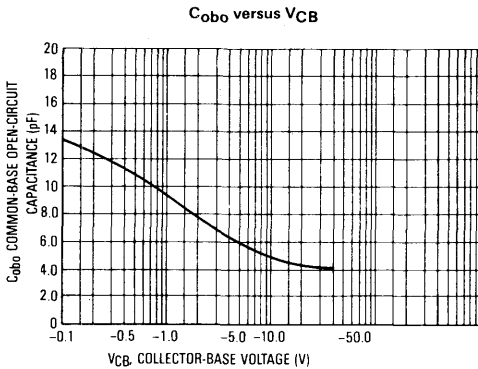
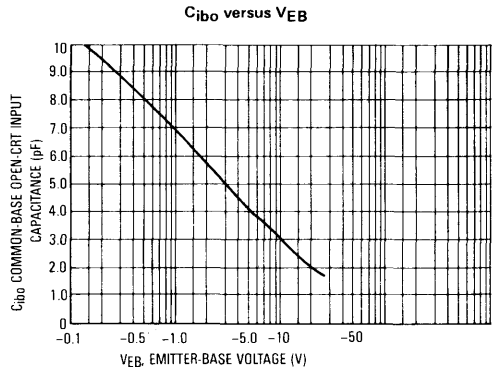
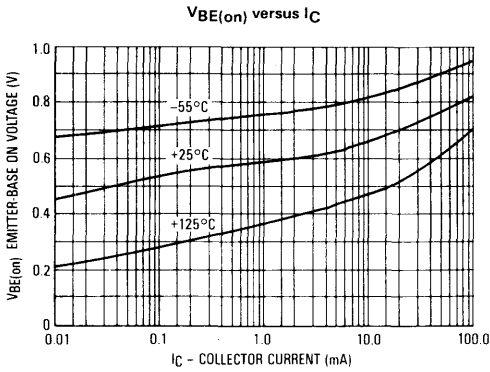
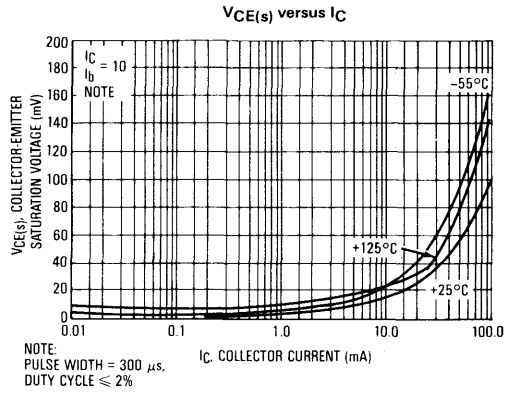
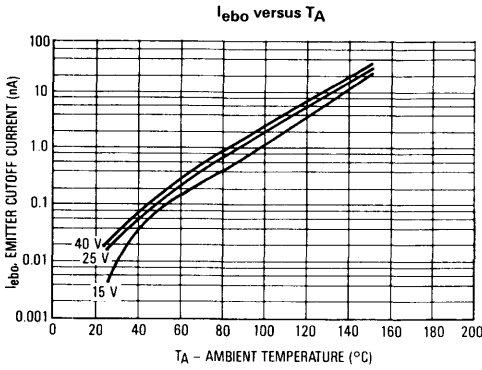


*NOTE:
 PULSE WIDTH = 300 μs .
 DUTY CYCLE \leq 2%

I_{CBO} versus T_A

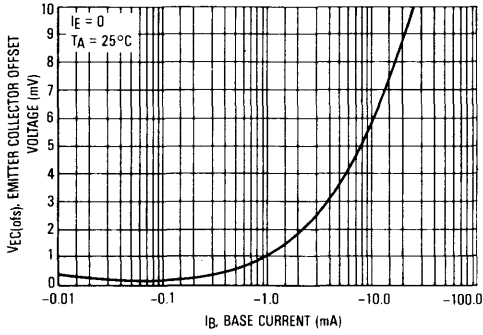


2N2944A, 2N2945A, 2N2946A

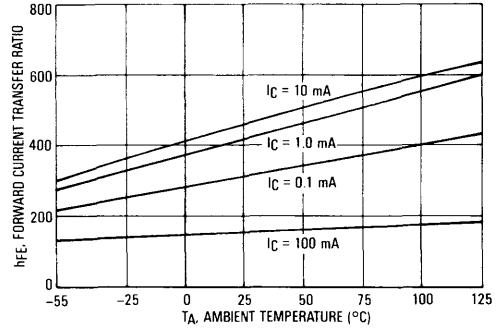


2N2944A, 2N2945A, 2N2946A

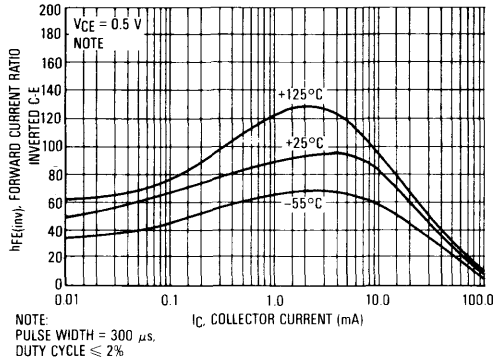
$V_{EC(ofs)}$ versus I_B



h_{FE} versus T_A



$h_{FE(inv)}$ versus I_C



2N2959

CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 20	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 4.00	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, pulsed, $I_B = 0$)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = 0.5$ Vdc)	I_{CEX}	—	.050	μ Adc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.025 15	μ Adc
Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = 0.5$ Vdc)	I_{BL}	—	.050	μ Adc

ON CHARACTERISTICS

DC Current Gain ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20$ mA, $V_{CE} = 20$ V, $f = 100$ MHz)	f_T	250	—	MHz
Output Capacitance ($V_{CB} = 10$ V, $I_E = 0$, $f = 100$ kHz)	C_{obo}	—	8.0	pF

SWITCHING CHARACTERISTICS

Delay Time ($V_{CC} = 30$ V, $I_{CS} = 150$ mA, $I_{B1} = 15$ mA)	t_d	—	20	ns
Rise Time ($V_{CC} = 30$ V, $I_{CS} = 150$ mA, $I_{B1} = 15$ mA)	t_r	—	75	ns
Storage Time ($V_{CC} = 6.0$ V, $I_{CS} = 150$ mA, $I_{B1} = 15$ mA, $I_{B2} = 15$ mA)	t_s	—	300	ns
Fall Time ($V_{CC} = 6.0$ V, $I_{CS} = 150$ mA, $I_{B1} = 15$ mA, $I_{B2} = 15$ mA)	t_f	—	200	ns

(1) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

2N3011

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	12	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous Peak (10 μ s Pulse)	I_C	200 500	mAdc
Total Device Dissipation (at $T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation (at $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$ Derate above 25°C)	P_D	1.20 0.68 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

Refer to 2N2368 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μ Adc, $V_{BE} = 0$)	$V_{(BR)CES}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$) ($V_{CE} = 20$ Vdc, $V_{BE} = 0$, $T_A = +85^\circ\text{C}$)	I_{CES}	—	0.4 10	μ Adc
Base Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$)	I_{BL}	—	0.4	μ Adc
ON CHARACTERISTICS (2)				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 0.35$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 0.4$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	30 25 12	120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc, $T_A = +85^\circ\text{C}$)	$V_{CE(sat)}$	— — — —	0.20 0.25 0.50 0.30	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{BE(sat)}$	0.72 — —	0.87 1.15 1.60	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	400	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, $f = 140$ kHz)	C_{obo}	—	4.0	pF

SWITCHING CHARACTERISTICS

Storage Time ($I_C = I_{B1} = -I_{B2} = 10$ mAdc)	t_s	—	13	ns
Turn-On Time ($V_{CC} = 2.0$ Vdc, $V_{EB(off)} = 0$, $I_C = 30$ mAdc, $I_{B1} = 3.0$ mAdc)	t_{on}	—	15	ns
Turn-Off Time ($V_{CC} = 2.0$ Vdc, $I_C = 30$ mAdc, $I_{B1} = -I_{B2} = 3.0$ mAdc)	t_{off}	—	20	ns

(1) Applicable from 0.01 mA to 10 mA (Pulsed).

(2) Pulse Test: Pulse Length = 30 μ s, Duty Cycle \leq 2.0%.

2N3012

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watts mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

Refer to 2N869A for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{Adc}, V_{BE} = 0$)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$) (Emitter-Base Termination — Open Base)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0$) ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0, T_A = +85^\circ\text{C}$)	I_{CES}	—	80 5.0	μAdc
Base Current ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0$)	I_B	—	30	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 0.3 \text{ Vdc}$) ($I_C = 30 \text{ mAdc}, V_{CE} = 0.5 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)(1)	h_{FE}	25 30 20	— 120 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 30 \text{ mAdc}, I_B = 3.0 \text{ mAdc}$) ($I_C = 30 \text{ mAdc}, I_B = 3.0 \text{ mAdc}, T_A = +85^\circ\text{C}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	$V_{CE(sat)}$	— — — —	0.15 0.2 0.4 0.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 30 \text{ mAdc}, I_B = 3.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	$V_{BE(sat)}$	0.78 0.85 —	0.98 1.2 1.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{ibo}	—	6.0	pF
Small-Signal Current Gain ($I_C = 30 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	h_{fe}	4.0	—	—

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 2.0 \text{ Vdc}, I_C \approx 30 \text{ mAdc}, I_{B1} \approx 1.5 \text{ mAdc}$)	t_{on}	—	60	ns
Turn-Off Time ($V_{CC} = 2.0 \text{ Vdc}, I_C \approx 30 \text{ mAdc}, I_{B1} = I_{B2} \approx 1.5 \text{ mAdc}$)	t_{off}	—	75	ns

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 1.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1) 2N3013 2N3014	V _{CEO}	15 20	V _{dc}
Collector-Emitter Voltage	V _{CES}	40	V _{dc}
Collector-Base Voltage	V _{CBO}	40	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	V _{dc}
Collector Current — Continuous (10 μs pulse) Peak	I _C	200 500	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T _C = 25°C @ T _C = 100°C Derate above 25°C	P _D	1.20 0.68 6.85	Watts Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

(1) Applicable from 0.01 mA to 10 mA (Pulsed)

**2N3013
2N3014**

**2N3013 JAN, JTX AVAILABLE
CASE 27, STYLE 1
TO-52 (TO-206AC)**

SWITCHING TRANSISTOR

NPN SILICON

4

Refer to 2N3510 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 100 μAdc, V _{BE} = 0)	V _{(BR)CES}	40	—	V _{dc}
Collector-Emitter Sustaining Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{CEO(sus)}	15 20	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CE} = 20 Vdc, V _{BE} = 0) (V _{CE} = 20 Vdc, V _{BE} = 0, T _A = +125°C)	I _{CES}	—	0.3 40	μAdc
Base Current (V _{CE} = 20 Vdc, V _{BE} = 0)	I _B	—	0.3	μAdc

ON CHARACTERISTICS(2)

DC Current Gain (I _C = 30 mAdc, V _{CE} = 0.4 Vdc) (I _C = 100 mAdc, V _{CE} = 0.5 Vdc) (I _C = 10 mAdc, V _{CE} = 0.4 Vdc) (I _C = 300 mAdc, V _{CE} = 1.0 Vdc) (I _C = 100 mAdc, V _{CE} = 1.0 Vdc) (I _C = 30 mAdc, V _{CE} = 0.4 Vdc, T _A = -55°C)	h _{FE}	30 25 25 15 25 12	120 — — — — —	—
Collector-Emitter Saturation Voltage (I _C = 30 mAdc, I _B = 3.0 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc) (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 30 mAdc, I _B = 3.0 mAdc, T _A = +125°C)	V _{CE(sat)}	— — — — — —	0.18 0.28 0.35 0.50 0.18 0.25	V _{dc}
Base-Emitter Saturation Voltage (I _C = 30 mAdc, I _B = 3.0 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc) (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	0.75 — — 0.70	0.95 1.20 1.70 0.80	V _{dc}

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 30\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	350	—	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{obo}	—	5.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ibo}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = I_{B1} = I_{B2} = 10\text{ mAdc}$)	t_s	—	18	ns
Turn-On Time ($V_{EB(\text{off})} = 5.0\text{ V}$, $V_{CC} = 15\text{ V}$, $I_C = 300\text{ mAdc}$, $I_{B1} = 30\text{ mAdc}$) 2N3013 ($V_{EB(\text{off})} = 0$, $V_{CC} = 2.0\text{ V}$, $I_C = 30\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$) 2N3014	t_{on}	—	15	ns
		—	16	
Turn-Off Time ($V_{CC} = 15\text{ V}$, $I_C = 300\text{ mAdc}$, $I_{B1} = I_{B2} = 30\text{ mAdc}$) 2N3013 ($V_{CC} = 2.0\text{ V}$, $I_C = 30\text{ mAdc}$, $I_{B1} = I_{B2} = 3.0\text{ mAdc}$) 2N3014	t_{off}	—	25	ns
		—	25	

(2) Pulse Test: Pulse Width = $300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	2N3019 2N3020	2N3700	Unit
Collector-Emitter Voltage	V _{CEO}	80	80	V _{dc}
Collector-Base Voltage	V _{CBO}	140	140	V _{dc}
Emitter-Base Voltage	V _{EBO}	7.0	7.0	V _{dc}
Collector Current — Continuous	I _C	1.0	1.0	A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.8 4.6	0.5 2.85	Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0 28.6	1.8 10.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3019 2N3020	2N3700	Unit
Thermal Resistance, Junction to Case	R _{θJC}	16.5	70	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	89.5	245	°C/W

**2N3019
2N3020
2N3700**

**JAN, JTX, JTXV AVAILABLE
2N3019, 2N3020
CASE 79-02, STYLE 1
TO-39 (TO-205AD)**

**2N3700
CASE 22, STYLE 1
TO-18 (TO-206AA)
GENERAL PURPOSE
TRANSISTOR
NPN SILICON**

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 30 mA _{dc} , I _B = 0)	V _{(BR)CEO}	80	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBO}	140	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μA _{dc} , I _C = 0)	V _{(BR)EBO}	7.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 90 V _{dc} , I _E = 0) (V _{CB} = 90 V _{dc} , I _E = 0, T _A = +150°C)	I _{CBO}	—	0.01 10	μA _{dc}
Emitter Cutoff Current (V _{BE} = 5.0 V _{dc} , I _C = 0)	I _{EBO}	—	0.010	μA _{dc}

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 0.1 mA _{dc} , V _{CE} = 10 V _{dc})		2N3700, 2N3019 2N3020	h _{FE}	50 30	— 100	—
(I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc})		2N3700, 2N3019 2N3020		90 40	— 120	
(I _C = 150 mA _{dc} , V _{CE} = 10 V _{dc})		2N3700, 2N3019 2N3020		100 40	300 120	
(I _C = 150 mA _{dc} , V _{CE} = 10 V _{dc} , T _C = -55°C)		2N3700, 2N3019		40	—	
(I _C = 500 mA _{dc} , V _{CE} = 10 V _{dc})		2N3700, 2N3019 2N3020		50 30	— 100	
(I _C = 1.0 A _{dc} , V _{CE} = 10 V _{dc})		All Types		15	—	
Collector-Emitter Saturation Voltage (I _C = 150 mA _{dc} , I _B = 15 mA _{dc}) (I _C = 500 mA _{dc} , I _B = 50 mA _{dc})	V _{CE(sat)}			— —	0.2 0.5	V _{dc}
Base-Emitter Saturation Voltage (I _C = 150 mA _{dc} , I _B = 15 mA _{dc})	V _{BE(sat)}			—	1.1	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mA _{dc} , V _{CE} = 10 V _{dc} , f = 20 MHz)		2N3020 2N3019, 2N3700	f _T	80 100	— 400	MHz
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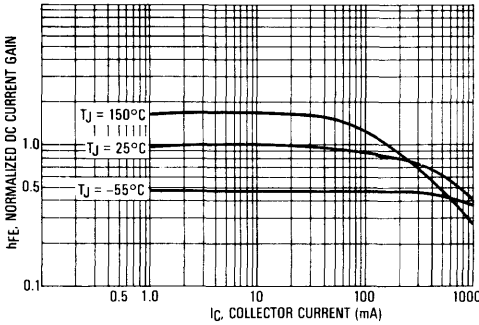
2N3019, 2N3020, 2N3700

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

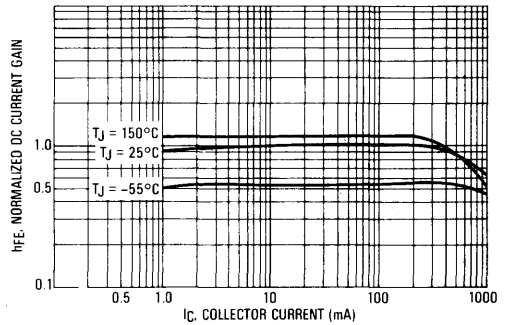
Characteristic	Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$)	C_{obo}	—	12	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 1.0\text{ MHz}$)	C_{ibo}	—	60	pF
Small-Signal Current Gain ($I_C = 1.0\text{ mA}, V_{CE} = 5.0\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{fe}	80 30	400 200	—
Collector Base Time Constant ($I_E = 10\text{ mA}, V_{CB} = 10\text{ Vdc}, f = 4.0\text{ MHz}$)	$rb'C_c$	— 15	400 400	ps
Noise Figure ($I_C = 100\text{ }\mu\text{A}, V_{CE} = 10\text{ Vdc}, R_S = 1.0\text{ k ohms}, f = 1.0\text{ kHz}$)	NF	—	4	dB

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 1.0\%$.

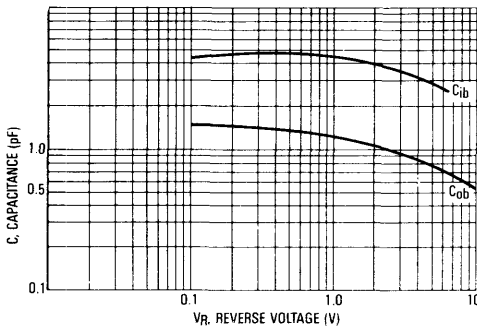
DC CURRENT GAIN
2N3019, 2N3700



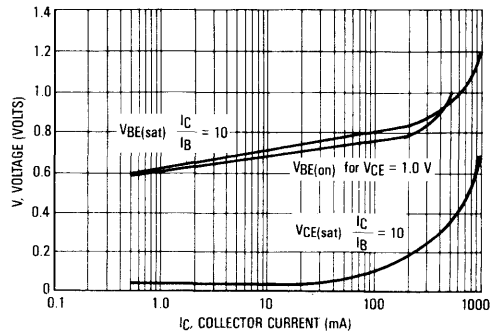
DC CURRENT GAIN
2N3020



CAPACITANCE

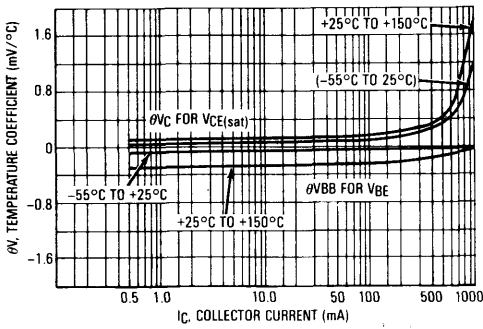


"ON" VOLTAGES

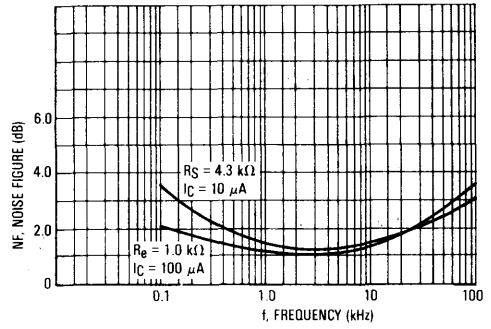


2N3019, 2N3020, 2N3700

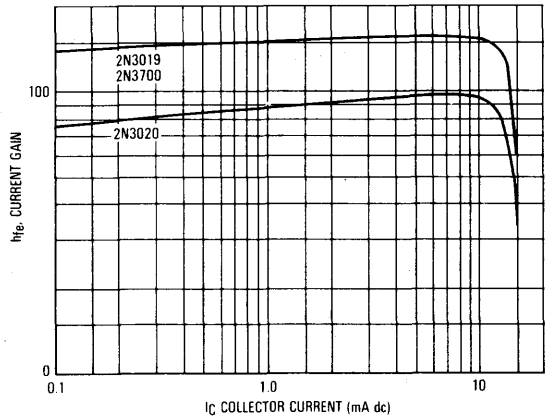
TEMPERATURE COEFFICIENTS



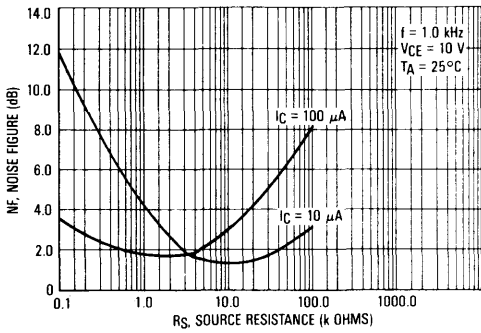
FREQUENCY EFFECTS



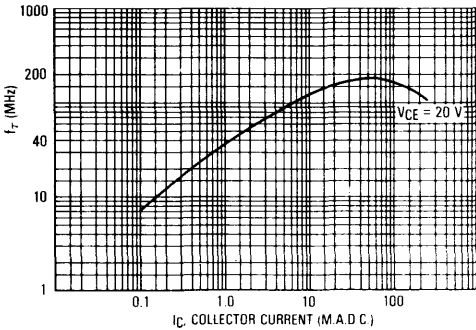
CURRENT GAIN BANDWIDTH versus COLLECTOR CURRENT — 1 kHz h_{fe}



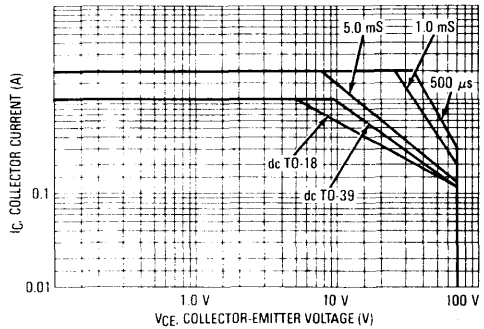
SOURCE RESISTANCE EFFECTS



CURRENT GAIN — BANDWIDTH PRODUCT



ACTIVE REGION SAFE OPERATING AREA



2N3053,A

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3053	2N3053A	Unit
Collector-Emitter Voltage(1)	V_{CE0}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	700		mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6		Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$
Lead Temperature $1/16", \pm 1/32"$ From Case for 10 s	T_L	+235		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C}/\text{W}$

(1) Applicable 0 to 100 mA (Pulsed):

Pulse Width $\leq 300 \mu\text{sec.}$, Duty Cycle $\leq 2.0\%$.

0 to 700 mA; Pulse Width $\leq 10 \mu\text{sec.}$, Duty Cycle $\leq 2.0\%$.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 100 \mu\text{Adc}$, $I_B = 0$)	2N3053 2N3053A	$V_{(BR)CEO}$	40 60	— — Vdc
Collector-Emitter Breakdown Voltage(2) ($I_C = 100 \text{mAdc}$, $R_{BE} = 10 \text{ohms}$)	2N3053 2N3053A	$V_{(BR)CER}$	50 70	— — Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	2N3053 2N3053A	$V_{(BR)CBO}$	60 80	— — Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}$, $I_C = 0$)		$V_{(BR)EBO}$	5.0	— Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{Vdc}$, $V_{BE(off)} = 1.5 \text{Vdc}$) ($V_{CE} = 60 \text{Vdc}$, $V_{BE(off)} = 1.5 \text{Vdc}$)	2N3053 2N3053A	I_{CEX}	—	0.25 μAdc
Emitter Cutoff Current ($V_{BE} = 4.0 \text{Vdc}$, $I_C = 0$)	2N3053	I_{EBO}	—	0.25 μAdc
Base Cutoff Current ($V_{CE} = 60 \text{Vdc}$, $V_{BE(off)} = 1.5 \text{Vdc}$)	2N3053A	I_{BL}	—	0.25 μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 150 \text{mAdc}$, $V_{CE} = 2.5 \text{Vdc}$) ($I_C = 150 \text{mAdc}$, $V_{CE} = 10 \text{Vdc}$)		h_{FE}	25 50	— 250 —
Collector-Emitter Saturation Voltage ($I_C = 150 \text{mAdc}$, $I_B = 15 \text{mAdc}$)	2N3053 2N3053A	$V_{CE(sat)}$	— —	1.4 0.3 Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{mAdc}$, $I_B = 15 \text{mAdc}$)	2N3053 2N3053A	$V_{BE(sat)}$	— 0.6	1.7 1.0 Vdc
Base-Emitter On Voltage ($I_C = 150 \text{mAdc}$, $V_{CE} = 2.5 \text{Vdc}$)	2N3053 2N3053A	$V_{BE(on)}$	— —	1.7 1.0 Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50 \text{mAdc}$, $V_{CE} = 10 \text{Vdc}$, $f = 20 \text{MHz}$)		f_T	100	— MHz
Output Capacitance ($V_{CB} = 10 \text{Vdc}$, $I_E = 0$, $f = 140 \text{kHz}$)		C_{obo}	—	15 pF
Input Capacitance ($V_{BE} = 0.5 \text{Vdc}$, $I_C = 0$, $f = 140 \text{kHz}$)		C_{ibo}	—	80 pF

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N3114

**CASE 79, STYLE 1
TO-39 (TO-205AD)
AMPLIFIER TRANSISTOR
NPN SILICON**

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	150	Vdc
Collector-Base Voltage	V_{CBO}	150	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

Refer to 2N3498 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) ($I_C = 30$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	150	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	150	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.010 10	μ Adc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.10	μ Adc

ON CHARACTERISTICS

DC Current Gain(2) ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55^\circ\text{C}$)	h_{FE}	15 30 12	— 120 —	—
Collector-Emitter Saturation Voltage(2) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage(2) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	—	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, $f = 140$ kHz)	C_{obo}	—	9.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 140$ kHz)	C_{ibo}	—	80	pF
Small-Signal Current Gain ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V, $f = 1$ kHz)	h_{fe}	25	—	—
Current Gain — High Frequency ($V_{CE} = 10$ Vdc, $I_C = 30$ mAdc, $f = 20$ MHz)	$ h_{fe} $	2.0	—	—
Real Part of Input Impedance ($I_C = 10$ mA, $V_{CE} = 10$ V, $f = 100$ MHz)	$Re(h_{ie})$	—	30	Ohms

(1) Between 0 and 30 mA.

(2) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 1.0\%$.

2N3227

For Specifications, See 2N2368 Data.

2N3244 2N3245

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE
TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3244	2N3245	Unit
Collector-Emitter Voltage	V_{CE0}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	5.71	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0	28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.175	$^\circ\text{C}/\text{mW}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$			Vdc
	2N3244	40	—	
	2N3245	50	—	
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$			Vdc
	2N3244	40	—	
	2N3245	50	—	
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current ($V_{CE} = 30 \text{ Vdc}, V_{BE} = 3.0 \text{ Vdc}$)	I_{BEV}	—	80	nAdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}, V_{BE} = 3.0 \text{ Vdc}$)	I_{CEX}	—	50	nAdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$) ($V_{CB} = 30 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$)	I_{CBO}	—	0.050 10	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0 \text{ Vdc}, I_C = 0$) ($V_{EB} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	30 30	nAdc
	2N3245			
	2N3244			

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 150 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}			
	2N3244	60	—	
	2N3245	35	—	
($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	2N3244	50	150	
	2N3245	30	90	
($I_C = 1.0 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc}$)	2N3244	25	—	
	2N3245	20	—	
Collector-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{CE(sat)}$			Vdc
	2N3244	—	0.3	
	2N3245	—	0.35	
($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$)	2N3244	—	0.5	
	2N3245	—	0.6	
($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$)	2N3244	—	1.0	
	2N3245	—	1.2	

2N3244, 2N3245

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}$, $I_B = 100 \text{ mAdc}$)	$V_{BE(sat)}$	— 0.75 —	1.1 1.5 2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N3244 2N3245	f_T	175 150	— —	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)		C_{obo}	—	25	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)		C_{ibo}	—	100	pF

SWITCHING CHARACTERISTICS

Delay Time	$(I_C = 500 \text{ mA}$, $I_{B1} = 50 \text{ mA}$ $V_{EB} = 2.0 \text{ V}$, $V_{CC} = 30 \text{ V}$)	2N3244 2N3245	t_d	—	15	ns
Rise Time			t_r	—	35 40	ns
Storage Time	$(I_C = 500 \text{ mA}$, $V_{CC} = 30 \text{ V}$ $I_{B1} = I_{B2} = 50 \text{ mA}$)	2N3244 2N3245	t_s	—	140 120	ns
Fall Time			t_f	—	45	ns
Total Control Charge ($I_C = 500 \text{ mA}$, $I_B = 50 \text{ mA}$, $V_{CC} = 30 \text{ V}$)		2N3244 2N3245	Q_T	— —	14 12	pC

(1) Pulse Test: $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 — MINIMUM CURRENT GAIN CHARACTERISTICS

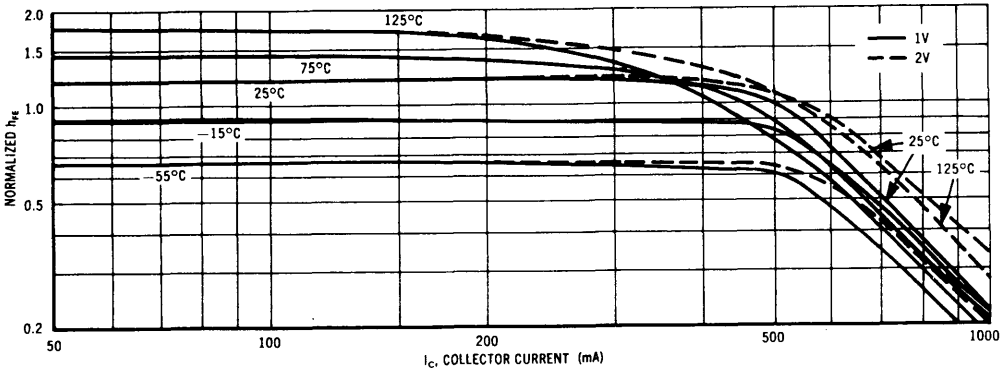


FIGURE 2 — COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS

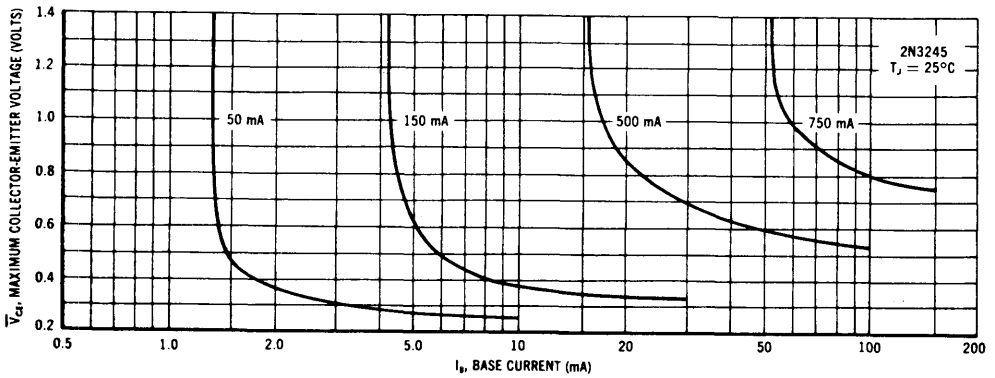
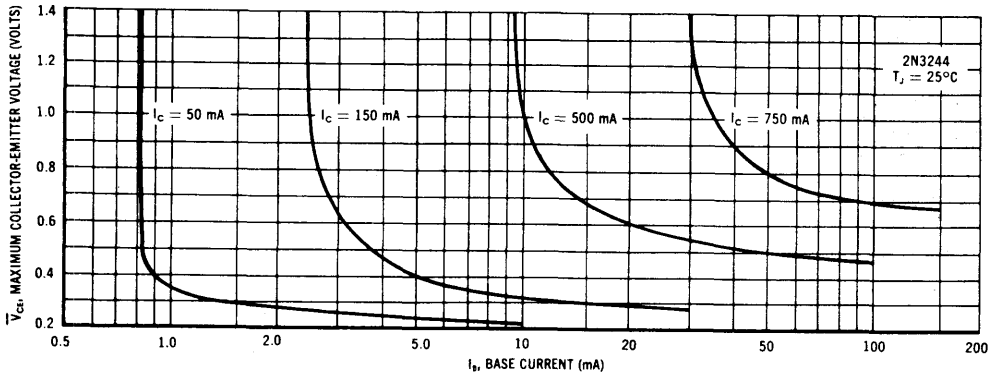


FIGURE 3 — MAXIMUM SATURATION VOLTAGES

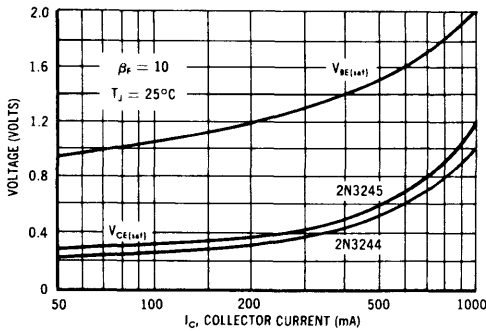
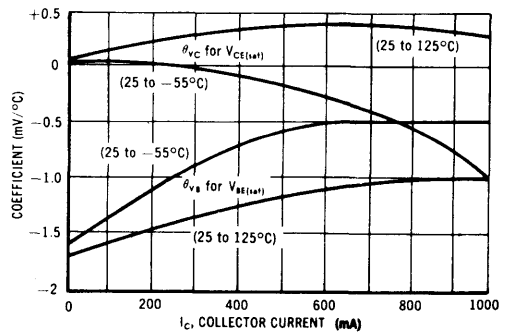


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS



2N3244, 2N3245

FIGURE 5 - JUNCTION CAPACITANCE

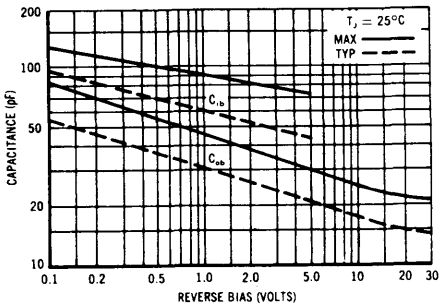


FIGURE 6 - TYPICAL SWITCHING TIMES

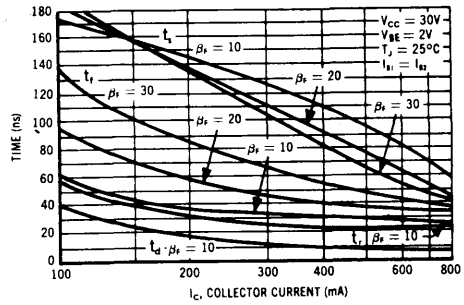


FIGURE 7 - CHARGE DATA

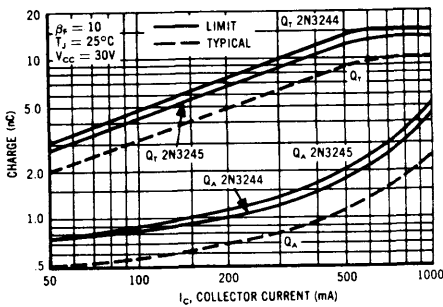


FIGURE 8 - TURN-ON EQUIVALENT TEST CIRCUIT

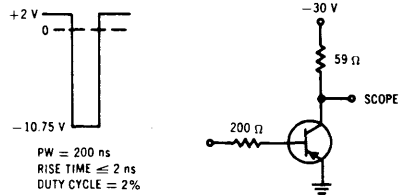


FIGURE 9 - TURN-OFF EQUIVALENT TEST CIRCUIT

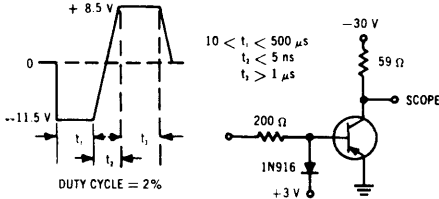


FIGURE 10 - Qc TEST CIRCUIT

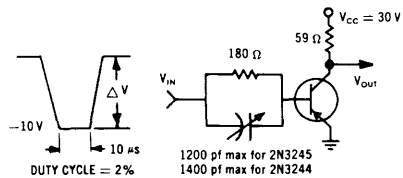
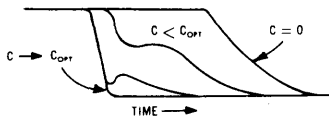


FIGURE 11 - TURN-OFF WAVEFORM



2N3250,A 2N3251,A

2N3250A, 2N3251A
JAN, JTX, JTXV AVAILABLE

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR
PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3250	2N3250A	Unit
		2N3251	2N3251A	
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06		Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.9		Watts mW/ $^\circ\text{C}$
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	- 65 to + 200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	mW/ $^\circ\text{C}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	mW/ $^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc)	2N3250, 2N3251 2N3250A, 2N3251A	$V_{(BR)CEO}$	40 60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc)	2N3250, 2N3251 2N3250A, 2N3251A	$V_{(BR)CBO}$	50 60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $V_{BE} = 3.0$ Vdc)		I_{CEX}	—	20	Adc
Base Cutoff Current ($V_{CE} = 40$ Vdc, $V_{BE} = 3.0$ Vdc)		I_{BL}	—	50	nAdc
ON CHARACTERISTICS					
DC Forward Current Transfer Ratio (1) ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3250, 2N3250A 2N3251, 2N3251A	h_{FE}	40 80	—	—
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		45 90	—	—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		50 100	150 300	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		15 30	—	—
Collector-Emitter Saturation Voltage (1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	— —	0.25 0.5	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	0.6 —	0.9 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, $f = 100$ MHz)	2N3250, 2N3250A 2N3251, 2N3251A	f_T	250 300	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 100$ kHz)		C_{obo}	—	6.0	pF
Input Capacitance ($V_{CB} = 1.0$ Vdc, $I_C = 0$, $f = 100$ kHz)		C_{ibo}	—	8.0	pF

2N3250,A, 2N3251,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Impedance ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$)	2N3250, 2N3250A	h_{ie}	1.0	6.0	kohms
	2N3251, 2N3251A		2.0	12	
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$)	2N3250, 2N3250A	h_{re}	—	10	$\times 10^{-4}$
	2N3251, 2N3251A		—	20	
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$)	2N3250, 2N3250A	h_{fe}	50	200	—
	2N3251, 2N3251A		100	400	
Output Admittance ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1.0\text{ kHz}$)	2N3250, 2N3250A	h_{oe}	4.0	40	μmhos
	2N3251, 2N3251A		10	60	
Collector Base Time Constant ($I_C = 10\text{ mA}$, $V_{CE} = 20\text{ V}$)		$rb' C_C$	—	250	ps
Noise Figure ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ V}$, $R_S = 1.0\text{ k}\Omega$, $f = 100\text{ Hz}$)		NF	—	6.0	dB

SWITCHING CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Delay Time ($V_{CC} = 3.0\text{ Vdc}$, $V_{BE} = 0.5\text{ Vdc}$, $I_C = 10\text{ mA}$, $I_{B1} = 1.0\text{ mA}$)		t_d	35	ns
	Rise Time	t_r	35	ns
Storage Time ($I_C = 10\text{ mA}$, $I_{B1} = I_{B2} = 1.0\text{ mA}$, $V_{CC} = 3.0\text{ V}$)	2N3250, 2N3250A	t_s	175	ns
	2N3251, 2N3251A		200	
Fall Time		t_f	50	ns

(1) Pulse Test: PW = 300 μs , Duty Cycle = 2.0%.

SWITCHING TIME CHARACTERISTICS

FIGURE 1 — DELAY AND RISE TIME

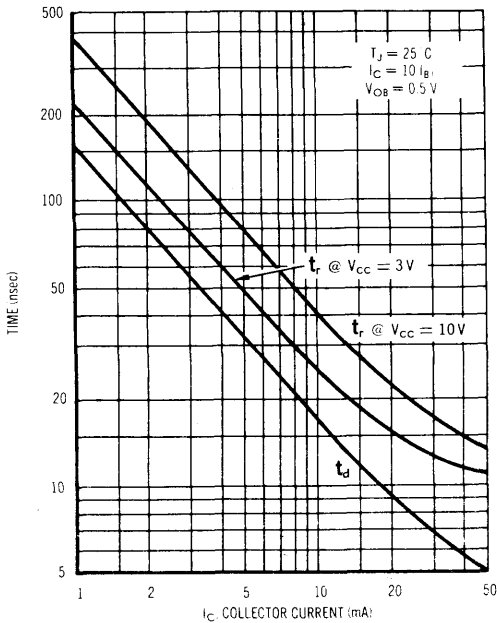
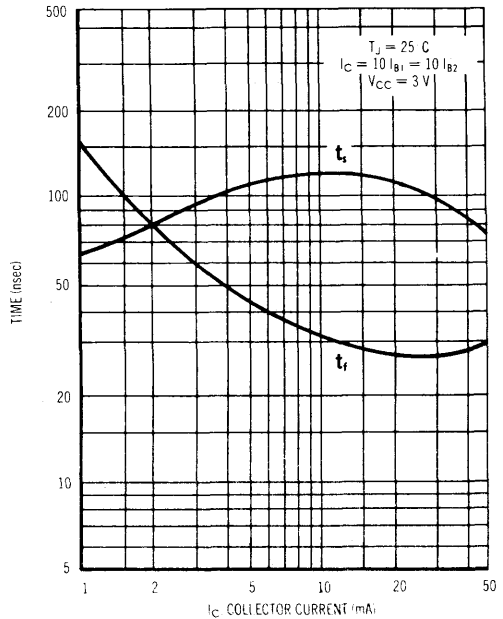


FIGURE 2 — STORAGE AND FALL TIME



2N3250,A, 2N3251,A

AUDIO SMALL SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS
($V_{ce} = 6V, T_A = 25^\circ C$)

FIGURE 3 — FREQUENCY

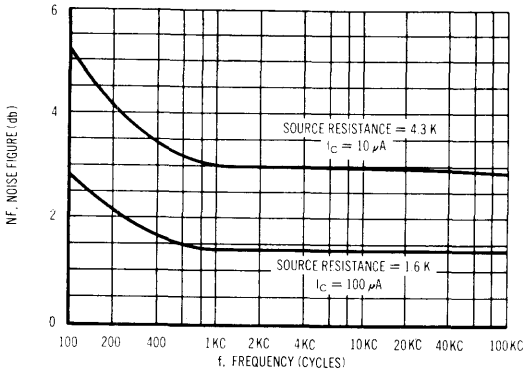
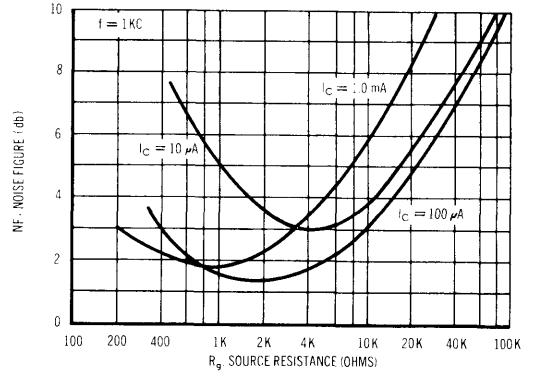


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS
 $V_{ce} = 10V, f = 1kc, T_A = 25^\circ C$

FIGURE 5 — CURRENT GAIN

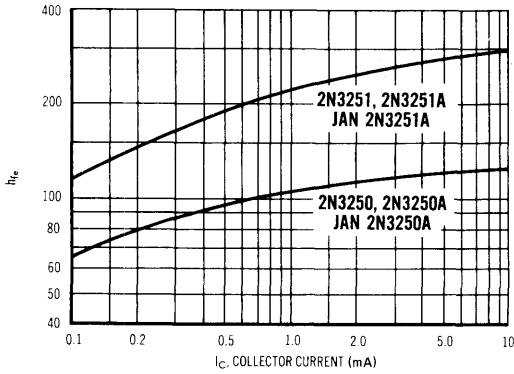


FIGURE 6 — OUTPUT ADMITTANCE

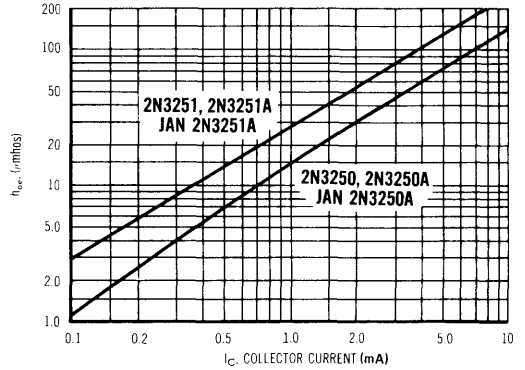


FIGURE 7 — VOLTAGE FEEDBACK RATIO

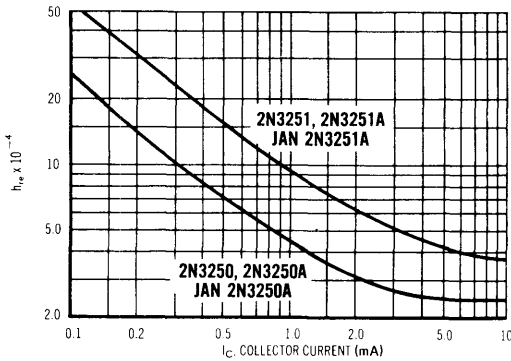


FIGURE 8 — INPUT IMPEDANCE

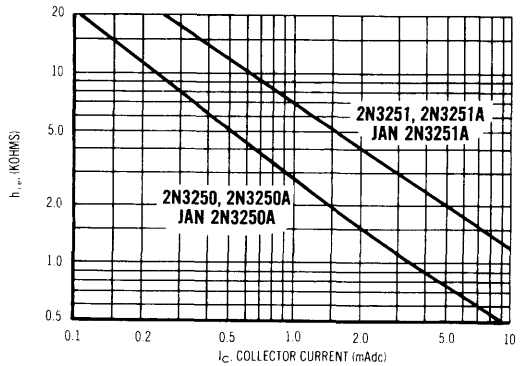


FIGURE 9 — NORMALIZED CURRENT GAIN CHARACTERISTICS

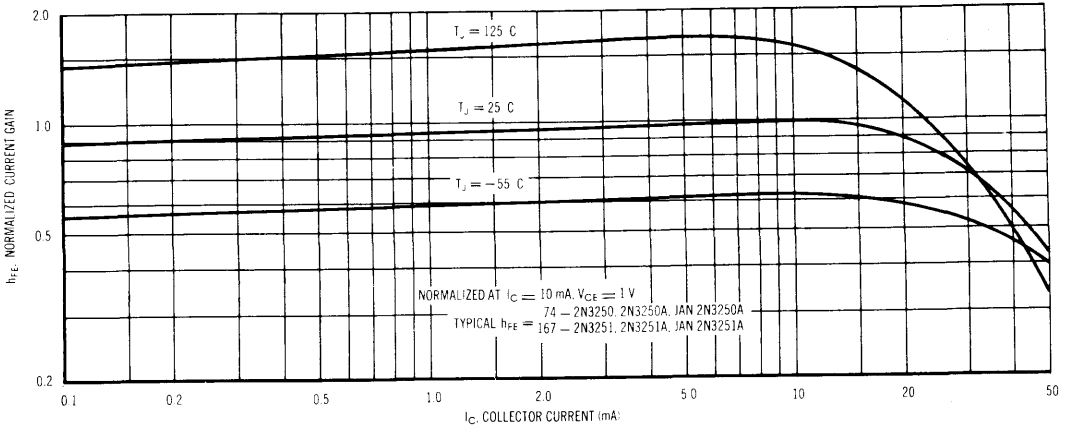
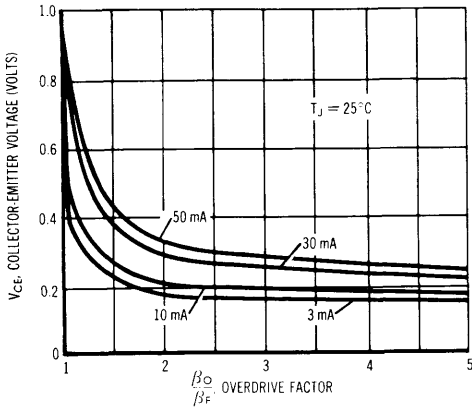


FIGURE 10 — COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C to I_B in a circuit. EXAMPLE: For type 2N3251, estimate a base current (I_B) to insure saturation at a temperature of 25°C and a collector current of 10 mA.

Observe that at $I_C = 10\text{ mA}$ an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that $h_{FE} @ 1\text{ volt}$ is typically 167 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design)...

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\text{ Volt}}{I_C / I_B} \quad 2.5 = \frac{167}{10\text{ mA} / I_B} \quad I_B \approx 6.68\text{ mA typ}$$

FIGURE 11 — SATURATION VOLTAGES

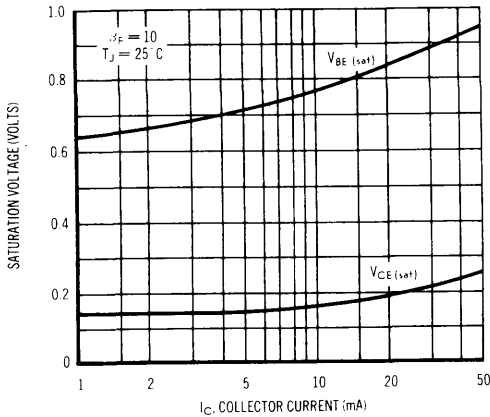
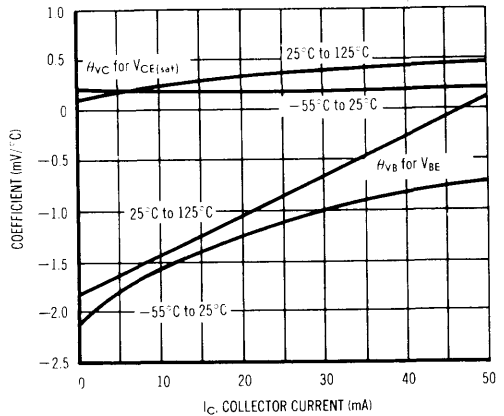


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N3250,A, 2N3251,A

FIGURE 13 — f_T AND $r_b C_C$ versus I_C

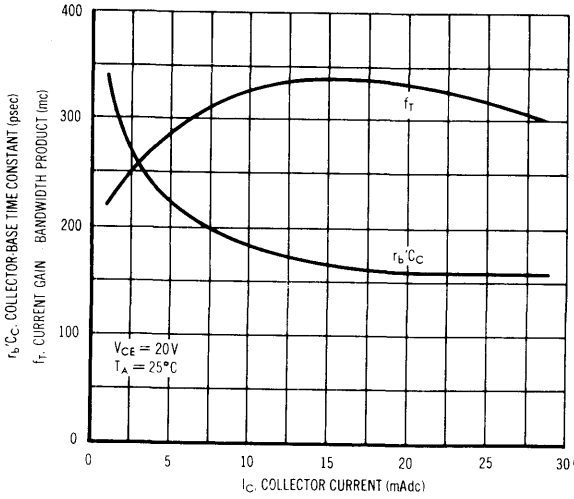


FIGURE 14 — 30 MC EQUIVALENT CIRCUIT

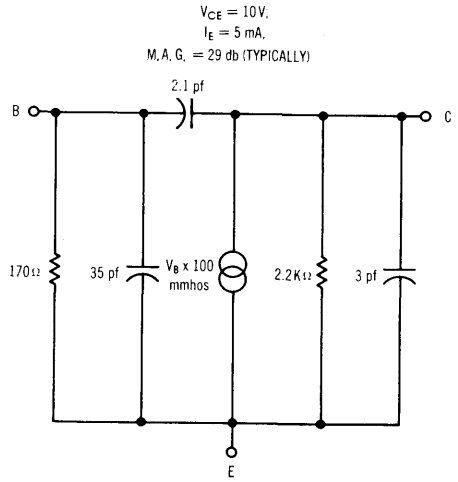


FIGURE 15 — JUNCTION CAPACITANCE

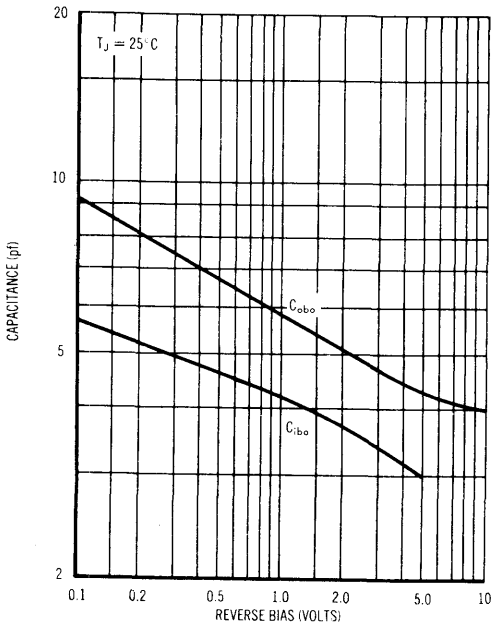
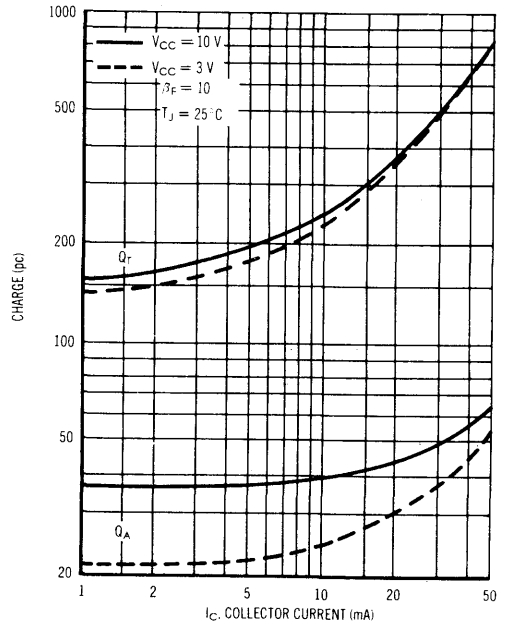


FIGURE 16 — CHARGE DATA



MAXIMUM RATINGS

Rating	Symbol	2N3252	2N3253	2N3444	Unit
Collector-Emitter Voltage	V _{CEO}	30	40	50	V _{dc}
Collector-Base Voltage	V _{CBO}	60	75	80	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 5.71			Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0 28.6			Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC} R _{θJA}	35 0.175	°C/W °C/mW

**2N3252
2N3253
2N3444**

GENERAL PURPOSE

NPN SILICON

**JAN, JTX AVAILABLE
2N3253, 2N3444
CASE 79, STYLE 1
TO-39 (TO-205AD)**

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, pulsed, I _B = 0)	V _{(BR)CEO}	30 40 50	—	V _{dc}
				2N3252 2N3253 2N3444
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60 75 80	—	V _{dc}
				2N3252 2N3253 2N3444
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CE} = 40 Vdc, V _{EB(off)} = 4.0 Vdc) (V _{CE} = 60 Vdc, V _{EB(off)} = 4.0 Vdc)	I _{CEX}	—	0.5 0.5	μAdc
				2N3252 2N3253, 2N3444
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0) (V _{CB} = 40 Vdc, I _E = 0, T _A = 100°C) (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0, T _A = 100°C)	I _{CBO}	—	0.50 75.0 0.50 75.0	μAdc
				2N3252 2N3252 2N3253, 2N3444 2N3253, 2N3444
Emitter Cutoff Current (V _{BE} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	0.05	μAdc
Base Cutoff Current (V _{CE} = 40 Vdc, V _{EB(off)} = 4.0 Vdc) (V _{CE} = 60 Vdc, V _{EB(off)} = 4.0 Vdc)	I _{BL}	—	0.50 0.50	μAdc
				2N3252 2N3253, 2N3444

ON CHARACTERISTICS

DC Current Gain(1)	h _{FE}	Min	Max	Unit
(I _C = 150 mAdc, V _{CE} = 1.0 Vdc)		30 25 20	—	—
				2N3252 2N3253 2N3444
(I _C = 500 mAdc, V _{CE} = 1.0 Vdc)		30 25 20	90 75 60	—
				2N3252 2N3253 2N3444
(I _C = 1.0 Adc, V _{CE} = 5.0 Vdc)		25 20 15	—	—
				2N3252 2N3253 2N3444

2N3252, 2N3253, 2N3444

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$)	$V_{CE(sat)}$	—	0.3	Vdc
2N3252		—	0.35	
2N3253, 2N3444		—	0.5	
($I_C = 500\text{ mAdc}, I_B = 500\text{ mAdc}$)		—	0.60	
($I_C = 1.0\text{ Adc}, I_B = 100\text{ mAdc}$)	2N3252	—	1.0	
2N3253, 2N3444	—	1.2		
Base-Emitter Saturation Voltage(1) ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	—	1.0	Vdc
($I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$)		0.7	1.3	
($I_C = 1.0\text{ Adc}, I_B = 100\text{ mAdc}$)		—	1.8	
		—	1.8	

SMALL-SIGNAL CHARACTERISTICS

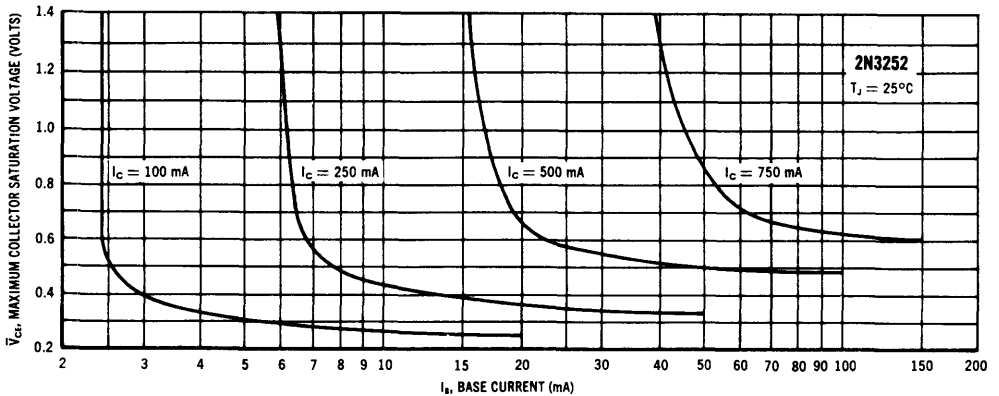
Current-Gain — Bandwidth Product ($I_C = 50\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 100\text{ MHz}$)	2N3252 2N3253, 2N3444	f_T	200 175	— —	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 100\text{ kHz}$)		C_{obo}	—	12	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}, I_C = 0, f = 100\text{ kHz}$)		C_{ibo}	—	80	pF

SWITCHING CHARACTERISTICS

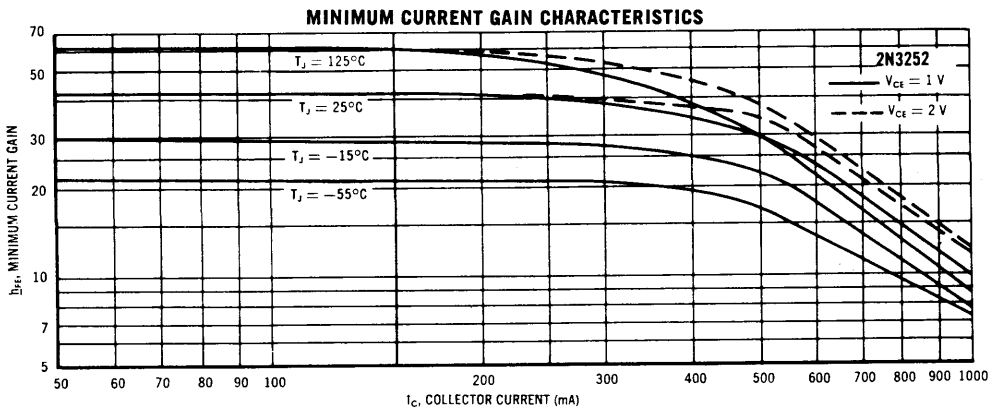
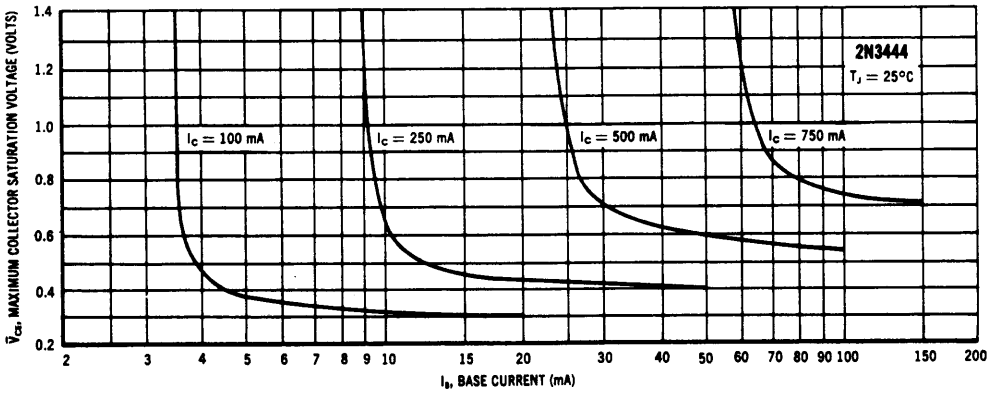
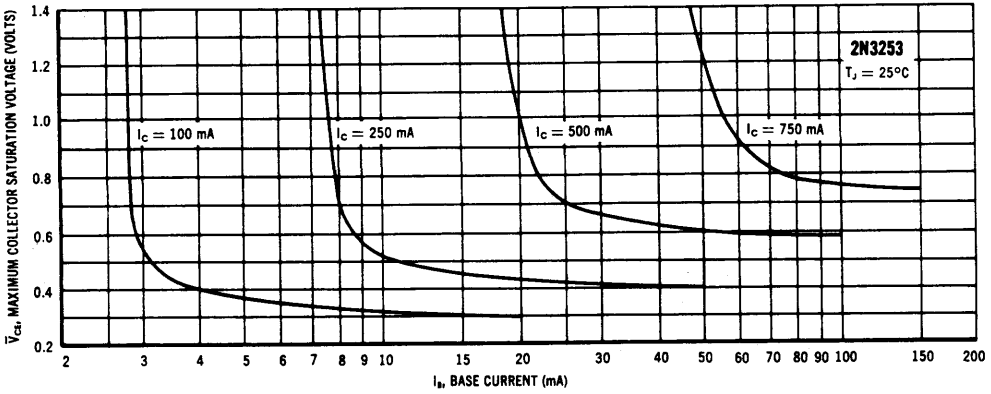
Delay Time	$I_C = 500\text{ mAdc}, I_{B1} = 50\text{ mAdc}$ $V_{CC} = 30\text{ V}, V_{BE} = 2.0\text{ V}$	2N3252 2N3253, 2N3444	t_d	—	15	ns
Rise Time			t_r	— —	30 35	ns
Storage Time	$I_C = 500\text{ mAdc}, I_{B1} = I_{B2} = 50\text{ mAdc}$ $V_{CC} = 30\text{ V}$		t_s	—	40	ns
Fall Time			t_f	—	30	ns
Total Control Charge ($I_C = 500\text{ mAdc}, I_{B1} = 50\text{ mAdc}, V_{CC} = 30\text{ V}$)			Q_T	—	5.0	nC

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2.0%.

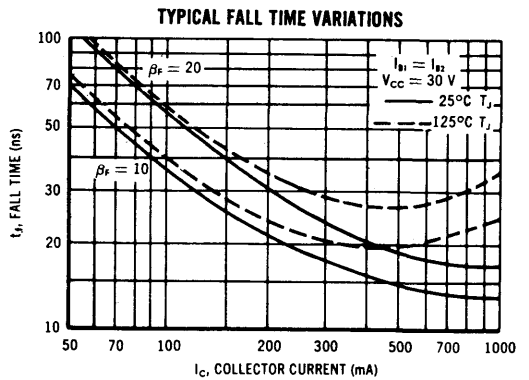
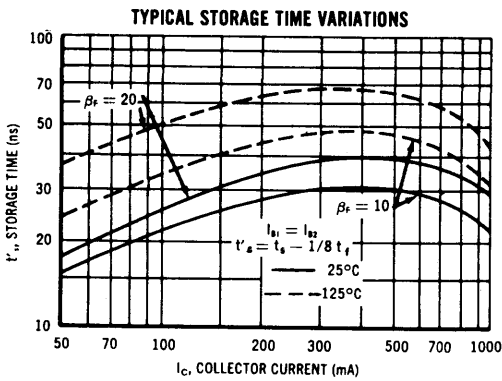
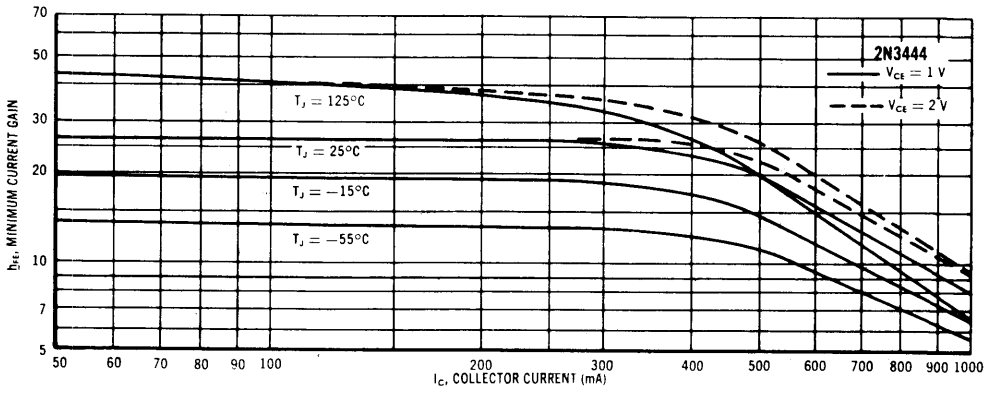
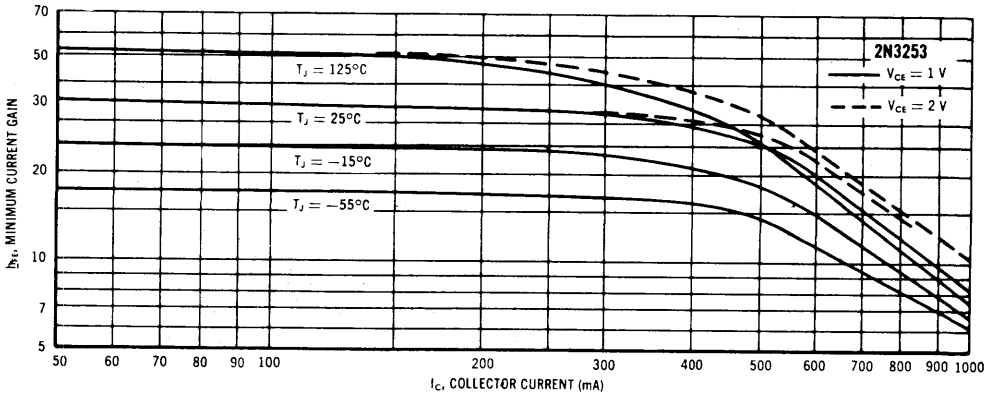
COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



2N3252, 2N3253, 2N3444

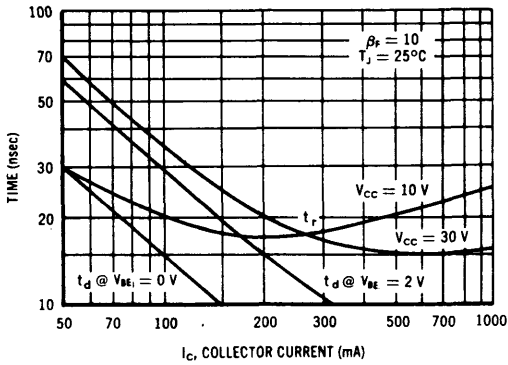


2N3252, 2N3253, 2N3444

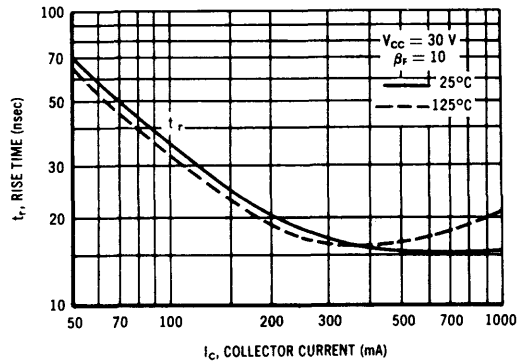


2N3252, 2N3253, 2N3444

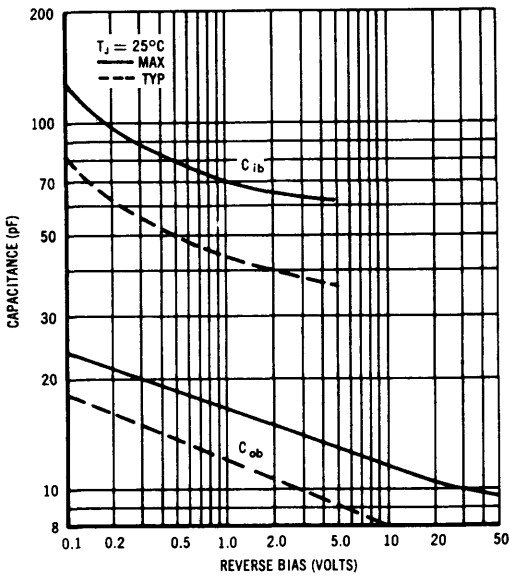
TYPICAL TURN-ON TIME VARIATIONS WITH VOLTAGE



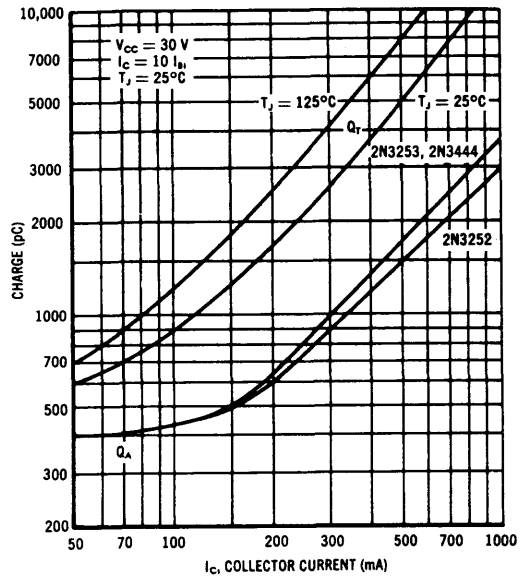
TYPICAL RISE TIME VARIATIONS WITH TEMPERATURE



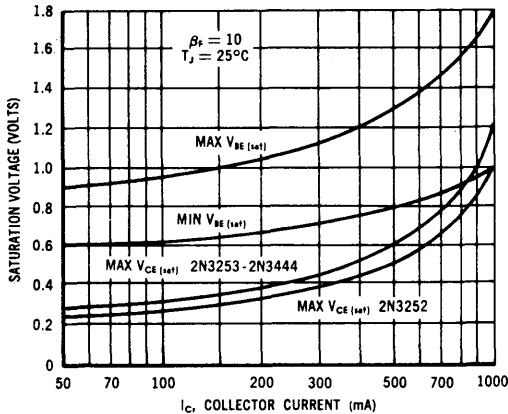
JUNCTION CAPACITANCE VARIATIONS



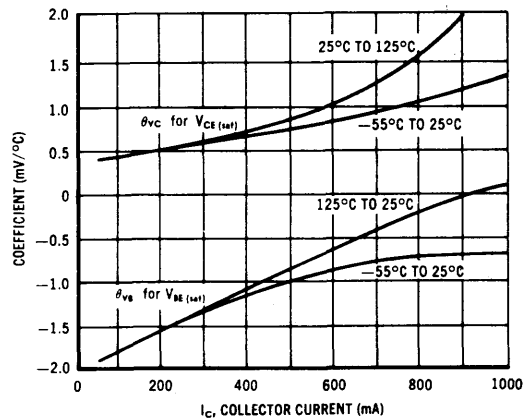
MAXIMUM CHARGE DATA



LIMITS OF SATURATION VOLTAGES



TYPICAL TEMPERATURE COEFFICIENTS



2N3299 2N3300

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE
TRANSISTOR

2N3301 2N3302

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage (Applicable 0 to 10 mAdc)	V _{CEO}	30	Vdc	
Collector-Base Voltage	V _{CBO}	60	Vdc	
Emitter-Base Voltage	V _{EBO}	5.0	Vdc	
Collector Current — Continuous	I _C	500	mAdc	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	2N3299 2N3300	0.8 4.56	Watt mW/°C
		2N3301 2N3302	0.36 2.06	
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2N3299 2N3300	3.0 17.2	Watts mW/°C
		2N3301 2N3302	1.8 10.3	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C	

Refer to 2N2218 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{CEO(sus)}	30	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CE} = 50 Vdc, V _{BE} = 0) (V _{CE} = 50 Vdc, V _{BE} = 0, T _A = 150°C)	I _{CES}	—	0.01	μAdc
			10	
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	10	nAdc
Base Current (V _{CE} = 50 Vdc, V _{BE} = 0)	I _B	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 10 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	2N3299, 2N3301	h _{FE}	20	—	—
	2N3300, 2N3302		35	—	
(I _C = 10 mAdc, V _{CE} = 10 Vdc)(1)	2N3299, 2N3301		25	—	
	2N3300, 2N3302		50	—	
(I _C = 150 mAdc, V _{CE} = 1.0 Vdc)(1)	2N3299, 2N3301		35	—	
	2N3300, 2N3302		75	—	
(I _C = 150 mAdc, V _{CE} = 10 Vdc)(1)	2N3299, 2N3301		20	—	
	2N3300, 2N3302		50	—	
(I _C = 500 mAdc, V _{CE} = 10 Vdc)(1)	2N3299, 2N3301		40	120	
	2N3300, 2N3302		100	300	
	2N3299, 2N3301 2N3300, 2N3302		20 50	—	
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	—	0.22	Vdc	
			0.45		
			0.6		
Base-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{BE(sat)}	—	1.1	Vdc	
			1.3		
			1.5		
Base Emitter Voltage (I _C = 150 mA, V _{CE} = 10 V)	V _{BE(on)}	—	1.1 V	Max	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	250	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	8.0	pF
Input Capacitance (V _{BE} = 2.0 Vdc, I _C = 0, f = 140 kHz)	C _{iBo}	—	20	pF

SWITCHING CHARACTERISTICS

Turn-On Time (V _{CC} = 25 Vdc, I _C = 300 mAdc, I _{B1} = 30 mAdc)	t _{on}	—	60	ns
Turn-Off Time (V _{CC} = 25 Vdc, I _C = 300 mAdc, I _{B1} = I _{B2} = 30 mAdc)	t _{off}	—	150	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3307 2N3308

CASE 20, STYLE 10
TO-72 (TO-206AF)

GENERAL PURPOSE
TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3307	2N3308	Unit
Collector-Emitter Voltage	V_{CE0}	35	25	Vdc
Collector-Emitter Voltage	V_{CES}	40	30	Vdc
Collector-Base Voltage	V_{CBO}	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200	1.14	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300	1.71	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 2.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	35 25	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{Adc}, V_{BE} = 0$)	$V_{(BR)CES}$	40 30	— —	Vdc
Collector-Base Breakdown Voltage(1) ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	40 30	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$) ($V_{CB} = 15 \text{ Vdc}, T = 150^\circ\text{C}$)	I_{CBO}	— —	0.010 3.0	μAdc

ON CHARACTERISTICS

DC Current Gain ($V_{CE} = 10 \text{ Vdc}, I_C = 2.0 \text{ mAdc}$)	h_{FE}	40 25	250 250	—
Collector-Emitter Saturation Voltage ($I_C = 3.0 \text{ mAdc}, I_B = 0.6 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 3.0 \text{ mAdc}, I_B = 0.6 \text{ mAdc}$)	$V_{BE(sat)}$	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($V_{CE} = 10 \text{ Vdc}, I_C = 2.0 \text{ mAdc}, f = 100 \text{ MHz}$)	f_T	300	1200	MHz
Maximum Frequency of Operation ($V_{CE} = 10 \text{ Vdc}, I_C = 2.0 \text{ mAdc}$)	f_{max}	Typical 2000		MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 0.1 \text{ MHz}$)	C_{obo}	— —	1.3 1.6	pF
Small-Signal Current Gain ($V_{CE} = 10 \text{ Vdc}, I_C = 2.0 \text{ mAdc}, f = 1 \text{ kHz}$)	h_{fe}	40 25	250 250	—
Collector Base Time Constant ($V_{CB} = 10 \text{ Vdc}, I_C = 2.0 \text{ mAdc}, f = 31.8 \text{ MHz}$)	$rb'C_C$	2.0 2.0	15 20	ps

2N3307, 2N3308

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Noise Figure ($V_{CE} = 10\text{ Vdc}$, $I_C = 2.0\text{ mAdc}$, $f = 200\text{ MHz}$)	NF	—	4.5	dB
2N3307		—	6.0	
2N3308		—	6.0	

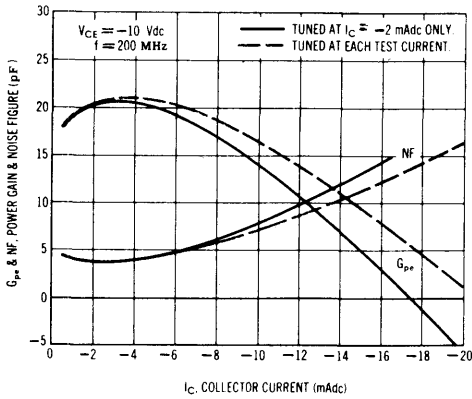
SWITCHING CHARACTERISTICS

Power Gain(2) ($V_{CE} = 10\text{ Vdc}$, $I_C = 2.0\text{ mAdc}$, $f = 200\text{ MHz}$)	G_e	17	—	dB
Power Gain (AGC)(2) ($V_{CE} = 5.0\text{ Vdc}$, $I_C = 20\text{ mAdc}$, $f = 200\text{ MHz}$)	G_e	—	0	dB
2N3307		—	—	
2N3308		—	—	

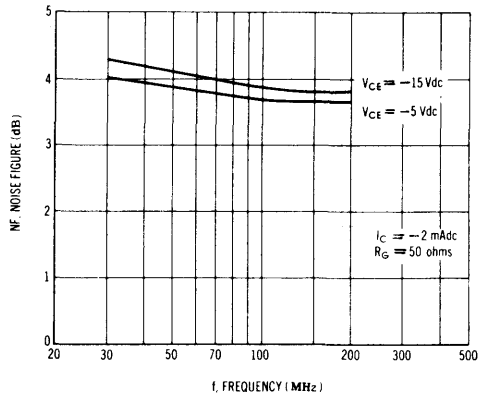
(1) C_{obo} is measured in guarded circuit such that the can capacitance is not included.

(2) AGC is obtained by increasing I_C . The circuit remains adjusted for $V_{CE} = -10\text{ Vdc}$, $I_C = -2\text{ mAdc}$ operation.

COMMON EMITTER AVERAGE SMALL POWER GAIN & NOISE FIGURE versus COLLECTOR CURRENT



NOISE FIGURE versus FREQUENCY



MAXIMUM RATINGS

Rating	Symbol	PNP		NPN		Unit
		2N5415	2N5416	2N3439	2N3440	
Collector-Emitter Voltage	V _{CEO}	200	300	350	250	Vdc
Collector-Base Voltage	V _{CBO}	200	350	450	300	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	6.0	7.0	7.0	Vdc
Base Current	I _B	0.5				Adc
Collector Current — Continuous	I _C	1.0				Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	—		1.0		Watts mW/°C
		—		5.7		
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	10 57		5.0 28.6		Watts mW/°C
Total Device Dissipation @ T _A = 50°C Derate above 50°C	P _D	1.0 6.7		— —		
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to +200				°C

**2N3439, 2N3440 NPN
2N5415, 2N5416 PNP**

**JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)**

4

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N5415	2N3439	Unit
		2N5416	2N3440	
Thermal Resistance, Junction to Case	R _{θJC}	17.5	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	150	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I _C = 50 mAdc, I _B = 0)	V _{CEO(sus)}	200 300 350 250	— — — —	Vdc
*Collector Cutoff Current (V _{CE} = 300 Vdc, I _B = 0) (V _{CE} = 200 Vdc, I _B = 0)	I _{CEO}	— —	20 50	μAdc
*Collector Cutoff Current (V _{CE} = 450 Vdc, V _{BE} = 1.5 Vdc) (V _{CE} = 300 Vdc, V _{BE} = 1.5 Vdc)	I _{CEX}	— —	500 500	μAdc
Collector Cutoff Current (V _{CB} = 175 Vdc, I _E = 0) (V _{CB} = 280 Vdc, I _E = 0) (V _{CB} = 360 Vdc, I _E = 0) (V _{CB} = 250 Vdc, I _E = 0)	I _{CBO}	— — — —	50 50 20 20	μAdc
Emitter Cutoff Current (V _{EB} = 4.0 Vdc, I _C = 0) (V _{EB} = 6.0 Vdc, I _C = 0)	I _{EBO}	— —	20 20	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 2.0 mAdc, V _{CE} = 10 Vdc) *(I _C = 20 mAdc, V _{CE} = 10 Vdc) *(I _C = 50 mAdc, V _{CE} = 10 Vdc)	h _{FE}	30 40 30 30	— 160 150 120	—
Collector-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 4.0 mAdc)	V _{CE(sat)}	—	0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 4.0 mAdc)	V _{BE(sat)}	—	1.3	Vdc

*Indicates Data in Addition to JEDEC Requirements.

2N3439, 2N3440 NPN / 2N5415, 2N5416 PNP

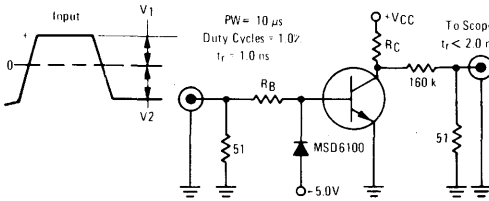
ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ V}$, $f = 50 \text{ MHz}$)	f_T	15	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ V}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	15 10	pF
Input Capacitance ($V_{EB} = 5.0 \text{ V}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{ibo}	—	75	pF
Small-Signal Current Gain ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ V}$, $f = 1.0 \text{ kHz}$) ($I_C = 10.0 \text{ mA}$, $V_{CE} = 10 \text{ V}$, $f = 5.0 \text{ MHz}$)	h_{fe}	25	—	—
Real Part of Input Impedance ($V_{CE} = 10 \text{ V}$, $I_C = 5.0 \text{ mA}$, $f = 1.0 \text{ MHz}$)	$\text{Re}(h_{ie})$	—	300	Ohms

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

CAUTION: The sustaining voltage *must not* be measured on a curve tracer. (See Fig. 15.)

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



NOTE: V_{CC} and R_C adjusted for $V_{CE(\text{off})} = 150 \text{ V}$ and I_C as desired, R_B chosen for desired I_{B1} . $V_1 \approx 10 \text{ V}$, $V_2 \approx 8.0 \text{ V}$

For t_d and t_r , D1 is disconnected and $V_2 = 2.0 \text{ V}$

For PNP test circuit, reverse all polarities.

PNP
2N5415, 2N5416

NPN
2N3439, 2N3440

FIGURE 2 — TURN-ON TIME

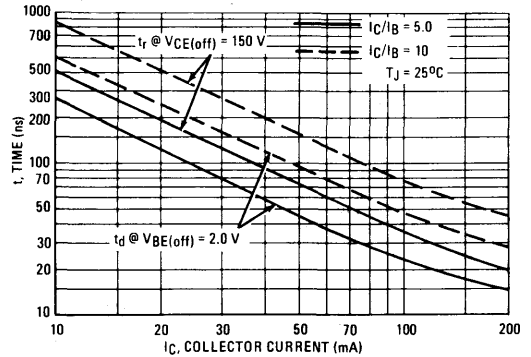
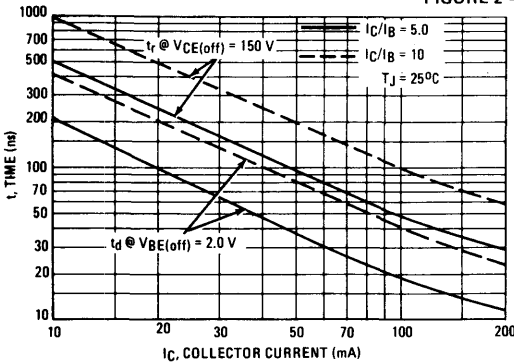
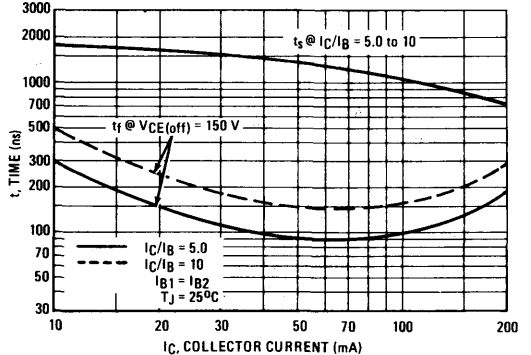
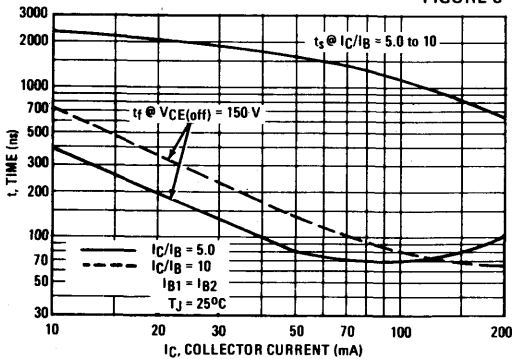


FIGURE 3 — TURN-OFF TIME



2N3439, 2N3440 NPN / 2N5415, 2N5416 PNP

FIGURE 4 - CURRENT-GAIN - BANDWIDTH PRODUCT

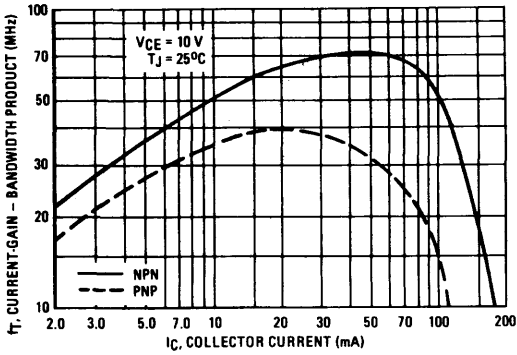


FIGURE 5 - CAPACITANCE

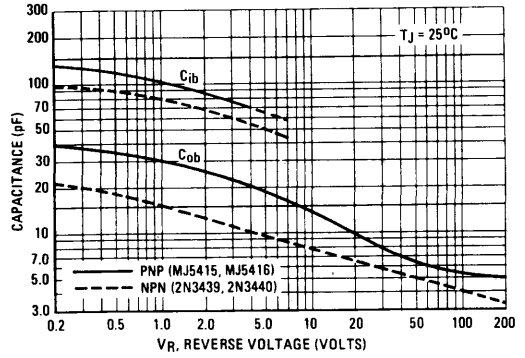


FIGURE 6 - THERMAL RESPONSE

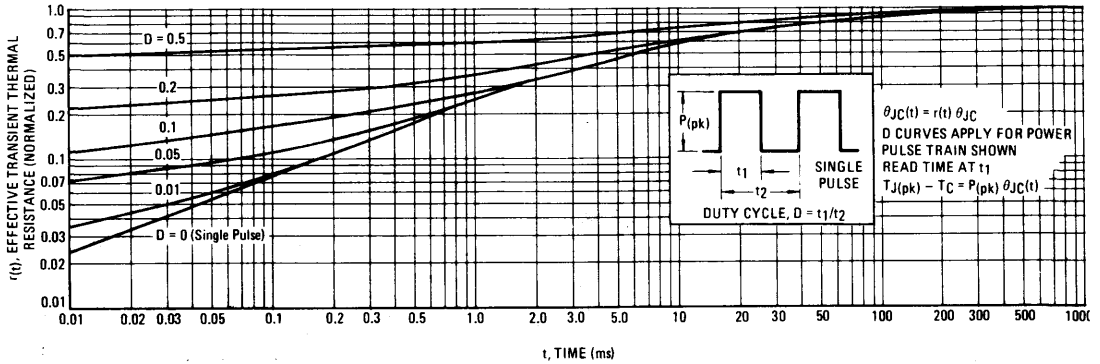
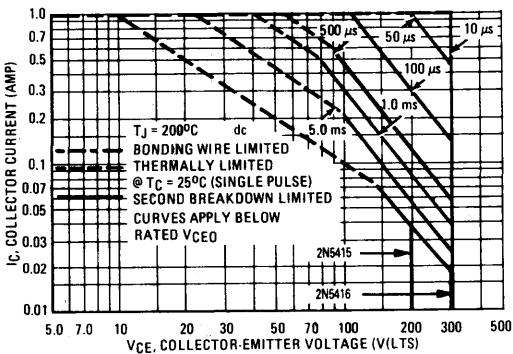
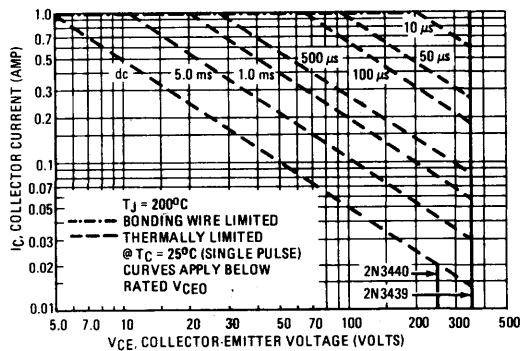


FIGURE 7 - ACTIVE-REGION SAFE OPERATING AREA

PNP - 2N5415, 2N5416

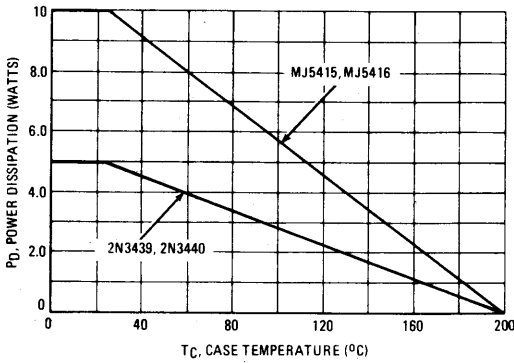


NPN - 2N3439, 2N3440



2N3439, 2N3440 NPN / 2N5415, 2N5416 PNP

FIGURE 8 – POWER DERATING



There are two limitations on the power handling ability of a transistor, average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

PNP
2N5415, 2N5416

NPN
2N3439 2N3440

FIGURE 9 – DC CURRENT GAIN

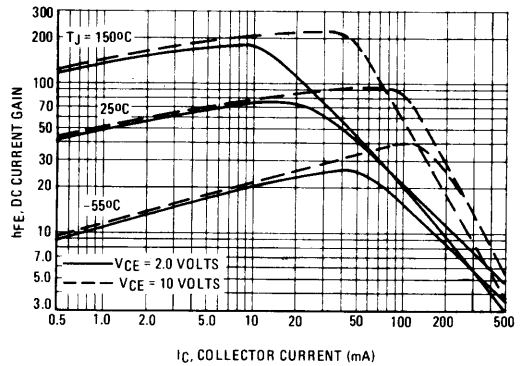
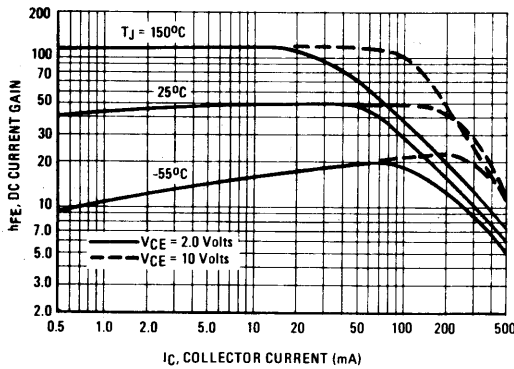
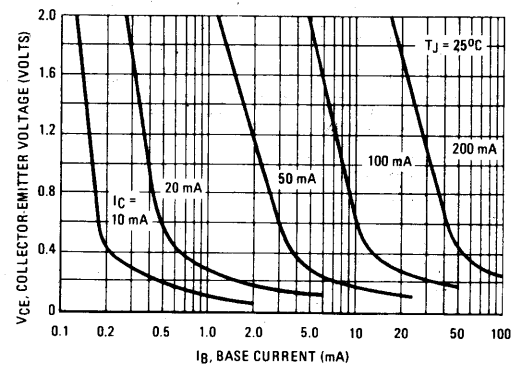
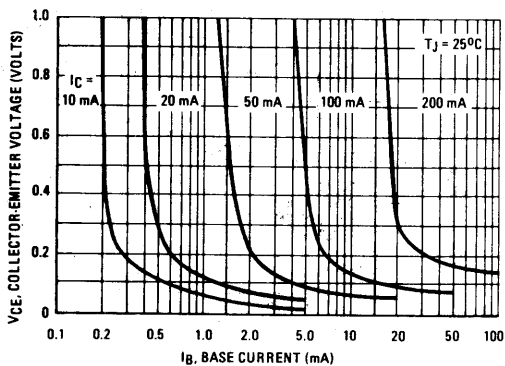


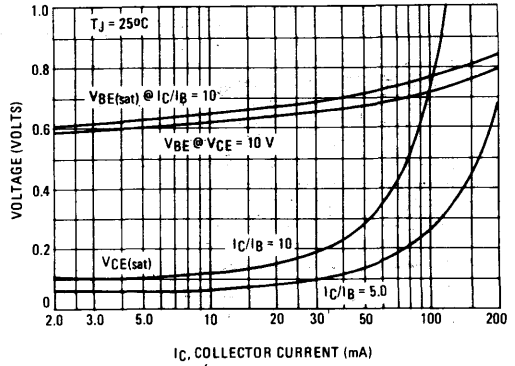
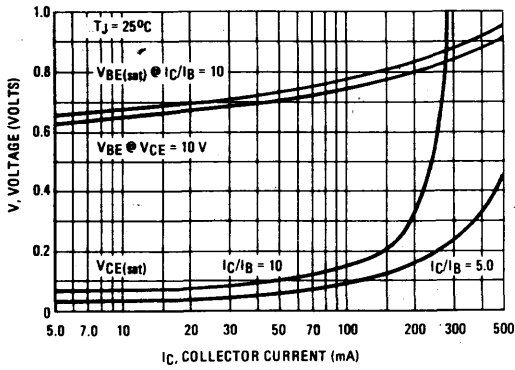
FIGURE 10 – COLLECTOR SATURATION REGION



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2N3439, 2N3440 NPN / 2N5415, 2N5416 PNP

FIGURE 11 - "ON" VOLTAGES



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FIGURE 12 - TEMPERATURE COEFFICIENTS

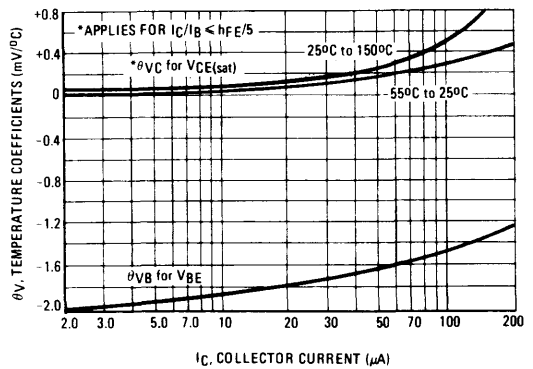
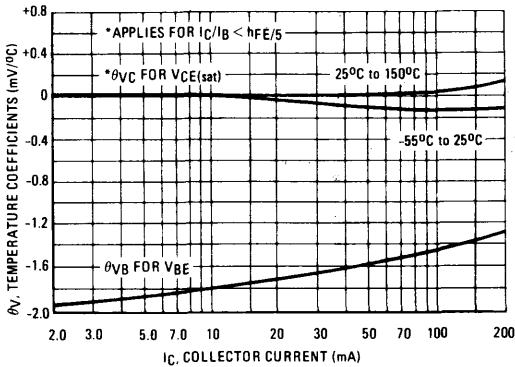
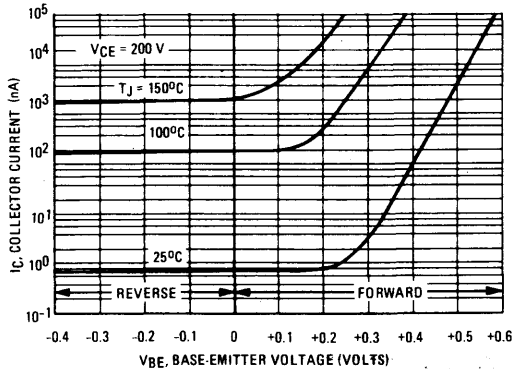
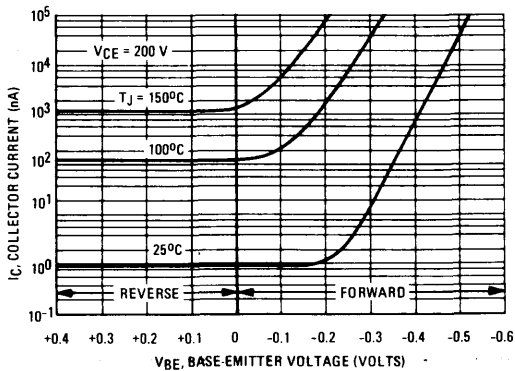


FIGURE 13 - COLLECTOR CUTOFF REGION



2N3439, 2N3440 NPN / 2N5415, 2N5416 PNP

FIGURE 14 — BASE CUTOFF REGION

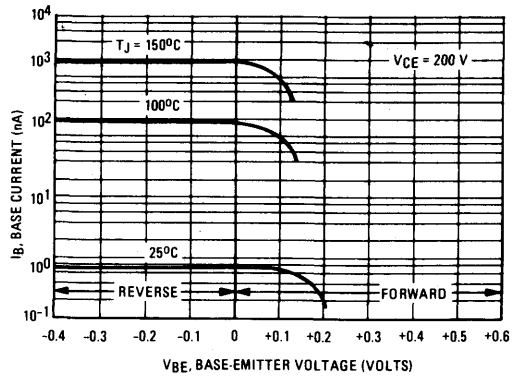
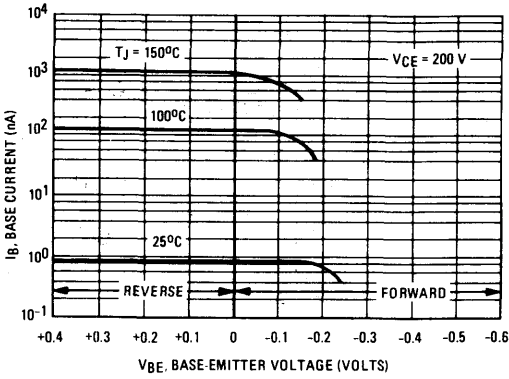
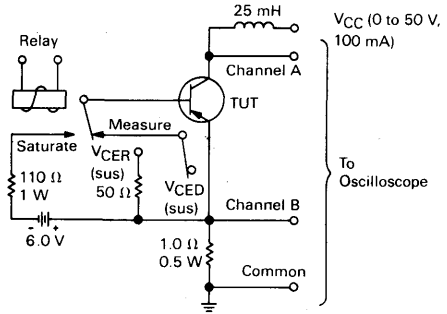


FIGURE 15 — CIRCUIT USED TO MEASURE SUSTAINING VOLTAGES



MAXIMUM RATINGS

Rating	Symbol	2N3467	2N3468	Unit
Collector-Emitter Voltage	V _{CEO}	40	50	Vdc
Collector-Base Voltage	V _{CBO}	40	50	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	1.0		Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0	5.71	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0	28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	0.175	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	2N3467 2N3468	V _{(BR)CEO}	40 50	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	2N3467 2N3468	V _{(BR)CBO}	40 50	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)		V _{(BR)EBO}	5.0	—	Vdc
Base Cutoff Current (V _{CE} = -30 Vdc, V _{BE} = 3.0 Vdc)		I _{BEV}	—	120	nAdc
Collector Cutoff Current (V _{CE} = -30 Vdc, V _{BE} = 3.0 Vdc)		I _{CEX}	—	100	Adc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 30 Vdc, I _E = 0, T _A = 100°C)		I _{CBO}	— —	0.10 15	μAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 150 mAdc, V _{CE} = 1.0 Vdc)	2N3467 2N3468	h _{FE}	40 25	— —	—
(I _C ≈ 500 mAdc, V _{CE} = 1.0 Vdc)	2N3467 2N3468		40 25	120 75	
(I _C = 1.0 Adc, V _{CE} = 5.0 Vdc)	2N3467 2N3468		40 20	— —	
Collector-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc)	2N3467 2N3468	V _{CE(sat)}	— —	0.3 0.36	Vdc
(I _C = 500 mAdc, I _B = 50 mAdc)	2N3467 2N3468		— —	0.5 0.6	
(I _C = 1.0 Adc, I _B = 100 mAdc)	2N3467 2N3468		— —	1.0 1.2	
Base-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc) (I _C = 1.0 Adc, I _B = 100 mAdc)		V _{BE(sat)}	— 0.8 —	1.0 1.2 1.6	Vdc

2N3467
2N3468

JAN, JTX, JTXV AVAILABLE
CASE 079-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

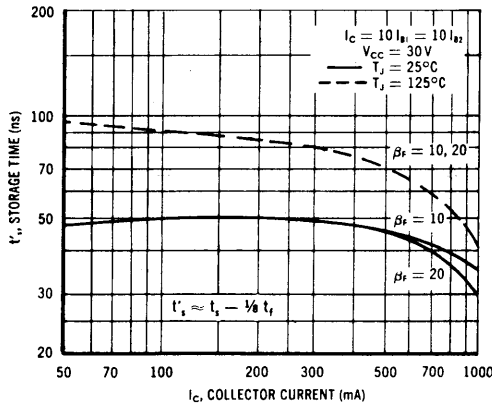
2N3467, 2N3468

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

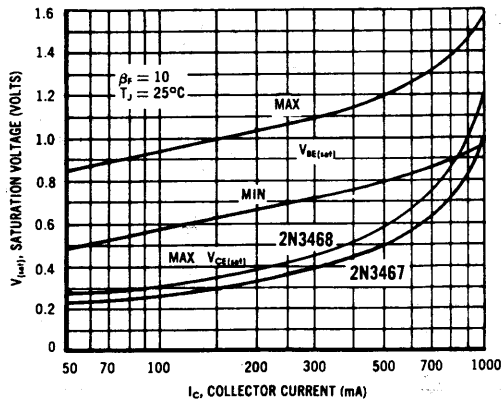
Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 100\text{ MHz}$)	f_T	175	—	MHz
		150	—	
Output Capacitance ($V_{CB} = 10\text{ V}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{obo}	—	25	pF
Input Capacitance ($V_{EB} = 0.5\text{ V}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ibo}	—	100	pF
SWITCHING CHARACTERISTICS				
Delay Time ($I_C = 500\text{ mA}$, $I_{B1} = 50\text{ mA}$, $V_{BE} = 2.0\text{ V}$, $V_{CC} = 30\text{ V}$)	t_d	—	10	ns
Rise Time	t_r	—	30	ns
Storage Time ($I_C = 500\text{ mA}$, $I_{B1} = I_{B2} = 50\text{ mA}$, $V_{CC} = 30\text{ V}$)	t_s	—	60	ns
Fall Time	t_f	—	30	ns
Total Control Charge ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$, $V_{CC} = 30\text{ V}$)	Q_T	—	6.0	nC

(1) Pulse Test: $PW \leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

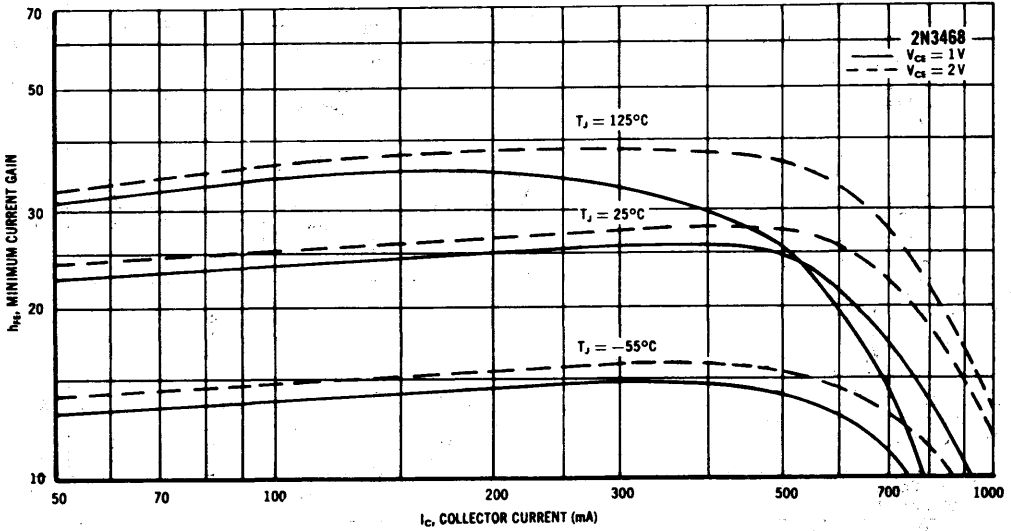
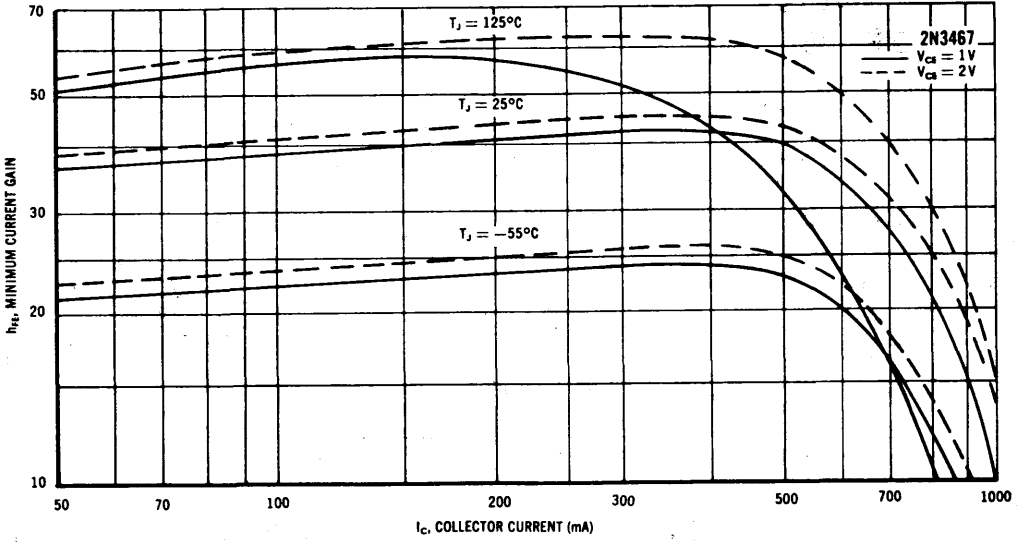
STORAGE TIME VARIATION WITH TEMPERATURE



LIMITS OF SATURATION VOLTAGE



MINIMUM CURRENT GAIN CHARACTERISTICS



4

2N3494
2N3495

CASE 31-03, STYLE 1
TO-39 (TO-205AD)

2N3496
2N3497

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

**GENERAL PURPOSE
TRANSISTOR**

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3494 2N3496	2N3495 2N3497	Unit
Collector-Emitter Voltage	V _{CEO}	80	120	Vdc
Collector-Base Voltage	V _{CBO}	80	120	Vdc
Emitter-Base Voltage	V _{EBO}	4.5		Vdc
Collector Current — Continuous	I _C	100		mAdc
		2N3494 2N3495	2N3496 2N3497	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	600 3.43	400 2.28	mW mW/°C
Total Device Dissipation @ T _C = 25°C* Derate above 25°C	P _D	3.0 17.2	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

*Indicates Data in addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	80 120	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	80 120	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	4.5	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 90 Vdc, I _E = 0)	I _{CBO}	— —	100 100	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	25	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I _C = 100 μAdc, V _{CE} = 10 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 50 mAdc, V _{CE} = 10 Vdc) (I _C = 100 mAdc, V _{CE} = 10 Vdc)	h _{FE}	35 40 40 40 35	— — — — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	— —	0.3 0.35	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	0.6	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	200 150	— —	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	— —	7.0 6.0	pF
Input Capacitance (V _{BE} = 2.0 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	30	pF

2N3494, 2N3495, 2N3496, 2N3497

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Impedance ($I_C = 10 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	h_{ie}	0.1	1.2	k ohms
Voltage Feedback Ratio ($I_C = 10 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	h_{re}	—	2.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	40	300	—
Output Admittance ($I_C = 10 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	—	300	μmhos
Real Part of Input Impedance ($I_C = 20 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 300 \text{ MHz}$)	$\text{Re}(h_{ie})$	—	30	Ohms

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 30 \text{ V dc}$, $I_C = 10 \text{ mA dc}$, $I_{B1} = 1.0 \text{ mA dc}$)	t_{on}	—	300	ns
Turn-Off Time ($V_{CC} = 30 \text{ V dc}$, $I_C = 10 \text{ mA dc}$, $I_{B1} = I_{B2} = 1.0 \text{ mA dc}$)	t_{off}	—	1000	ns

- (1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle = 2.0%.
 (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — TURN-ON TIME TEST CIRCUIT

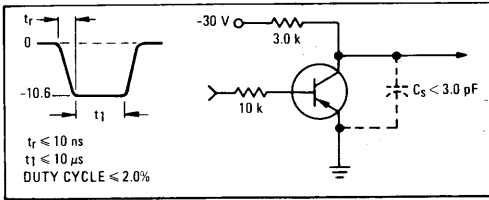


FIGURE 2 — TURN-OFF TIME TEST CIRCUIT

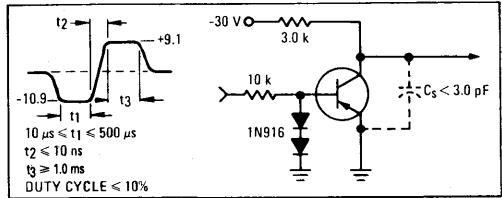


FIGURE 3 — $V_{CE(sat)}$ versus I_C

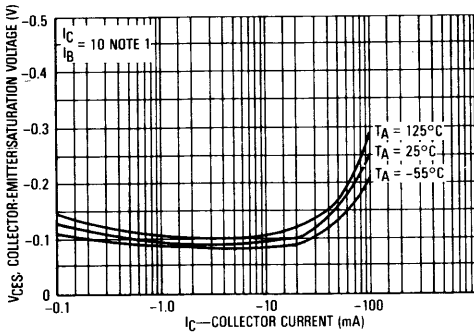


FIGURE 5 — h_{FE} versus I_C

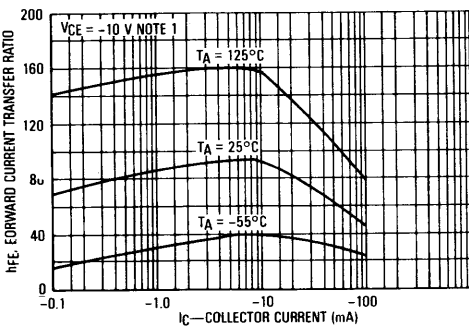


FIGURE 4 — I_{CBO} versus T_A

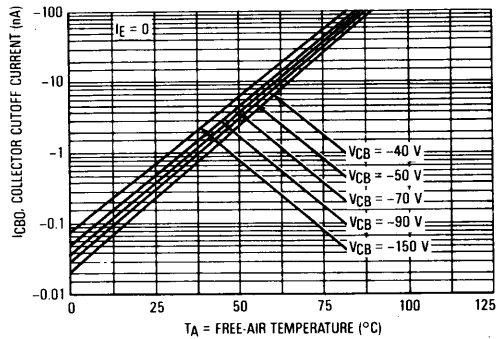


FIGURE 6 — V_{BE} versus I_C

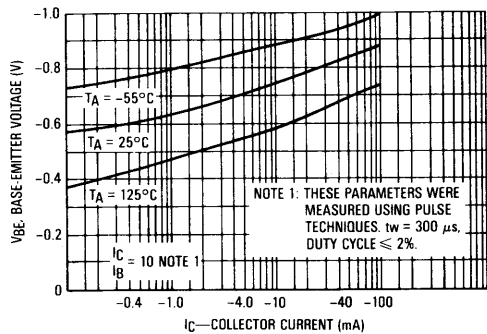


FIGURE 7 — f_r versus I_C

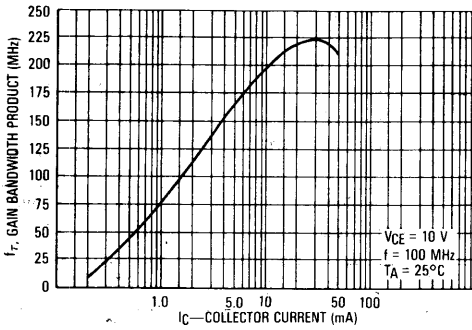


FIGURE 8 — C_{OB0} versus V_{CB}

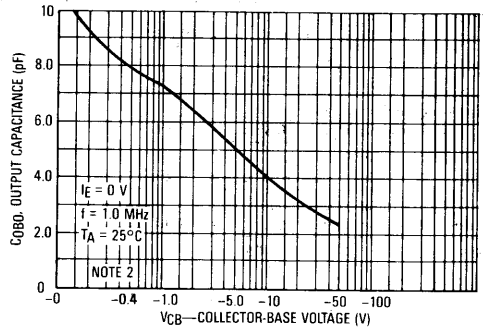
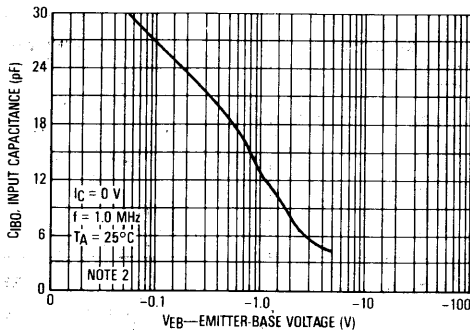


FIGURE 9 — C_{IB0} versus V_{EB}



NOTE 2: CAPACITANCE MEASURE MADE WITH TO-18 PACKAGE.

MAXIMUM RATINGS

Rating	Symbol	2N3498	2N3500	Unit
		2N3499	2N3501	
Collector-Emitter Voltage	V _{CEO}	100	150	Vdc
Collector-Base Voltage	V _{CBO}	100	150	Vdc
Emitter-Base Voltage	V _{EBO}	6.0		Vdc
Collector Current — Continuous	I _C	500	300	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0		Watt mW/°C
		5.71		
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0		Watts mW/°C
		28.6		
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	175	°C/W

2N3498 thru 2N3501

**JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)**

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) (I _C = 10 mAdc, I _B = 0)	2N3498, 2N3499 2N3500, 2N3501	V _{(BR)CEO}	100 150	— —	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	2N3498, 2N3499 2N3500, 2N3501	V _{(BR)CBO}	100 150	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)		V _{(BR)EBO}	6.0	— —	— —	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0, T _A = 150°C) (V _{CB} = 75 Vdc, I _E = 0) (V _{CB} = 75 Vdc, I _E = 0, T _A = 150°C)	2N3498, 2N3499 2N3500, 2N3501	I _{CBO}	— — — —	— — — —	0.050 50 0.050 50	μAdc
Emitter Cutoff Current (V _{BE(off)} = 4.0 Vdc, I _C = 0)		I _{EBO}	—	—	25	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 10 Vdc)	2N3498, 2N3500 2N3499, 2N3501	h _{FE}	20 35	— —	— —	—
(I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	2N3498, 2N3500 2N3499, 2N3501		25 50	— —	— —	—
(I _C = 10 mAdc, V _{CE} = 10 Vdc)	2N3498, 2N3500 2N3499, 2N3501		35 75	— —	— —	—
(I _C = 150 mAdc, V _{CE} = 10 Vdc)	2N3498, 2N3500 2N3499, 2N3501		40 100	— —	120 300	—
(I _C = 300 mAdc, V _{CE} = 10 Vdc)	2N3500 2N3501		15 20	— —	— —	—
(I _C = 500 mAdc, V _{CE} = 10 Vdc)	2N3498 2N3499		15 20	— —	— —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 5.0 mAdc) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc)	All Types All Types 2N3500, 2N3501 2N3498, 2N3499		V _{CE(sat)}	— — — —	— — — —	0.2 0.25 0.4 0.6

2N3498 thru 2N3501

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}, I_B = 5.0\text{ mAdc}$) ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$) ($I_C = 300\text{ mAdc}, I_B = 30\text{ mAdc}$)	All Types All Types 2N3500, 2N3501 2N3498, 2N3499	$V_{BE(sat)}$	—	—	0.8 0.9 1.2 1.4	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($V_{CE} = 20\text{ Vdc}, I_C = 20\text{ mAdc}, f = 100\text{ MHz}$)		f_T	150	—	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 100\text{ kHz}$)	2N3498, 2N3499 2N3500, 2N3501	C_{obo}	—	—	10 8.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 100\text{ kHz}$)		C_{ibo}	—	—	80	pF
Input Impedance ($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$)	2N3498, 2N3500 2N3499, 2N3501	h_{ie}	0.2 0.25	—	1.0 1.25	k ohms
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$)	2N3498, 2N3500 2N3499, 2N3501	h_{re}	—	—	2.5 4.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$)	2N3498, 2N3500 2N3499, 2N3501	h_{fe}	50 75	—	300 375	—
Output Admittance ($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$)	2N3498, 2N3500 2N3499, 2N3501	h_{oe}	—	—	100 200	μmhos

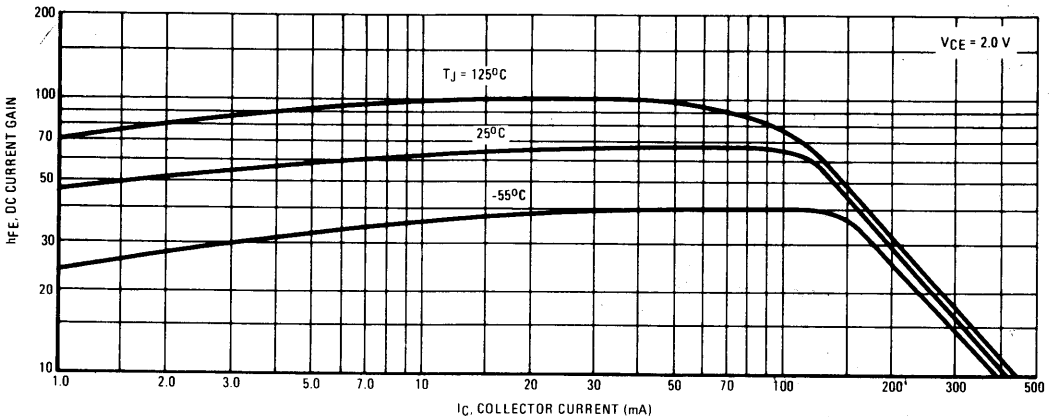
SWITCHING CHARACTERISTICS

Delay Time ($I_C = 150\text{ mAdc}, I_{B1} = 15\text{ mAdc}, V_{CC} = 100\text{ Vdc}, V_{BE(off)} = 2.0\text{ Vdc}$)		t_d	—	20	—	ns
Rise Time ($I_C = 150\text{ mAdc}, I_{B1} = 15\text{ mAdc}, V_{CC} = 100\text{ Vdc}, V_{BE(off)} = 2.0\text{ Vdc}$)		t_r	—	35	—	ns
Storage Time ($I_C = 150\text{ mAdc}, I_{B1} = I_{B2} = 15\text{ mAdc}, V_{CC} = 100\text{ Vdc}$)		t_s	—	800	—	ns
Fall Time ($I_C = 150\text{ mAdc}, I_{B1} = I_{B2} = 15\text{ mAdc}, V_{CC} = 100\text{ Vdc}$)		t_f	—	80	—	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 1 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3498



2N3499

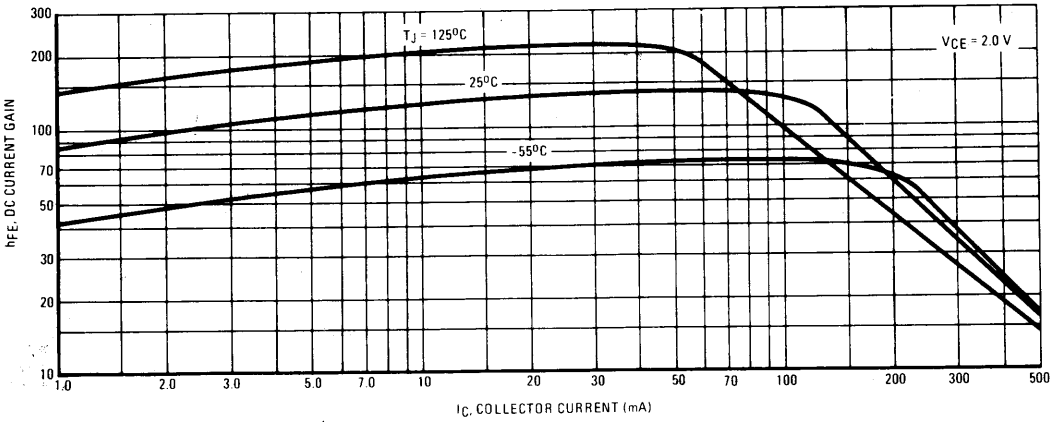


FIGURE 2 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

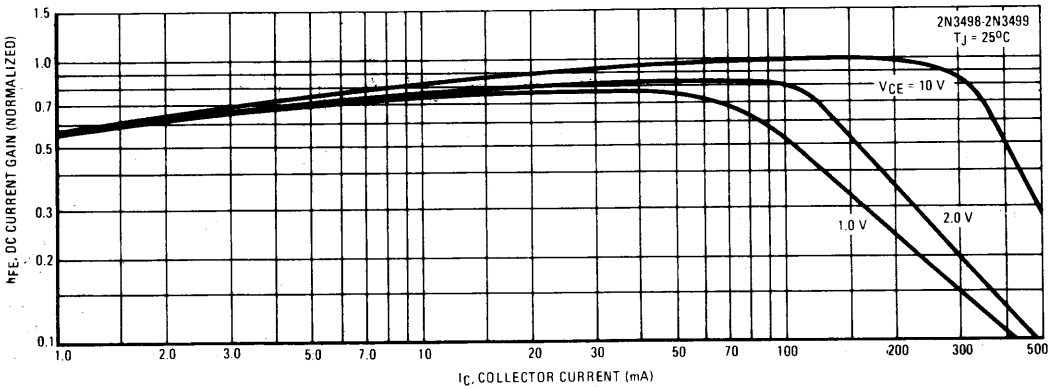
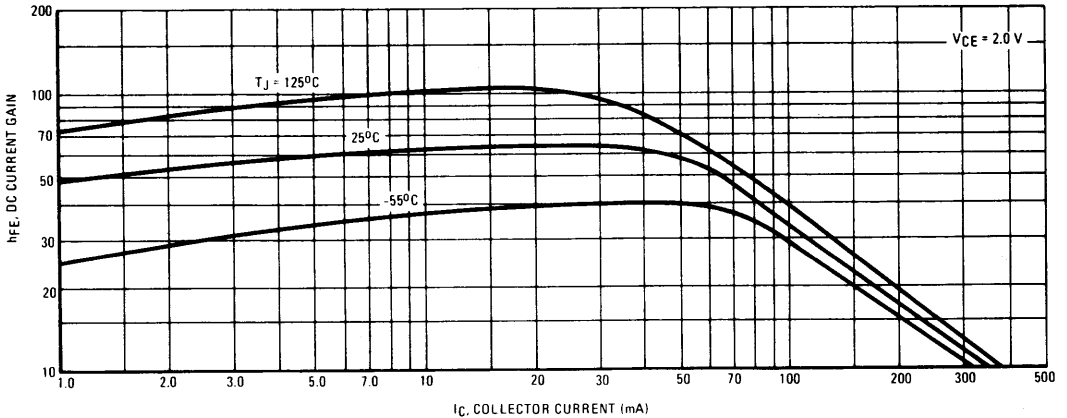


FIGURE 3 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3500



2N3498 thru 2N3501

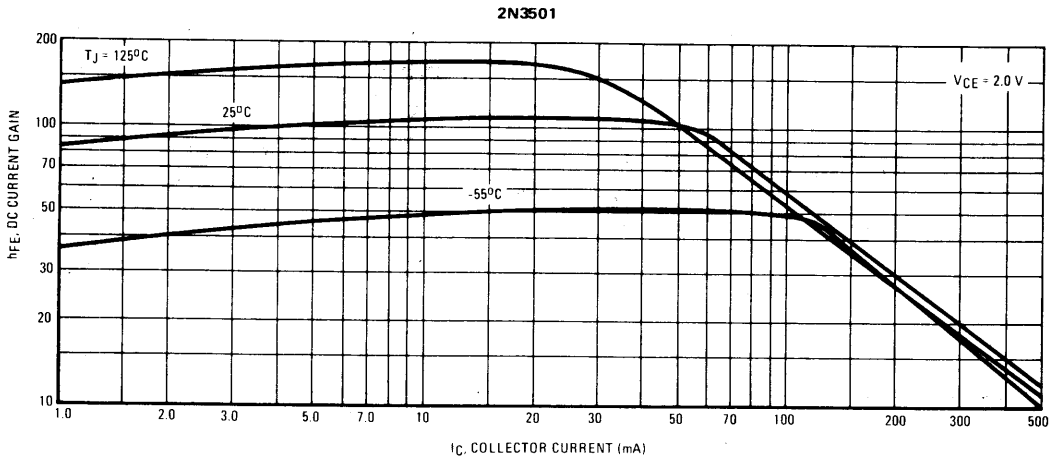


FIGURE 4 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

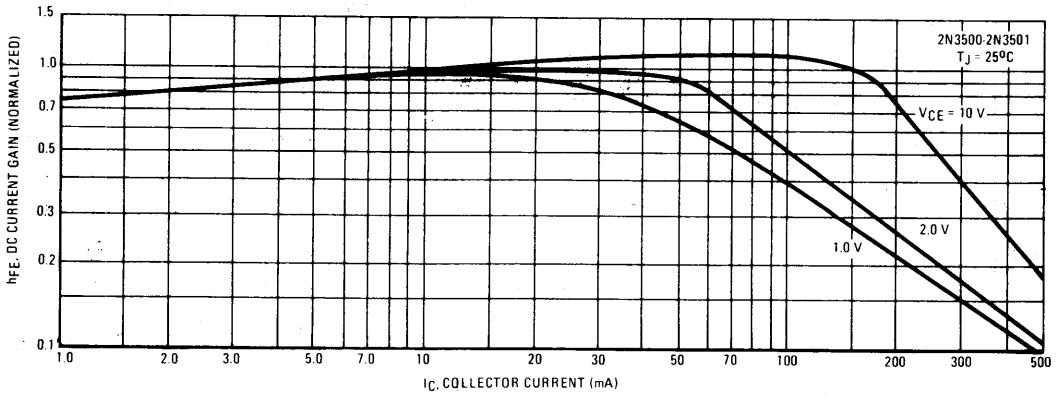
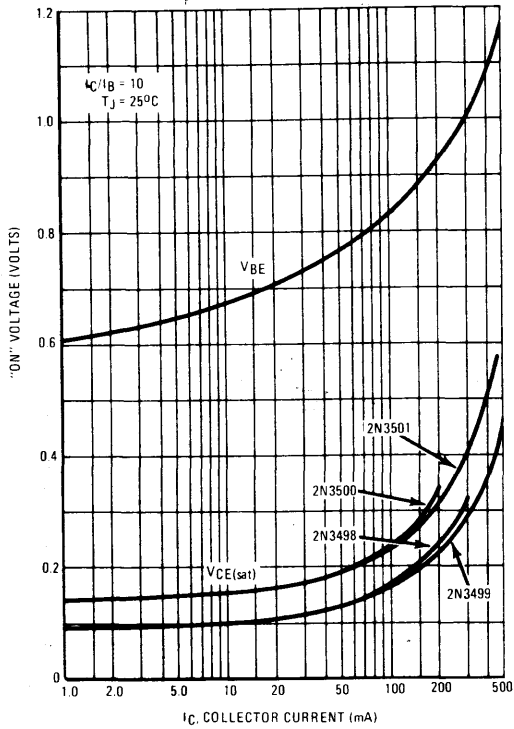


FIGURE 5 - "ON" VOLTAGES



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FIGURE 6 - TEMPERATURE COEFFICIENTS

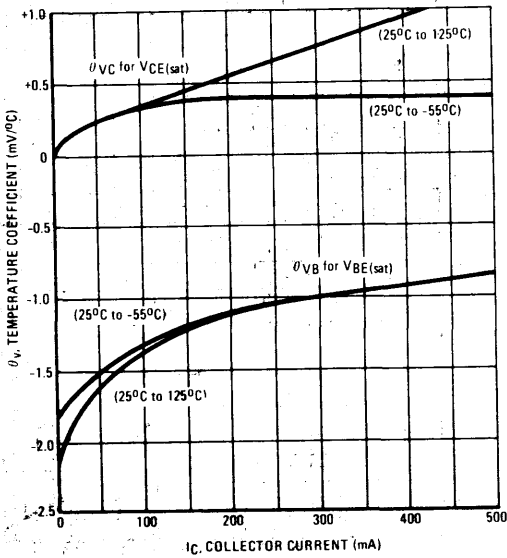
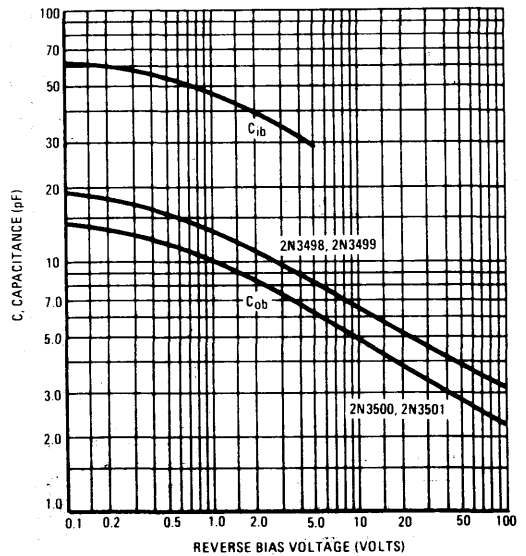


FIGURE 7 - CAPACITANCE



AUDIO SMALL-SIGNAL h PARAMETER CHARACTERISTICS

($V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$, $f = 1.0 \text{ kHz}$)

FIGURE 8 - CURRENT GAIN

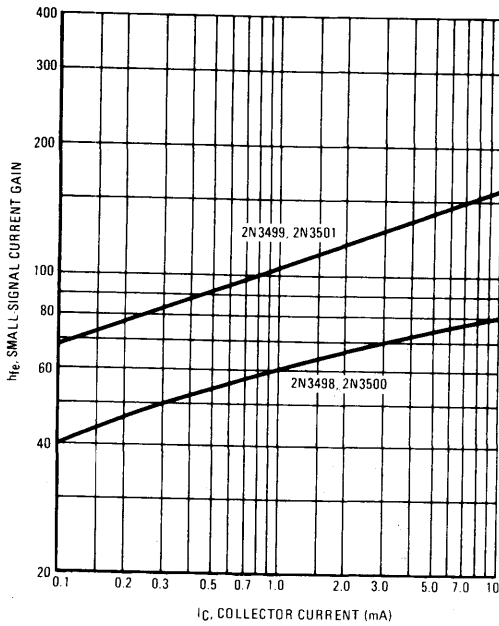


FIGURE 9 - OUTPUT IMPEDANCE

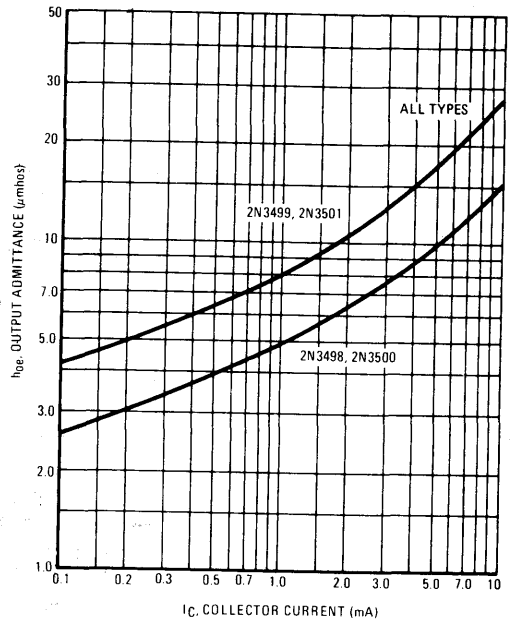


FIGURE 10 - INPUT IMPEDANCE

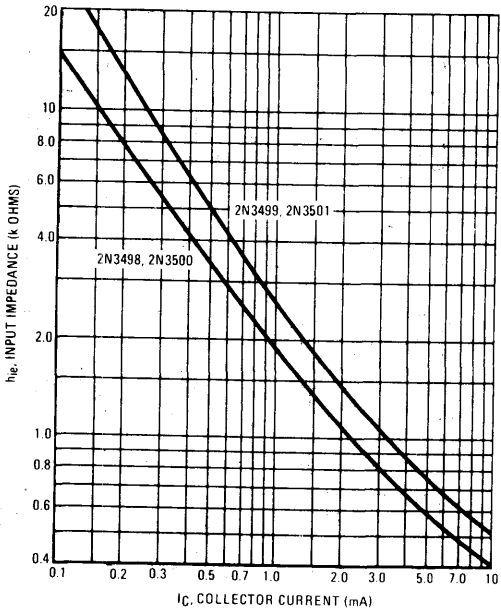
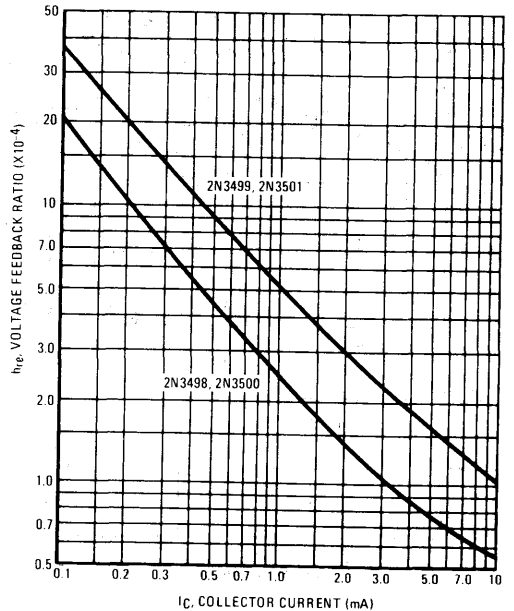


FIGURE 11 - VOLTAGE FEEDBACK RATIO



4

MAXIMUM RATINGS

Rating	Symbol	2N3506	2N3507	Unit
Collector-Emitter Voltage	V _{CEO}	40	50	Vdc
Collector-Base Voltage	V _{CBO}	60	80	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	3.0		Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0	5.71	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0	28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	0.175	°C/mW
Thermal Resistance, Junction to Ambient	R _{θJA}	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mA _{dc} , pulsed, I _B = 0)	V _{(BR)CEO}	40 50	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBQ}	60 80	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CE} = 40 Vdc, V _{EB(off)} = 4.0 Vdc) (V _{CE} = 40 Vdc, V _{EB(off)} = 4.0 Vdc, T _A = 100°C) (V _{CE} = 60 Vdc, V _{EB(off)} = 4.0 Vdc) (V _{CE} = 60 Vdc, V _{EB(off)} = 4.0 Vdc, T _A = 100°C)	I _{CEX}	— — — —	1.0 150 1.0 150	μA _{dc}
Base Cutoff Current (V _{CE} = 40 Vdc, V _{EB(off)} = 4.0 Vdc) (V _{CE} = 60 Vdc, V _{EB(off)} = 4.0 Vdc)	I _{BL}	— —	1.0 1.0	μA _{dc}
ON CHARACTERISTICS				
DC Current Gain(1) (I _C = 500 mA _{dc} , V _{CE} = 1.0 Vdc) (I _C = 1.5 A _{dc} , V _{CE} = 2.0 Vdc) (I _C = 2.5 A _{dc} , V _{CE} = 3.0 Vdc) (I _C = 3.0 A _{dc} , V _{CE} = 5.0 Vdc)	h _{FE}	50 35 40 30 30 25 25 20	— — 200 150 — — — —	—
Collector-Emitter Saturation Voltage(1) (I _C = 500 mA _{dc} , I _B = 50 mA _{dc}) (I _C = 1.5 A _{dc} , I _B = 150 mA _{dc}) (I _C = 2.5 A _{dc} , I _B = 250 mA _{dc})	V _{CE(sat)}	— — —	0.5 1.0 1.5	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 500 mA _{dc} , I _B = 50 mA _{dc}) (I _C = 1.5 A _{dc} , I _B = 150 mA _{dc}) (I _C = 2.5 A _{dc} , I _B = 250 mA _{dc})	V _{BE(sat)}	— 0.9 —	1.0 1.4 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 100 mA _{dc} , V _{CE} = 5 Vdc, f = 20 MHz)	f _T	60	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	40	pF
Input Capacitance (V _{BE} = 3 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	300	pF

2N3506
2N3507

JAN, JTX, JTXV AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

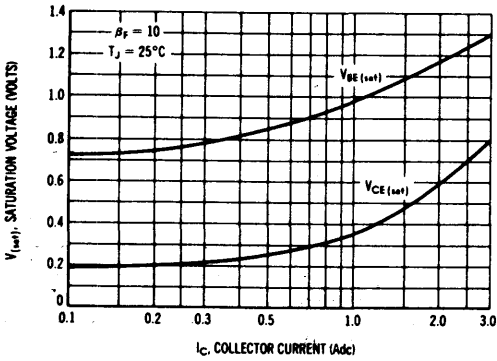
2N3506, 2N3507

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

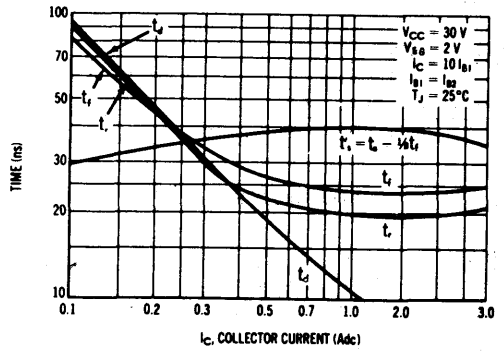
Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	$I_C = 1.5 \text{ Adc}, I_{B1} = 150 \text{ mAdc}$	t_d	—	15	ns
Rise Time	$V_{CC} = 30 \text{ V}, V_{EB} = 0 \text{ V}$	t_r	—	30	ns
Storage Time	$I_C = 1.5 \text{ Adc}, I_{B1} = I_{B2} = 150 \text{ mAdc}$	t_s	—	55	ns
Fall Time	$V_{CC} = 30 \text{ V}$	t_f	—	35	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle = 2.0%.

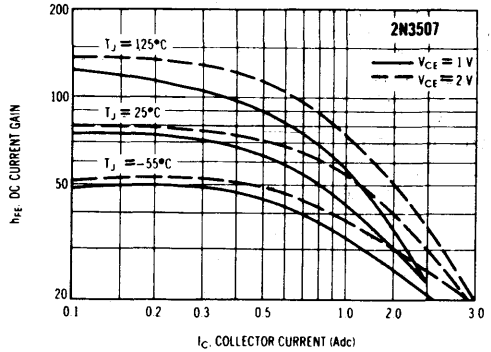
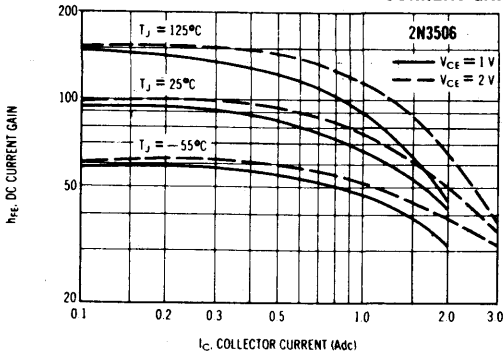
SATURATION VOLTAGES



SWITCHING TIMES



CURRENT GAIN CHARACTERISTICS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	Vdc
Collector-Emitter Voltage	V _{CES}	40	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current (10 μs pulse) (Peak)	I _C	500	mA
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.40 2.29	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.0 11.43	Watts mW/°C
Operating and Storage Temperature Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	0.0875	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	0.438	°C/W

2N3508
2N3509

CASE 26, STYLE 1
TO-46 (TO-206AB)

SWITCHING TRANSISTOR

NPN SILICON

4

Refer to 2N2368 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _B = 0)	V _{(BR)CBO}	40	—	Vdc	
Collector-Emitter Breakdown Voltage (1) (I _C = 10 mAdc)	V _{(BR)CEO}	20	—	Vdc	
Collector-Emitter Voltage (I _C = 10 μAdc, I _B = 0)	V _{(BR)CES}	40	—	Vdc	
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	Vdc	
Collector Cutoff Current (V _{CE} = 20 Vdc, V _{EB(off)} = 3.0 Vdc)	I _{CEX}	—	0.2	μAdc	
Collector Cutoff Current (V _{CB} = 20 Vdc) (V _{CB} = 20 Vdc, T _A = 150°C)	I _{CBO}	—	0.2 30 50	μAdc	
Base Cutoff Current (V _{CE} = 20 Vdc, V _{EB(off)} = 3.0 Vdc)	I _{BL}	—	0.5	μAdc	
ON CHARACTERISTICS					
DC Current Gain (I _C = 10 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	40 100	2N3508 2N3509	120 300	
(I _C = 10 mAdc, V _{CE} = 1.0 Vdc, T _A = -55°C)			2N3508 2N3509	20 40	— —
(I _C = 100 mAdc, V _{CE} = 1.0 Vdc)			2N3508 2N3509	20 30	— —
Collector-Emitter Saturation Voltage (1) (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc)	V _{CE(sat)}	—	0.25 0.45	Vdc	
Base-Emitter Saturation Voltage (1) (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc)	V _{BE(sat)}	0.70 0.8	0.85 1.4	Vdc	
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	4.0	pF	

2N3508, 2N3509

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance ($V_{BE} = 1.0\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ibo}	—	4.0	pF
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	h_{fe}	5.0	—	—

SWITCHING CHARACTERISTICS

Storage Time ($I_C = I_{B1} = I_{B2} = 10\text{ mA}$)	$t_s(\tau_s)$	—	13	ns	
Turn-On Time ($I_C = 10\text{ mA}$, $I_{B1} = 3.0\text{ mA}$, $V_{CC} = 3.0\text{ V}$, $V_{OB} = 1.5\text{ V}$)	t_{on}	—	12	ns	
Turn-Off Time ($I_C = 10\text{ mA}$, $I_{B1} = 3.0\text{ mA}$, $I_{B2} = 1.5\text{ mA}$, $V_{CC} = 3.0\text{ V}$)	t_{off}	—	18	ns	
Total Control Charge ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$, $V_{CC} = 3.0\text{ V}$)	Q_r	—	50	pC	
Delay Time	$V_{CC} = 10\text{ V}$, $V_{EB} = 2.0\text{ V}$, $I_C = 100\text{ mA}$, $I_{B1} = 10\text{ mA}$	t_d	—	5.0	ns
Rise Time		t_r	—	18	ns
Storage Time	$V_{CC} = 10\text{ V}$, $I_C = 100\text{ mA}$, $I_{B1} = I_{B2} = 10\text{ mA}$	t_s	—	13	ns
Fall Time		t_f	—	15	ns

(1) Pulse Test: $PW = 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N3510 2N3511

CASE 27, STYLE 1
TO-52 (TO-206AC)

2N3647 2N3648

CASE 26, STYLE 1
TO-46 (TO-206AB)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3510 2N3647	2N3511 2N3648	Unit
Collector-Emitter Voltage	V _{CEO}	10	15	Vdc
Collector-Base Voltage	V _{CBO}	40	40	Vdc
Emitter-Base Voltage	V _{EBO}	6.0		Vdc
Collector Current — Continuous	I _C	500		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	TO-46 2N3647 2N3648	TO-52 2N3510 2N3511	mW mW/°C
		400 2.28	360 2.06	
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.0 11.43	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	10 15	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	Vdc
Collector Cutoff Current (V _{CE} = 10 Vdc, V _{EB(off)} = 1.0 Vdc) (V _{CE} = 10 Vdc, V _{EB(off)} = 1.0 Vdc, T _A = 150°C)	I _{CEX}	— —	.025 50	μAdc
Base Cutoff Current (V _{CE} = 10 Vdc, V _{OB} = 1.0 Vdc)	I _{BL}	—	.025	μAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	12 15	— —	—
(I _C = 10 mAdc, V _{CE} = 1.0 Vdc)		20 25	— —	
(I _C = 150 mAdc, V _{CE} = 1.0 Vdc)		25 30	150 120	
(I _C = 150 mAdc, V _{CE} = 1.0 Vdc, T _A = -55°C)		12	—	
(I _C = 300 mAdc, V _{CE} = 1.0 Vdc)		15	—	
(I _C = 500 mAdc, V _{CE} = 1.0 Vdc)		12	—	
Collector-Emitter Saturation Voltage(1) (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	— — — —	0.25 0.4 0.6 0.8	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 300 mAdc, I _B = 30 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{BE(sat)}	— 0.8 — —	0.8 1.0 1.15 1.5	Vdc

2N3510, 2N3511 / 2N3647, 2N3648

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

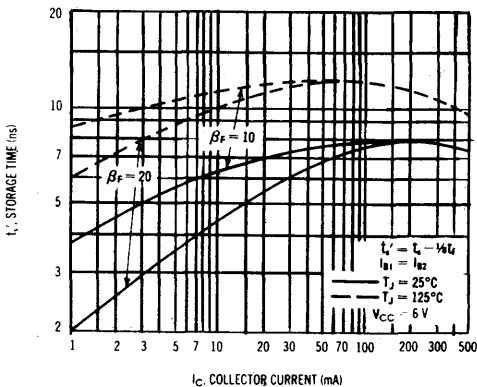
Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 100\text{ kHz}$)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 100\text{ kHz}$)	C_{ibo}	—	8.0	pF
Input Impedance ($I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V}, f = 1.0\text{ kHz}$)	h_{ie}	0.6	4.5	kohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V}, f = 1.0\text{ kHz}$)	h_{re}	—	25	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 15\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 100\text{ MHz}$)	h_{fe}	2N3510, 2N3647	3.5	—
($I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V}, f = 1.0\text{ kHz}$)		2N3511, 2N3648	4.5	—
Output Admittance ($I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V}, f = 1.0\text{ kHz}$)	h_{oe}	10	100	μmhos

SWITCHING CHARACTERISTICS

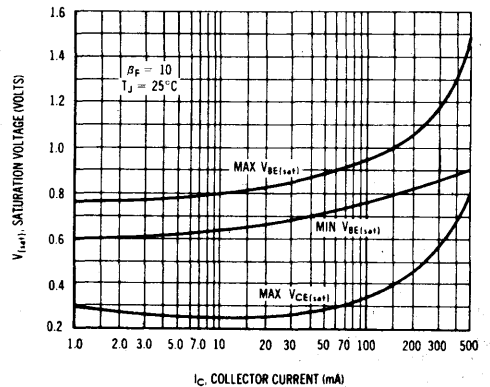
Delay Time	$(I_C = 150\text{ mA}, I_{B1} = 15\text{ mA}, V_{EB} = 0.5\text{ V}, V_{CC} = 6.0\text{ V})$	2N3510, 2N3647 2N3511, 2N3648	t_d	—	10	ns
Rise Time				—	8.0	
Storage Time	$(I_C = 150\text{ mA}, I_{B1} = -I_{B2} = 15\text{ mA}, V_{CC} = 6.0\text{ V})$	2N3510, 2N3647 2N3511, 2N3648	t_s	—	16	ns
Fall Time				—	12	
Turn-On Time	$(I_C = 150\text{ mA}, I_{B1} = 15\text{ mA}, V_{EB} = 0.5\text{ V}, V_{CC} = 6.0\text{ V})$	2N3510, 2N3647 2N3511, 2N3648	t_{on}	—	20	ns
Turn-Off Time				—	16	
Turn-Off Time	$(I_C = 150\text{ mA}, I_{B1} = -I_{B2} = 15\text{ mA}, V_{CC} = 6.0\text{ V})$	2N3510, 2N3647 2N3511, 2N3648	t_{off}	—	25	ns
Total Control Charge				—	18	
$(I_C = 150\text{ mA}, I_B = 15\text{ mA}, V_{CC} = 6.0\text{ V})$	Q_T	—	300	pC		

(1) Pulse Test: $PW \leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

STORAGE TIME VARIATION

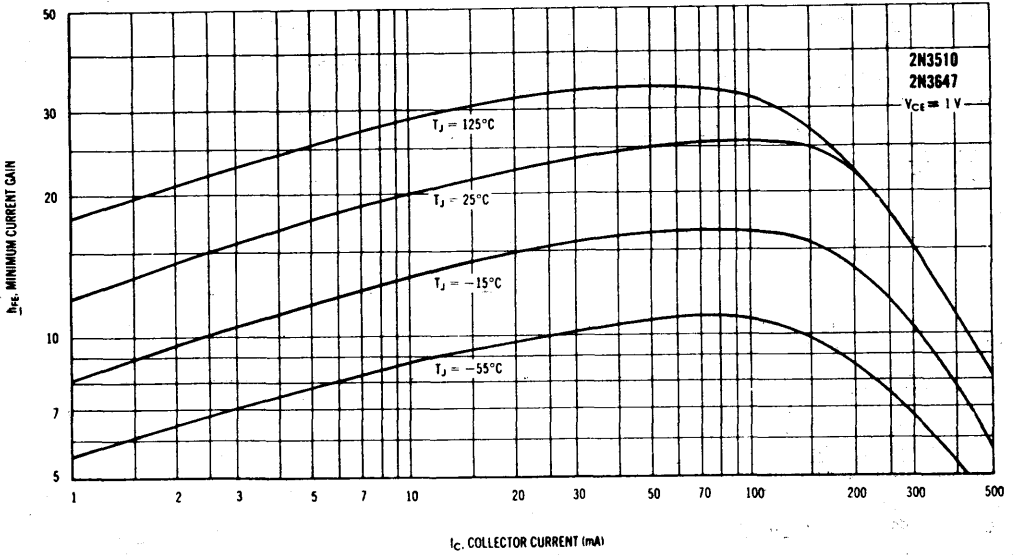
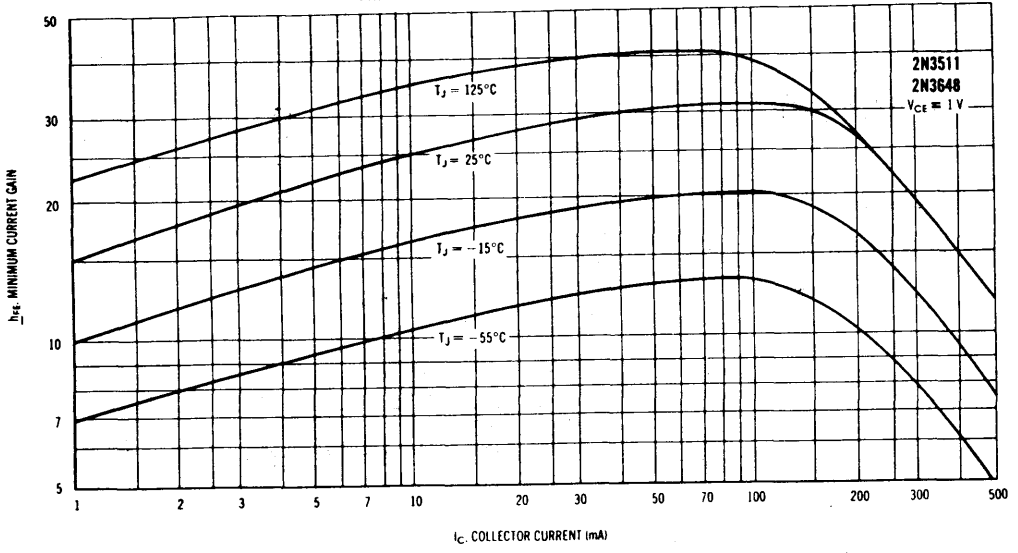


LIMITS OF SATURATION VOLTAGE



2N3510, 2N3511 / 2N3647, 2N3648

MINIMUM CURRENT GAIN CHARACTERISTICS



4

2N3546

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
DC Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.9	Watts mW/ $^\circ\text{C}$
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.5	—	Vdc
Base Cutoff Current ($V_{CE} = 10\text{ Vdc}, V_{BE(off)} = 3.0\text{ Vdc}$)	I_{BEV}	—	0.10	μAdc
Collector Cutoff Current ($V_{CE} = 10\text{ Vdc}, V_{BE(off)} = 3.0\text{ Vdc}$)	I_{CEX}	—	0.010	μAdc
Collector Cutoff Current ($V_{CB} = 10\text{ Vdc}$) ($V_{CB} = 10\text{ Vdc}, T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.010 10	μAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 1.0\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 50\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$) ($I_C = 100\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	20 30 15 25 15	— 120 — — —	—
Collector-Emitter Saturation Voltage (1) ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}, I_B = 5.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}, I_B = 10\text{ mAdc}$)	$V_{CE(sat)}$	— — —	0.15 0.25 0.50	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}, I_B = 5.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}, I_B = 10\text{ mAdc}$)	$V_{BE(sat)}$	0.7 0.8 —	0.9 1.3 1.6	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 100\text{ MHz}$)	f_T	700	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 1.0\text{ MHz}$)	C_{ibo}	—	5.0	pF

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Delay Time	$I_C = 50\text{ mA}, I_{B1} = 5.0\text{ mA}$ $V_{BE} = 2.0\text{ V}, V_{CC} = 3.0\text{ V}$	—	10	ns
Rise Time				
Storage Time	$I_C = 50\text{ mA}, I_{B1} = I_{B2} = 5.0\text{ mA}$ $V_{CC} = 3.0\text{ V}$	—	20	ns
Fall Time				
Turn-On Time		—	40	ns
Turn-Off Time				
Total Control Charge ($I_C = 50\text{ mA}, I_B = 5.0\text{ mA}, V_{CC} = 3.0\text{ V}$)	Q_T	—	400	pC

(1) Pulse Test: $PW = 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1

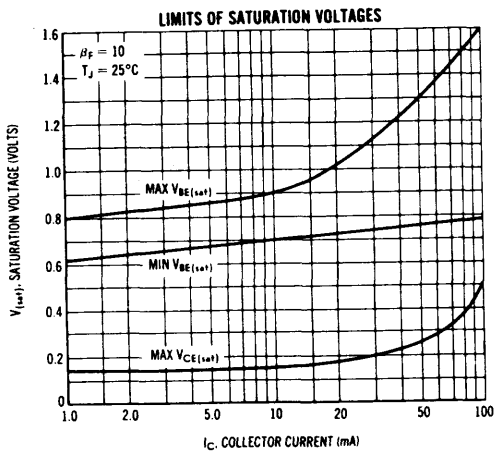


FIGURE 2

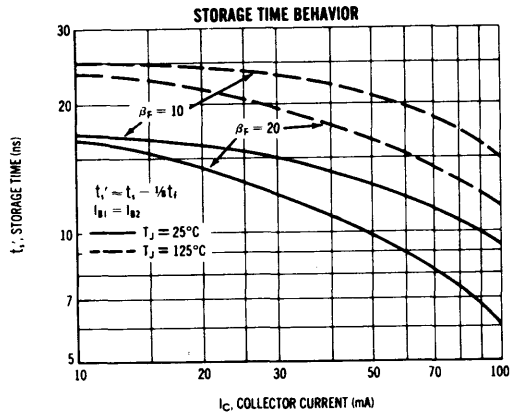
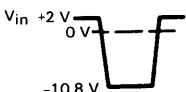
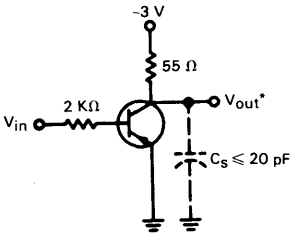


FIGURE 3

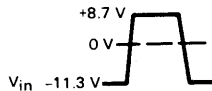
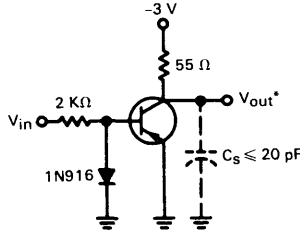
DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT



PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE $\leq 10\%$

FIGURE 4

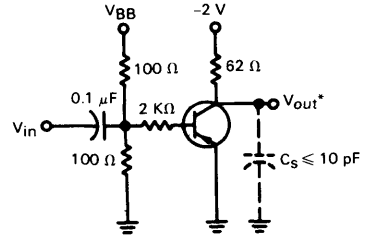
STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE $\leq 10\%$

FIGURE 5

SWITCHING TIME TEST CIRCUIT

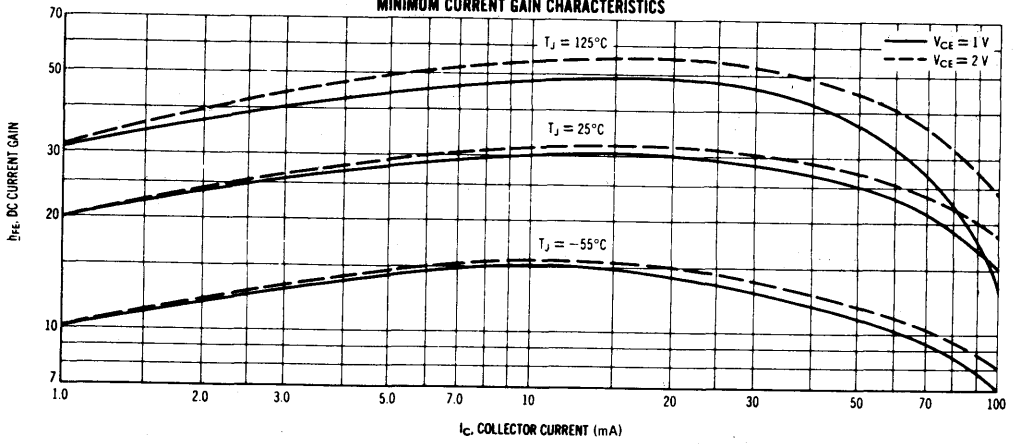


PULSE WIDTH > 200 ns
RISE TIME < 2 ns
 $Z_{in} = 50\ \Omega$

t_{on} : $V_{BB} = +3\text{ V}, V_{in} = -7\text{ V}$
 t_{off} : $V_{BB} = -4\text{ V}, V_{in} = +6\text{ V}$

*OSCILLOSCOPE RISE TIME ≤ 1 ns

FIGURE 6
MINIMUM CURRENT GAIN CHARACTERISTICS



4

2N3634 thru 2N3637

JAN, JTX AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-39-205AD)

HIGH VOLTAGE
TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3634	2N3636	Unit
		2N3635	2N3637	
Collector-Emitter Voltage	V _{CEO}	140	175	V _{dc}
Collector-Base Voltage	V _{CBO}	140	175	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0		V _{dc}
Collector Current — Continuous	I _C	1.0		A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0	1.0	Watt
		5.71		mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0	5.0	Watts
		28.6		mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mA _{dc} , I _B = 0)	2N3634, 2N3635 2N3636, 2N3637	V _{(BR)CEO}	140 175	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	2N3634, 2N3635 2N3636, 2N3637	V _{(BR)CBO}	140 175	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)		V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 100 V _{dc} , I _E = 0)		I _{CBO}	—	100	nA _{dc}
Emitter Cutoff Current (V _{BE} = 3.0 V _{dc} , I _C = 0)		I _{EBO}	—	50	nA _{dc}

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 0.1 mA _{dc} , V _{CE} = 10 V _{dc})	2N3634, 2N3636 2N3635, 2N3637	h _{FE}	40 80	— —	—
(I _C = 1.0 mA _{dc} , V _{CE} = 10 V _{dc})	2N3634, 2N3636 2N3635, 2N3637		45 90	— —	
(I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc})	2N3634, 2N3636 2N3635, 2N3637		50 100	— —	
(I _C = 50 mA _{dc} , V _{CE} = 10 V _{dc})	2N3634, 2N3636 2N3635, 2N3637		50 100	150 300	
(I _C = 150 mA _{dc} , V _{CE} = 10 V _{dc})	2N3634, 2N3636 2N3635, 2N3637		25 50	— —	
Collector-Emitter Saturation Voltage(1) (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})		V _{CE(sat)}	— —	0.3 0.5	V _{dc}
Base-Emitter Saturation Voltage(1) (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})		V _{BE(sat)}	— 0.65	0.8 0.9	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (V _{CE} = 30 V _{dc} , I _C = 30 mA _{dc} , f = 100 MHz)	2N3634, 2N3636 2N3635, 2N3637	f _T	150 200	— —	MHz
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2N3634 thru 2N3637

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{obo}	—	10	pF
Input Capacitance ($V_{BE} = 1.0\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ibo}	—	75	pF
Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	100 200	600 1200	ohms
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	—	3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	40 80	160 320	—
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	—	200	μmhos
Noise Figure ($I_C = 0.5\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 1.0\text{ k ohms}$, $f = 1.0\text{ kHz}$)	NF	—	3.0	dB

SWITCHING CHARACTERISTICS

Turn-On Time	($V_{CC} = 100\text{ Vdc}$, $V_{BE} = 4.0\text{ Vdc}$, $I_C = 50\text{ mAdc}$, $I_{B1} = I_{B2} = 5.0\text{ mAdc}$)	t_{on}	—	400	ns
Turn-Off Time		t_{off}	—	600	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 — JUNCTION CAPACITANCE VARIATIONS

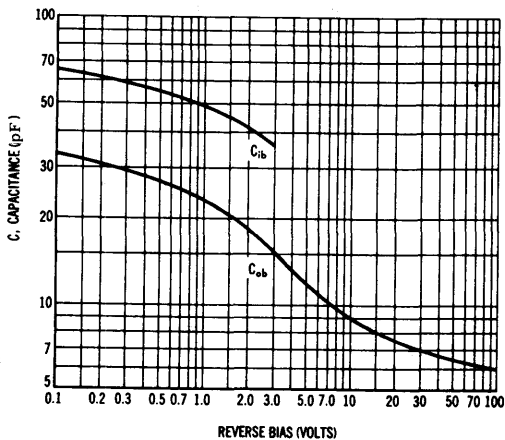


FIGURE 2 — GAIN-BANDWIDTH PRODUCT

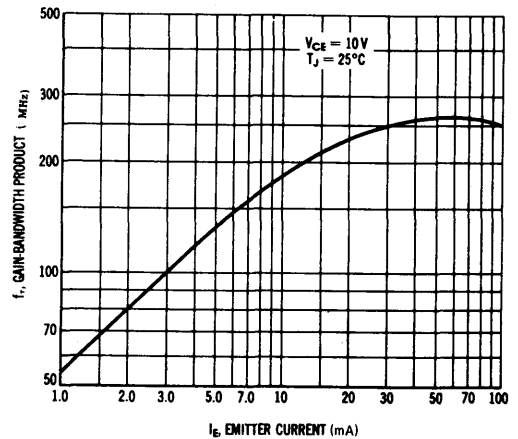
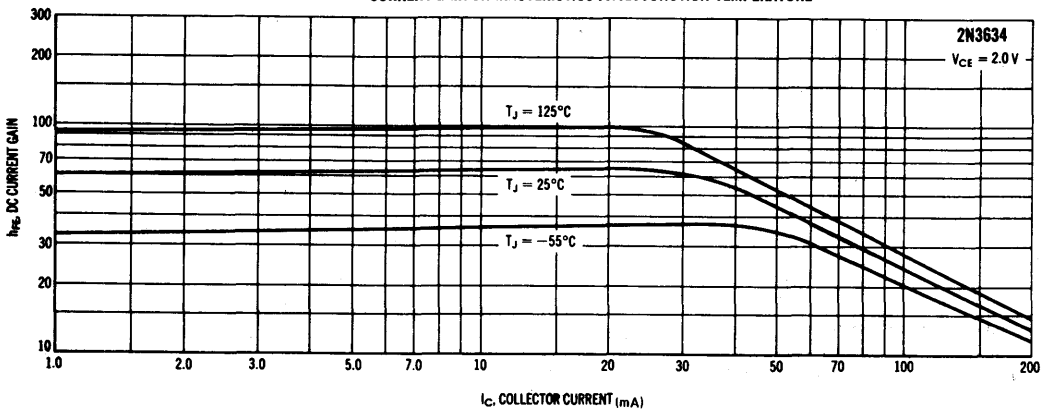


FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



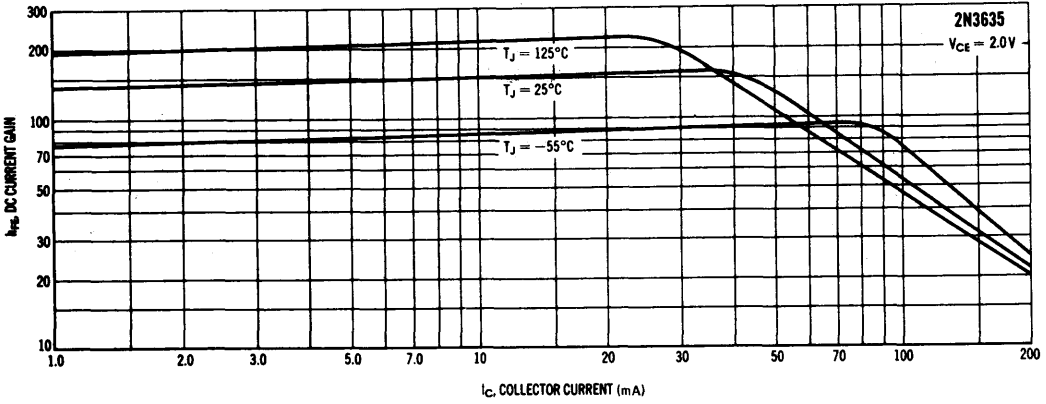


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

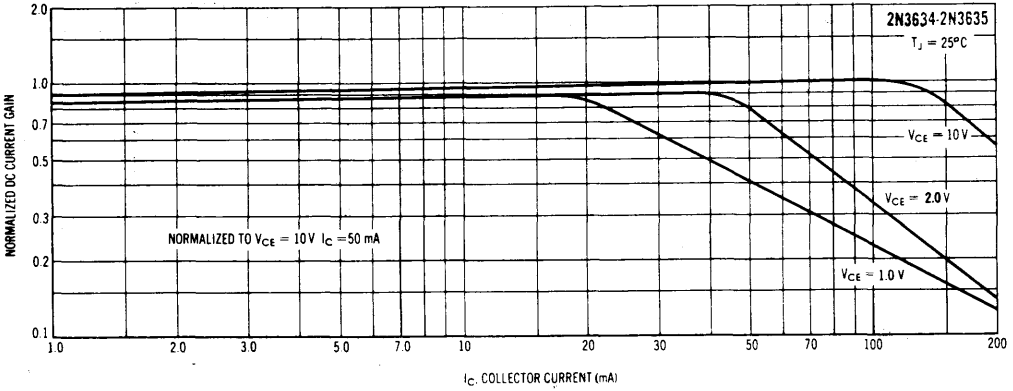
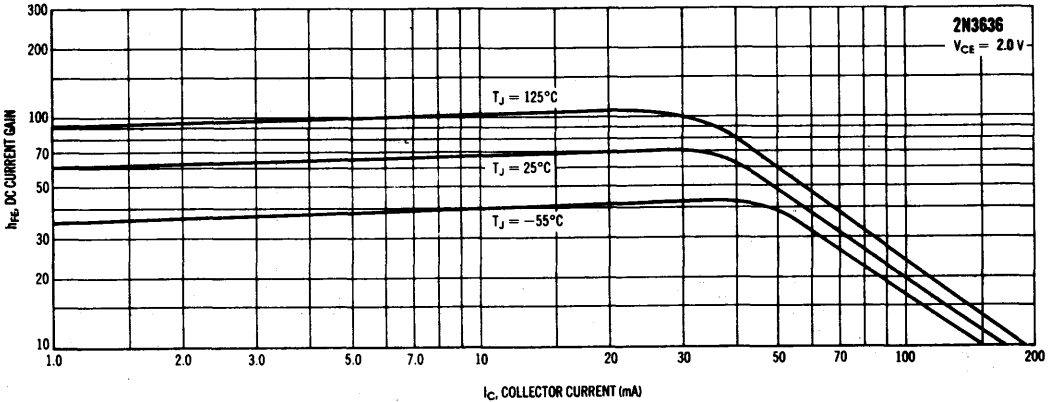


FIGURE 5 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



2N3634 thru 2N3637

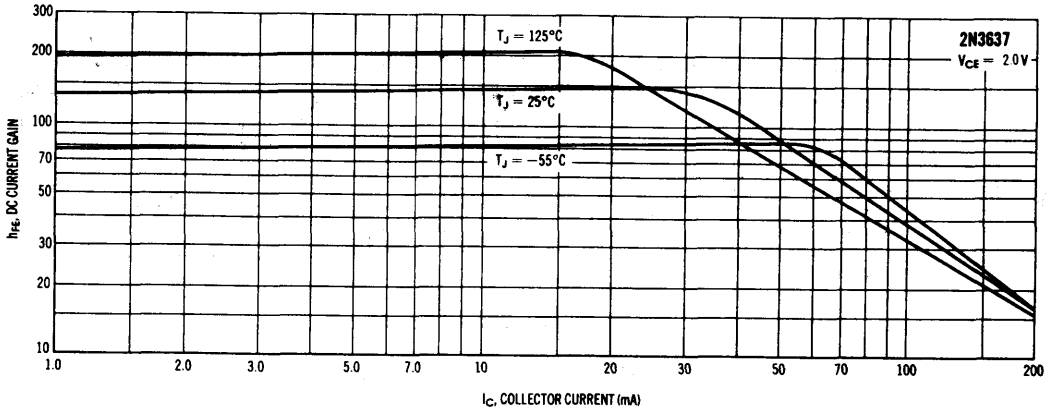


FIGURE 6 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

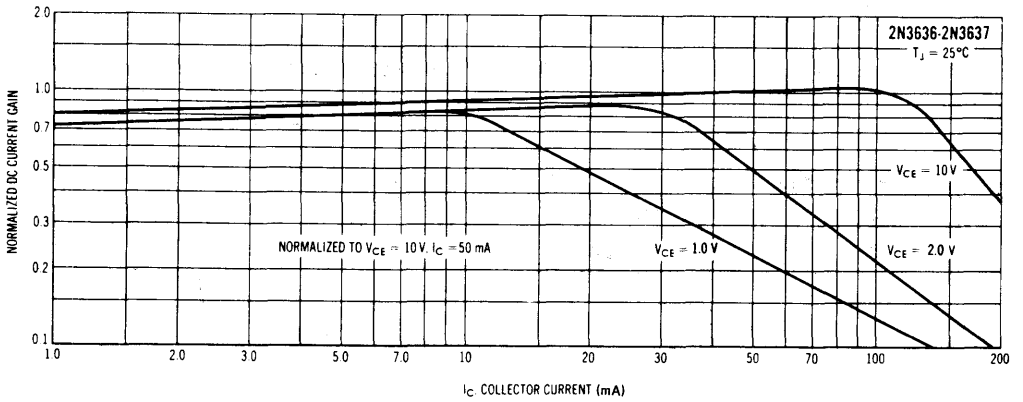


FIGURE 7 — INPUT IMPEDANCE

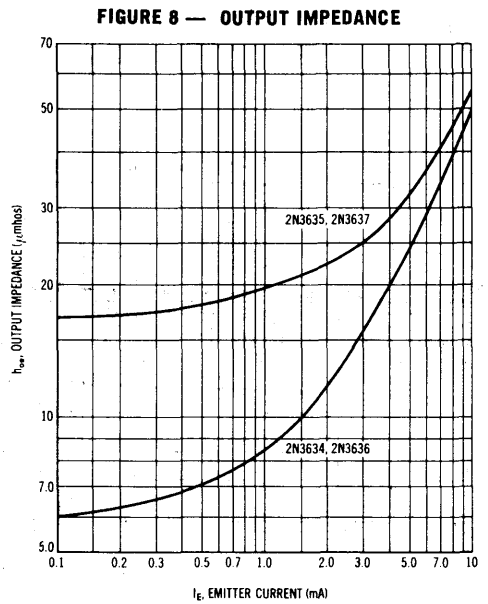


FIGURE 8 — OUTPUT IMPEDANCE

FIGURE 9 — CURRENT GAIN

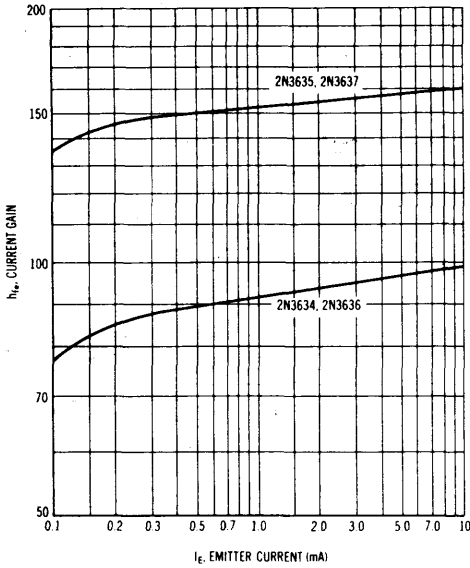


FIGURE 10 — VOLTAGE FEEDBACK RATIO

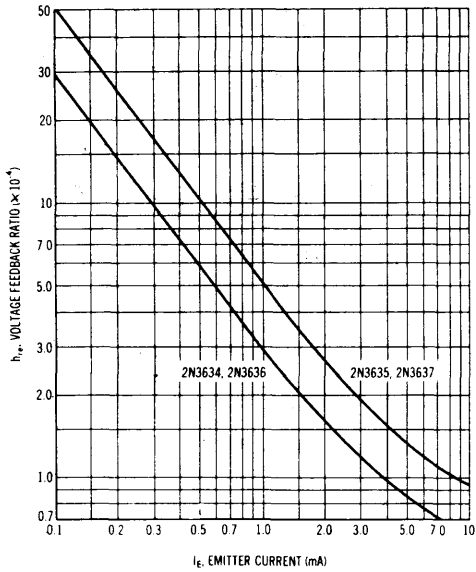


FIGURE 11 — SATURATION VOLTAGES

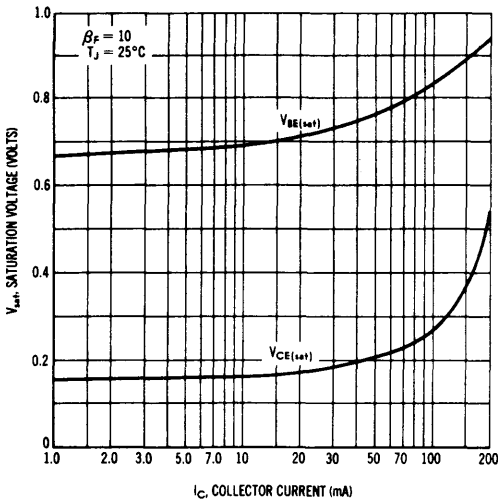


FIGURE 12 — TEMPERATURE COEFFICIENTS

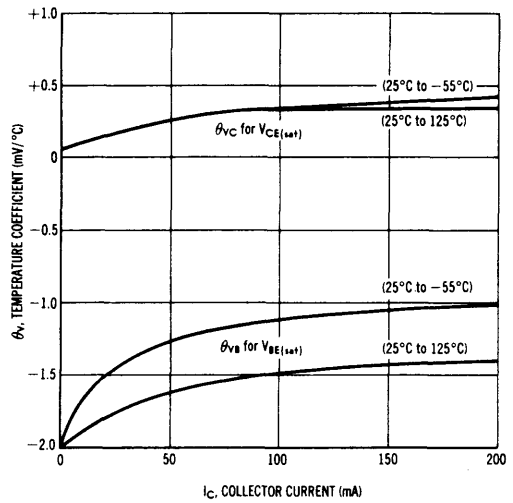
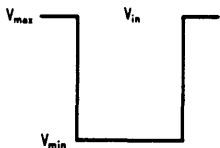
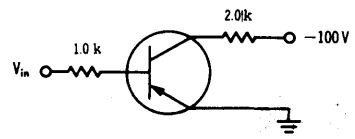


FIGURE 13 — SWITCHING TIME TEST CIRCUIT



P.W. $\approx 20 \mu\text{s}$
 DUTY CYCLE $\leq 2\%$
 RISE TIME $\leq 20 \text{ ns}$

	V_{max}	V_{min}
TURN-ON	+4.0 V	-5.65 V
TURN-OFF	+4.1 V	-5.9 V



2N3634 thru 2N3637

FIGURE 14 — TURN-ON TIME VARIATIONS WITH VOLTAGE

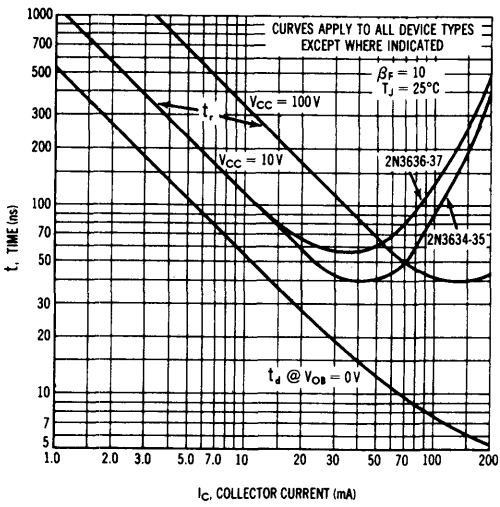
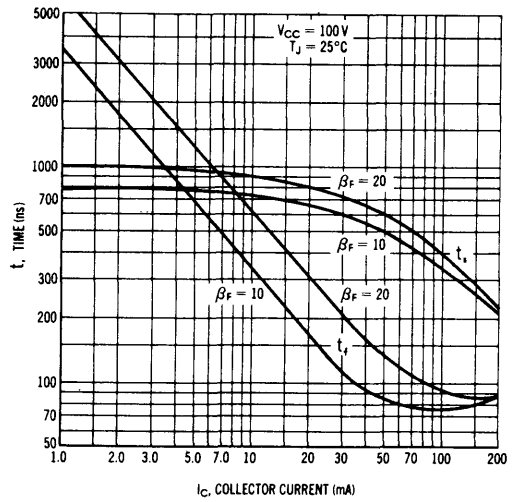


FIGURE 15 — TURN-OFF TIME VARIATIONS WITH CIRCUIT GAIN*



2N3647, 2N3648

For Specifications, See 2N3510 Data.

2N3677

CASE 026-03, STYLE 1
TO-46 (TO-206AB)

LOW POWER CHOPPER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	20	V
Collector-Base Voltage	V_{CBO}	30	V
Emitter-Base Voltage	V_{EBO}	30	V
Collector Current — Continuous	I_C	100	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	400 2.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Emitter-Collector Breakdown Voltage ($I_C = 1.0 \text{ nA}$)	$V_{(BR)ECS}$	20	—	V
Collector-Base Breakdown Voltage ($I_C = 1.0 \text{ mA}$)	$V_{(BR)CBO}$	30	—	V
Emitter-Base Breakdown Voltage ($I_E = 1.0 \text{ mA}$)	$V_{(BR)EBO}$	30	—	V
Collector Cutoff Current ($V_{CB} = 30 \text{ V}$)	I_{CBO}	—	1.0	nA
Emitter Cutoff Current ($V_{EB} = 30 \text{ V}$)	I_{EBO}	—	1.0	nA

ON CHARACTERISTICS

Offset Voltage ($I_B = 1.0 \text{ mA}$)	$V_{EC(ofs)}$	—	1.0	mV
Common-Collector static forward transfer ratio ($I_E = 1.0 \text{ mA}, V_{EC} = 6.0 \text{ V}$)	h_{fe}	4.0	—	—
On series resistance ($I_B = 1.0 \text{ mA}$)	r_s	0.1	8.0	ohms

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 6.0 \text{ V}, f = 159 \text{ kHz}$)	C_{obo}	—	10	pF
Input Capacitance ($V_{EB} = 6.0 \text{ V}, f = 159 \text{ kHz}$)	C_{ibo}	—	6.0	pF
Magnitude of Forward Current Transfer Ratio, Common-Emitter ($I_C = 1.0 \text{ mA}, V_{CE} = 6.0 \text{ V}, f = 1.0 \text{ MHz}$)	$ h_{fe} $	5.0	—	—

2N3724 2N3725

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3724	2N3725	Unit
Collector-Emitter Voltage	V_{CE0}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	50	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8	4.6	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.5	2.0	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	2N3725 2N3724	$V_{(BR)CEO}$	50 30	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{Adc}, V_{BE} = 0$)	2N3725 2N3724	$V_{(BR)CES}$	80 50	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	2N3725 2N3724	$V_{(BR)CBO}$	80 50	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$) ($V_{CB} = 40 \text{ Vdc}, I_E = 0$) ($V_{CB} = 60 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$) ($V_{CB} = 60 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$)	2N3725 2N3724 2N3725 2N3724	I_{CBO}	— — — —	0.12 0.12 — —	μAdc
Collector Cutoff Current ($V_{CE} = 80 \text{ Vdc}, V_{EB} = 0$) ($V_{CE} = 50 \text{ Vdc}, V_{EB} = 0$)	2N3725 2N3724	I_{CES}	— —	0.15 0.15	μAdc
Base Current ($V_{CE} = 50 \text{ V}, V_{EB} = 0$) ($V_{CE} = 80 \text{ V}, V_{EB} = 0$)	2N3724 2N3725	I_B	—	—	μAdc

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 300 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 800 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 800 \text{ mA}, V_{CE} = 2.0 \text{ V}$) ($I_C = 1.0 \text{ Adc}, V_{CE} = 5.0 \text{ V}$)	2N3725 2N3725 2N3725 2N3725 2N3725 2N3725 2N3725 2N3725 2N3725	h_{FE}	30 60 30 40 35 20 25 30 20 25	— — — — — — — — — —	— 150 — — — — — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	2N3725 2N3724	$V_{CE(sat)}$	— —	0.17 0.17	0.25 0.25	Vdc

2N3724, 2N3725

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
$(I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc})$	2N3725	—	0.19	0.26	
	2N3724	—	0.19	0.20	
$(I_C = 300 \text{ mAdc}, I_B = 30 \text{ mAdc})$	2N3725	—	0.25	0.40	
	2N3724	—	0.25	0.32	
$(I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc})$	2N3725	—	0.30	0.52	
	2N3724	—	0.30	0.42	
$(I_C = 800 \text{ mAdc}, I_B = 80 \text{ mAdc})$	2N3725	—	0.43	0.80	
	2N3724	—	0.43	0.65	
$(I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc})$	2N3725	—	0.55	0.95	
	2N3724	—	0.55	0.75	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	—	—	0.76	Vdc
$(I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc})$					
$(I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc})$					
$(I_C = 300 \text{ mAdc}, I_B = 30 \text{ mAdc})$					
$(I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc})$					
$(I_C = 800 \text{ mAdc}, I_B = 80 \text{ mAdc})$					
$(I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc})$	—	—	—	1.7	

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) $(I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz})$	f_T	300	—	—	MHz
Output Capacitance $(V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz})$	C_{obo}	2N3725	—	10	pF
		2N3724	—	12	
Input Capacitance $(V_{EB} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz})$	C_{ibo}	—	—	55	pF

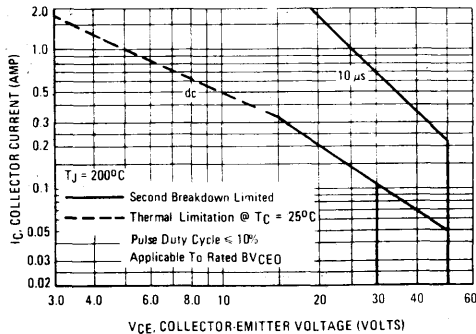
(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle = 1.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$.

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30 \text{ Vdc}, V_{BE(off)} = 3.8 \text{ Vdc}, I_C = 500 \text{ mAdc}, I_{B1} = 50 \text{ mAdc})$ (Figures 8, 10)	t_d	—	5.0	10	ns
Rise Time		t_r	—	15	30	ns
Turn-On Time		t_{on}	—	20	35	ns
Storage Time	$(V_{CC} = 30 \text{ Vdc}, I_C = 500 \text{ mAdc}, I_{B1} = I_{B2} = 50 \text{ mAdc})$ (Figures 9, 10)	t_s	—	35	50	ns
Fall Time		t_f	—	20	25	ns
Turn-Off Time		t_{off}	—	50	60	ns

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

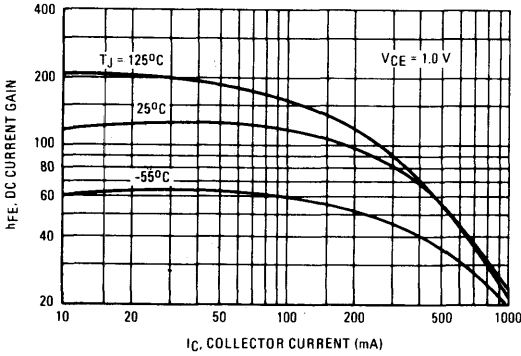


FIGURE 3 – "ON" VOLTAGES

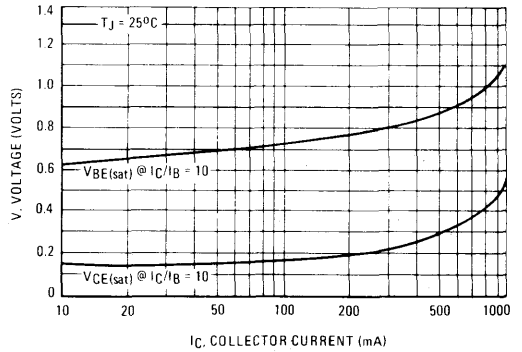


FIGURE 4 – COLLECTOR SATURATION REGION

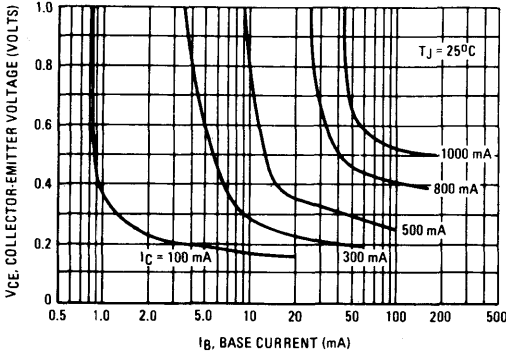
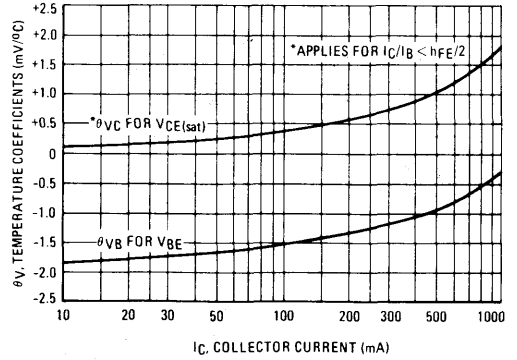


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

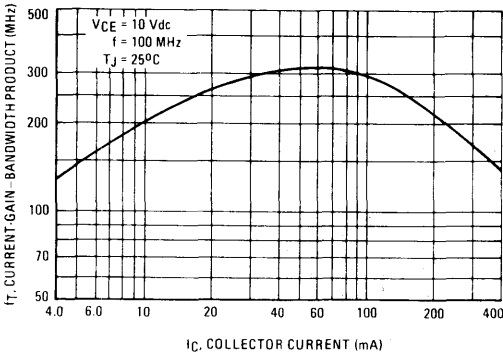


FIGURE 7 – CAPACITANCE

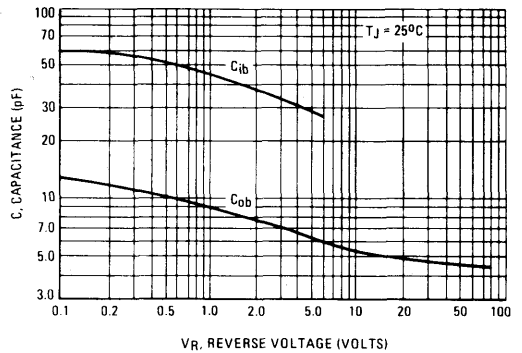


FIGURE 8 - TURN-ON TIME

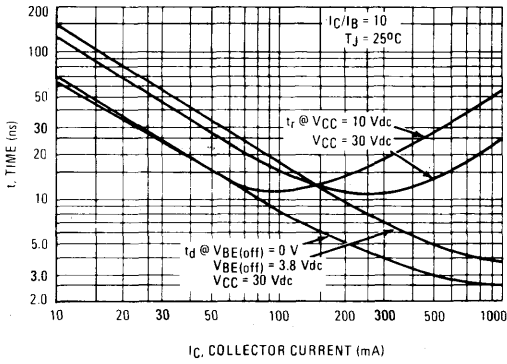


FIGURE 9 - TURN-OFF TIME

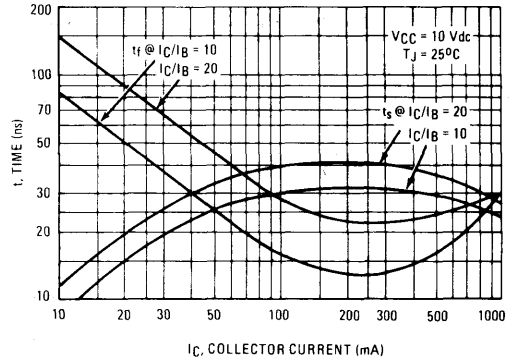


FIGURE 10 - SWITCHING TIME TEST CIRCUIT

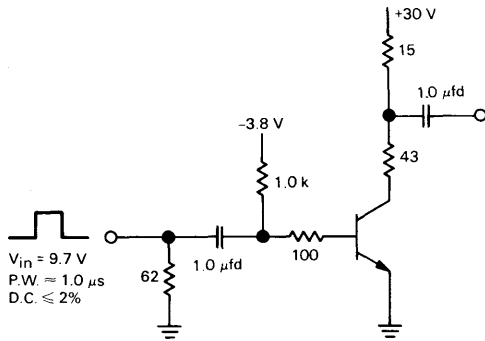
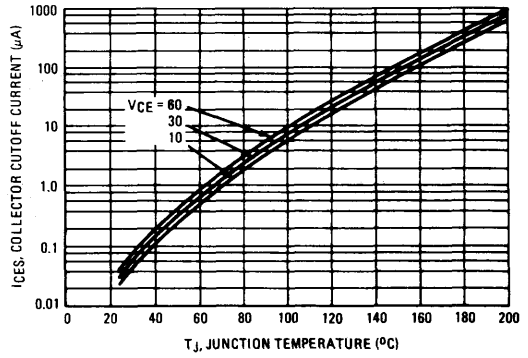


FIGURE 11 - COLLECTOR CUTOFF CURRENT



2N3734 2N3735

CASE 79, STYLE 1
TO-39 (TO-205AD)

2N3736 2N3737

CASE 26, STYLE 1
TO-46 (TO-206AD)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3734	2N3735	Unit
		2N3736	2N3737	
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	50	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		TO-39 2N3734 2N3735	TO-46 2N3736 2N3737	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3734 2N3736	2N3735 2N3737	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.044	0.088	$^\circ\text{C}/\text{mW}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.175	0.35	$^\circ\text{C}/\text{mW}$

Refer to 2N3725 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	30 50	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	50 75	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 25 \text{ Vdc}, V_{EB} = 2 \text{ Vdc}$) ($V_{CE} = 25 \text{ Vdc}, V_{EB} = 2 \text{ Vdc}, T_A = 100^\circ\text{C}$) ($V_{CE} = 40 \text{ Vdc}, V_{EB} = 2 \text{ Vdc}$) ($V_{CE} = 40 \text{ Vdc}, V_{EB} = 2 \text{ Vdc}, T_A = 100^\circ\text{C}$)	I_{CEX}	— — — —	0.20 20 0.20 20	μAdc
Base Cutoff Current ($V_{CE} = 25 \text{ Vdc}, V_{EB} = 2 \text{ Vdc}$) ($V_{CE} = 40 \text{ Vdc}, V_{EB} = 2 \text{ Vdc}$)	I_{BL}	— —	0.3 0.3	μAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 1 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 1 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1 \text{ Vdc}$) ($I_C = 1 \text{ Adc}, V_{CE} = 1.5 \text{ Vdc}$) ($I_C = 1.5 \text{ Adc}, V_{CE} = 5 \text{ Vdc}$)	h_{FE}	35 40 35 30 20 30 20	— — — 120 80 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 1 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1 \text{ Adc}, I_B = 100 \text{ mAdc}$)	$V_{CE(sat)}$	— — — —	0.2 0.3 0.5 0.9	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 1 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1 \text{ Adc}, I_B = 100 \text{ mAdc}$)	$V_{BE(sat)}$	— — — 0.9	0.8 1.0 1.2 1.4	Vdc

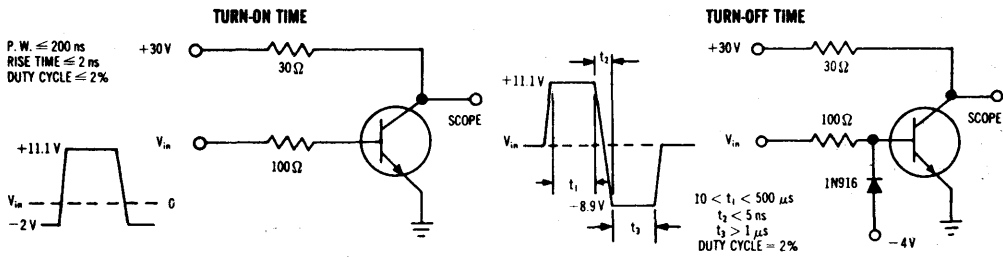
2N3734, 2N3735, 2N3736, 2N3737

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{obo}	—	9.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ibo}	—	80	pF
Small-Signal Current Gain ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	h_{fe}	2.5	—	—
SWITCHING CHARACTERISTICS				
Turn-On Time ($V_{CC} = 30\text{ V}$, $V_{BE(off)} = 2.0\text{ V}$, $I_C = 1.0\text{ Amp}$, $I_{B1} = 100\text{ mA}$)	t_{on}	—	40	ns
Turn-Off Time ($V_{CC} = 30\text{ V}$, $V_{BE(off)} = 2.0\text{ V}$, $I_C = 1.0\text{ Amp}$, $I_{B1} = 100\text{ mA}$)	t_{off}	—	60	ns
Total Control Charge ($I_C = 1\text{ Amp}$, $I_B = 100\text{ mA}$, $V_{CC} = 30\text{ V}$)	Q_T	—	10	pC

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

SWITCHING TIME EQUIVALENT TEST CIRCUITS



2N3742

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200 \text{ Vdc}, I_E = 0$) ($V_{CB} = 200 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$)	I_{CBO}	— —	0.2 20	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.2	μAdc
ON CHARACTERISTICS(2)				
DC Current Gain ($I_C = 3.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 30 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 50 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}$)	h_{FE}	10 15 20 20	— — 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 30 \text{ mAdc}, I_B = 3.0 \text{ mAdc}$)	$V_{CE(sat)}$	— —	0.75 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 30 \text{ mAdc}, I_B = 3.0 \text{ mAdc}$)	$V_{BE(sat)}$	— —	1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(3) ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	30	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	80	pF
Input Impedance ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ie}	—	2.0	k ohms
Voltage Feedback Ratio ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{re}	—	2.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 10 \text{ kHz}$)	h_{fe}	20	200	—

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	—	50	mhos
Real Part of Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 5.0\text{ MHz}$)	$\text{Re}(h_{ie})$	—	200	Ohms

- (1) Pulse Test: Pulse Width $\leq 30\ \mu\text{s}$, Duty Cycle $\leq 1.0\%$.
- (2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.
- (3) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – DC CURRENT GAIN

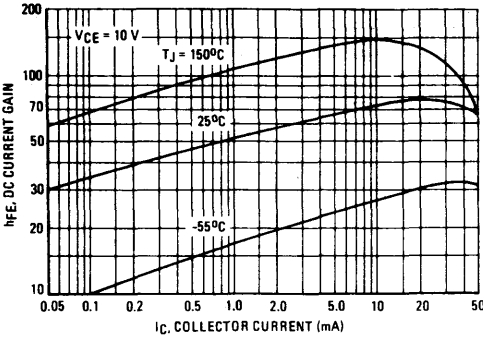


FIGURE 2 – DC SAFE OPERATING AREA

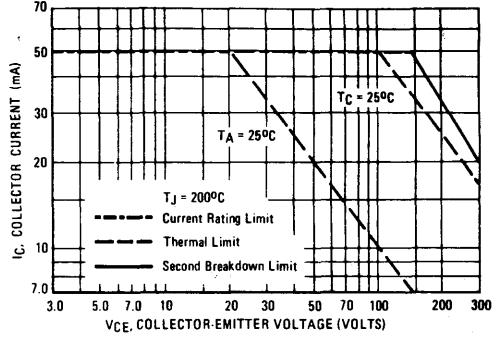


FIGURE 3 – "ON" VOLTAGES

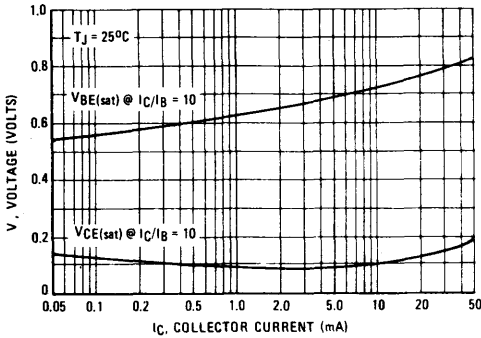


FIGURE 4 – TEMPERATURE COEFFICIENTS

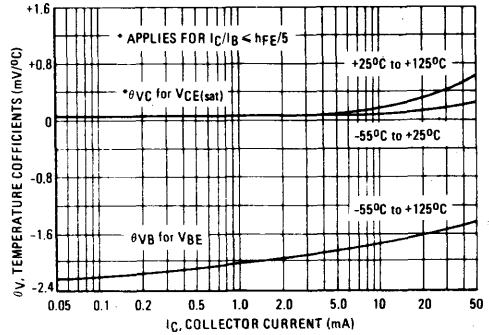


FIGURE 5 – CURRENT-GAIN-BANDWIDTH PRODUCT

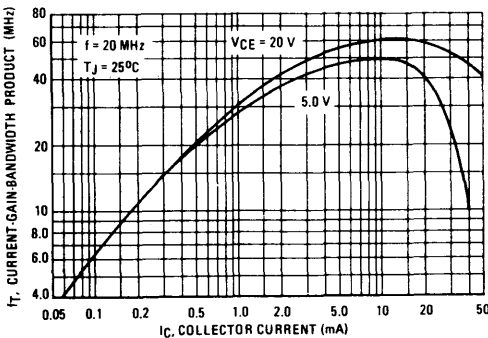
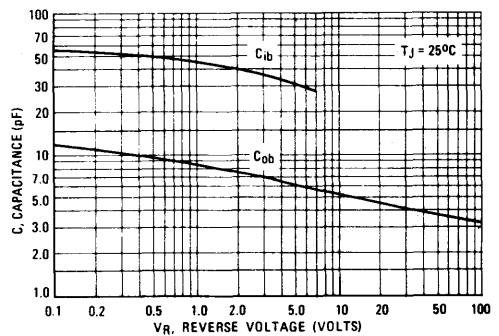


FIGURE 6 – CAPACITANCE



2N3743

JAN, JTX AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	300	Vdc
Collector-Base Voltage	V _{CBO}	300	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	50	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 5.7	Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	300	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	300	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 200 Vdc, I _E = 0) (V _{CB} = 200 Vdc, I _E = 0, T _A = 100°C)	I _{CBO}	—	0.3 30	μAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain(2) (I _C = 100 μAdc, V _{CE} = 10 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 30 mAdc, V _{CE} = 10 Vdc) (I _C = 50 mAdc, V _{CE} = 20 Vdc)	h _{FE}	20 25 25 25 25	— — — 250 —	—
Collector-Emitter Saturation Voltage(2) (I _C = 10 mAdc, I _B = 1 mAdc) (I _C = 30 mAdc, I _B = 3 mAdc)	V _{CE(sat)}	— —	5.0 8.0	Vdc
Base-Emitter Saturation Voltage(2) (I _C = 10 mAdc, I _B = 1 mAdc) (I _C = 30 mAdc, I _B = 3 mAdc)	V _{BE(sat)}	— —	1.0 1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

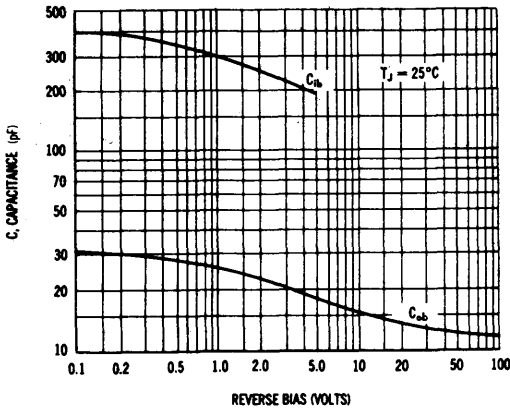
Output Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	15	pF
Input Capacitance (V _{EB} = 1.0 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	400	pF
Input Impedance (V _{CE} = 10 V, I _C = 10 mA, f = 1 kHz)	h _{ie}	—	1.0	kohms
Voltage Feedback Ratio (V _{CE} = 10 V, I _C = 10 mA, f = 1 kHz)	h _{re}	—	4.0	X 10 ⁻⁴
Small-Signal Current Gain (V _{CE} = 10 V, I _C = 10 mA, f = 1 kHz)	h _{fe}	30	300	—

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

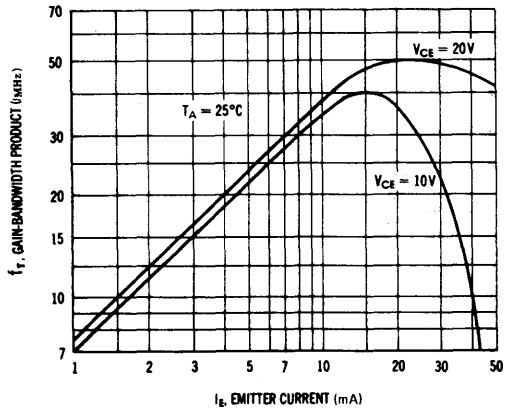
Characteristic	Symbol	Min	Max	Unit
Current Gain — High Frequency ($I_C = 10\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 20\text{ MHz}$)	$ h_{fe} $	1.5	—	—
Output Admittance ($V_{CE} = 10\text{ V}$, $I_C = 10\text{ mA}$, $f = 1\text{ kHz}$)	h_{oe}	—	200	μmhos
Real Part of Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 5\text{ MHz}$)	$\text{Re}(h_{ie})$	—	40	ohms

- (1) $PW \leq 30\ \mu\text{s}$, Duty Cycle $\leq 1.0\%$.
- (2) $PW \leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

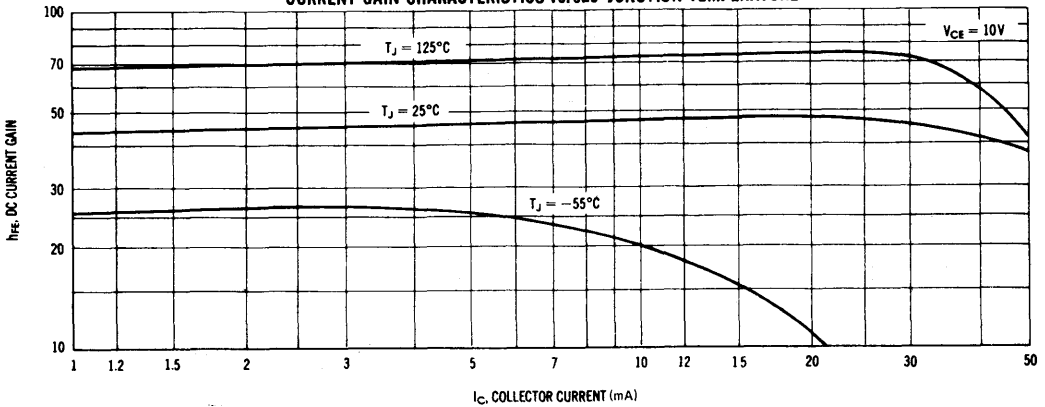
JUNCTION CAPACITANCE



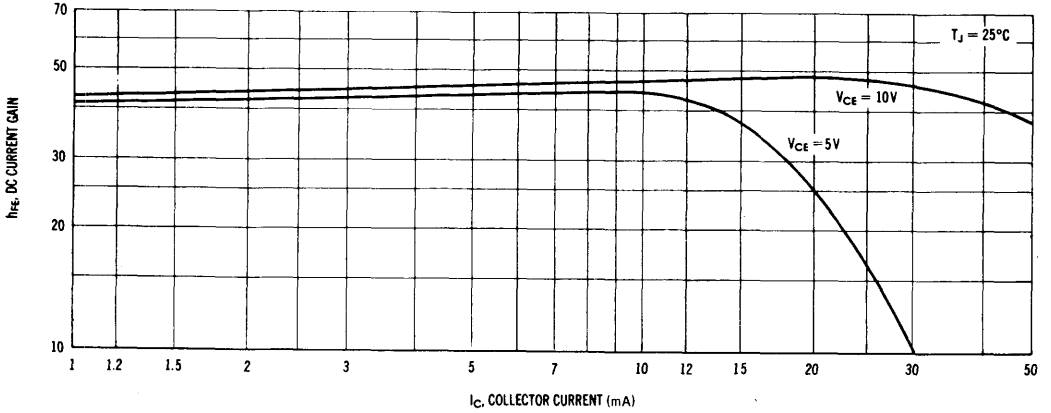
GAIN-BANDWIDTH PRODUCT



CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

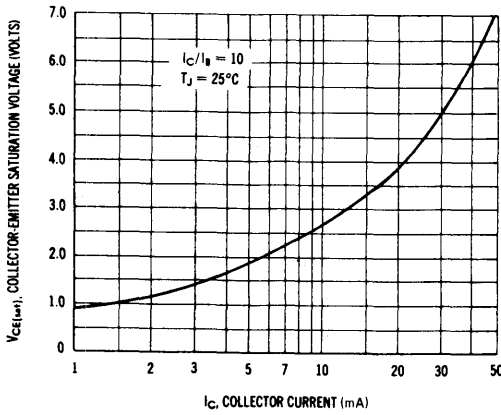


CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

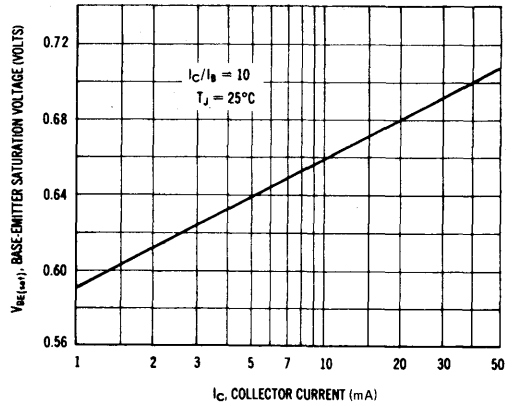


4

COLLECTOR-EMITTER SATURATION VOLTAGE



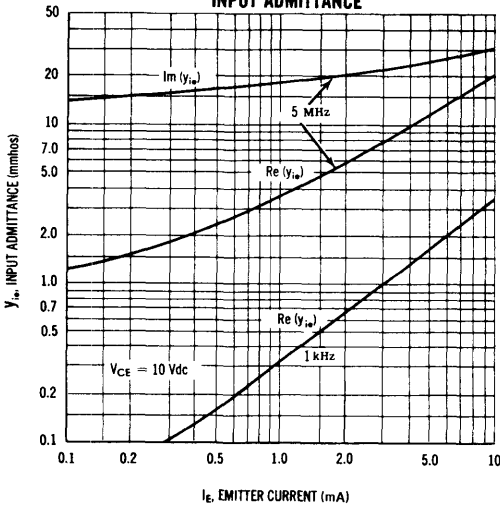
BASE-EMITTER SATURATION VOLTAGE



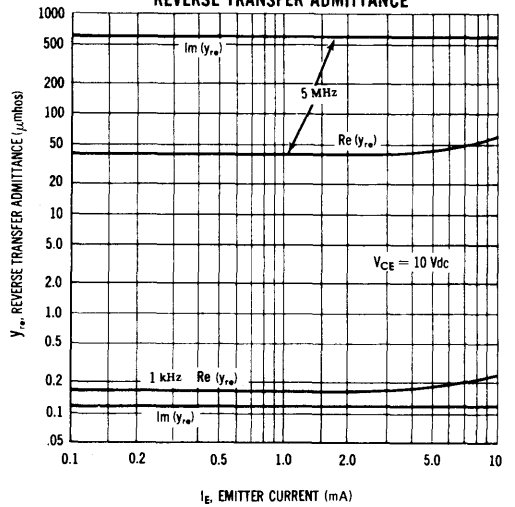
SMALL SIGNAL Y PARAMETERS

$T_A = 25^\circ C$

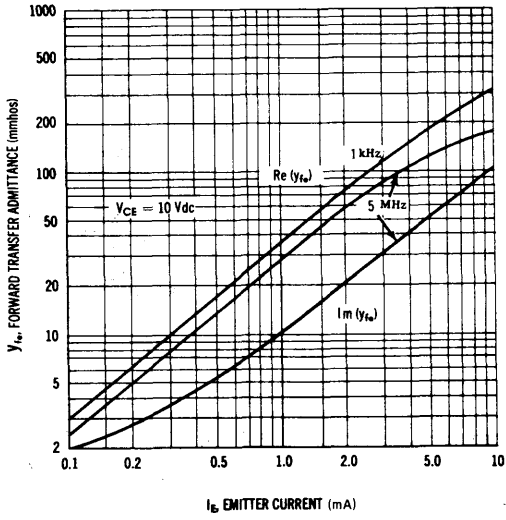
INPUT ADMITTANCE



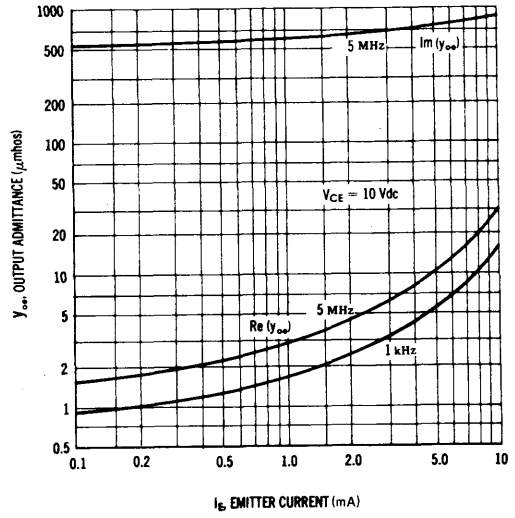
REVERSE TRANSFER ADMITTANCE



FORWARD TRANSFER ADMITTANCE



OUTPUT ADMITTANCE



2N3762, 2N3763 2N3764, 2N3765

JAN, JTX, JTXV AVAILABLE
CASE 79, CASE 26, STYLE 1
TO-39, TO-46

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3762	2N3763	Unit
		2N3764	2N3765	
Collector-Emitter Voltage	V_{CE0}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	40	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		TO-5 2N3762	TO-46 2N3764 2N3765	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
Lead Temperature 1/16" from Case for 10 Seconds	T_L	+235		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3762	2N3764	Unit
		2N3763	2N3765	
Thermal Resistance, Junction to Case	$R_{\theta JC}$	44	88	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	350	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40 60	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	40 60	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}, V_{EB} = 2.0 \text{ Vdc}$) ($V_{CE} = 20 \text{ Vdc}, V_{EB} = 2.0 \text{ Vdc}, T_A = 100^\circ\text{C}$) ($V_{CE} = 30 \text{ Vdc}, V_{EB} = 2.0 \text{ Vdc}$) ($V_{CE} = 30 \text{ Vdc}, V_{EB} = 2.0 \text{ Vdc}, T_A = 100^\circ\text{C}$)	I_{CEX}	— — — —	0.10 10 0.10 10	μAdc
Base Cutoff Current ($V_{CE} = 20 \text{ Vdc}, V_{EB} = 2.0 \text{ Vdc}$) ($V_{CE} = 30 \text{ Vdc}, V_{EB} = 2.0 \text{ Vdc}$)	I_{BL}	— —	0.2 0.2	μAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}, V_{CE} = 1.5 \text{ Vdc}$)	h_{FE}	35 40 35 20	— — — 120 80	—
($I_C = 1.5 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc}$)		30 20	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$)	$V_{CE(sat)}$	— — — —	0.1 0.22 0.5 0.9	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$)	$V_{BE(sat)}$	— — — 0.9	0.8 1.0 1.2 1.4	Vdc

2N3762, 2N3763, 2N3764, 2N3765

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

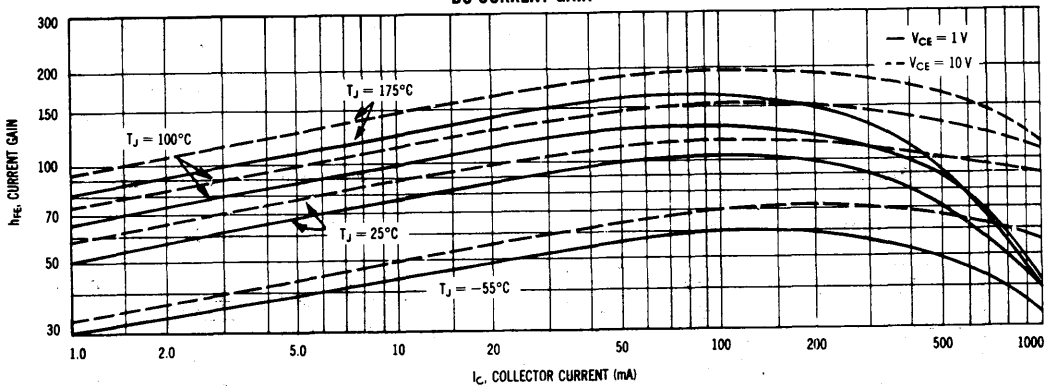
Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 100\text{ kHz}$)	C_{obo}	—	15	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 100\text{ kHz}$)	C_{ibo}	—	80	pF
Current Gain — High Frequency ($I_C = 50\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 100\text{ MHz}$)	$ h_{fe} $	1.8	—	—
		1.5	—	—

SWITCHING CHARACTERISTICS

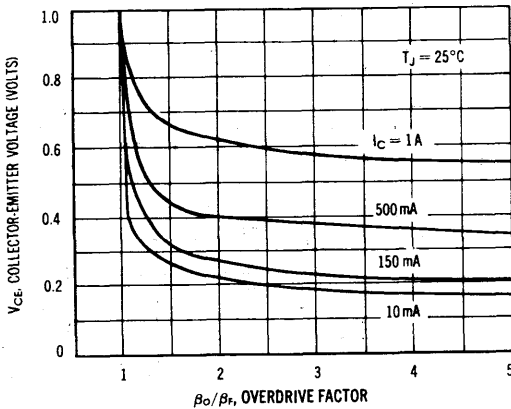
Delay Time	($V_{CC} = 30\text{ V}, V_{BE(off)} = 2.0\text{ V}, I_C = 1.0\text{ Amp}, I_{B1} = 100\text{ mA}$)	t_d	—	8.0	ns
Rise Time		t_r	—	3.5	ns
Storage Time	($V_{CC} = 30\text{ V}, I_C = 1.0\text{ Amp}, I_{B1} = -I_{B2} = 100\text{ mA}$)	t_s	—	80	ns
Fall Time		t_f	—	35	ns
Total Control Charge ($I_C = 1.0\text{ Amp}, I_B = 100\text{ mA}, V_{CC} = 30\text{ V}$)		Q_T	—	30	pC

(1) Pulse Test: $PW \leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

"ON" CONDITION CHARACTERISTICS DC CURRENT GAIN



COLLECTOR SATURATION REGION



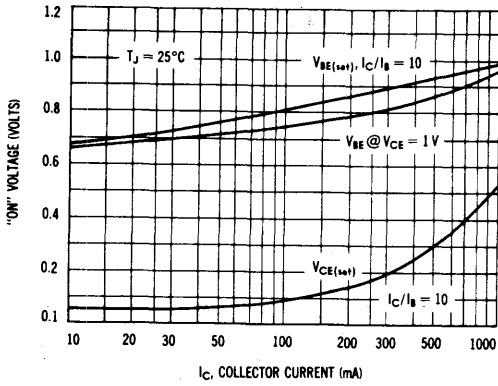
This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to ensure saturation at a temperature of 25°C and a collector of 500 mA.

Observe that at $I_C = 500\text{ mA}$ an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

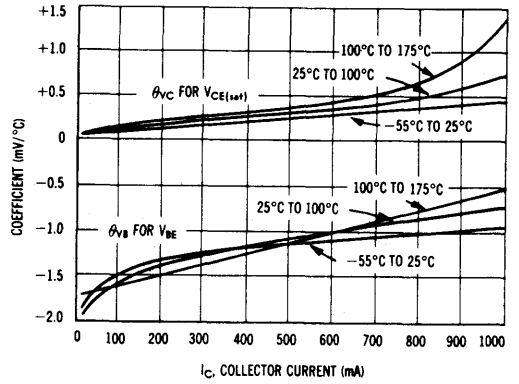
$$\frac{\beta_O}{\beta_F} = \frac{h_{FE@1\text{ Volt}}}{I_C/I_{BF}} \quad 2 = \frac{54}{500\text{ mA}/I_{BF}} \quad I_{BF} \approx 18.5\text{ mA typ}$$

2N3762, 2N3763, 2N3764, 2N3765

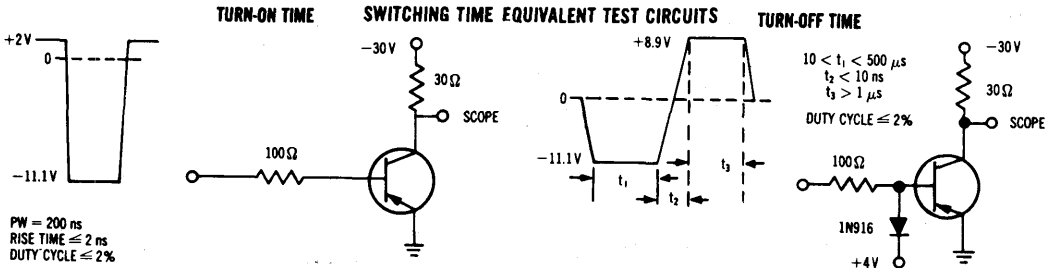
"ON" VOLTAGES



TEMPERATURE COEFFICIENTS

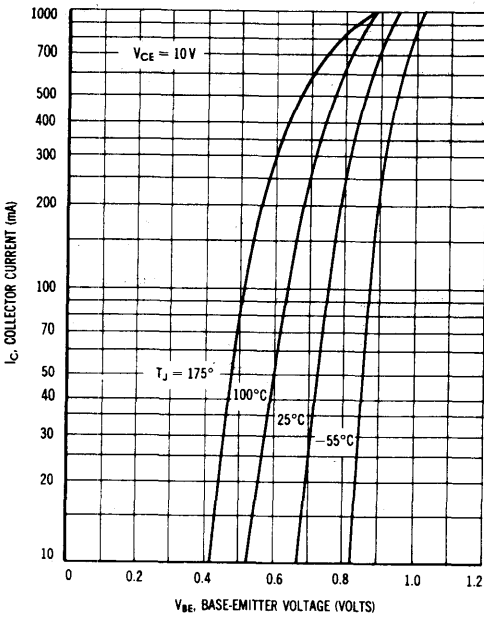


4



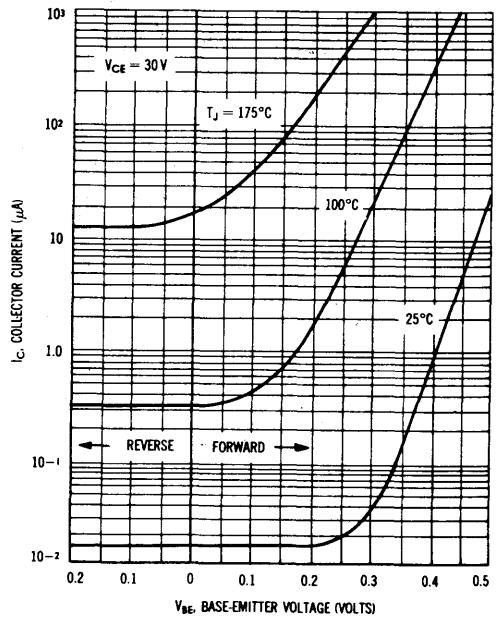
LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

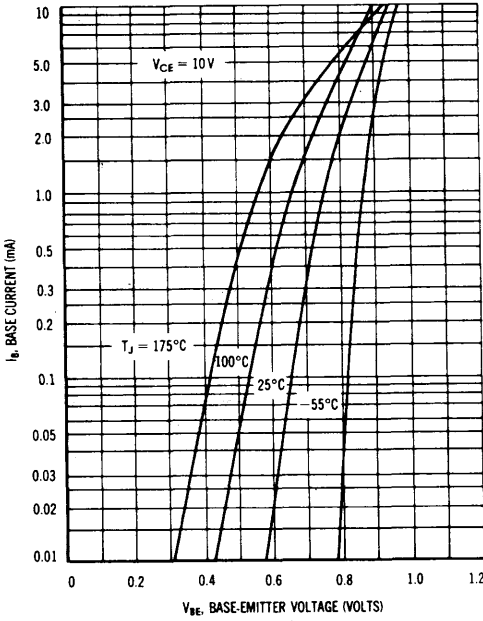


"OFF" CONDITION CHARACTERISTICS

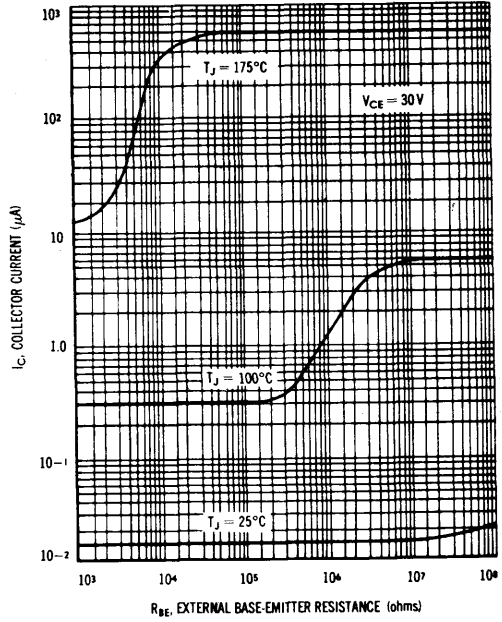
TRANSCONDUCTANCE



INPUT ADMITTANCE



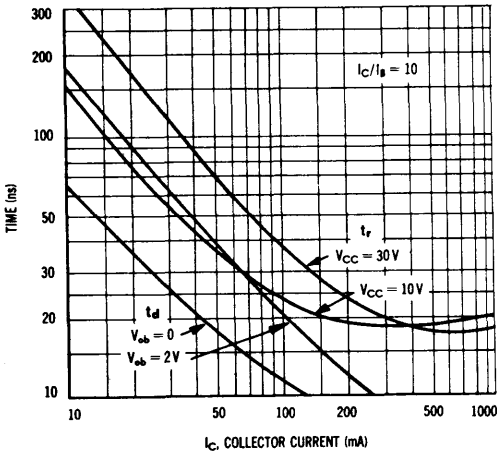
EFFECT OF BASE-EMITTER RESISTANCE



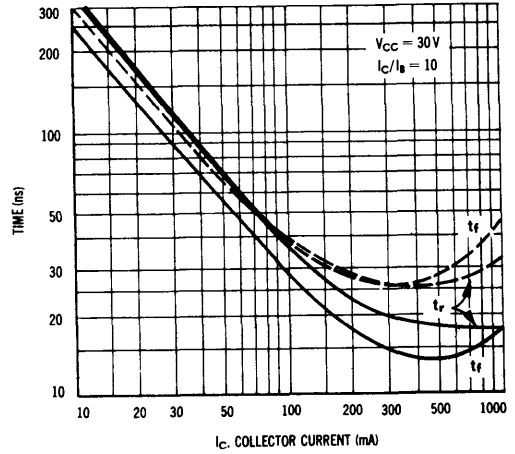
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— $T_J = 25^\circ C$ SWITCHING CHARACTERISTICS — $T_J = 150^\circ C$

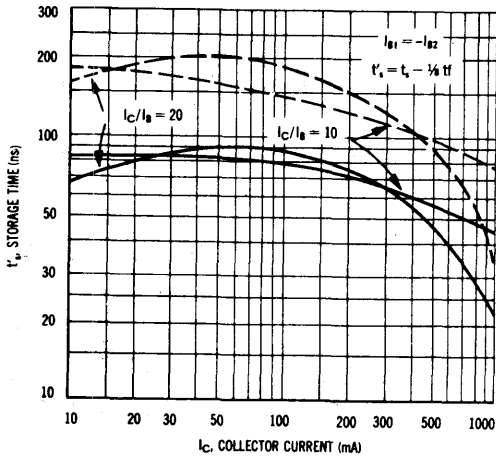
TURN-ON TIME



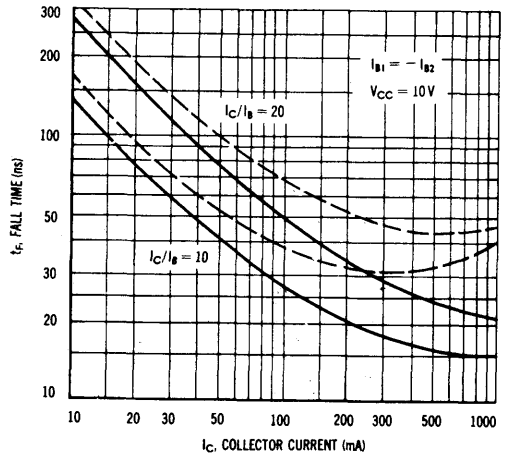
RISE AND FALL TIME



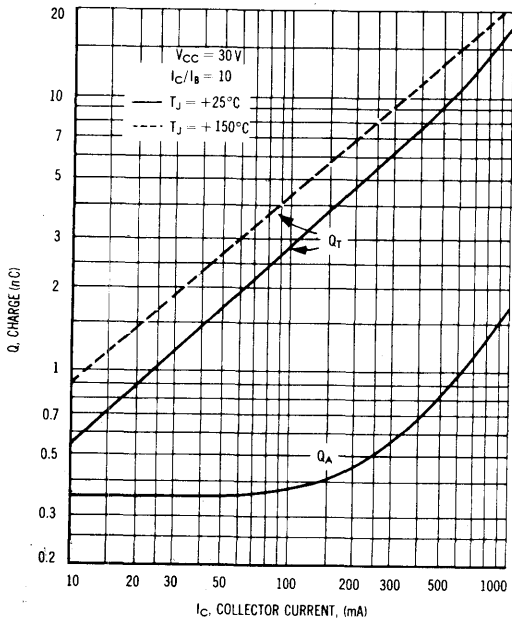
STORAGE TIME



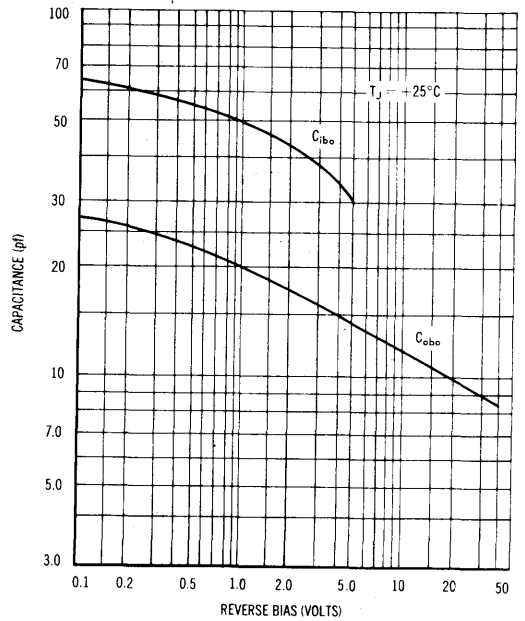
FALL TIME



CHARGE DATA



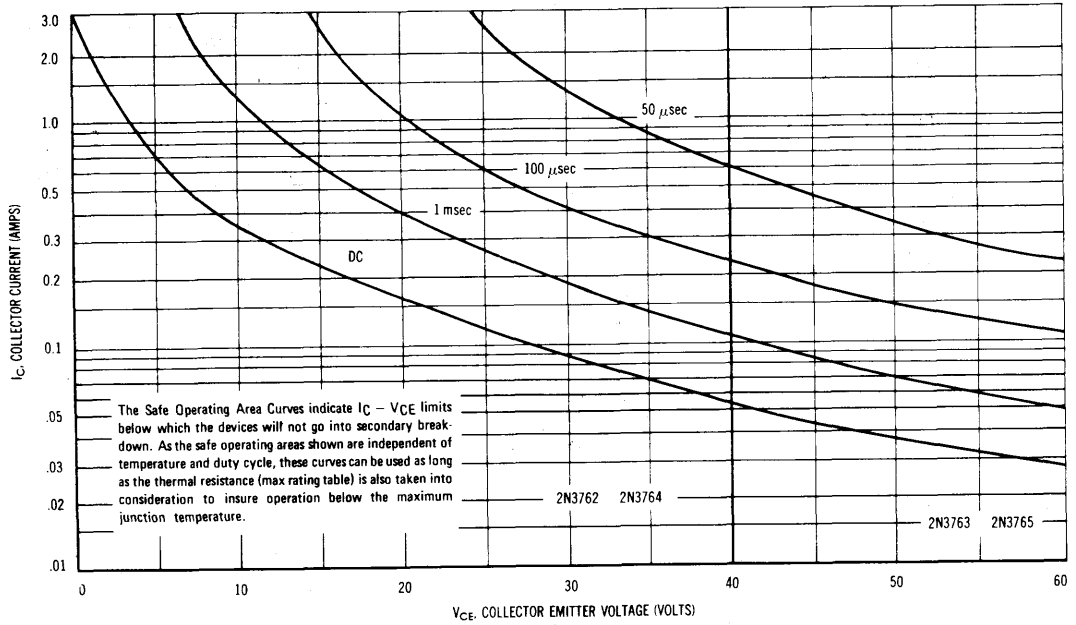
CAPACITANCE



4

2N3762, 2N3763, 2N3764, 2N3765

ACTIVE REGION SAFE OPERATING AREAS



2N3798 2N3799

CASE 22-03, STYLE 1
TO-18 (TO-206AA)
AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3798	2N3798A	Unit
		2N3799	2N3799A	
Collector-Emitter Voltage	V_{CEO}	60	90	Vdc
Collector-Base Voltage	V_{CBO}	60	90	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06		Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.86		Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	$^\circ\text{C}/\text{mW}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	$^\circ\text{C}/\text{mW}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	60	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$) ($V_{CB} = 50 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	0.01 10	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 1.0 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)	2N3799	h_{FE}	75	—	—	—
($I_C = 10 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)	2N3798 2N3799		100 225	— —	— —	
($I_C = 100 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)	2N3798 2N3799		150 300	— —	— —	
($I_C = 100 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}, T_A = -55^\circ\text{C}$)	2N3798 2N3799		75 150	— —	— —	
($I_C = 500 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)	2N3798 2N3799		150 300	— —	450 900	
($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	2N3798 2N3799		150 300	— —	— —	
($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	2N3798 2N3799		125 250	— —	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 100 \mu\text{Adc}, I_B = 10 \mu\text{Adc}$) ($I_C = 1.0 \text{ mAdc}, I_B = 100 \mu\text{Adc}$)		$V_{CE(sat)}$	— —	— —	0.2 0.25	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 100 \mu\text{Adc}, I_B = 10 \mu\text{Adc}$) ($I_C = 1.0 \text{ mAdc}, I_B = 100 \mu\text{Adc}$)		$V_{BE(sat)}$	— —	— —	0.7 0.8	Vdc
Base-Emitter On Voltage ($I_C = 100 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)		$V_{BE(on)}$	—	—	0.7	Vdc

2N3798, 2N3799

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 500 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 30 \text{ MHz}$) ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	30 100	— —	— 500	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	—	8.0	pF
Input Impedance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ie}	3.0 10	— —	15 40	k ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{re}	—	—	25	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	150 300	— —	600 900	—
Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	5.0	—	60	μmhos
Noise Figure ($I_C = 100 \mu\text{A}$, $V_{CE} = 10 \text{ Vdc}$, $R_G = 3.0 \text{ k ohms}$, $f = 100 \text{ Hz}$, B.W. = 20 Hz)	NF	— —	4.0 2.5	7.0 4.0	dB
Spot Noise $f = 1.0 \text{ kHz}$, B.W. = 200 Hz		— —	1.5 0.8	3.0 1.5	
Spot Noise $f = 10 \text{ kHz}$, B.W. = 2.0 kHz		— —	1.0 0.8	2.5 1.5	
Broadband Noise-Bandwidth 10 Hz to 15.7 kHz		— —	2.5 1.5	3.5 2.5	

- (1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.
- (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SPOT NOISE FIGURE
($V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$)

FIGURE 1 — SOURCE RESISTANCE EFFECTS, $f = 1.0 \text{ kHz}$

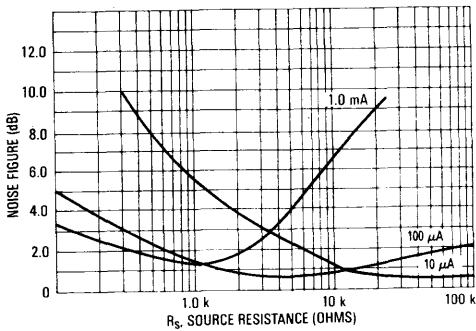
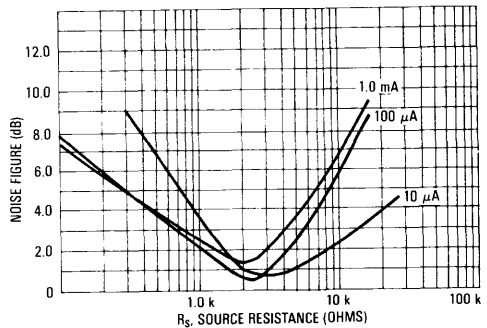


FIGURE 2 — SOURCE RESISTANCE EFFECTS, $f = 10 \text{ Hz}$



2N3798, 2N3799

FIGURE 3 — FREQUENCY EFFECTS

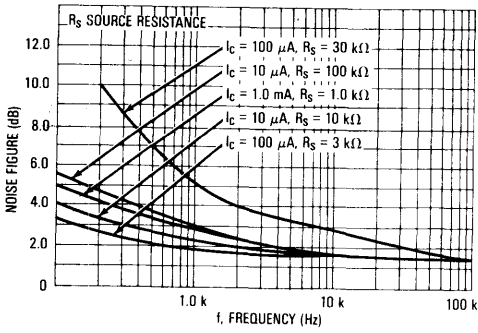


FIGURE 4a — TYPICAL CURRENT GAIN CHARACTERISTICS—2N3798

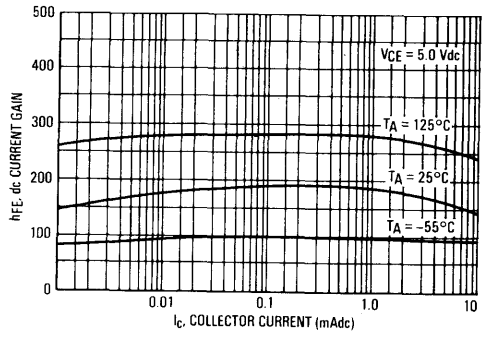
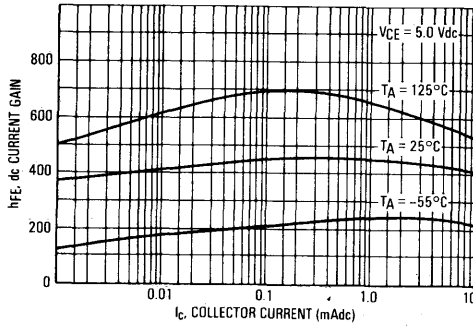


FIGURE 4b — TYPICAL CURRENT GAIN CHARACTERISTICS — 2N3799



4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CB0}	60	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current — Continuous	I _C	200	mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	0.15	°C/mW
Thermal Resistance, Junction to Ambient	R _{θJA}	0.49	°C/mW

2N3946
2N3947

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mA _{dc})	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	6.0	—	Vdc
Collector Cutoff Current (V _{CE} = 40 Vdc, V _{OB} = 3.0 Vdc) (V _{CE} = 40 Vdc, V _{OB} = 3.0 Vdc, T _A = 150°C)	I _{CEX}	—	0.010 15	μA _{dc}
Base Cutoff Current (V _{CE} = 40 Vdc, V _{OB} = 3.0 Vdc)	I _{BL}	—	.025	μA _{dc}

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 0.1 mA _{dc} , V _{CE} = 1.0 Vdc)	2N3946 2N3947	h _{FE}	30	—	—
(I _C = 1.0 mA _{dc} , V _{CE} = 1.0 Vdc)	2N3946 2N3947		45 90	—	
(I _C = 10 mA _{dc} , V _{CE} = 1.0 Vdc)	2N3946 2N3947	50 100	150 300		
(I _C = 50 mA _{dc} , V _{CE} = 1.0 Vdc)	2N3946 2N3947	20 40	—		
Collector-Emitter Saturation Voltage(1) (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})		V _{CE(sat)}	—	0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})		V _{BE(sat)}	0.6	0.9 1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mA _{dc} , V _{CE} = 20 Vdc, f = 100 MHz)	2N3946 2N3947	f _T	250 300	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)		C _{obo}	—	4.0	pF

2N3946, 2N3947

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

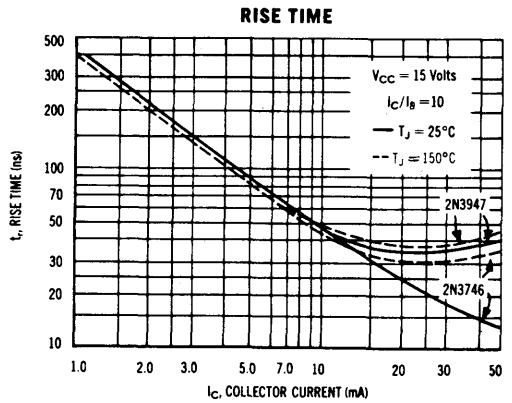
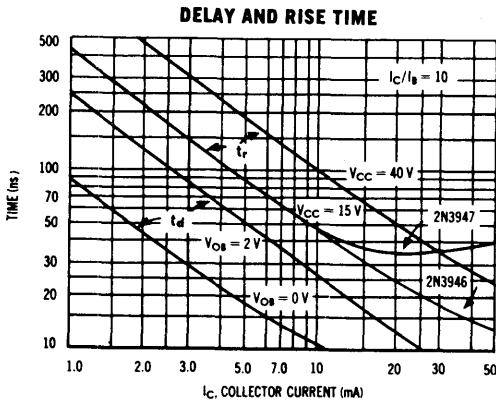
Characteristic	Symbol	Min	Max	Unit
Input Capacitance ($V_{BE} = 1.0\text{ Vdc}, I_C = 0, f = 100\text{ kHz}$)	C_{ibo}	—	8.0	pF
Input Impedance ($I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V}, f = 1.0\text{ kHz}$)	h_{ie}	0.5 2.0	6.0 12	kohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V}, f = 1.0\text{ kHz}$)	h_{re}	— —	10 20	$\times 10^{-4}$
Small Signal Current Gain ($I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V}, f = 1.0\text{ kHz}$)	h_{fe}	50 100	250 700	—
Output Admittance ($I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V}, f = 1.0\text{ kHz}$)	h_{oe}	1.0 5.0	30 50	μmhos
Collector Base Time Constant ($I_C = 10\text{ mA}, V_{CE} = 20\text{ V}, f = 31.8\text{ MHz}$)	r_b/C_c	—	200	ps
Noise Figure ($I_C = 100\ \mu\text{A}, V_{CE} = 5.0\text{ V}, R_g = 1.0\text{ k}\Omega, f = 10\text{ Hz to }15.7\text{ kHz}$)	NF	—	5.0	dB

SWITCHING CHARACTERISTICS

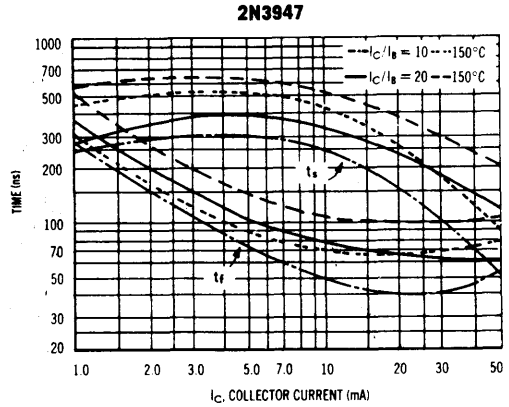
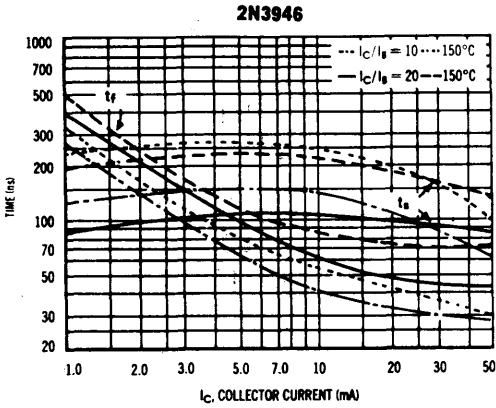
Delay Time	$V_{CC} = 3.0\text{ Vdc}, V_{OB} = 0.5\text{ Vdc},$ $I_C = 10\text{ mA}, I_{B1} = 1.0\text{ mA}$	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	$V_{CC} = 3.0\text{ V}, I_C = 10\text{ mA},$ $I_{B1} = I_{B2} = 1.0\text{ mA}$	t_s	—	300	ns
Fall Time		t_f	—	75	ns

(1) Pulse Test: $PW \leq 300\ \mu\text{s}$, Duty Cycle $\leq 2\%$.

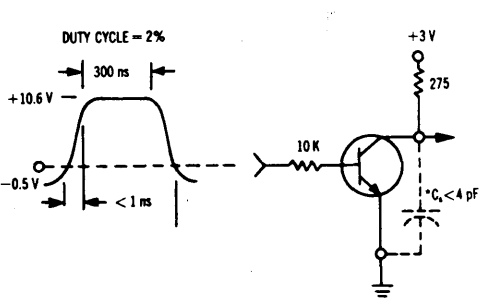
TYPICAL SWITCHING CHARACTERISTICS
($T_A = 25^\circ\text{C}$ unless otherwise noted)



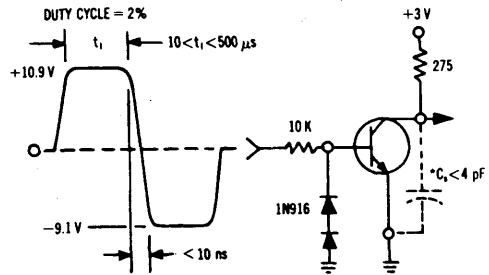
STORAGE AND FALL TIMES



TURN-ON TIME EQUIVALENT TEST CIRCUIT



TURN-OFF TIME EQUIVALENT TEST CIRCUIT

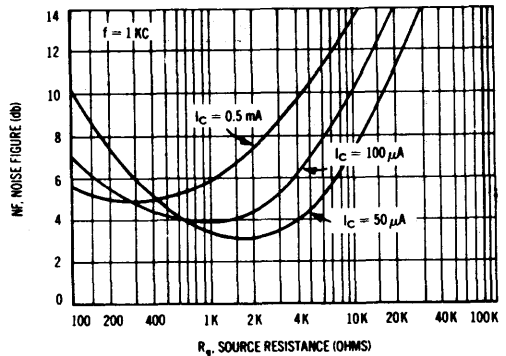
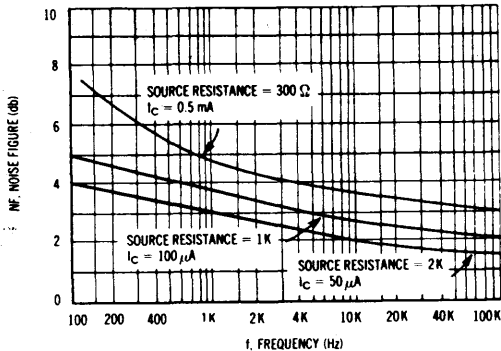


*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS

AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

$V_{CE} = 5 \text{ V}$, $T_A = 25^\circ\text{C}$

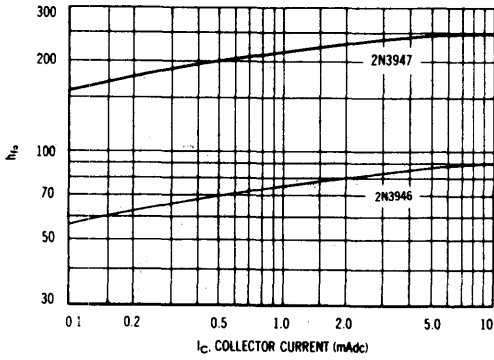


2N3946, 2N3947

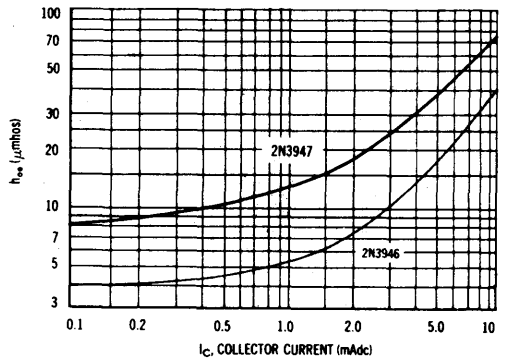
h PARAMETERS

$V_{ce} = 10 \text{ V}$, $T_A = 25^\circ\text{C}$, $f = 1 \text{ Kc}$

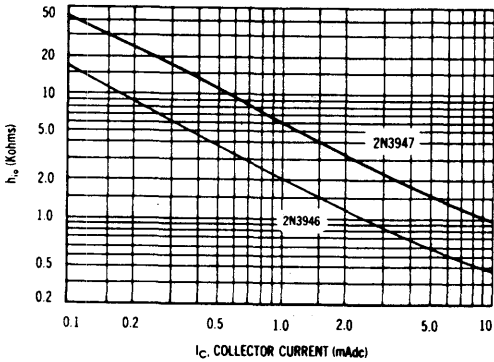
CURRENT GAIN



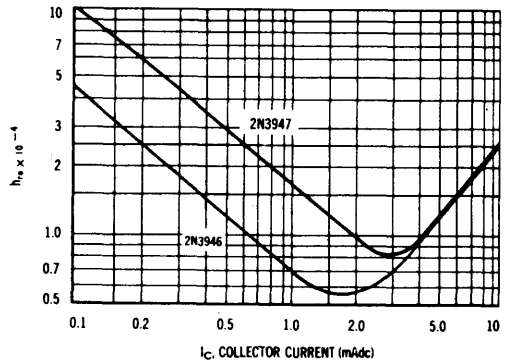
OUTPUT ADMITTANCE



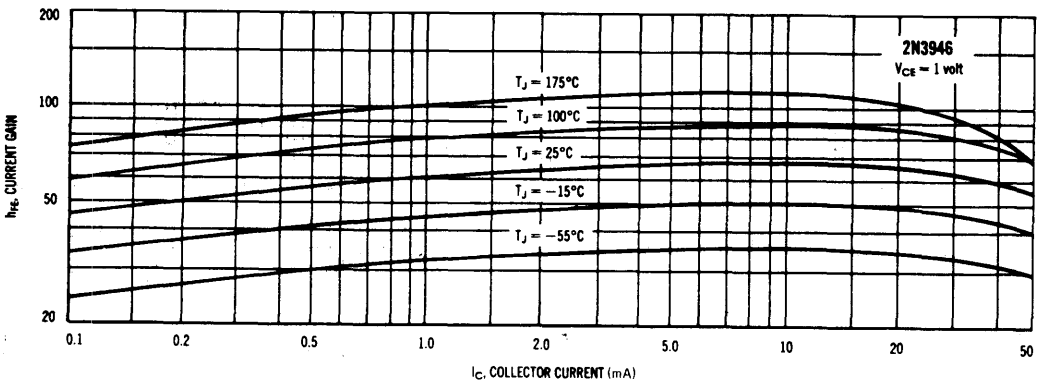
INPUT IMPEDANCE



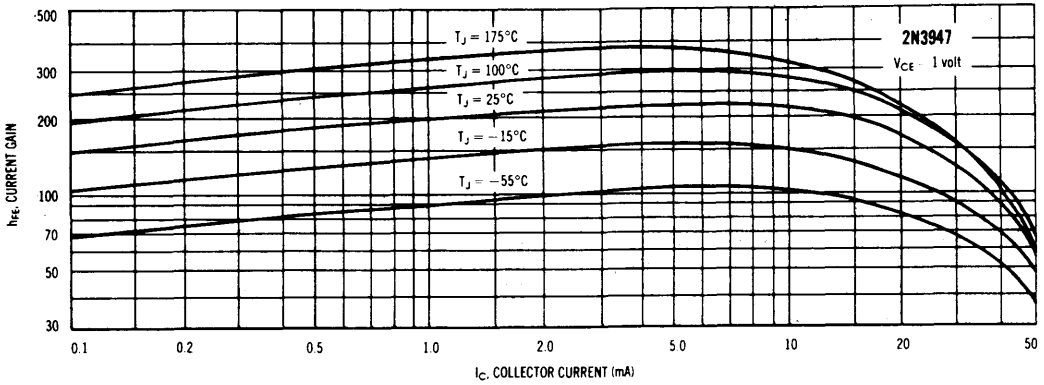
VOLTAGE FEEDBACK RATIO



CURRENT GAIN CHARACTERISTICS

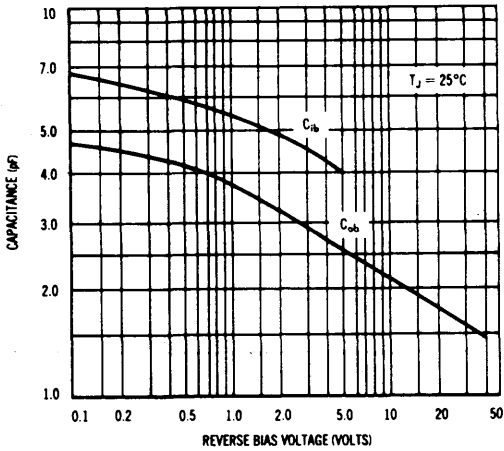


2N3946, 2N3947

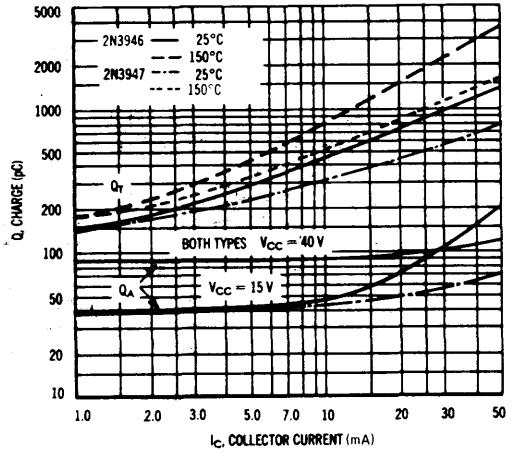


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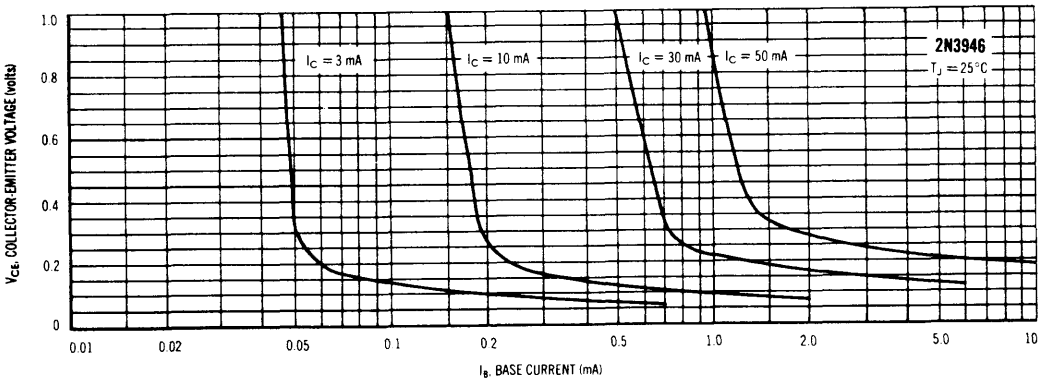
CAPACITANCE



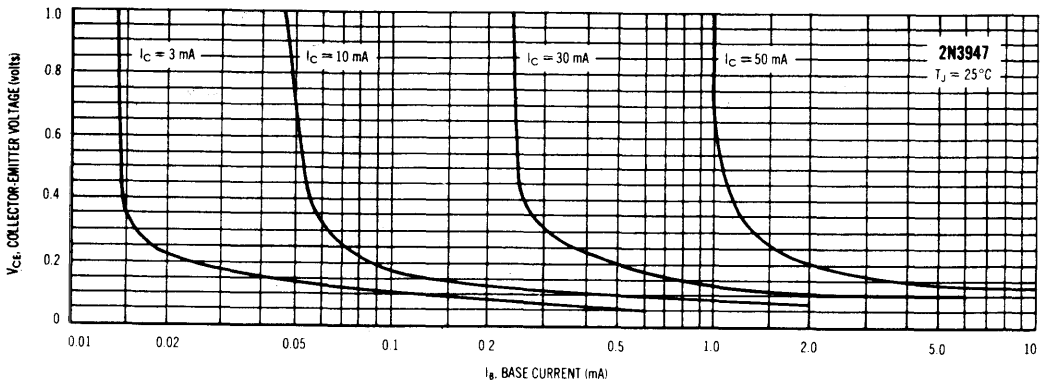
CHARGE DATA



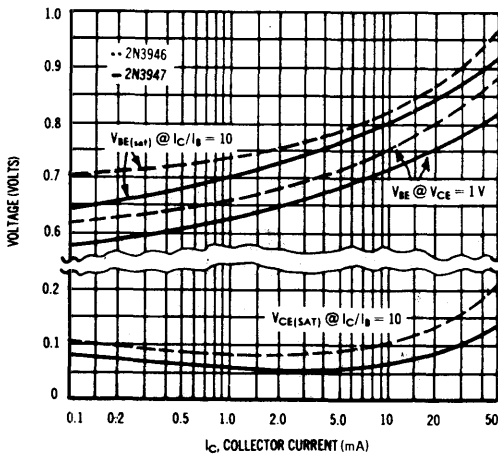
COLLECTOR SATURATION REGION



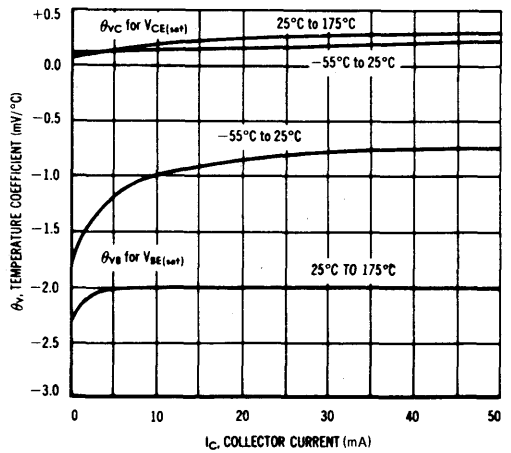
2N3946, 2N3947



"ON" VOLTAGES



TEMPERATURE COEFFICIENTS



MAXIMUM RATINGS

Rating	Symbol	2N3962	2N3964	2N3963	Unit
		2N3965			
Collector-Emitter Voltage	V _{CEO}	60	45	80	V
Collector-Base Voltage	V _{CBO}	60	45	80	V
Emitter-Base Voltage	V _{EBO}	6.0			V
Collector Current — Continuous	I _C	200			mA
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.36 2.06			Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.2 6.85			Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

**2N3962
2N3963
2N3964
2N3965**

**CASE 22-03, STYLE 1
TO-18 (TO-206AA)**

AMPLIFIER TRANSISTOR

PNP SILICON

4

Refer to 2N3798 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 5.0 ma)	V _{(BR)CEO}	60 80 45	— — —	Vdc
		2N3962, 2N3965 2N3963 2N3964		
Collector-Emitter Breakdown Voltage (I _C = 10 μA)	V _{(BR)CES}	60 80 45	— — —	Vdc
		2N3962, 2N3965 2N3963 2N3964		
Collector-Base Breakdown Voltage (I _C = 10 μA)	V _{(BR)CBO}	60 80 45	— — —	Vdc
		2N3962, 2N3965 2N3963 2N3964		
Emitter-Base Breakdown Voltage (I _C = 10 μA)	V _{(BR)EBO}	6.0	—	Vdc
Collector Cutoff Current (V _{CE} = 50 V; 2N3964 = 40 V) (V _{CE} = 70 V)	I _{CBO}	— —	10 10	nAdc
		2N3965, 2N3962 2N3963		
Collector Cutoff Current (V _{CE} = 50 V) (V _{CE} = 70 V) (V _{CE} = 40 V) (V _{CE} = 50 V)	I _{CES}	— — — —	10 10 10 10	nAdc
		2N3962 2N3963 2N3964 2N3965		
Emitter Cutoff Current (V _{EB} = 4.0 V)	I _{EBO}	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain(1)	h _{FE}	Min	Max	Unit
(I _C = 10 μA, V _{CE} = 5.0 V)		100 250	300 500	—
		2N3962, 2N3963 2N3964, 2N3965		
(I _C = 100 μA, V _{CE} = 5.0 V)		100 250	— —	—
		2N3962, 2N3963 2N3964, 2N3965		
(I _C = 1.0 mA, V _{CE} = 5.0)		100 250	450 600	—
		2N3962, 2N3963 2N3964, 2N3965		
(I _C = 10 μA, V _{CE} = 5.0, T _A = -55°C)		40 100	— —	—
		2N3962, 2N3963 2N3964, 2N3965		

2N3962, 2N3963, 2N3964, 2N3965

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
$(I_C = 1.0 \text{ mA}, V_{CE} = 5.0 \text{ V}, T_A = 100^\circ\text{C})$	2N3962, 2N3963		—	600	
	2N3964, 2N3965		—	800	
$(I_C = 1.0 \mu\text{A}, V_{CE} = 5.0 \text{ V})$	2N3962, 2N3963		60	—	
	2N3964, 2N3965		180	—	
$(I_C = 10 \text{ mA}, V_{CE} = 5.0 \text{ V})$	2N3962, 2N3963		100	—	
	2N3964, 2N3965		200	—	
$(I_C = 50 \text{ mA}, V_{CE} = 5.0 \text{ V})$	2N3962, 2N3963		90	—	
	2N3964, 2N3965		180	—	
$(I_C = 50 \text{ mA}, V_{CE} = 5.0 \text{ V}, T_A = -55^\circ\text{C})$	2N3962, 2N3963		45	—	
	2N3964, 2N3965		90	—	
Collector-Emitter Saturation Voltage $(I_C = 10 \text{ mA}, I_B = 0.5 \text{ mA})$ $(I_C = 50 \text{ mA}, I_B = 5.0 \text{ mA})(1)$		$V_{CE(sat)}$	—	0.25	V
			—	0.4	V
Base-Emitter Saturation Voltage $(I_C = 10 \text{ mA}, I_B = 0.5 \text{ mA})$ $(I_C = 50 \text{ mA}, I_B = 5.0 \text{ mA})(1)$		$V_{BE(sat)}$	—	0.9	V
			—	0.95	V

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance $(V_{CB} = 5.0 \text{ V}, f = 1.0 \text{ MHz})$		C_{obo}	—	6.0	pF
Input Capacitance $(V_{EB} = 0.5 \text{ V}, f = 1.0 \text{ MHz})$		C_{ibo}	—	15	pF
Input Impedance $(I_C = 1.0 \text{ mA}, V_{CE} = 5.0 \text{ V}, f = 1.0 \text{ kHz})$	2N3962, 2N3963 2N3964, 2N3965	h_{ie}	2.5 6.0	17 20	k Ω
Voltage Feedback Ratio $(I_C = 1.0 \text{ mA}, V_{CE} = 5.0, f = 1.0 \text{ kHz})$		h_{re}	—	10	10^{-4}
Small-Signal Current Gain $(I_C = 1.0 \text{ mA}, V_{CE} = 5.0 \text{ V}, f = 1.0 \text{ kHz})$	2N3962, 2N3963 2N3964, 2N3965	h_{fe}	100 250	550 700	— —
Magnitude of Forward Current Transfer Ratio, Common-Emitter $(I_C = 0.5 \text{ mA}, V_{CE} = 5.0 \text{ V}, f = 200 \text{ MHz})$	2N3962, 2N3963 2N3964, 2N3965	$ h_{fe} $	2.0 2.5	8.0 8.0	— —
Output Admittance $(I_C = 1.0 \text{ mA}, V_{CE} = 5.0, f = 1.0 \text{ kHz})$	2N3962, 2N3963 2N3964, 2N3965	h_{oe}	5.0 5.0	40 50	μmhos
Noise Figure $(I_C = 20 \text{ mA}, V_{CE} = 5.0 \text{ V}, \text{BW} = 15.7 \text{ kHz})$	2N3962, 2N3963 2N3964, 2N3965	NF	— —	3 2	dB
$(I_C = 20 \mu\text{A}, V_{CE} = 5.0 \text{ V}, \text{BW} = 1.5 \text{ kHz}, f = 10 \text{ kHz}, R_S = 10 \text{ k}\Omega)$	2N3962, 2N3963		—	3	
	2N3964, 2N3965		—	2	
$(I_C = 20 \mu\text{A}, V_{CE} = 5.0 \text{ V}, \text{BW} = 150 \text{ Hz}, f = 1.0 \text{ kHz}, R_S = 10 \text{ k}\Omega)$	2N3962, 2N3963		—	3	
	2N3964, 2N3965		—	2	
$(I_C = 20 \mu\text{A}, V_{CE} = 5.0 \text{ V}, \text{BW} = 15 \text{ Hz}, f = 100 \text{ Hz}, R_S = 10 \text{ k}\Omega)$	2N3962, 2N3963		—	10	
	2N3964, 2N3965		—	4	
$(I_C = 20 \mu\text{A}, V_{CE} = 5.0 \text{ V}, \text{BW} = 2.0 \text{ Hz}, f = 10 \text{ Hz}, R_S = 10 \text{ k}\Omega)$	2N3962, 2N3963		—	8	
	2N3964, 2N3965		—	8	

(1) Pulse Test: $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 2\%$.

2N4013 2N4014

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	2N4013	2N4014	Unit
Collector-Emitter Voltage	V_{CE0}	30	50	Vdc
Collector-Base Voltage	V_{CB0}	50	80	Vdc
Emitter-Base Voltage	V_{EB0}	6.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
— Peak		2.0		
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5		Watt mW/°C
		28.6		
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.4		Watts mW/°C
		6.8		
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	2N4014 50	—	—	Vdc
		2N4013 30	—	—	
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{Adc}, V_{BE} = 0$)	$V_{(BR)CES}$	2N4014 80	—	—	Vdc
		2N4013 50	—	—	
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	2N4014 80	—	—	Vdc
		2N4013 50	—	—	
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$)	I_{CBO}	2N4014	—	0.12	1.7
($V_{CB} = 40 \text{ Vdc}, I_E = 0$)		2N4013	—	0.12	1.7
($V_{CB} = 60 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$)		2N4014	—	—	120
($V_{CB} = 40 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$)		2N4013	—	—	120
Collector Cutoff Current ($V_{CE} = 80 \text{ Vdc}, V_{EB} = 0$)	I_{CES}	2N4014	—	0.15	10
($V_{CE} = 50 \text{ Vdc}, V_{EB} = 0$)		2N4013	—	0.15	10

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 300 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 800 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$)	2N4014 2N4013	h_{FE}	30	—	—	—
($I_C = 1.0 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc}$)			2N4014 25	—	—	
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	2N4014 2N4013	$V_{CE(sat)}$	—	0.17	0.25	Vdc
($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)			—	0.17	0.25	
	2N4014 2N4013	$V_{CE(sat)}$	—	0.19	0.26	Vdc
			—	0.19	0.20	

2N4013, 2N4014

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
$(I_C = 300 \text{ mA}, I_B = 30 \text{ mA})$	2N4014	—	0.25	0.40		
	2N4013	—	0.25	0.32		
$(I_C = 500 \text{ mA}, I_B = 50 \text{ mA})$	2N4014	—	0.30	0.52		
	2N4013	—	0.30	0.42		
$(I_C = 800 \text{ mA}, I_B = 80 \text{ mA})$	2N4014	—	0.43	0.80		
	2N4013	—	0.43	0.65		
$(I_C = 1.0 \text{ A}, I_B = 100 \text{ mA})$	2N4014	—	0.55	0.95		
	2N4013	—	0.55	0.75		
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	—	—	—	Vdc	
$(I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA})$						0.76
$(I_C = 100 \text{ mA}, I_B = 10 \text{ mA})$						0.86
$(I_C = 300 \text{ mA}, I_B = 30 \text{ mA})$						1.1
$(I_C = 500 \text{ mA}, I_B = 50 \text{ mA})$						1.1
$(I_C = 800 \text{ mA}, I_B = 80 \text{ mA})$						1.5
$(I_C = 1.0 \text{ A}, I_B = 100 \text{ mA})$						1.7

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) $(I_C = 50 \text{ mA}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz})$	f_T	300	—	—	MHz
Output Capacitance $(V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz})$	C_{obo}	—	—	10	pF
		2N4014	—	—	
Input Capacitance $(V_{EB} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz})$	C_{ibo}	—	—	55	pF

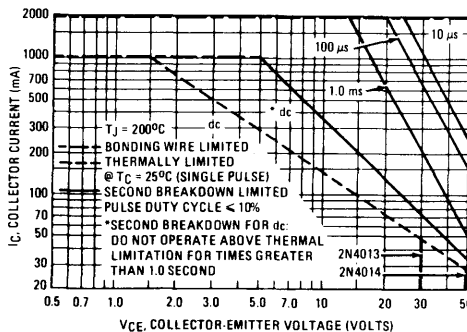
SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30 \text{ Vdc}, V_{BE(off)} = 3.8 \text{ Vdc}, I_C = 500 \text{ mA}, I_{B1} = 50 \text{ mA})$ (Figures 8, 10)		t_d	—	5.0	10	ns
Rise Time			t_r	—	15	30	ns
Storage Time	$(V_{CC} = 30 \text{ Vdc}, I_C = 500 \text{ mA}, I_{B1} = I_{B2} = 50 \text{ mA})$ (Figures 9, 10)	2N4014	t_s	—	30	50	ns
Fall Time		2N4013	t_f	—	20	25	ns
					25	30	
Turn-On Time	$(V_{CC} = 30 \text{ Vdc}, V_{BE(off)} = 3.8 \text{ Vdc}, I_C = 500 \text{ mA}, I_{B1} = 50 \text{ mA})$ (Figures 8, 10)		t_{on}	—	20	35	ns
Turn-Off Time	$(V_{CC} = 30 \text{ Vdc}, I_C = 500 \text{ mA}, I_{B1} = I_{B2} = 50 \text{ mA})$ (Figures 9, 10)	2N4014 2N4013	t_{off}	—	50	60	ns

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 1.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

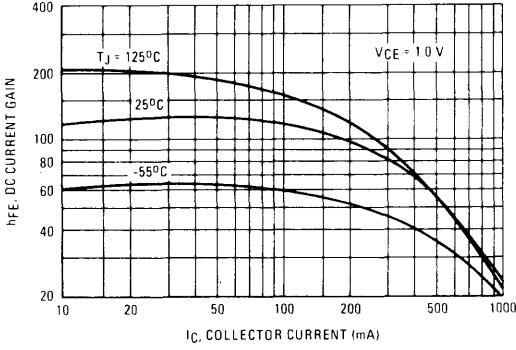


FIGURE 3 – "ON" VOLTAGES

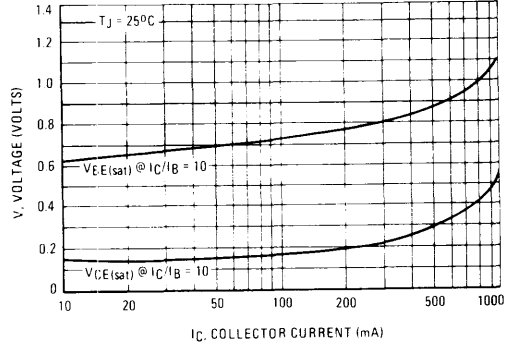


FIGURE 4 – COLLECTOR SATURATION REGION

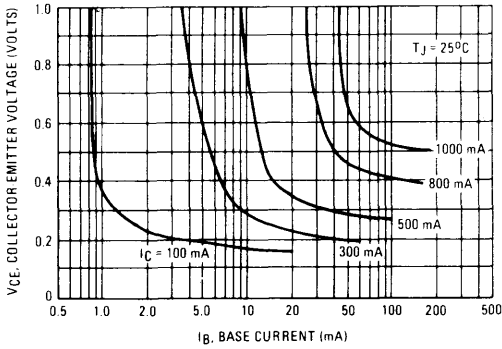
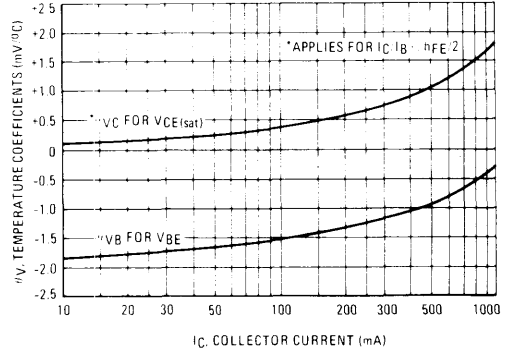


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

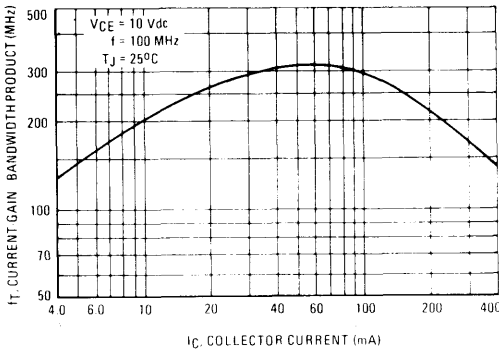
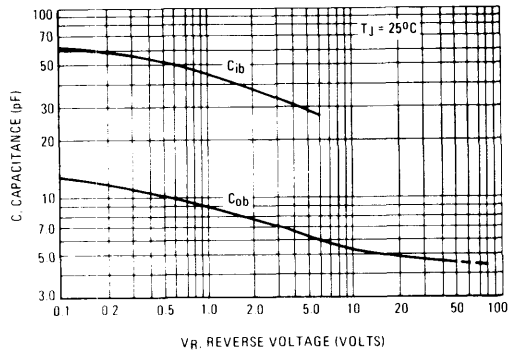


FIGURE 7 – CAPACITANCE



2N4013, 2N4014

FIGURE 8 - TURN-ON TIME

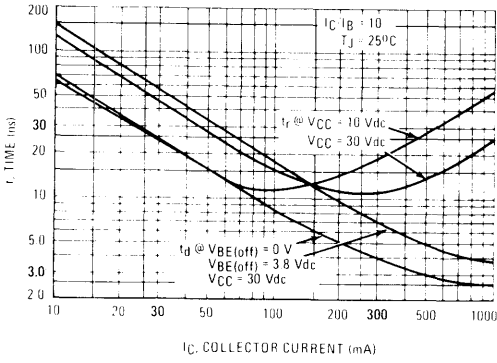


FIGURE 9 - TURN-OFF TIME

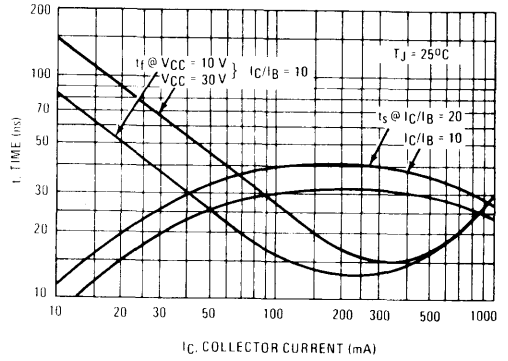


FIGURE 10 - SWITCHING TIME TEST CIRCUIT

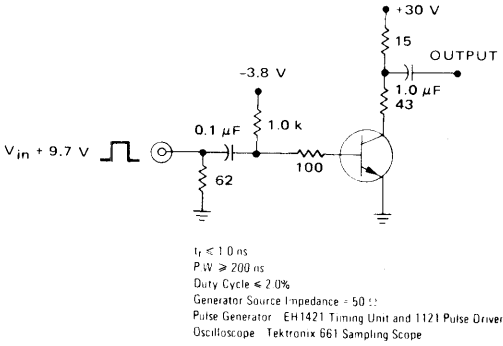
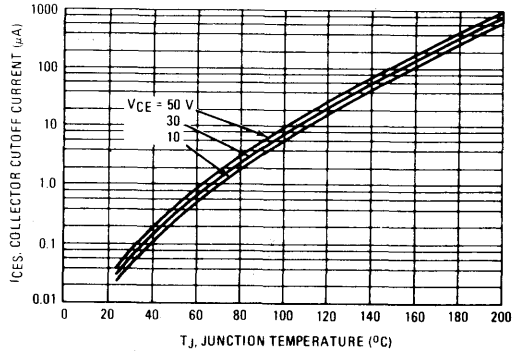


FIGURE 11 - COLLECTOR CUTOFF CURRENT



MAXIMUM RATINGS

Rating	Symbol	2N4026/28	2N4027/29	Unit
		2N4030/32	2N4031/33	
Collector-Emitter Voltage(1)	V _{CEO}	60	80	Vdc
Collector-Base Voltage	V _{CBO}	60	80	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	5.0	Vdc
Collector Current — Continuous	I _C	2N4026-2N4029	2N4030-2N4033	Adc
		1.0	1.0	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	.5	1.25	W
		2.85	7.15	mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.0	7.0	W
		11.4	40	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C
Lead or Terminal Temperature(2)	T _L	+300		°C

(1) Applicable 0 to 10 mA

(2) Measured at a distance not less than 1/16" from seated surface (or case) for 60 Sec.

THERMAL CHARACTERISTICS

Characteristic	Symbol	TO-18	TO-39	Unit
Thermal Resistance, Junction to Case	R _{θJC}	40	20	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	280	140	°C/W

2N4026 thru 2N4033

**2N4026-2N4029
CASE 22-03, STYLE 1
TO-18 (TO-206AA)**

**JAN, JTX, TXV AVAILABLE IN
2N4033**

**2N4030-2N4033
CASE 79-02, STYLE 1
TO-39 (TO-205AD)**

**GENERAL PURPOSE
TRANSISTOR**

PNP SILICON

Refer to 2N4405 for graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mA)	2N4026,28,30,32 2N4027,29,31,33	V _{(BR)CEO}	60 80	—	V
Collector-Base Breakdown Voltage (I _C = 10 μA)	2N4026,28,30,32 2N4027,29,31,33	V _{(BR)CBO}	60 80	—	V
Emitter-Base Breakdown Voltage (I _E = 10 μA)		V _{(BR)EBO}	5.0	—	V
Collector Cutoff Current (V _{CB} = 50 V) (V _{CB} = 60 V) (V _{CB} = 50 V, T _A = 150°C) (V _{CB} = 60 V, T _A = 150°C)	2N4026,28,30,32 2N4027,29,31,33 2N4026,28,30,32 2N4027,29,31,33	I _{CBO}	— — — —	50 50 50 50	nA μA
Emitter Cutoff Current (V _{EB} = 5.0 V)		I _{EBO}	—	10	μA

ON CHARACTERISTICS

DC Current Gain (I _C = 100 mA, V _{CE} = 5.0 V, @ -55°C)	2N4026,27,30,31 2N4028,29,32,33	h _{FE}	15 40	— —	—
(I _C = 100 μA, V _{CE} = 5.0 V)	2N4026,27,30,31 2N4028,29,32,33		30 75	— —	—
(I _C = 100 mA, V _{CE} = 5.0 V)	2N4026,27,30,31 2N4028,29,32,33		40 100	120 300	—
(I _C = 500 mA, V _{CE} = 5.0 V)	2N4026,27,30,31 2N4028,29,32,33		25 70	— —	—
(I _C = 1.0 A, V _{CE} = 5.0 V)	2N4026,30 2N4027,31		15 10	— —	—
(I _C = 1.0 A, V _{CE} = 5.0 V)	2N4028,32 2N4029,33		40 25	— —	—

2N4026 thru 2N4033

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$) ($I_C = 1.0\text{ A}$, $I_B = 100\text{ mA}$)	$V_{CE(sat)}$	—	0.15 0.15 1.0	V
Base-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)	$V_{BE(sat)}$	—	0.9	V
Base-Emitter On Voltage ($I_C = 1.0\text{ A}$, $V_{CE} = 1.0\text{ V}$) ($I_C = 500\text{ mA}$, $V_{CE} = 0.5\text{ V}$)	$V_{BE(on)}$	—	1.2 1.1	V

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CE} = 10\text{ V}$, $f = 1.0\text{ MHz}$)	C_{obo}	—	20	pF
Input Capacitance ($V_{EB} = 0.5\text{ V}$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	110	pF
Small Signal Current Gain ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 100\text{ MHz}$)	h_{fe}	1.0	4.0	—

SWITCHING CHARACTERISTICS

Storage Time ($I_C = 500\text{ mA}$, $I_{B1} = I_{B2} = 50\text{ mA}$)	t_s	—	350	ns
Turn-On Time ($I_C = 500\text{ mA}$, $I_{B1} = 50\text{ mA}$)	t_{on}	—	100	ns
Turn-Off Time ($I_C = 500\text{ mA}$, $I_{B1} = I_{B2} = 50\text{ mA}$)	t_{off}	—	50	ns

(3) Pulse Width = 300 μs , Duty Cycle 1.0%.

MAXIMUM RATINGS

Rating	Symbol	2N4036	2N4037	Unit
Collector-Emitter Voltage	V _{CEO}	65	40 (sus)(1)	V _{dc}
Collector-Base Voltage	V _{CBO}	90	60	V _{dc}
Emitter-Base Voltage	V _{EBO}	7.0	7.0	V _{dc}
Base Current	I _B	0.5		A _{dc}
Collector Current — Continuous	I _C	1.0		A _{dc}
Continuous Power Dissipation at or Below T _C = 25°C Linear Derating Factor	P _D	5.0 28.6	1.0 5.72	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C
Lead Temperature 1/16" from Case for 10 Seconds	T _L	230		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N4036	2N4037	Unit
Thermal Resistance, Junction to Case	R _{θJC}	25	—	°C/W

(1) Must not be tested on a curve tracer.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (I _C = 100 mA _{dc} , I _B = 0)	2N4036 2N4037	V _{CEO(sus)}	65 40	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 0.1 mA dc)	2N4037	V _{(BR)CBO}	60	—	V _{dc}
Collector Cutoff Current (V _{CE} = 85 V, V _{BE} = 1.5 V) (V _{CE} = 30 V, V _{BE} = 1.5 V, T _C = 150°C)	2N4036	I _{CEX}	—	100 0.1	mA _{dc}
Collector Cutoff Current (V _{CB} = 90 V, I _E = 0) (V _{CB} = 60 V, I _E = 0)	2N4036 2N4037	I _{CBO}	—	100 0.25	μA _{dc}
Emitter Cutoff Current (V _{BE} = 7.0 V _{dc} , I _C = 0) (V _{BE} = 5.0 V _{dc} , I _C = 0)	2N4036 2N4037	I _{EBO}	— —	10.0 1.0	μA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 150 mA _{dc} , V _{CE} = 2.0 V) (I _C = 0.1 mA _{dc} , V _{CE} = 10 V) (I _C = 1.0 mA _{dc} , V _{CE} = 10 V) (I _C = 150 mA _{dc} , V _{CE} = 10 V) (I _C = 500 mA _{dc} , V _{CE} = 10 V)	2N4036 2N4036 2N4037 2N4036 2N4037 2N4036	h _{FE}	20 20 15 40 50 20	200 — — 140 250 —	—
Collector-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA)	2N4036 2N4037	V _{CE(sat)}		0.65 1.4	V
Base-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA)	2N4036	V _{BE(sat)}		1.4	V
Base-Emitter On Voltage (I _C = 150 mA, V _{CE} = 10 V)	2N4037	V _{BE(on)}		1.5	V

SMALL-SIGNAL CHARACTERISTICS

Collector-Base Capacitance (V _{CB} = 10 V, f = 1.0 MHz)	2N4037	C _{cb}	—	30	pF
Current Gain — High Frequency (I _C = 50 mA, V _{CE} = 10 V, f = 20 MHz)	2N4036 2N4037	h _{fe}	3.0 3.0	— 10.0	—

**2N4036
2N4037**

**CASE 79-02, STYLE 1
TO-39 (TO-205AD)**

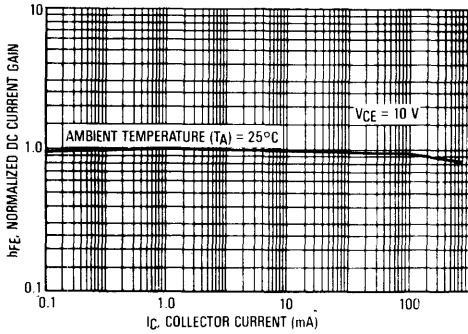
**GENERAL PURPOSE
TRANSISTOR**

PNP SILICON

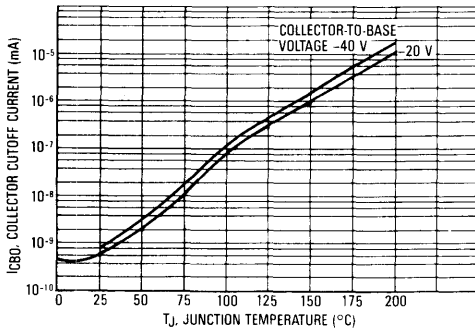
ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Rise Time ($I_{B1} = 15\text{ mA}$)	t_r	—	70	ns
Storage Time ($I_{B2} = 15\text{ mA}$)	t_s	—	600	ns
Fall Time ($I_{B2} = 15\text{ mA}$)	t_f	—	100	ns
Turn-On Time ($I_{B1} = I_{B2}$)	t_{on}	—	110	ns
Turn-Off Time ($I_{B1} = I_{B2}$)	t_{off}	—	700	ns

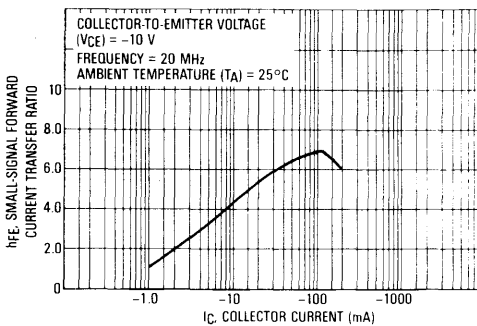
CURRENT GAIN CHARACTERISTICS
versus COLLECTOR-EMITTER VOLTAGE



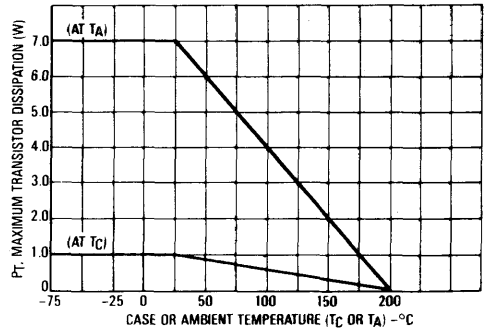
TYPICAL COLLECTOR-CUTOFF CURRENT
versus JUNCTION TEMPERATURE



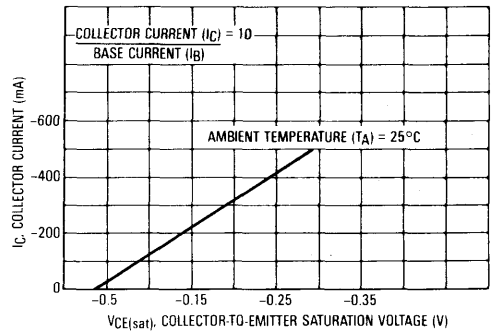
TYPICAL SMALL SIGNAL BETA CHARACTERISTICS



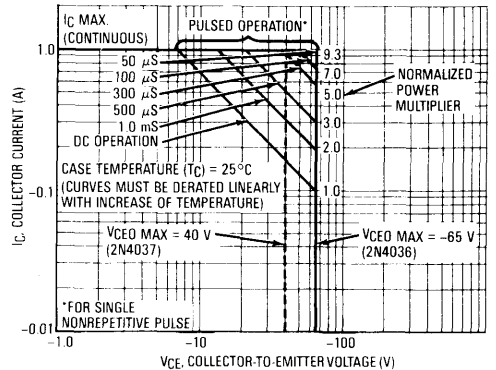
DISSIPATION DERATING CURVE



TYPICAL SATURATION-VOLTAGE CHARACTERISTICS



MAXIMUM SAFE OPERATING AREAS (SOA)



4

2N4208 2N4209

JAN TX, TXV AVAILABLE
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N4208	2N4209	Unit
Collector-Emitter Voltage	V_{CE0}	12	15	Vdc
Collector-Base Voltage	V_{CBO}	12	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50-200		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.30-0.36	1.72-2.06	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	0.70-1.2	4.0-6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 3.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	12 15	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}, V_{BE} = 0$)	$V_{(BR)CES}$	12 15	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	12 15	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.5	5.9	—	Vdc
Collector Cutoff Current ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0$)	I_{CES}	—	—	10	nAdc
($V_{CE} = 8.0 \text{ Vdc}, V_{BE} = 0$)		—	—	10	nAdc
($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0, T_A = 125^\circ\text{C}$)		—	—	5.0	μAdc
($V_{CE} = 8.0 \text{ Vdc}, V_{BE} = 0, T_A = 125^\circ\text{C}$)		—	—	5.0	μAdc
Base Current ($V_{CE} = 6.0 \text{ Vdc}, V_{BE} = 0$)	I_B	—	—	1.0	nAdc
($V_{CE} = 8.0 \text{ Vdc}, V_{BE} = 0$)		—	—	1.0	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 0.5 \text{ Vdc}$)	h_{FE}	2N4208 2N4209	15 35	— —	— —	—	
($I_C = 10 \text{ mAdc}, V_{CE} = 0.3 \text{ Vdc}$)		2N4208 2N4209	30 50	— —	120 120		
($I_C = 10 \text{ mAdc}, V_{CE} = 0.3 \text{ Vdc}, T_A = -55^\circ\text{C}$)		2N4208 2N4209	12 20	— —	— —		
($I_C = 50 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)(1)		2N4208 2N4209	30 40	— —	— —		
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ mAdc}, I_B = 0.1 \text{ mAdc}$)		$V_{CE(sat)}$	2N4208 2N4209	— —	— —	0.13 0.15	Vdc
($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	2N4208 2N4209		— —	— —	0.15 0.18		
($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$)(1)	2N4208 2N4209		— —	— —	0.5 0.6		
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ mAdc}, I_B = 0.1 \text{ mAdc}$)	$V_{BE(sat)}$		—	—	0.7	0.8	Vdc
($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)			0.75	0.86	0.90		
($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$)(1)			—	1.1	1.5		

2N4208, 2N4209

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit	
SMALL-SIGNAL CHARACTERISTICS							
Current-Gain — Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	2N4208 2N4209	f_T	700 850	1000 1100	— —	MHz	
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)		C_{obo}	—	2.0	3.0	pF	
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)		C_{ibo}	—	2.0	3.5	pF	
SWITCHING CHARACTERISTICS							
Turn-On Time	$(V_{CC} = 1.5\text{ Vdc}$, $V_{BE} = 0$, $I_C = 10\text{ mAdc}$, $I_{B1} = 1.0\text{ mAdc}$)	t_{on}	—	10	15	ns	
Delay Time		t_d	—	5.0	10	ns	
Rise Time		t_r	—	5.0	15	ns	
Turn-Off Time	$(V_{CC} = 1.5\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = I_{B2} = 1.0\text{ mAdc}$)	2N4208 2N4209	t_{off}	— —	12 16	15 20	ns
Storage Time		2N4208 2N4209	t_s	— —	12 17	15 20	ns
Fall Time	2N4208 2N4209	t_f	—	6.0 8.0	10 10	ns	
Storage Time ($I_C \approx 10\text{ mAdc}$, $I_{B1} \approx 10\text{ mAdc}$, $I_{B2} \approx 10\text{ mAdc}$)	2N4208 2N4209	t_s	— —	— —	15 20	ns	

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MAXIMUM RATINGS

Rating	Symbol	2N4234	2N4235	2N4236	Unit
Collector-Emitter Voltage	V _{CEO}	40	60	80	Vdc
Collector-Base Voltage	V _{CBO}	40	60	80	Vdc
Emitter-Base Voltage	V _{EBO}	7.0			Vdc
Base Current	I _B	0.2			Vdc
Collector Current — Continuous	I _C	1.0 3.0*			Adc
Total Device Dissipation (α T _A = 25°C Derate above 25°C)	P _D	1.0 5.7			Watt mW/°C
Total Device Dissipation (α T _C = 25°C Derate above 25°C)	P _D	6.0 34			Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	29	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) (I _C = 100 mAdc, I _B = 0)	2N4234 2N4235 2N4236	V _{CEO(sus)}	40 60 80	— — —	Vdc
Collector Cutoff Current (V _{CE} = 30 Vdc, I _B = 0) (V _{CE} = 40 Vdc, I _B = 0) (V _{CE} = 60 Vdc, I _B = 0)	2N4234 2N4235 2N4236	I _{CEO}	— — —	1.0 1.0 1.0	mAdc
Collector Cutoff Current (V _{CE} = 40 Vdc, V _{BE} = 1.5 Vdc) (V _{CE} = 60 Vdc, V _{BE} = 1.5 Vdc) (V _{CE} = 80 Vdc, V _{BE} = 1.5 Vdc) (V _{CE} = 30 Vdc, V _{BE} = 1.5 Vdc, T _C = 150°C) (V _{CE} = 40 Vdc, V _{BE} = 1.5 Vdc, T _C = 150°C) (V _{CE} = 60 Vdc, V _{BE} = 1.5 Vdc, T _C = 150°C)	2N4234 2N4235 2N4236 2N4234 2N4235 2N4236	I _{CEX}	— — — — — —	0.1 0.1 0.1 1.0 1.0 1.0	mAdc
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 80 Vdc, I _E = 0)	2N4234 2N4235 2N4236	I _{CBO}	— — —	0.1 0.1 0.1	mAdc
Emitter Cutoff Current (V _{BE} = 7 Vdc, I _C = 0)		I _{EBO}	—	0.5	mAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 100 mAdc, V _{CE} = 1.0 Vdc) (I _C = 250 mAdc, V _{CE} = 1.0 Vdc) (I _C = 500 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1.0 Adc, V _{CE} = 1.0 Vdc)		h _{FE}	40 30 20 10	— 150 — —	—
Collector-Emitter Saturation Voltage(1) (I _C = 1.0 Adc, I _B = 125 mAdc)		V _{CE(sat)}	—	0.6	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 1.0 Adc, I _B = 100 mAdc)		V _{BE(sat)}	—	1.5	Vdc
Base-Emitter On Voltage (I _C = 250 mAdc, V _{CE} = 1.0 Vdc)		V _{BE}	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 100 mAdc, V _{CE} = 10 Vdc, f = 1.0 MHz)		f _T	3.0	—	MHz
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**2N4234
2N4235
2N4236**

**CASE 079-02, STYLE 1
TO-39 (TO-205AD)**

POWER TRANSISTOR

PNP SILICON

4

2N4234, 2N4235, 2N4236

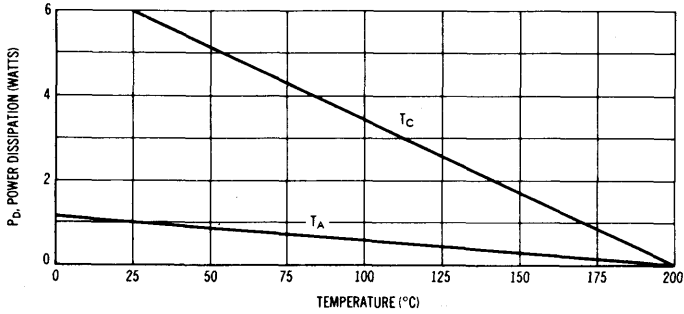
ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{obo}	—	100	pF
Small-Signal Current Gain ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	25	—	—

(1) Pulse Test: $PW \leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

*Indicates Data in addition to JEDEC Requirements.

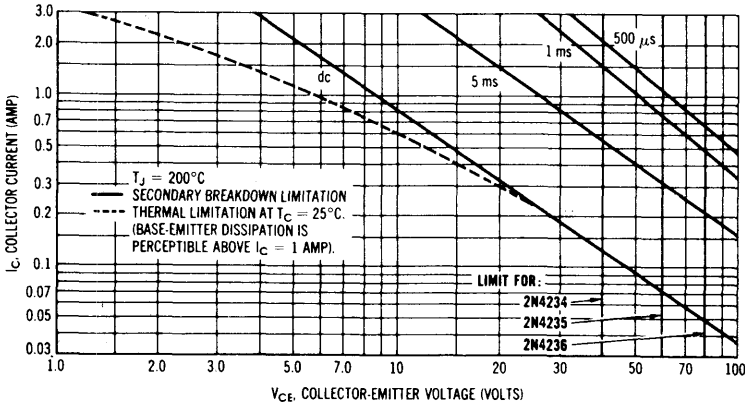
FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.

All limits are applicable and must be observed.

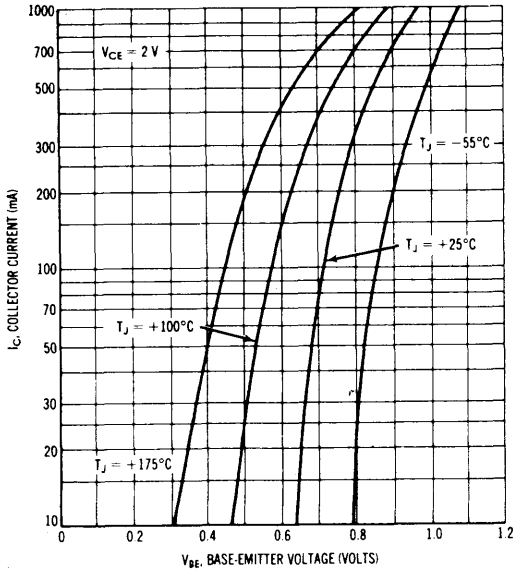
FIGURE 2 — ACTIVE-REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J , power-temperature derating must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 — TRANSCONDUCTANCE

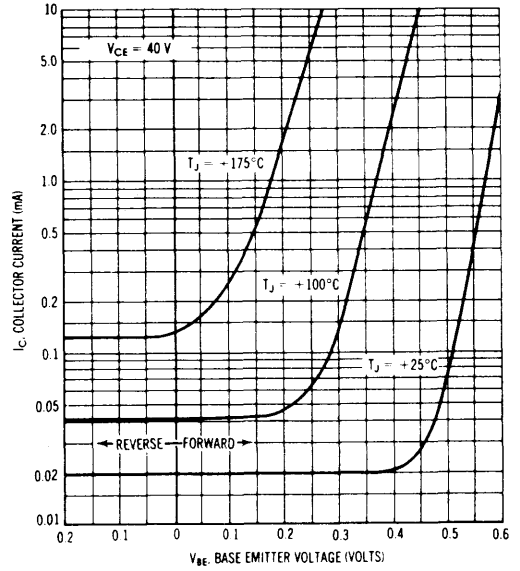


FIGURE 4 — INPUT ADMITTANCE

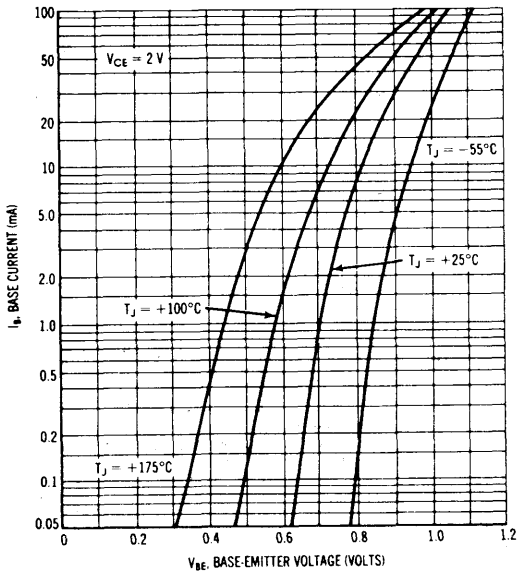


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

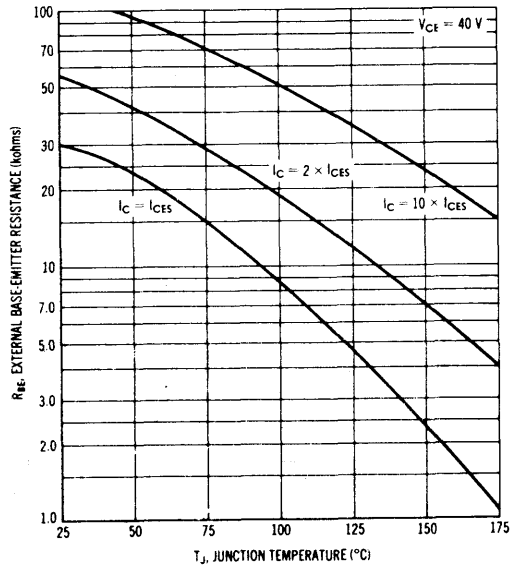
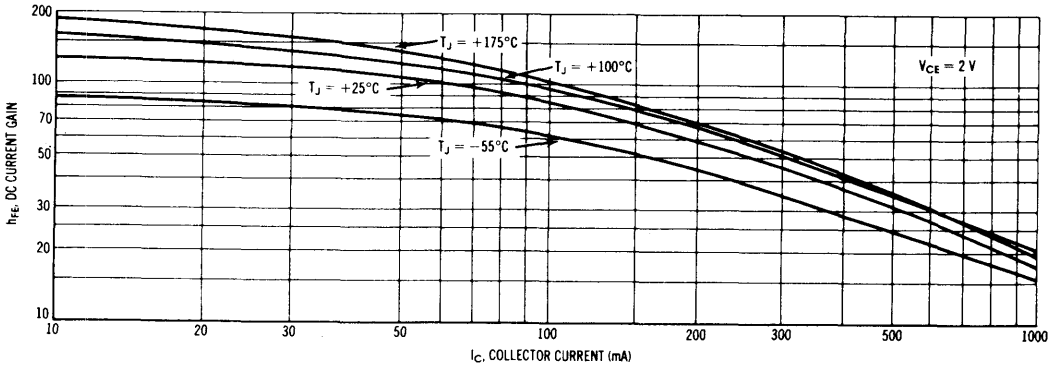


FIGURE 7 — CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 8 — COLLECTOR SATURATION REGION

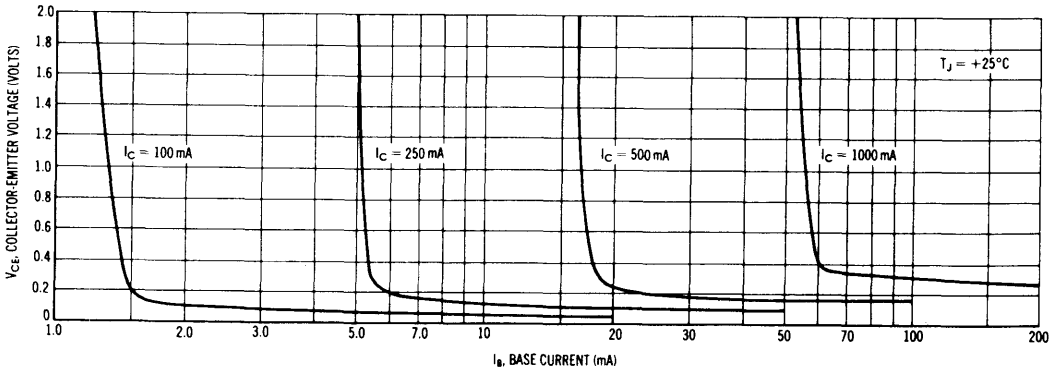


FIGURE 9 — "ON" VOLTAGES

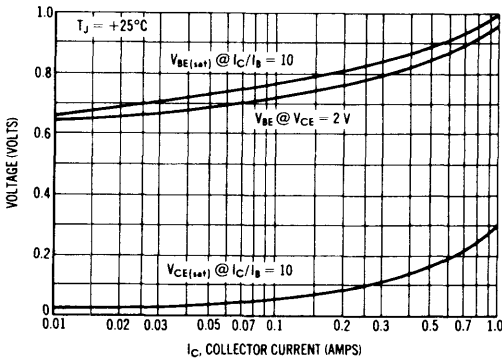
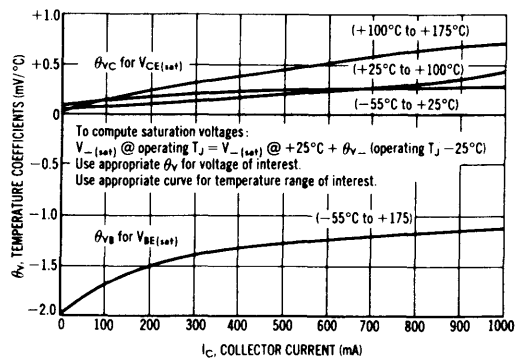


FIGURE 10 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

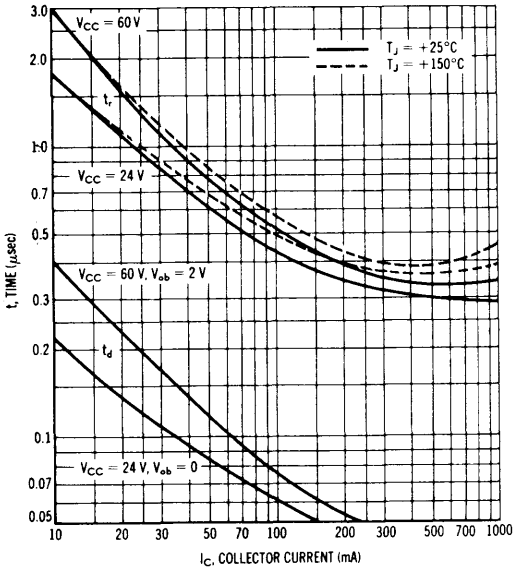


FIGURE 13 — CAPACITANCE

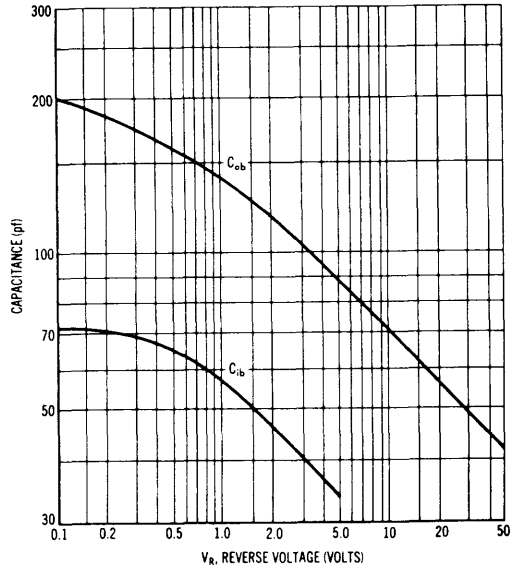


FIGURE 12 — STORAGE TIME

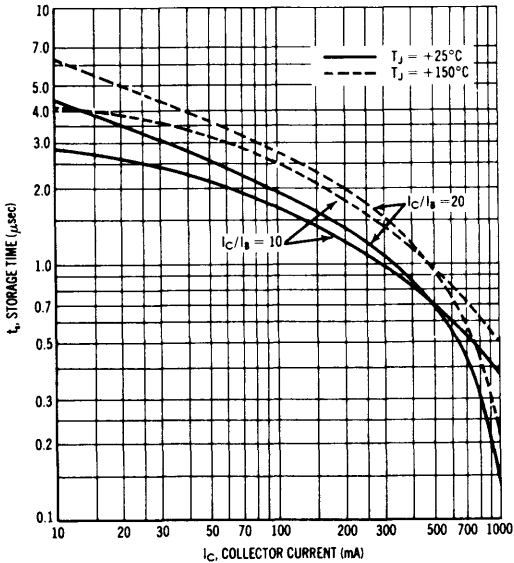
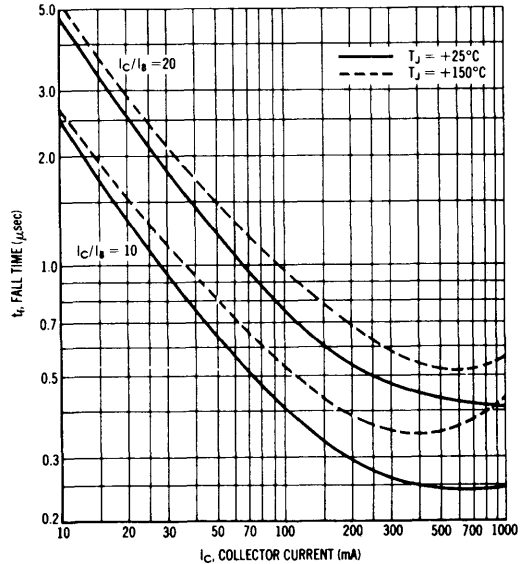


FIGURE 14 — FALL TIME



2N4237 2N4238 2N4239

CASE 079-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4237	2N4238	2N4239	Unit
Collector-Emitter Voltage	V_{CE0}	40	60	80	Vdc
Collector-Base Voltage	V_{CBO}	50	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Base Current	I_B	500			Vdc
Collector Current — Continuous	I_C	1.0 3.0*			Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.3			Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	6.0 34			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	$R_{\theta JC}$	29	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) ($I_C = 100 \text{ mAdc}, I_B = 0$)	$V_{CE0(sus)}$	40 60 80	— — —	Vdc
Collector Cutoff Current ($V_{CE} = 50 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}$) ($V_{CE} = 80 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}$)	I_{CEX}	— —	0.1 0.1	mAdc
($V_{CE} = 100 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}$) ($V_{CE} = 30 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$)	I_{CEX}	— —	0.1 1.0	mAdc
($V_{CE} = 50 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$) ($V_{CE} = 70 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$)	I_{CEX}	— —	1.0 1.0	mAdc
Collector Cutoff Current ($V_{CB} = \text{Rated } V_{CBO}, I_E = 0$) ($V_{CE} = \text{Rated } V_{CE0}, I_B = 0$)	I_{CBO}	— —	0.1 .07	mAdc
Emitter Cutoff Current ($V_{EB} = 6.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.5	mAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 50 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 250 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30 30 30 15	— 150 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 0.1 \text{ Adc}$)	$V_{CE(sat)}$	— —	0.3 0.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 1.0 \text{ Adc}, I_B = 0.1 \text{ Adc}$)	$V_{BE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage(1) ($I_C = 250 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	$V_{BE(on)}$	—	1.0	Vdc

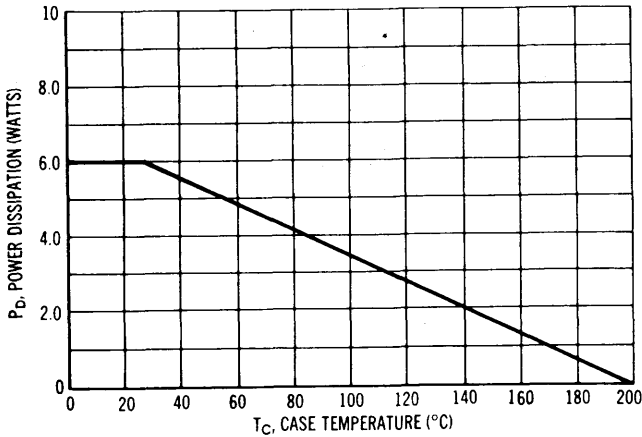
SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_C = 0, f = 0.1 \text{ MHz}$)	C_{obo}	—	100	pF
Small Signal Current Gain ($I_C = 100 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	30	—	—
Current Gain — High Frequency ($V_{CE} = 10 \text{ V}, I_C = 100 \text{ mA}, f = 1 \text{ MHz}$)	$ h_{fe} $	1.0	—	—

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle 2.0%.

*Indicates Data in addition to JEDEC Requirements.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

SWITCHING CHARACTERISTICS

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

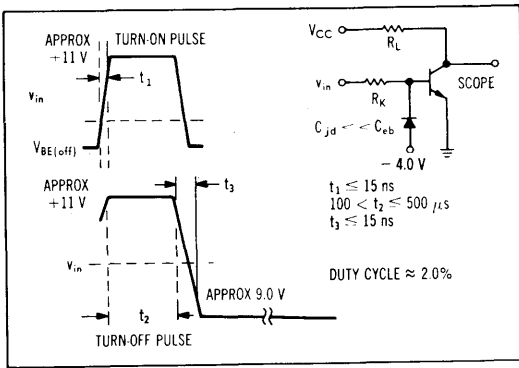


FIGURE 3 — TURN-ON TIME

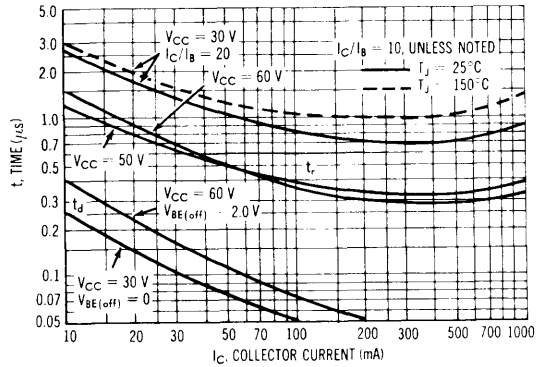


FIGURE 4 — THERMAL RESPONSE

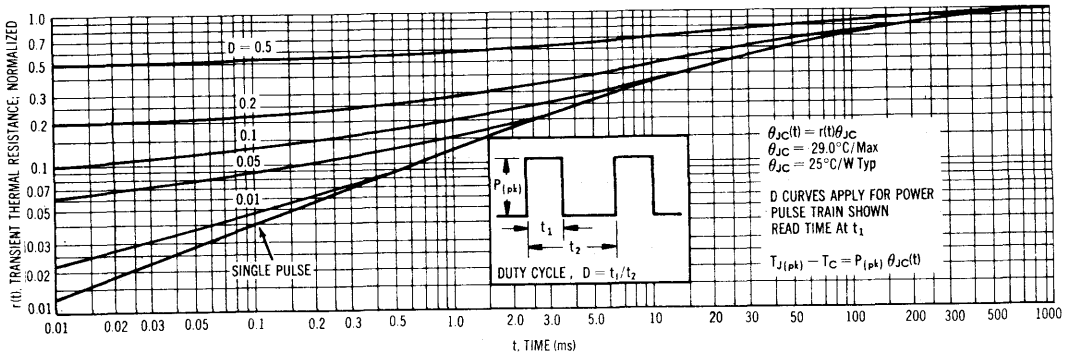
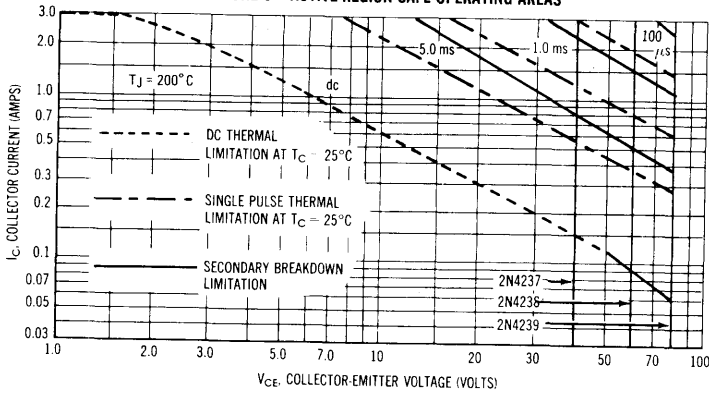


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

For this particular transistor family, the thermal curves are the limiting design values, except for a small portion of the dc curve. The pulse secondary breakdown curves are shown for information only.

FIGURE 6 — STORAGE TIME

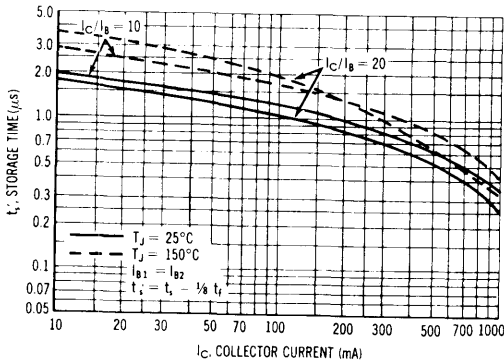
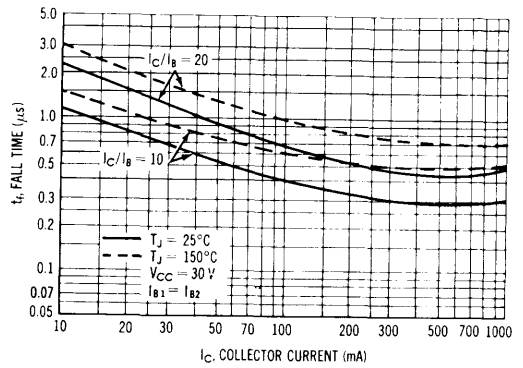


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

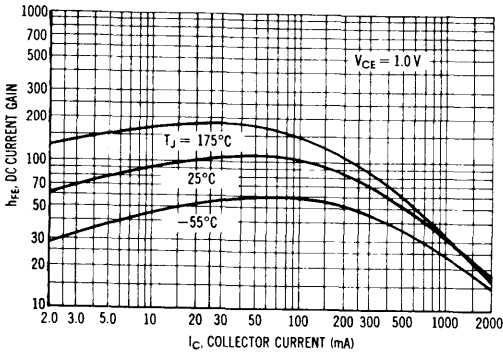


FIGURE 9 — COLLECTOR SATURATION REGION

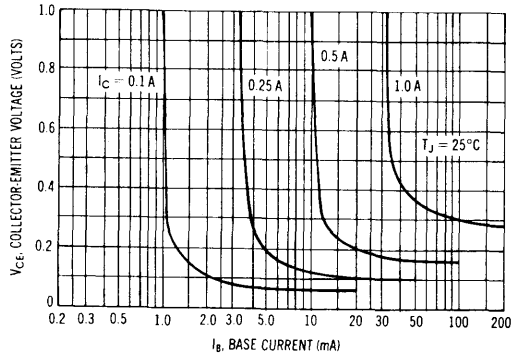


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

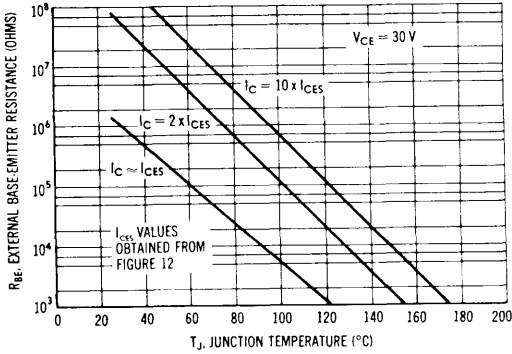


FIGURE 11 — "ON" VOLTAGE

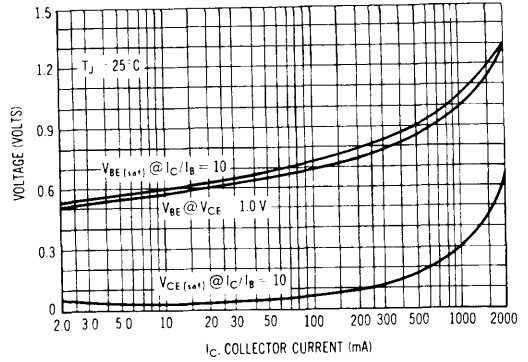


FIGURE 12 — COLLECTOR CUTOFF REGION

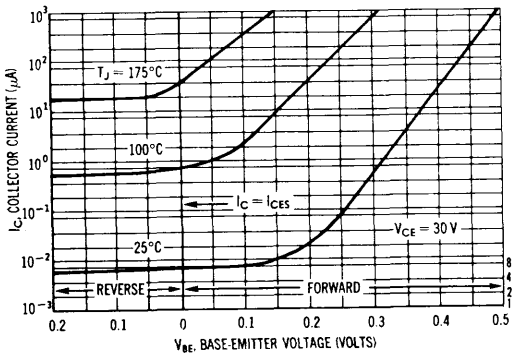
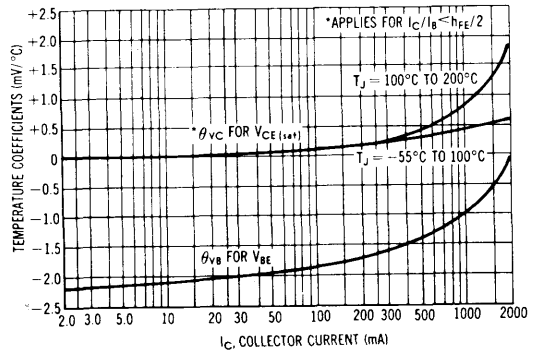


FIGURE 13 — TEMPERATURE COEFFICIENTS



2N4260 2N4261

2N4261 JAN, JTX AVAILABLE
CASE 20, STYLE 10
TO-72

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation (at $T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ mAdc}, I_E = 0$)	$V_{(BR)CEO}$	15	—	Vdc	
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	15	—	Vdc	
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.5	—	Vdc	
Collector Cutoff Current ($V_{CE} = 10\text{ Vdc}, V_{BE(off)} = 2.0\text{ Vdc}$) ($V_{CE} = 10\text{ Vdc}, V_{BE(off)} = 2.0\text{ Vdc}, T_A = 150^\circ\text{C}$) ($V_{CE} = 10\text{ Vdc}, V_{EB(on)} = 0.4\text{ Vdc}$)	I_{CEX}	— — —	0.005 5.0 0.05	μAdc	
Base Cutoff Current ($V_{CE} = 10\text{ Vdc}, V_{BE(off)} = 2.0\text{ Vdc}$)	I_{BL}	—	0.005	μAdc	
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$) ($I_C = 30\text{ mAdc}, V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	25 30 20	— 150 —	—	
Collector-Emitter Saturation Voltage ($I_C = 1.0\text{ mAdc}, I_B = 0.1\text{ mAdc}$) ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.15 0.35	Vdc	
Base-Emitter On Voltage ($I_C = 1.0\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$)	$V_{BE(on)}$	— —	0.8 1.0	Vdc	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0\text{ mAdc}, V_{CE} = 4.0\text{ Vdc}, f = 100\text{ MHz}$)	f_T	2N4260 2N4261	1200	—	MHz
			1500		
($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 100\text{ MHz}$)		2N4260 2N4261	1600 2000	— —	
Output Capacitance ($V_{CB} = 4.0\text{ Vdc}, I_E = 0, f = 100\text{ kHz}$)	C_{obo}	—	2.5	pF	
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 100\text{ kHz}$)	C_{ibo}	—	2.5	pF	
Current Gain — High Frequency ($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 100\text{ MHz}$)	$ h_{fe} $	2N4260 2N4261	16 20	— —	

2N4260, 2N4261

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
Collector Base Time Constant ($I_C = 5.0 \text{ mA}$, $V_{CE} = 4.0 \text{ V}$, $f = 31.8 \text{ MHz}$)	$rb'C_C$	—	35	ps	
					2N4260
					2N4261
					—
$(I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ V}$, $f = 31.8 \text{ MHz}$)	—	—	30	ps	
					2N4260
					2N4261
					—

Typical Performance
($v_{out} = 1.0 \text{ V}$)

@ 10 mA @ 30 mA

SWITCHING CHARACTERISTICS

Characteristic	Symbol	10 mA	30 mA	Unit
Rise Time	t_r	0.5	0.9	ns
Fall Time	t_f	1.0	1.2	ns
Turn-On Time	$t_{on}(\text{delay})$	1.0	1.2	ns
Turn-Off Delay Time	$t_{off}(\text{delay})$	1.0	1.2	ns

FIGURE 1 — DC CURRENT GAIN

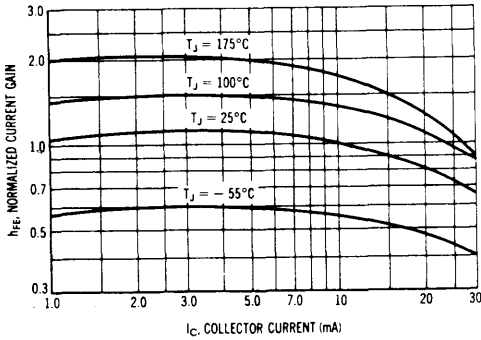


FIGURE 2 — COLLECTOR SATURATION REGION

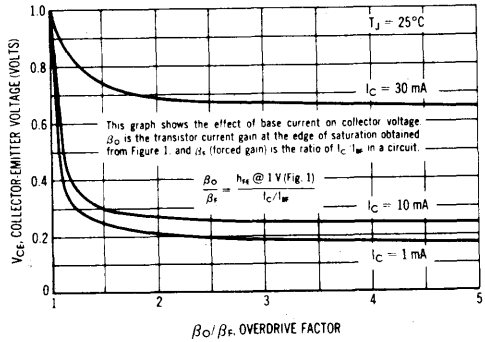


FIGURE 3 — "ON" VOLTAGES

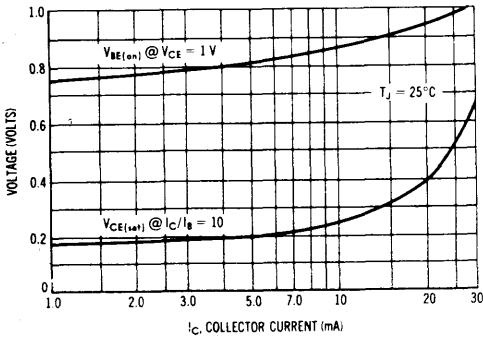


FIGURE 4 — TEMPERATURE COEFFICIENTS

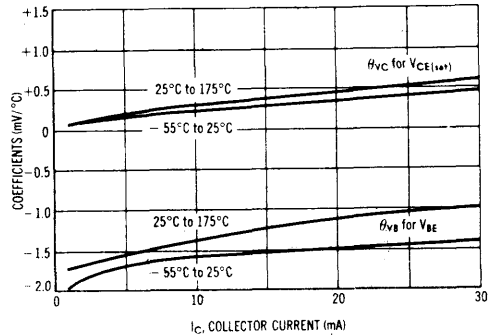


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT

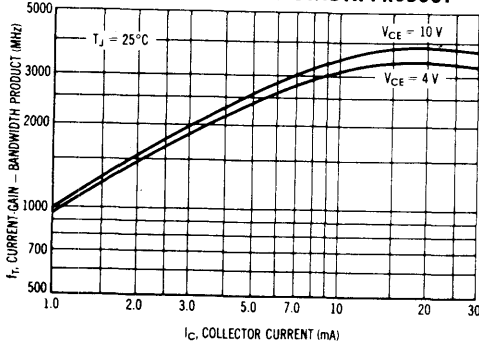


FIGURE 6 — COLLECTOR-BASE TIME CONSTANT

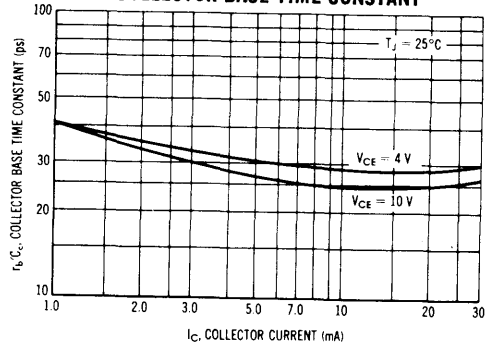


FIGURE 7 — SWITCHING TIMES

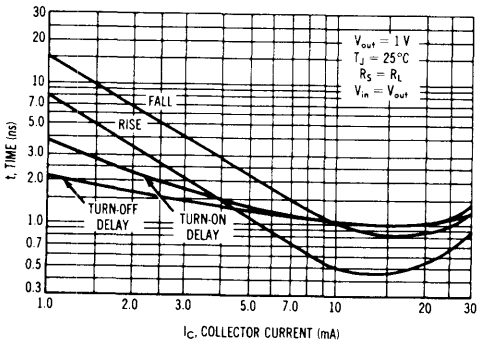


FIGURE 8 — CAPACITANCE

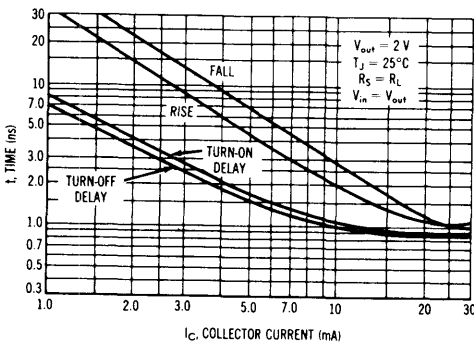
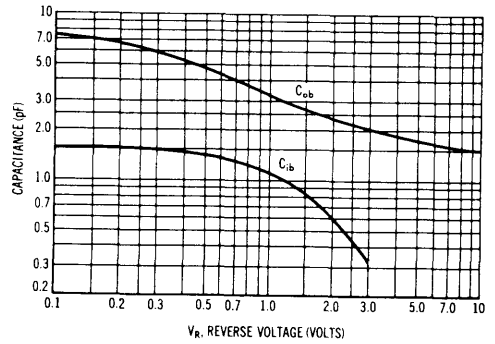
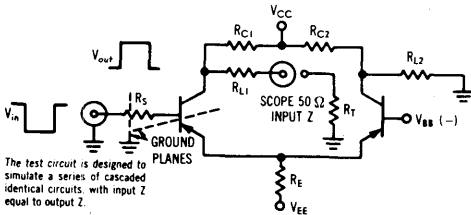
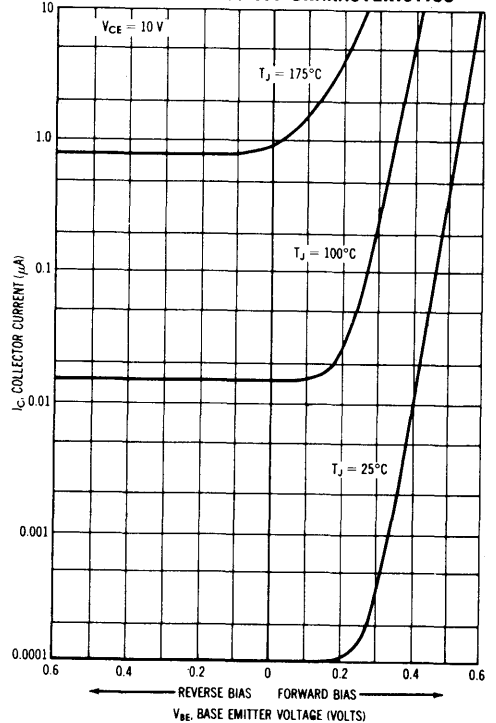


FIGURE 9 — CUT-OFF CHARACTERISTICS



The test circuit is designed to simulate a series of cascaded identical circuits with input Z equal to output Z.

I_C mA	$V_{in} = V_{out} = 2V$					$V_{in} = V_{out} = 1V$					$V_{in} = V_{out} = 0.5V$						
	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{CC} volts	V_{EE} volts	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{CC} volts	V_{EE} volts	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms
1	2k	6k	3k	3k	10k	10	16	1k	6k	1.2k	1.2k	24k	24	3k	3k	24	32
5	360	3.56k	400	450	2k	10	47	175	1k	200	150	3k	15	27	3k	30	17
10	160	1k	200	250	3k	30	26.3	75	300	100	150	3k	30	17	3k	30	17
20	62	300	100	150	1k	20	16	25	150	25	75	1k	20	11	3k	30	11
30	28	157	66	116	1k	30	13	8	77	0	50	1k	30	9	3k	30	9

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	80	Vdc
Collector-Base Voltage	V_{CB0}	80	Vdc
Emitter-Base Voltage	V_{EB0}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation ($\alpha T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	1.25 7.15	Watts $\text{mW}/^\circ\text{C}$
Total Device Dissipation ($\alpha T_C = 25^\circ\text{C}$ Derate above 25°C)	P_D	8.75 50	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	$^\circ\text{C}/\text{W}$

2N4404
2N4405

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	25	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	25	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	2N4404 2N4405	h_{FE}	30 75	—	—
($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	2N4404 2N4405		40 100	—	—
($I_C = 150 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}(1)$)	2N4404 2N4405		40 100	120 300	
($I_C = 500 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}(1)$)	2N4404 2N4405		30 50	—	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}(1)$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}(1)$)		$V_{CE(sat)}$	— — —	0.15 0.2 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}(1)$)		$V_{BE(sat)}$	— 0.85	0.8 1.2	Vdc
Base-Emitter On Voltage ($I_C = 150 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)		$V_{BE(on)}$	—	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	200	600	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$)	C_{eb}	—	75	pF

2N4404, 2N4405

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
SWITCHING CHARACTERISTICS					
Delay Time	$(V_{CC} = 30 \text{ Vdc}, V_{BE(\text{off})} = 2.0 \text{ Vdc}, I_C = 500 \text{ mA}, I_{B1} = 50 \text{ mA})$	t_d	—	15	ns
Rise Time		t_r	—	25	ns
Storage Time	$(V_{CC} = 30 \text{ Vdc}, I_C = 500 \text{ mA}, I_{B1} = I_{B2} = 50 \text{ mA})$	t_s	—	175	ns
Fall Time		t_f	—	35	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON

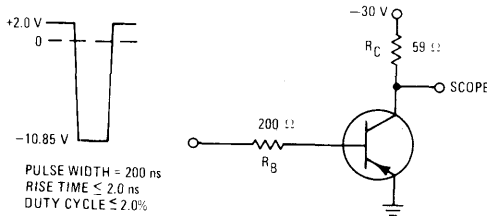
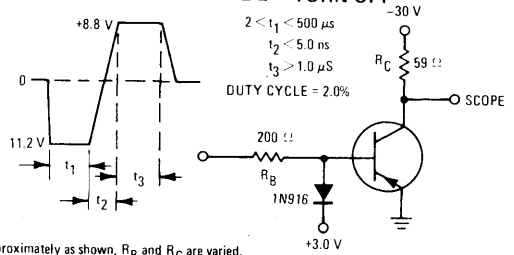


FIGURE 2 – TURN-OFF



To obtain data for curves, voltage levels are approximately as shown, R_B and R_C are varied.

TRANSIENT CHARACTERISTICS

————— 25°C - - - - 100°C

FIGURE 3 – CAPACITANCES

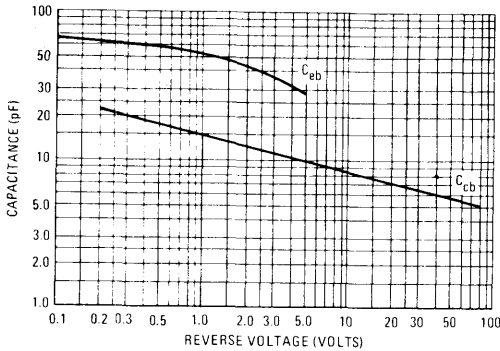


FIGURE 4 – CHARGE DATA

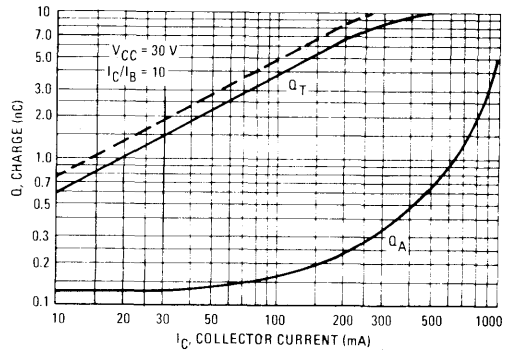


FIGURE 5 – DELAY TIME

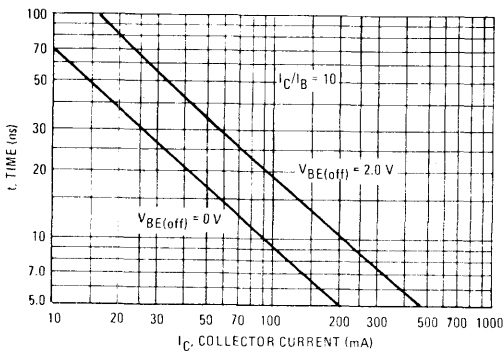


FIGURE 6 – RISE TIME

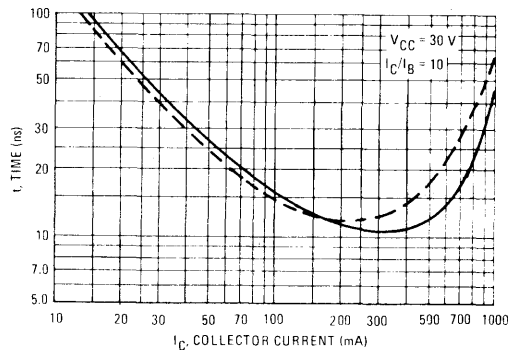


FIGURE 7 – STORAGE TIME

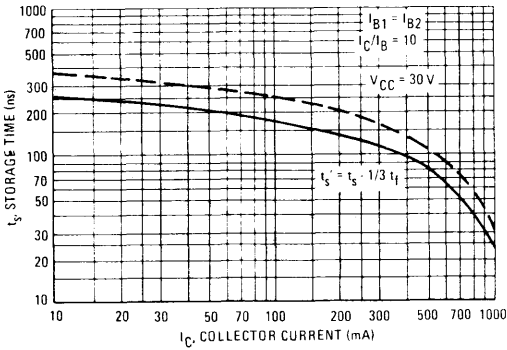
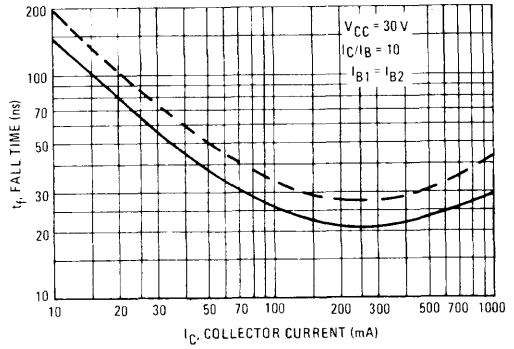


FIGURE 8 – FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$

FIGURE 9 – FREQUENCY EFFECTS

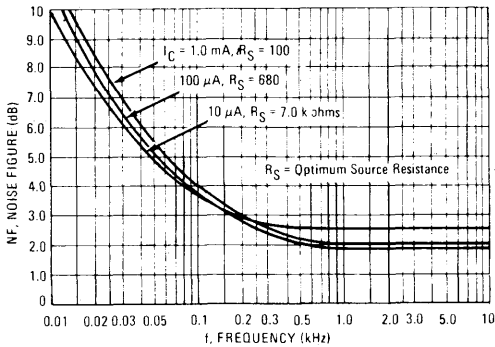
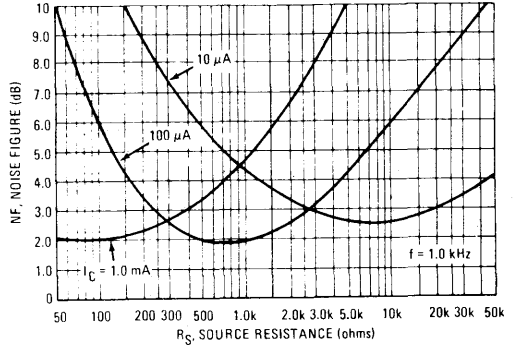


FIGURE 10 – SOURCE RESISTANCE EFFECTS



h PARAMETERS

$V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number – the same units were used to develop curves on each graph.

FIGURE 11 – CURRENT GAIN

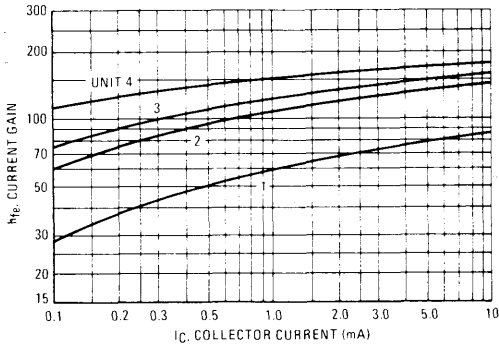
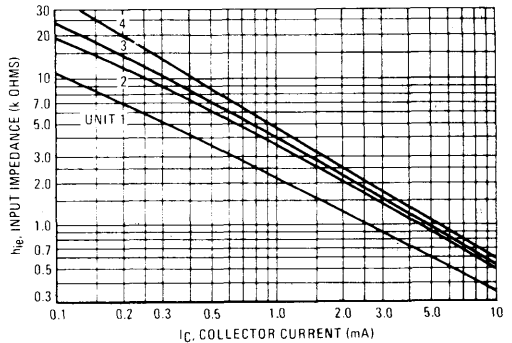


FIGURE 12 – INPUT IMPEDANCE



2N4404, 2N4405

FIGURE 13 – VOLTAGE FEEDBACK RATIO

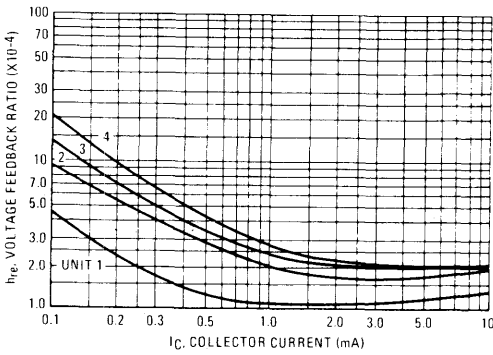
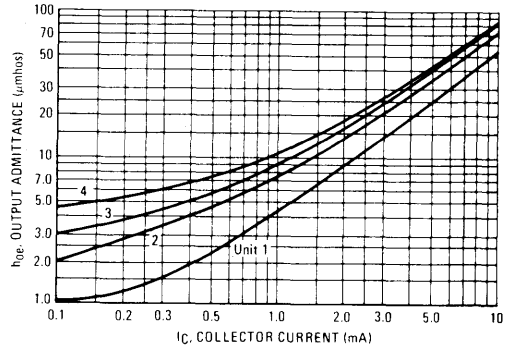


FIGURE 14 – OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

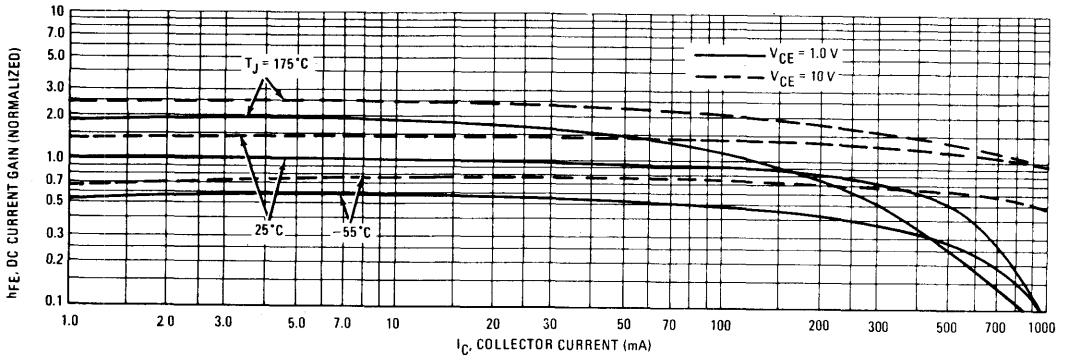
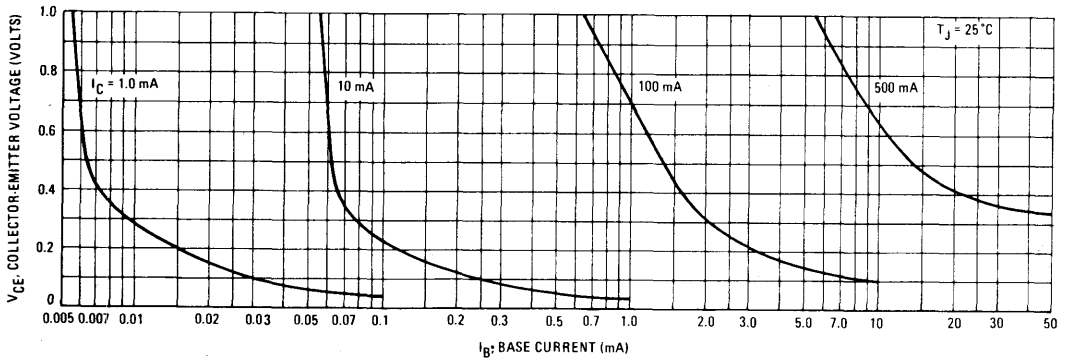


FIGURE 16 – COLLECTOR SATURATION REGION



2N4404, 2N4405

FIGURE 17 – "ON" VOLTAGES

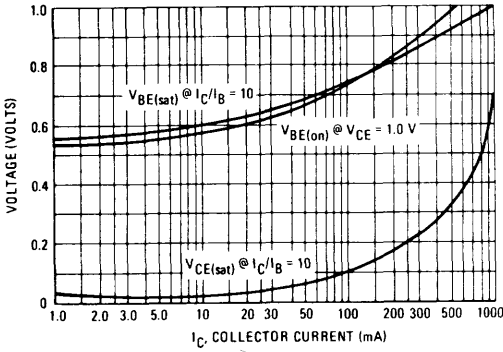
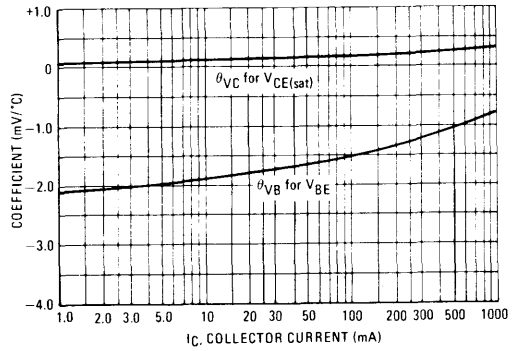
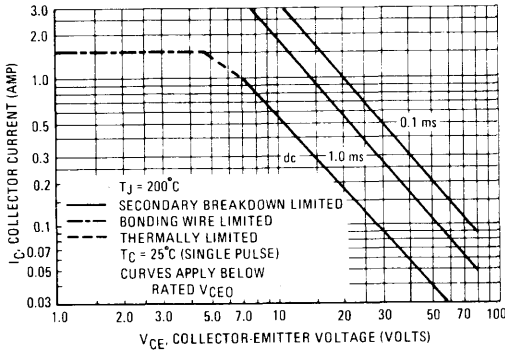


FIGURE 18 – TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

FIGURE 19 – SAFE OPERATING AREA



The safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 19 is based upon $T_{J(pk)} = 200^\circ\text{C}$. T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

2N4406 2N4407

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	80	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	2.0	Amps
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.25 7.15	Watts $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	8.75 50	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	25	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	25	μAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	2N4406 2N4407	h_{FE}	30 80	—	—
($I_C = 150 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	2N4406 2N4407		30 80	—	—
($I_C = 500 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	2N4406 2N4407		30 80	120 240	—
($I_C = 1.0 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc}$)	2N4406 2N4407		20 30	—	—
($I_C = 1.5 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc}$)	2N4406, 2N4407		10	—	—
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$) ($I_C = 1.5 \text{ Adc}, I_B = 150 \text{ mAdc}$)		$V_{CE(sat)}$	— — — —	0.2 0.4 0.7 1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$) ($I_C = 1.5 \text{ Adc}, I_B = 150 \text{ mAdc}$)		$V_{BE(sat)}$	— 0.9 —	0.9 1.3 1.5	Vdc
Base-Emitter On Voltage ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)		$V_{BE(on)}$	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)		f_T	150	750	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)		C_{cb}	—	15	pF
Emitter-Base Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$)		C_{eb}	—	160	pF

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30 \text{ Vdc}, V_{BE(off)} = 2.0 \text{ Vdc}, I_C = 1.0 \text{ Adc}, I_{B1} = 100 \text{ mAdc})$	t_d	—	15	ns
Rise Time		t_r	—	60	ns
Storage Time	$(V_{CC} = 30 \text{ Vdc}, I_C = 1.0 \text{ Adc}, I_{B1} = I_{B2} = 100 \text{ mAdc})$	t_s	—	175	ns
Fall Time		t_f	—	50	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$. * Indicates Data in addition to JEDEC Requirements.

STATIC CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

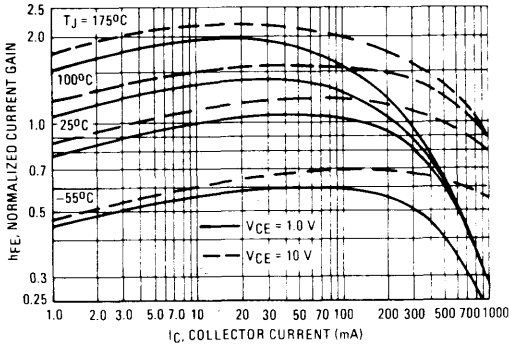


FIGURE 2 — COLLECTOR SATURATION REGION

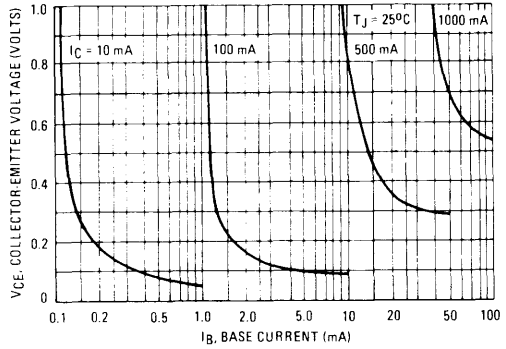


FIGURE 3 — "ON" VOLTAGES

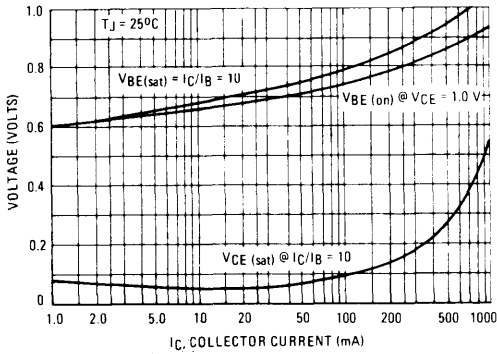


FIGURE 4 — TEMPERATURE COEFFICIENTS

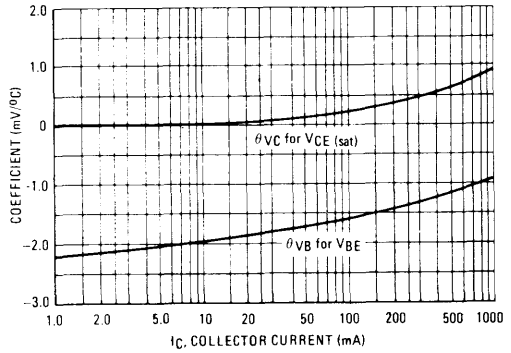
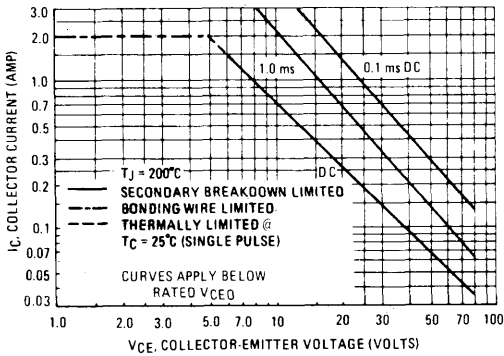


FIGURE 5 — SAFE OPERATING AREA



The safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 5 is based upon $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TRANSIENT CHARACTERISTICS
 ——— 25°C — — — 100°C

FIGURE 7 - CAPACITANCES

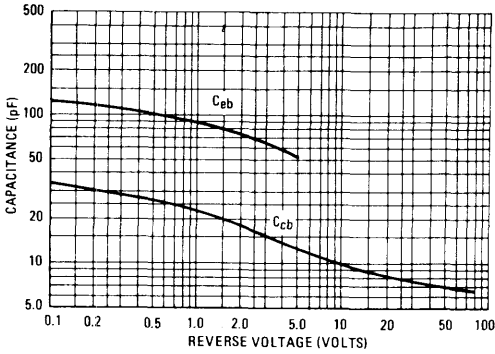


FIGURE 8 - CHARGE DATA

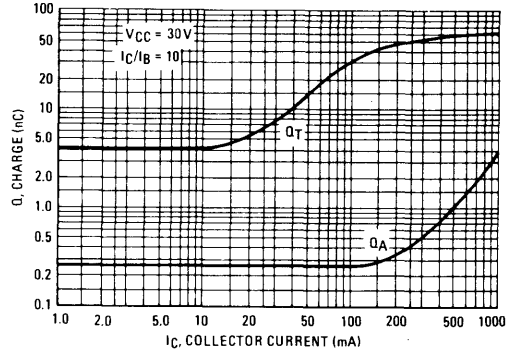


FIGURE 9 - TURN-ON TIME

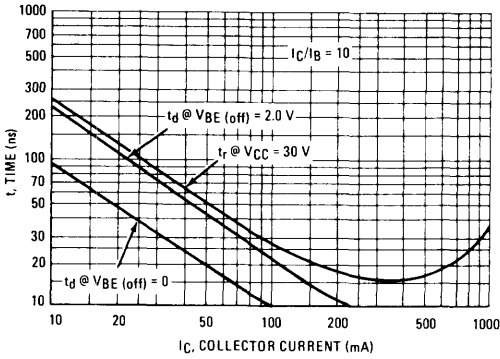
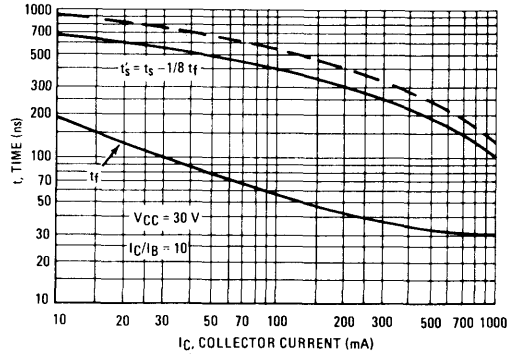


FIGURE 10 - TURN-OFF TIME



SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 11 - TURN-ON TIME

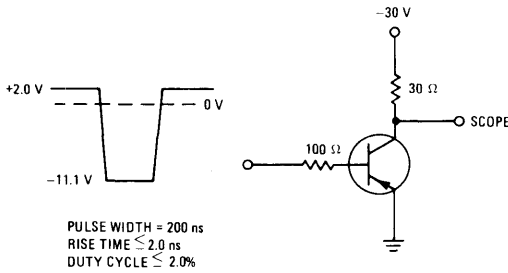
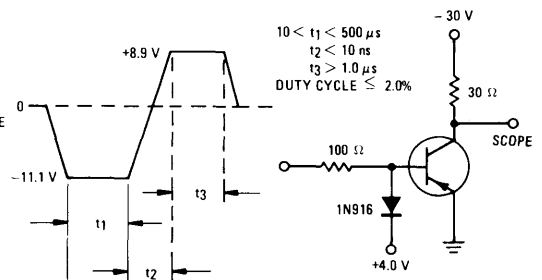


FIGURE 12 - TURN-OFF TIME



2N4453

For Specifications, See 2N869A Data.

2N4890**CASE 79-02, STYLE 1
TO-39 (TO-205AD)****GENERAL PURPOSE
TRANSISTOR****PNP SILICON****4****MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation ($T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	1.0 5.7	Watt mW/ $^\circ\text{C}$
Total Device Dissipation ($T_C = 25^\circ\text{C}$ Derate above 25°C)	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

Refer to 2N4033 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 100 \mu\text{Adc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}, R_{BE} = 10 \text{ ohms}$)	$V_{(BR)CER}$	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 60 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}$)	I_{CEX}	—	—	0.25	μAdc
Base Cutoff Current ($V_{CE} = 60 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}$)	I_{BL}	—	—	0.25	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 150 \text{ mAdc}, V_{CE} = 2.5 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) *($I_C = 500 \text{ mA}, V_{CE} = 5 \text{ Vdc}(1)$)	h_{FE}	25 50 15	130 140 —	— 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.12	1.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.82	1.7	Vdc
Base-Emitter On Voltage ($I_C = 150 \text{ mAdc}, V_{CE} = 2.5 \text{ Vdc}$)	$V_{BE(on)}$	—	0.74	1.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	100	280	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{obo}	—	9.0	15	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{ibo}	—	60	80	pF

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30 \text{ Vdc}, V_{BE(off)} = 0.8 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = 15 \text{ mAdc})$	t_d	—	15	50	ns
Rise Time		t_r	20	20	50	ns
Storage Time	$(V_{CC} = 30 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = I_{B2} = 15 \text{ mAdc})$	t_s	—	110	200	ns
Fall Time		t_f	—	20	70	ns

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2.0\%$.

*Indicates Data in Addition to JEDEC Requirements.

2N4924 2N4925

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4924	2N4925	Unit
Collector-Emitter Voltage	V_{CE0}	100	150	Vdc
Collector-Base Voltage	V_{CBO}	100	150	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	5.71	Watt $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0	28.6	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	$^\circ\text{C}/\text{W}$

Refer to 2N3498 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	100 150	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	100 150	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$) ($V_{CB} = 75 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	25 35 40	— — 200	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$)	$V_{CE(sat)}$	— —	0.25 0.4	Vdc
Base-Emitter On Voltage ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	$V_{BE(on)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (2) ($I_C = 20 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	100	500	MHz
Collector-Base Capacitance ($V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{EB} = 1.0 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{eb}	—	80	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) $f_T = |h_{fe}| \bullet f_{test}$.

MAXIMUM RATINGS

Rating	Symbol	2N4926	2N4927	Unit
Collector-Emitter Voltage	V _{CEO}	200	250	V _{dc}
Collector-Base Voltage	V _{CBO}	200	250	V _{dc}
Emitter-Base Voltage	V _{EBO}	7.0		V _{dc}
Collector Current — Continuous	I _C	50		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0		Watt
		5.71		mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0		Watts
		28.6		mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	200 250	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _C = 0)	V _{(BR)CBO}	200 250	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	V _{(BR)EBO}	7.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 100 Vdc, I _E = 0) (V _{CB} = 100 Vdc, I _E = 0, T _A = 100°C) (V _{CB} = 150 Vdc, I _E = 0) (V _{CB} = 150 Vdc, I _E = 0, T _A = 100°C)	I _{CBO}	— — — —	0.1 10 0.1 10	μAdc
Emitter Cutoff Current (V _{BE} = 5.0 Vdc)	I _{EBO}	—	0.1	μAdc

ON CHARACTERISTICS (1)

DC Current Gain (I _C = 3.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 30 mAdc, V _{CE} = 10 Vdc) (I _C = 50 mAdc, V _{CE} = 20 Vdc)	h _{FE}	10 15 20 20	— — 200 —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 30 mAdc, I _B = 3.0 mAdc)	V _{CE(sat)}	— —	1.0 2.0	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 50 mAdc, I _B = 3.0 mAdc)	V _{BE(sat)}	— —	1.2 1.5	V _{dc}
Base-Emitter On Voltage (I _C = 30 mAdc, V _{CE} = 10 Vdc)	V _{BE(on)}	—	1.5	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 20 MHz)	f _T	30	300	MHz
Collector-Base Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 140 kHz)	C _{cb}	—	6.0	pF
Input Impedance (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{ie}	75	2000	ohm
Voltage Feedback Ratio (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{re}	0.1	2.0	X 10 ⁻⁴
Small-Signal Current Gain (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	25	250	—
Output Admittance (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{oe}	—	50	μmhos
Real Part of Input Impedance (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 5.0 MHz)	Re(h _{ie})	4.0	200	ohms

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N4926 2N4927

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

2N4928 thru 2N4931

2N4930 and 2N4931 JAN, JTX &
JTXV AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE
TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4928	2N4929	2N4930	2N4931	Unit
Collector-Emitter Voltage	V _{CEO}	100	150	200	250	V _{dc}
Collector-Base Voltage	V _{CBO}	100	150	200	250	V _{dc}
Emitter-Base Voltage	V _{EBO}	4.0	4.0	4.0	4.0	V _{dc}
Collector Current — Continuous	I _C	100	500	500	500	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.6 3.4	1.0 5.71	1.0 5.71	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	3.0 17.2	5.0 28.6	5.0 28.6	5.0 28.6	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200				°C

Refer to 2N3494 for graphs for 2N4928.*

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	2N4928 2N4929 2N4930 2N4931	V _{(BR)CEO}	100 150 200 250	— — — —	V _{dc}
Collector-Base Breakdown Voltage (I _E = 0, I _C = 100 μAdc)	2N4928 2N4929 2N4930 2N4931	V _{(BR)CBO}	100 150 200 250	— — — —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)		V _{(BR)EBO}	4.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 75 Vdc, I _E = 0) (V _{CB} = 150 Vdc, I _E = 0)	2N4928 2N4929 2N4930, 2N4931	I _{CBO}	— — —	0.5 0.5 1.0	μAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0) (V _{BE} = 3.0 Vdc, I _C = 0)	2N4928, 2N4929 2N4930, 2N4931	I _{EBO}	— —	0.5 1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	All Types	h _{FE}	20	—	—
(I _C = 10 mAdc, V _{CE} = 10 Vdc)(1)	2N4928, 2N4929 2N4930, 2N4931		25 20	200 200	
(I _C = 50 mAdc, V _{CE} = 10 Vdc)(1) (I _C = 30 mAdc, V _{CE} = 10 Vdc)(1)	2N4928, 2N4929 2N4930, 2N4931		20 20	— —	
Collector-Emitter Saturation Voltage(1) (I _C = 10 mAdc, I _B = 1.0 mAdc)	2N4928, 2N4929 2N4930, 2N4931	V _{CE(sat)}	— —	0.5 5.0	V _{dc}
Base-Emitter On Voltage (I _C = 10 mAdc, V _{CE} = 10 Vdc)		V _{BE(on)}	—	1.0	V _{dc}

2N4928 thru 2N4931

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$) ($I_C = 20 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 20 \text{ MHz}$)	2N4928, 2N4929 2N4930, 2N4931	f_T	100 20	1,000 200	MHz
Collector-Base Capacitance ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$) ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$) ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	2N4928 2N4929 2N4930, 2N4931	C_{cb}	— — —	6.0 10 20	pF
Emitter-Base Capacitance ($V_{BE} = 2.0 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$) ($V_{BE} = 1.0 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$) ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$)	2N4928 2N4929 2N4930, 2N4931	C_{eb}	— — —	40 80 400	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.
Refer to 2N3634 for graphs for 2N4929.
Refer to 2N3743 for graphs for 2N4930 and 2N4931.

2N5022 2N5023

CASE 079-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE
TRANSISTOR

PNP SILICON

Refer to 2N3467 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N5022	2N5023	Unit
Collector-Emitter Voltage	V_{CE0}	50	30	V
Collector-Emitter Voltage	V_{CES}	50	30	V
Collector-Base Voltage	V_{CBO}	50	30	V
Emitter-Base Voltage	V_{EBO}	5		V
Collector Current — Continuous (Pulse Width = 300 μ s, DC = 1%)	I_C	1.0*		A
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	5.72	Watts $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	4.0	22.8	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$
Maximum Lead Temperature (Soldering, 60 sec max)	T_L	+300		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	43.8	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	$^\circ\text{C}/\text{W}$

*Indicates Data in Addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A dc}$)	$V_{(BR)CES}$	50 30	— —	V
Collector-Emitter Sustaining Voltage ($I_C = 10 \text{ mA dc}$)	$V_{(BR)CEO(sus)*}$	50 30	— —	V
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A dc}$)	$V_{(BR)CBO}$	50 30	— —	V
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A dc}$)	$V_{(BR)EBO}$	5.0	—	V
Collector Cutoff Current ($V_{CE} = 30 \text{ V dc}$) ($V_{CE} = 20 \text{ V dc}$) ($T_A = 100^\circ\text{C dc}$)	I_{CES}	— —	100 15	nA μA

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 100 \text{ mA}$, $V_{CE} = 1.0 \text{ V dc}$)	h_{FE}	15 30	— —	—
($I_C = 500 \text{ mA}$, $V_{CE} = 1.0 \text{ V dc}$)		25 40	100 100	
($I_C = 1.0 \text{ A}$, $V_{CE} = 5.0 \text{ V dc}$)		25 40	— —	
($I_C = 500 \text{ ma}$, $V_{CE} = 1.0 \text{ V}$, $T_A = -55^\circ\text{C}$)		10 20	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 100 \text{ mA dc}$, $I_B = 10 \text{ mA dc}$)	$V_{CE(sat)}$	— —	0.20 0.17	V
($I_C = 500 \text{ mA dc}$, $I_B = 50 \text{ mA dc}$)		— —	0.40 0.35	V
($I_C = 1.0 \text{ A dc}$, $I_B = 100 \text{ mA dc}$)		— —	0.80 0.70	V

2N5022, 2N5023

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage ($I_C = 100\text{ mA}$, $I_B = 10\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$) ($I_C = 1.0\text{ A}$, $I_B = 100\text{ mA}$)	$V_{BE(sat)}$	— 0.8 —	1.0 1.4 1.75	V V V

SMALL-SIGNAL CHARACTERISTICS

Collector-Base Capacitance ($V_{BE} = 0.5\text{ V}$, $f = 100\text{ kHz}$)	C_{cb}	—	25	pF
Emitter-Base Capacitance ($V_{BE} = 0.5\text{ V}$, $f = 100\text{ kHz}$)	C_{eb}	—	100	pF
Small-Signal Current Gain ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 100\text{ MHz}$)	h_{fe}	1.7 2.0	— —	—

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CE} = -30\text{ V}$, $I_C \approx 500\text{ mA}$, $I_B \approx 50\text{ mA}$)	t_{on}	—	40	ns
Turn-Off Time ($V_{CE} = 30\text{ V}$, $I_C \approx 500\text{ mA}$, $I_{B1} = I_{B2} \approx 50\text{ mA}$)	t_{off}	—	90	ns

(1) Pulse Width = $300\ \mu\text{s}$, Duty Cycle = 1.0%.

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2N5058 2N5059

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3724 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N5058	2N5059	Unit
Collector-Emitter Voltage	V_{CE0}	300	250	Vdc
Collector-Base Voltage	V_{CB0}	300	250	Vdc
Emitter-Base Voltage	V_{EB0}	7.0	6.0	Vdc
Collector Current — Continuous	I_C	150		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	6.67	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0	33.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	30	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	150	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) ($I_C = 30$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300 250	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	300 250	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	7.0 6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = +125^\circ\text{C}$)	I_{CBO}	—	0.05 20	μ Adc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	10	nAdc

ON CHARACTERISTICS (2)

DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 25$ Vdc)	h_{FE}	10 10	—	—
($I_C = 30$ mAdc, $V_{CE} = 25$ Vdc)		35 30	150 150	
($I_C = 30$ mAdc, $V_{CE} = 25$ Vdc, $T_A = -55^\circ\text{C}$)		10	—	
($I_C = 100$ mAdc, $V_{CE} = 25$ Vdc)		35 30	—	
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	$V_{BE(sat)}$	—	0.85	Vdc
Base-Emitter On Voltage ($I_C = 30$ mAdc, $V_{CE} = 25$ Vdc)	$V_{BE(on)}$	—	0.82	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (3) ($I_C = 10$ mAdc, $V_{CE} = 25$ Vdc, $f = 20$ MHz)	f_T	30	160	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 1.0$ MHz)	C_{eb}	—	75	pF

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

(2) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

(3) f_T is defined as the frequency at which the $|h_{fe}|$ extrapolates to unity.

2N5229 2N5230 2N5231

**CASE 26-03, STYLE 1
TO-46 (TO-206AB)**

**LOW POWER CHOPPER
TRANSISTOR**

PNP SILICON

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MAXIMUM RATINGS

Rating	Symbol	2N5229	2N5230	2N5231	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	30	Vdc
Collector-Base Voltage	V_{CBO}	15	30	50	Vdc
Emitter-Base Voltage	V_{EBO}	15	30	50	Vdc
Collector Current — Continuous	I_C	50			mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 2.86			Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0 12			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Emitter-Collector Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_B = 0$)	$V_{(BR)ECO}$	10 20 30	— — —	Vdc
		2N5229 2N5230 2N5231		
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	15 30 50	— — —	Vdc
		2N5229 2N5230 2N5231		
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	15 30 50	— — —	Vdc
		2N5229 2N5230 2N5231		
Collector Cutoff Current ($V_{CB} = 12 \text{ Vdc}, I_E = 0$) ($V_{CB} = 25 \text{ Vdc}, I_E = 0$) ($V_{CB} = 40 \text{ Vdc}, I_E = 0$)	I_{CBO}	— — —	1.0 1.0 1.0	nAdc
		2N5229 2N5230 2N5231		
Emitter Cutoff Current ($V_{EB} = 12 \text{ Vdc}, I_C = 0$) ($V_{EB} = 25 \text{ Vdc}, I_C = 0$) ($V_{EB} = 40 \text{ Vdc}, I_C = 0$)	I_{EBO}	— — —	1.0 1.0 1.0	nAdc
		2N5229 2N5230 2N5231		

ON CHARACTERISTICS

DC Current Gain ($I_C = 100 \mu\text{Adc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 200 \mu\text{Adc}, V_{CE} = 0.5 \text{ Vdc}$) (Inverted Connection)	h_{FE}	50 15	— —	—
Offset Voltage ($I_B = 100 \mu\text{Adc}, I_E = 0$) ($I_B = 1.0 \text{ mAdc}, I_E = 0$)	$V_{EC(ofs)}$	— — — —	0.5 0.8 0.8 1.0	mVdc
		2N5229, 2N5230, 2N5231 2N5229, 2N5230, 2N5231		

SMALL-SIGNAL CHARACTERISTICS

Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{cb}	—	5.0	pF
Emitter-Base Capacitance ($V_{EB} = 10 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{eb}	—	4.0	pF
Small Signal Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 4.0 \text{ MHz}$)	h_{fe}	2.0	—	—

2N5229, 2N5230, 2N5231

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
"ON" Series Resistance ($I_B = 1.0\text{ mAdc}$, $I_E = 0$, $I_C = 100\ \mu\text{A RMS}$, $f = 1.0\text{ kHz}$)	$r_{ec(on)}$	1.0	6.0	Ohms
		2.0	8.0	
		2.0	10	

TYPICAL CHARACTERISTICS

FIGURE 1 – EMITTER-COLLECTOR VOLTAGE versus BASE CURRENT

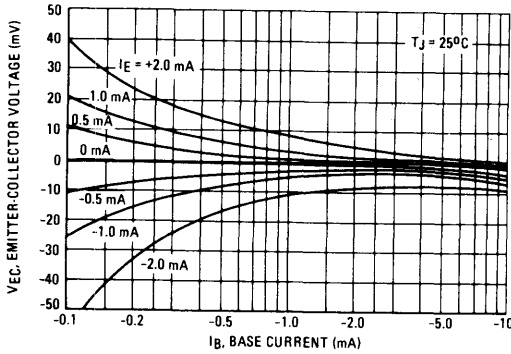


FIGURE 2 – EMITTER-COLLECTOR VOLTAGE versus JUNCTION TEMPERATURE

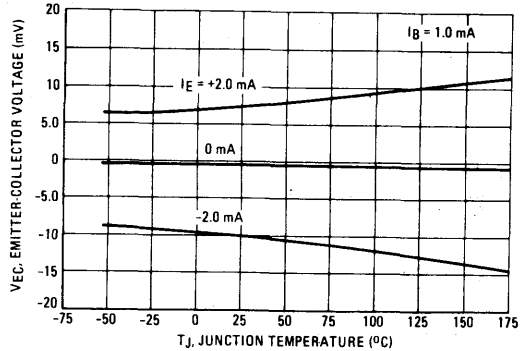


FIGURE 3 – EMITTER-COLLECTOR "ON" RESISTANCE versus BASE CURRENT

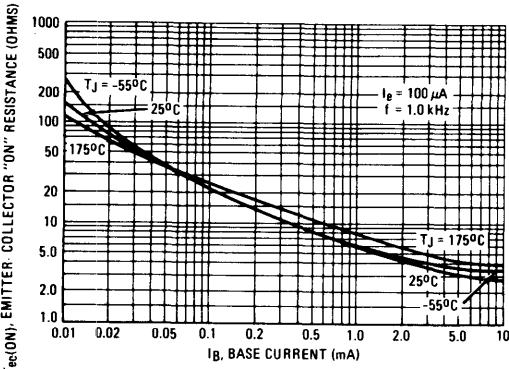


FIGURE 4 – EMITTER-COLLECTOR "ON" RESISTANCE TEMPERATURE COEFFICIENT versus BASE CURRENT

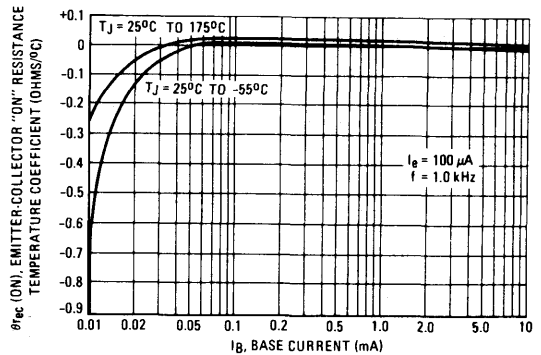


FIGURE 5 – CURRENT GAIN versus COLLECTOR CURRENT

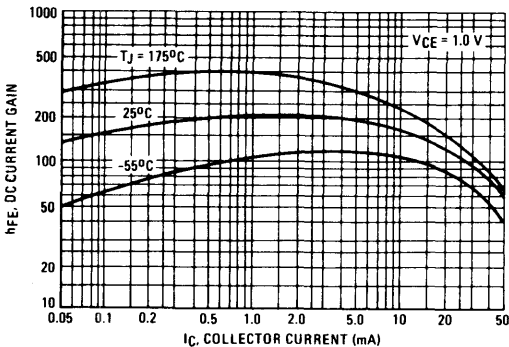


FIGURE 6 – CURRENT GAIN (Inverted Connection) versus EMITTER CURRENT

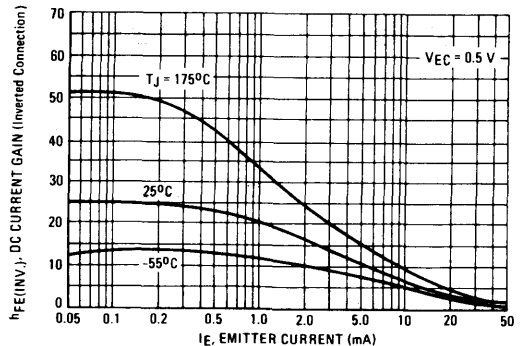


FIGURE 7 – COLLECTOR CUTOFF CURRENT versus JUNCTION TEMPERATURE

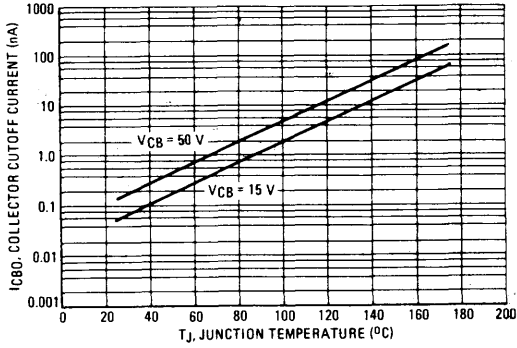
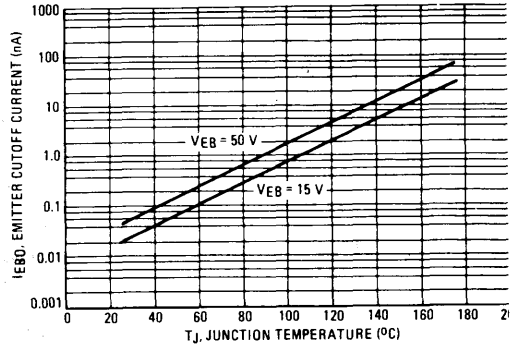


FIGURE 8 – EMITTER CUTOFF CURRENT versus JUNCTION TEMPERATURE



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FIGURE 9 – COLLECTOR-EMITTER SATURATION VOLTAGE versus COLLECTOR CURRENT

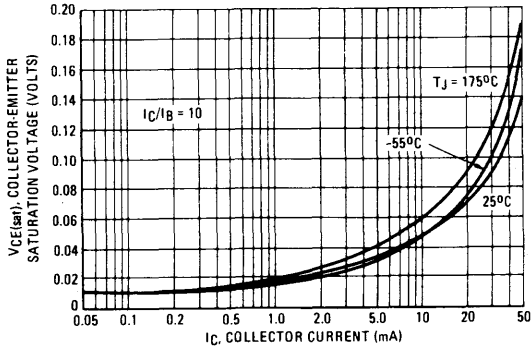
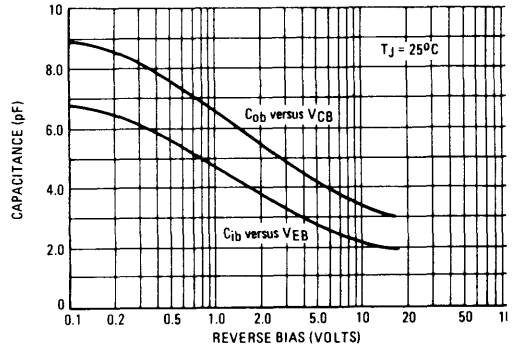


FIGURE 10 – JUNCTION CAPACITANCE versus REVERSE BIAS VOLTAGE



2N5320 2N5321

CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5320	2N5321	Unit
Collector-Emitter Voltage	V_{CEO}	75	50	Vdc
Collector-Base Voltage	V_{CBO}	100	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	5.0	Vdc
Base Current	I_B	1.0		Adc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	10	0.057	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	75 50	— —	Vdc
Collector Cutoff Current ($V_{CE} = 100 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}$)	I_{CEX}	—	0.1	mAdc
($V_{CE} = 70 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$)		—	5.0	
($V_{CE} = 75 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}$)		—	0.1	
($V_{CE} = 45 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$)		—	5.0	
Emitter Cutoff Current ($V_{BE} = 7.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.1	mAdc
($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)			0.1	

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 500 \text{ mAdc}, V_{CE} = 4.0 \text{ Vdc}$)	h_{FE}	30	130	—
		40	250	
($I_C = 1.0 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$)		10	—	
Collector-Emitter Saturation Voltage ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.5	Vdc
		—	0.8	
Base-Emitter On Voltage ($I_C = 500 \text{ mAdc}, V_{CE} = 4.0 \text{ Vdc}$)	$V_{BE(on)}$	—	1.1	Vdc
			1.4	

SMALL-SIGNAL CHARACTERISTICS

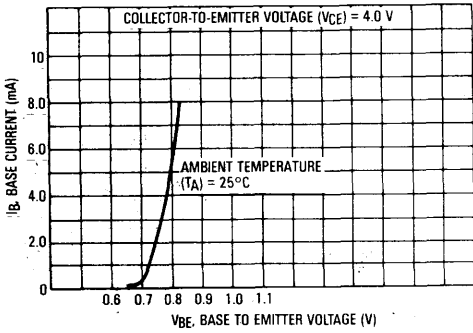
Small-Signal Current Gain ($I_C = 50 \text{ mAdc}, V_{CE} = 4.0 \text{ Vdc}, f = 10 \text{ MHz}$)	h_{fe}	5	—	—
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SWITCHING CHARACTERISTICS

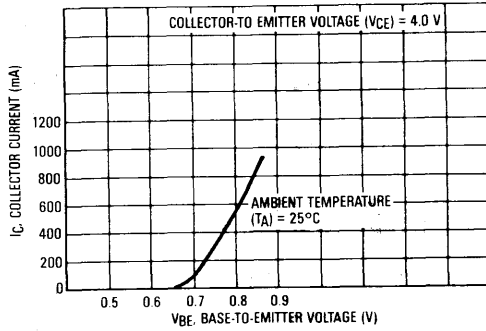
Turn-On Time ($V_{CC} \approx 30 \text{ Vdc}, I_C = 500 \text{ mAdc}, I_{B1} = 50 \text{ mAdc}$)	t_{on}	—	80	ns
Turn-Off Time ($V_{CC} \approx 30 \text{ Vdc}, I_C = 500 \text{ mAdc}, I_{B1} = I_{B2} = 50 \text{ mAdc}$)	t_{off}	—	800	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

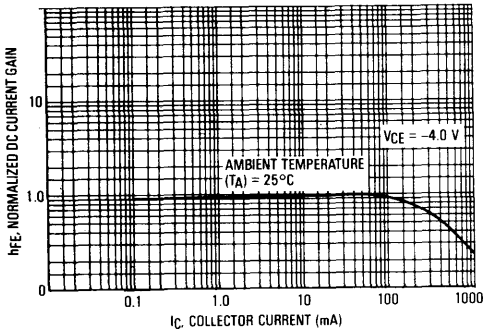
TYPICAL INPUT CHARACTERISTICS



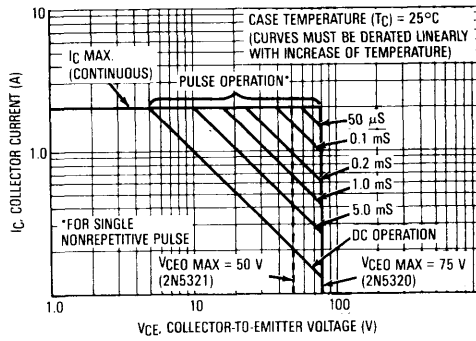
TYPICAL TRANSFER CHARACTERISTICS



CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



MAXIMUM SAFE OPERATING AREAS (SOA)



2N5322 2N5323

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5322	2N5323	Unit
Collector-Emitter Voltage	V_{CE0}	75	50	Vdc
Collector-Base Voltage	V_{CBO}	100	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	5.0	Vdc
Base Current	I_B	1.0		Adc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	10	0.057	Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	$^\circ\text{C/W}$

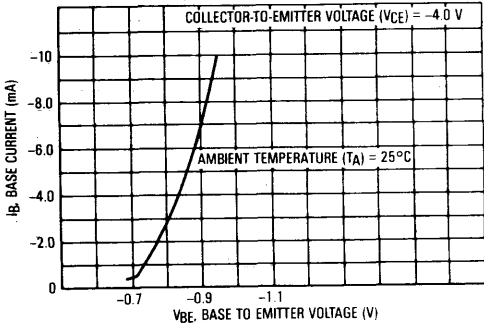
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 100 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	75 50	— —	Vdc
Collector Cutoff Current ($V_{CE} = 100 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}$)	I_{CEX}	—	0.1	mAdc
($V_{CE} = 70 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$)		—	5.0	
($V_{CE} = 75 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}$)		—	0.1	
($V_{CE} = 45 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$)		—	5.0	
Emitter Cutoff Current ($V_{BE} = 7.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.1	mAdc
($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)		—	0.1	
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 500 \text{ mAdc}, V_{CE} = 4.0 \text{ Vdc}$)	h_{FE}	30	130	—
		40	250	
($I_C = 1.0 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$)		10	—	
Collector-Emitter Saturation Voltage ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.7 1.2	Vdc
Base-Emitter On Voltage ($I_C = 500 \text{ mAdc}, V_{CE} = 4.0 \text{ Vdc}$)	$V_{BE(on)}$	—	1.1 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Small-Signal Current Gain ($I_C = 50 \text{ mAdc}, V_{CE} = 4.0 \text{ Vdc}, f = 10 \text{ MHz}$)	h_{fe}	5	—	—
SWITCHING CHARACTERISTICS				
Turn-On Time ($V_{CC} = 30 \text{ Vdc}, I_C = 500 \text{ mAdc}, I_{B1} = 50 \text{ mAdc}$)	t_{on}	—	100	ns
Turn-Off Time ($V_{CC} = 30 \text{ Vdc}, I_C = 500 \text{ mAdc}, I_{B1} = I_{B2} = 50 \text{ mAdc}$)	t_{off}	—	1000	ns

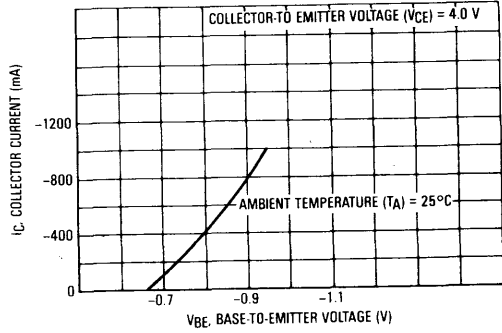
(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N5322, 2N5323

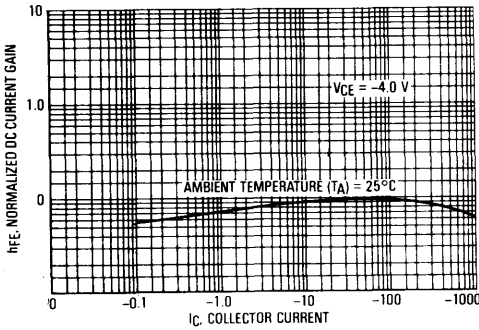
TYPICAL INPUT CHARACTERISTICS



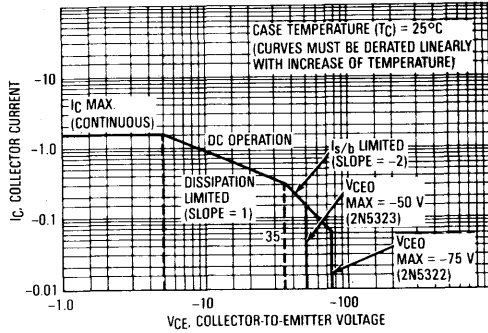
TYPICAL TRANSFER CHARACTERISTICS



CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



MAXIMUM SAFE OPERATING AREAS (SOA)



2N5415, 2N5416

For Specifications, See 2N3439 Data.

2N5581

For Specifications, See 2N2218 Data.

2N5679
2N5680

PNP SILICON

2N5681
2N5682

NPN SILICON

CASE 79-02, STYLE 1
TO-5 (TO-205AA)

GENERAL PURPOSE
TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	2N5679 2N5681	2N5680 2N5682	Unit
Collector-Emitter Voltage	V_{CE0}	100	120	Vdc
Collector-Base Voltage	V_{CB0}	100	120	Vdc
Emitter-Base Voltage	V_{EB0}	4.0		Vdc
Base Current	I_B	0.5		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	5.7	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	10	57	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

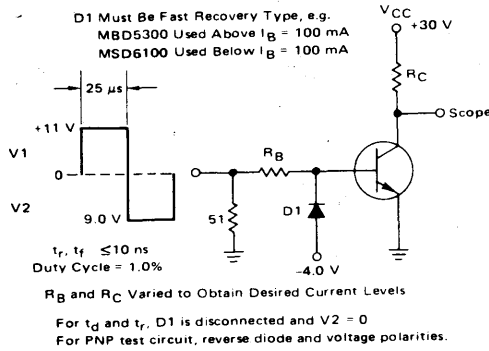
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{CE0(sus)}$	100 120	— —	Vdc
Collector Cutoff Current ($V_{CE} = 70 \text{ Vdc}, I_B = 0$) ($V_{CE} = 80 \text{ Vdc}, I_B = 0$)	I_{CEO}	— —	10 10	μAdc
Collector Cutoff Current ($V_{CE} = 100 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}$) ($V_{CE} = 120 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}$)	I_{CEX}	— —	1.0 1.0	μAdc mAdc
($V_{CE} = 100 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$) ($V_{CE} = 120 \text{ Vdc}, V_{EB} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$)		— —	1.0 1.0	
Collector Cutoff Current ($V_{CB} = 100 \text{ Vdc}, I_E = 0$) ($V_{CB} = 120 \text{ Vdc}, I_E = 0$)	I_{CBO}	— —	1.0 1.0	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 250 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$)	h_{FE}	40 5.0	150 —	—
Collector-Emitter Saturation Voltage ($I_C = 250 \text{ mAdc}, I_B = 25 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 200 \text{ mAdc}$)	$V_{CE(sat)}$	— — —	0.6 1.0 2.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 250 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 100 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 10 \text{ MHz}$)	f_T	30	—	—
Output Capacitance ($V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{ob0}	—	50	pF
Small-Signal Current Gain ($I_C = 0.2 \text{ Adc}, V_{CE} = 1.5 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	40	—	—

FIGURE 1 - SWITCHING TIMES TEST CIRCUIT



PNP
 2N5679, 2N5680

NPN
 2N5681, 2N5682

FIGURE 2 - TURN-ON TIME

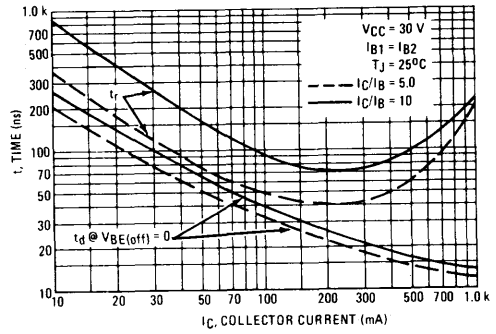
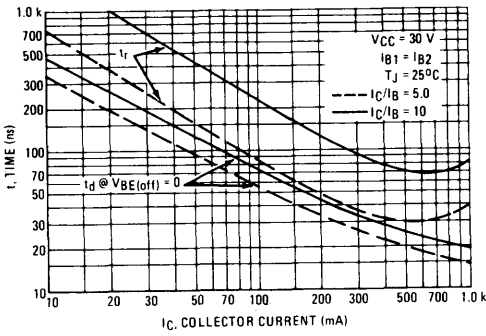
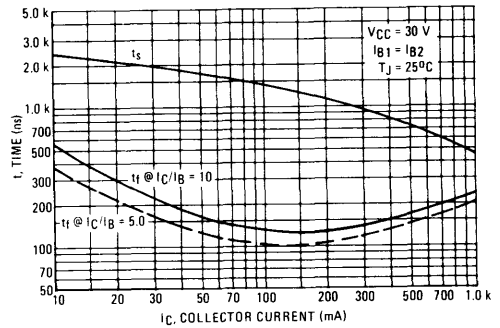
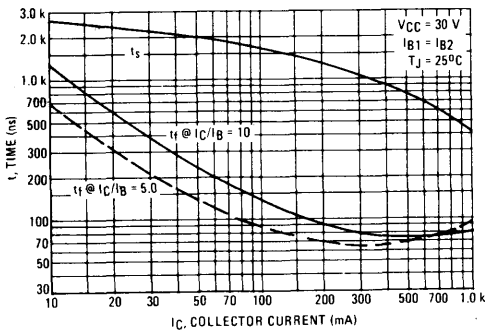


FIGURE 3 - TURN-OFF TIME



2N5679, 2N5680, 2N5681, 2N5682

FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

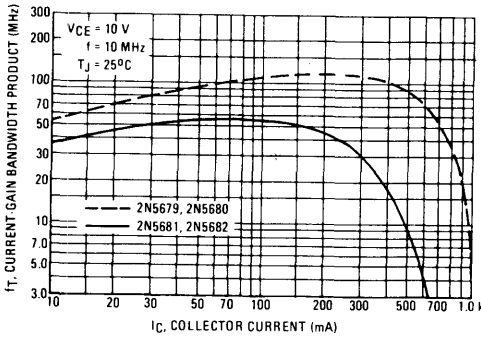


FIGURE 5 – CAPACITANCE

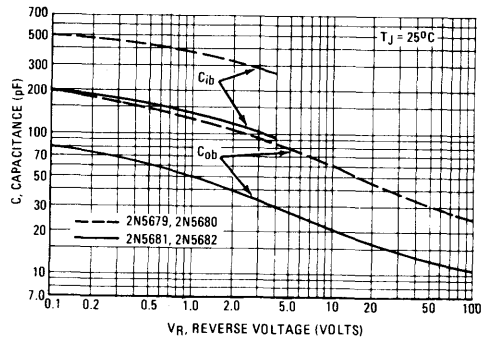


FIGURE 6 – THERMAL RESISTANCE

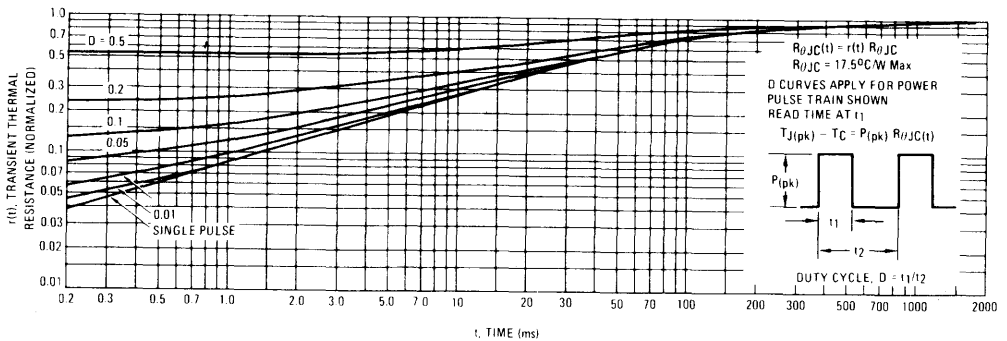


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA

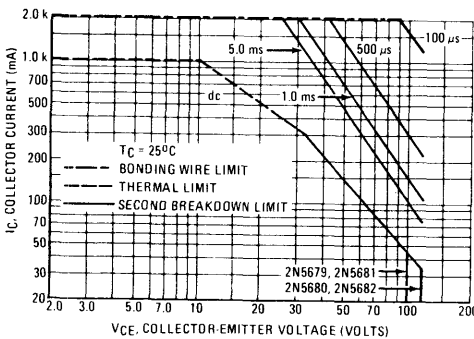
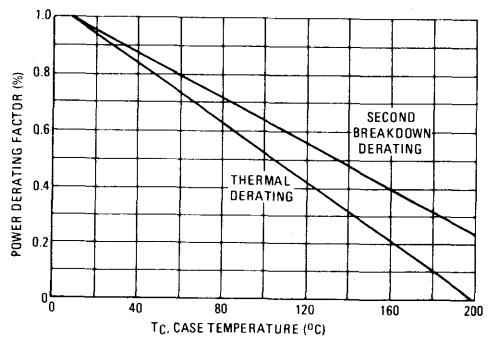


FIGURE 8 – POWER DERATING



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on $T_C = 25^\circ\text{C}$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 7 may be found at any case temperature by using the appropriate curve on Figure 8.

PNP
2N5679, 2N5680

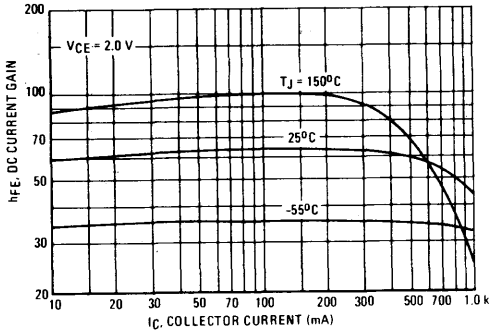


FIGURE 9 - DC CURRENT GAIN

NPN
2N5681, 2N5682

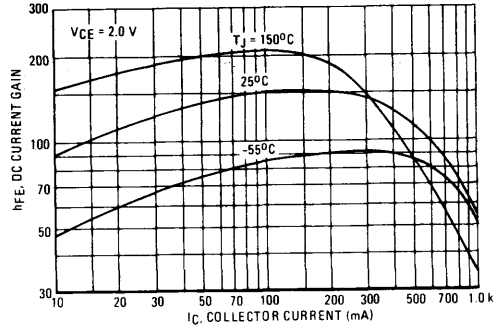


FIGURE 10 - COLLECTOR SATURATION REGION

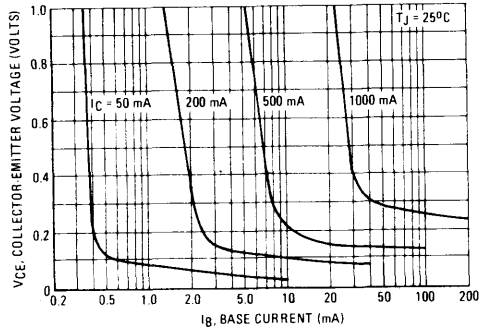
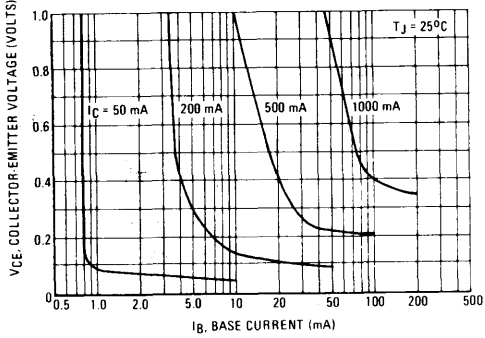
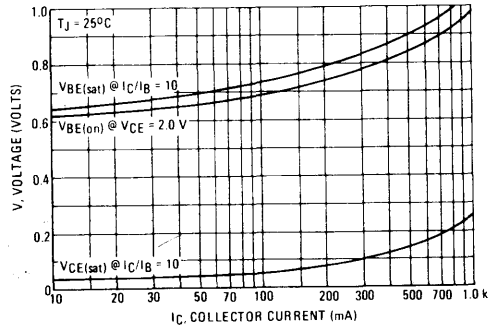
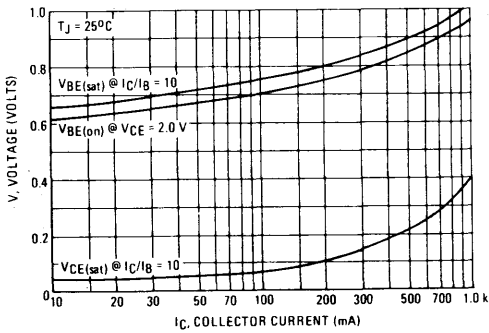


FIGURE 11 - "ON" VOLTAGES



PNP
2N5679, 2N5680

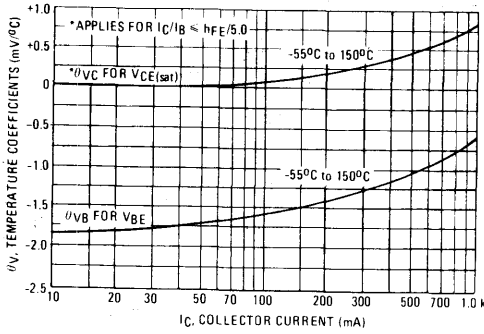


FIGURE 12 - TEMPERATURE COEFFICIENTS

NPN
2N5681, 2N5682

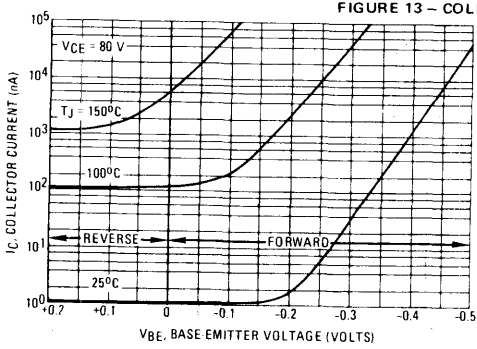
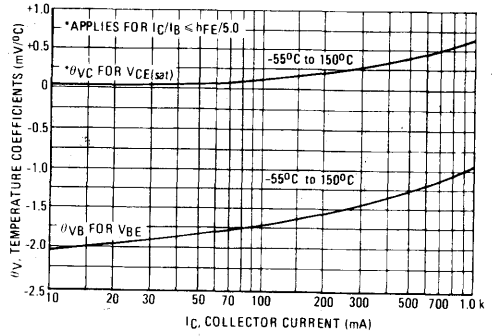


FIGURE 13 - COLLECTOR CUTOFF REGION

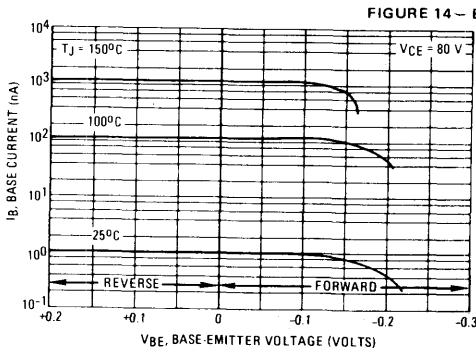
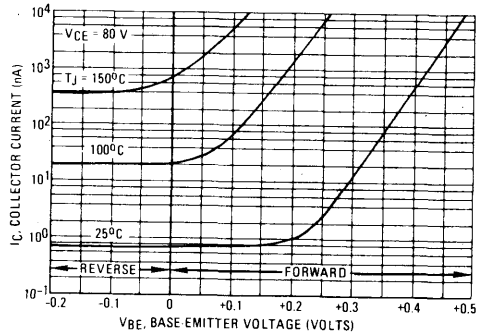
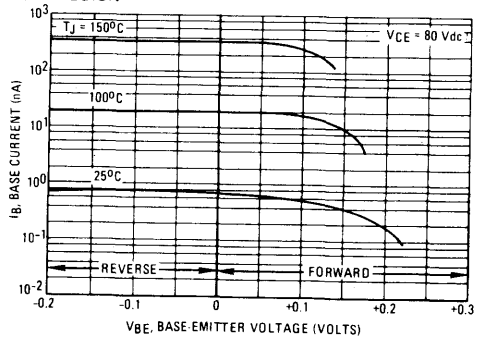


FIGURE 14 - BASE CUTOFF REGION



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	80	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current — Continuous	I _C	2.0	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 6.0	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	175	°C/W

2N5859

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mA _{dc} , I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBO}	80	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	6.0	—	Vdc
Collector Cutoff Current (V _{CE} = 50 Vdc, V _{BE(off)} = 2.0 Vdc) (V _{CE} = 50 Vdc, V _{BE(off)} = 2.0 Vdc, T _A = 75°C)	I _{CEX}	—	0.2 5.0	μA _{dc}
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0, T _A = 75°C)	I _{CBO}	—	0.25 5.0	μA _{dc}
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	0.1	μA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 500 mA _{dc} , V _{CE} = 1.0 Vdc) (I _C = 1.0 A _{dc} , V _{CE} = 1.0 Vdc) (I _C = 1.0 A _{dc} , V _{CE} = 1.0 Vdc, T _A = -55°C)	h _{FE}	30 15 10	120 100 —	—
Collector-Emitter Saturation Voltage (I _C = 500 mA _{dc} , I _B = 50 mA _{dc}) (I _C = 1.0 A _{dc} , I _B = 100 mA _{dc})	V _{CE(sat)}	—	0.4 0.7	Vdc
Base-Emitter Saturation Voltage (I _C = 500 mA _{dc} , I _B = 50 mA _{dc}) (I _C = 1.0 A _{dc} , I _B = 100 mA _{dc})	V _{BE(sat)}	0.8 0.9	1.0 1.25	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mA _{dc} , V _{CE} = 10 Vdc, f = 100 MHz)	f _T	250	—	MHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{cb}	—	7.0	pF
Emitter-Base Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{eb}	—	60	pF

SWITCHING CHARACTERISTICS

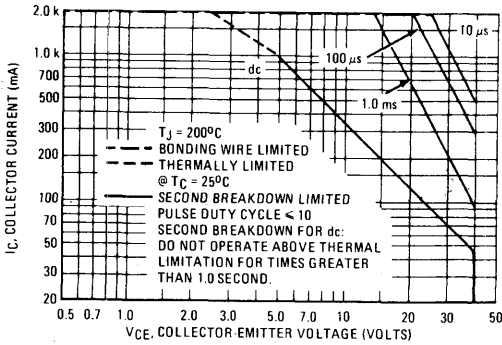
Delay Time (V _{CC} = 30 Vdc, V _{BE(off)} = 2.0 Vdc, I _C = 1.0 A _{dc} , I _{B1} = 100 mA _{dc}) (Figures 8 and 10)	t _d	—	6.0	ns
Rise Time (V _{CC} = 30 Vdc, V _{BE(off)} = 2.0 Vdc, I _C = 1.0 A _{dc} , I _{B1} = 100 mA _{dc}) (Figures 8 and 10)	t _r	—	30	ns
Storage Time (V _{CC} = 30 Vdc, I _C = 1.0 A _{dc} , I _{B1} = I _{B2} = 100 mA _{dc}) (Figures 9 and 11)	t _s	—	35	ns
Fall Time (V _{CC} = 30 Vdc, I _C = 1.0 A _{dc} , I _{B1} = I _{B2} = 100 mA _{dc}) (Figures 9 and 11)	t _f	—	35	ns

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Turn-On Time ($V_{CC} = 30\text{ Vdc}$, $V_{BE(\text{off})} = 2.0\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $I_{B1} = 100\text{ mAdc}$) (Figures 8 and 10)	t_{on}	—	35	ns
Turn-Off Time ($V_{CC} = 30\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $I_{B1} = I_{B2} = 100\text{ mAdc}$) (Figures 9 and 11)	t_{off}	—	60	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

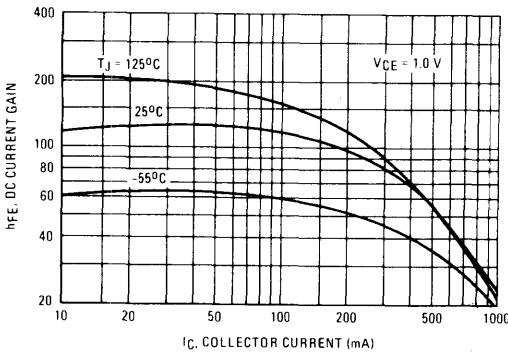


FIGURE 3 – "ON" VOLTAGES

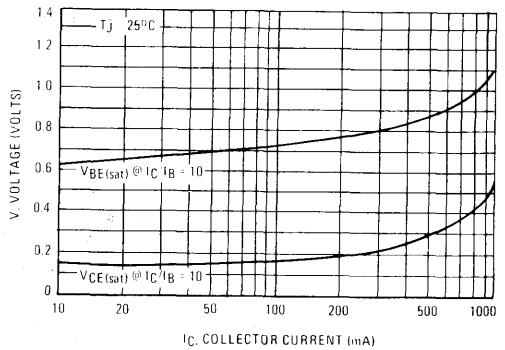


FIGURE 4 – COLLECTOR SATURATION REGION

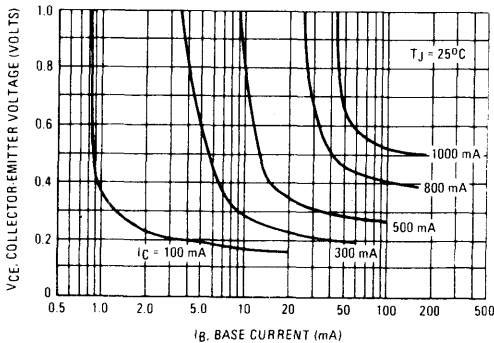
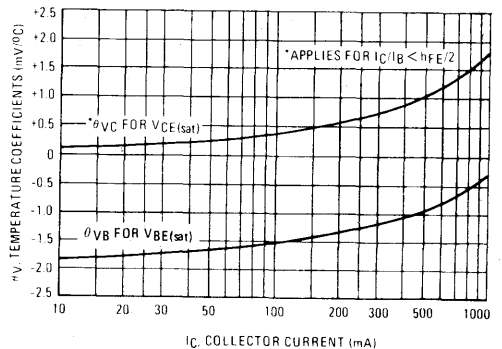


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 - CURRENT-GAIN-BANDWIDTH PRODUCT

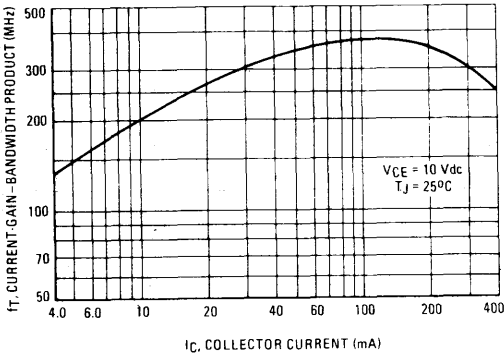


FIGURE 7 - CAPACITANCE

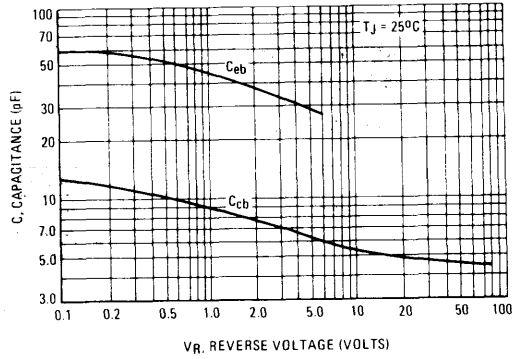


FIGURE 8 - TURN-ON TIME

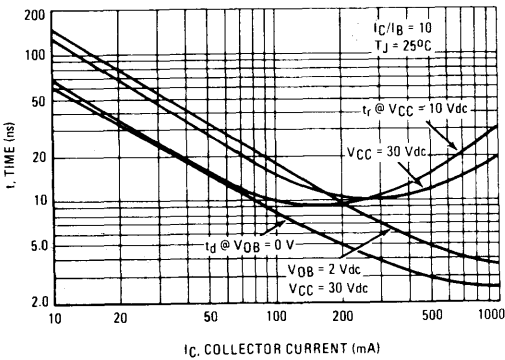


FIGURE 9 - TURN-OFF TIME

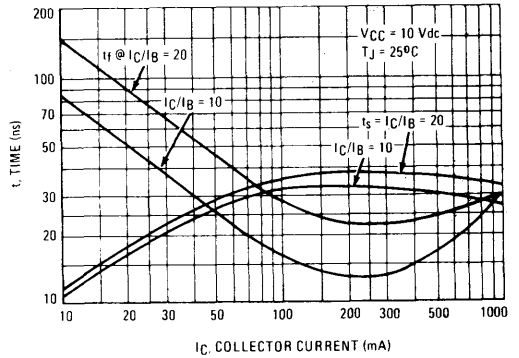


FIGURE 10 - TURN-ON TIME TEST CIRCUIT

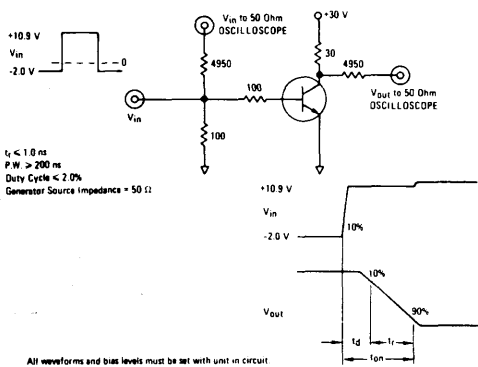
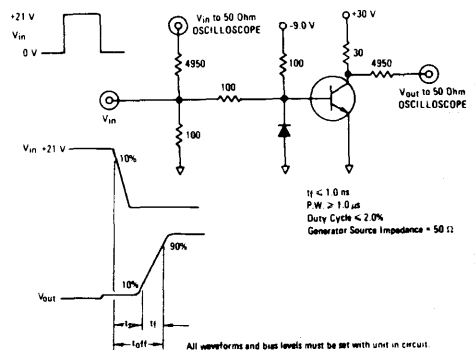


FIGURE 11 - TURN-OFF TIME TEST CIRCUIT



2N5861

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 6.0	Watt $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	100	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 50 \text{ Vdc}, V_{BE(off)} = 2.0 \text{ Vdc}$) ($V_{CE} = 50 \text{ Vdc}, V_{BE(off)} = 2.0 \text{ Vdc}, T_A = 75^\circ\text{C}$)	I_{CEX}	—	0.3 10	μAdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$) ($V_{CB} = 50 \text{ Vdc}, I_E = 0, T_A = +75^\circ\text{C}$)	I_{CBO}	—	0.3 10	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.1	μAdc

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$)	h_{FE}	25 10	100 —	—
Collector-Emitter Saturation Voltage ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$)	$V_{BE(sat)}$	0.8	1.1	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	200	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{cb}	—	7.0	pF
Emitter-Base Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{eb}	—	60	pF

SWITCHING CHARACTERISTICS

Turn-On Time	($V_{CC} = 30 \text{ Vdc}, V_{BE(off)} = 2.0 \text{ Vdc},$ $I_C = 500 \text{ mAdc}, I_{B1} = 50 \text{ mAdc}$)	t_{on}	—	25	ns
Delay Time		t_d	—	8.0	ns
Rise Time		t_r	—	18	ns

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Turn-Off Time	$(V_{CE} = 30\text{ Vdc}, I_C = 500\text{ mAdc}, I_{B1} = I_{B2} = 50\text{ mAdc})$	t_{off}	—	60	ns
Storage Time		t_s	—	35	ns
Fall Time		t_f	—	35	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 1 – CURRENT-GAIN-BANDWIDTH PRODUCT

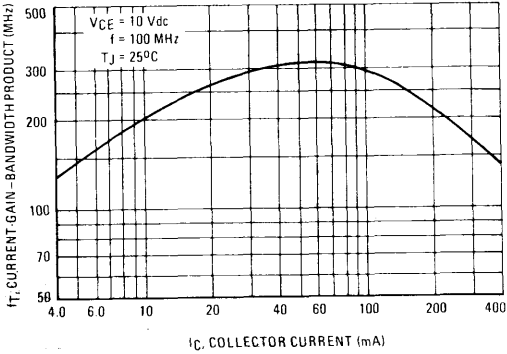


FIGURE 2 – CAPACITANCE

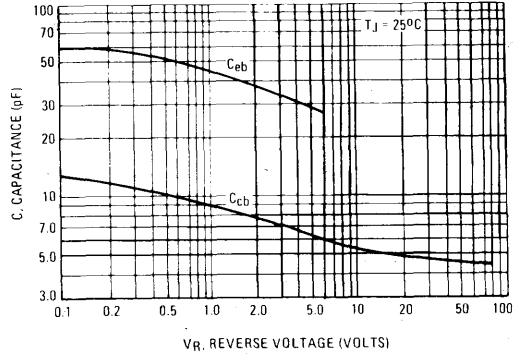


FIGURE 3 – TURN-ON TIME

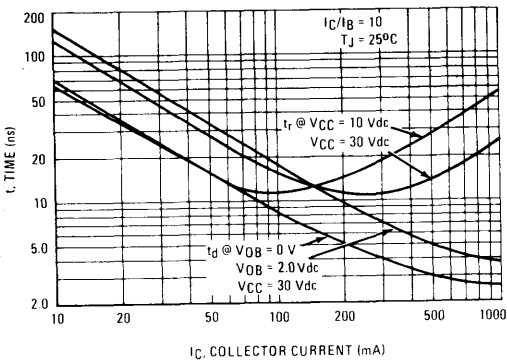


FIGURE 4 – TURN-OFF TIME

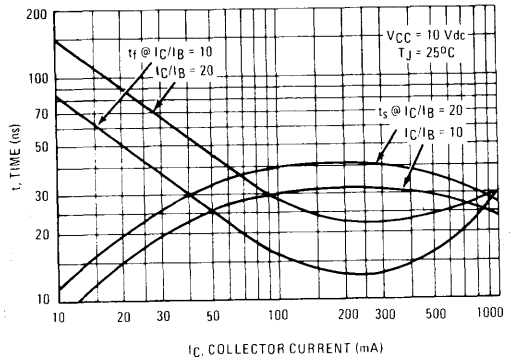
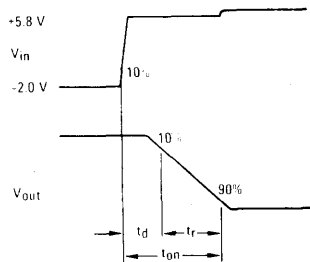
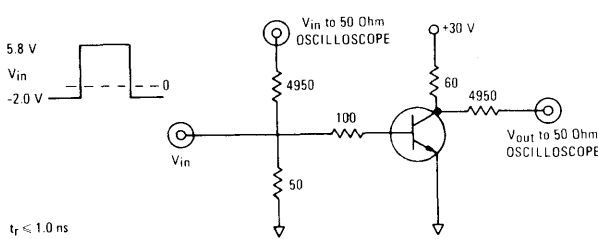


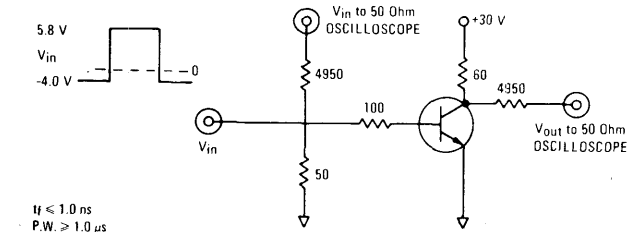
FIGURE 5 – TURN-ON TIME TEST CIRCUIT



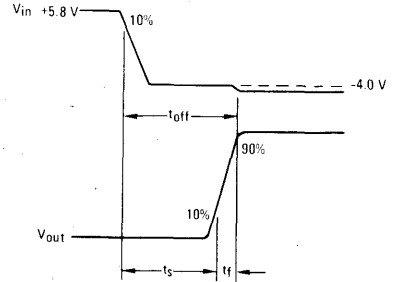
$t_r \leq 1.0\text{ ns}$
 P.W. $\geq 200\text{ ns}$
 Duty Cycle $\leq 2.0\%$
 Generator Source Impedance = $50\ \Omega$
 Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
 Oscilloscope: Tektronix 661 Sampling Scope

V_{in} during t_{on} interval must be $+5.8\text{ V}$.
 All waveforms and bias levels must be set with unit in circuit.

FIGURE 8 – "ON" VOLTAGES



$t_f \leq 1.0$ ns
 P.W. ≥ 1.0 μ s
 Duty Cycle $\leq 2.0\%$
 Generator Source Impedance = 50 Ω
 Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
 Oscilloscope: Tektronix 661 Sampling Scope



V_{in} during t_{off} interval must be -4.0 V.
 All waveforms and bias levels must be set with unit in circuit.

FIGURE 7 – DC CURRENT GAIN

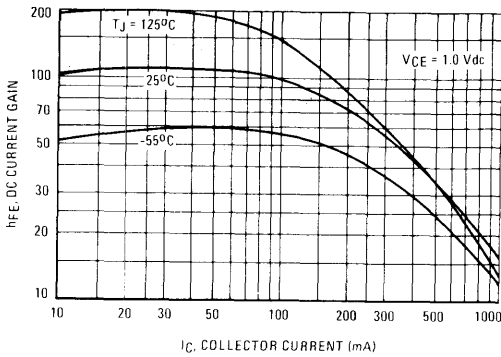


FIGURE 9 – ACTIVE-REGION SAFE OPERATING AREA

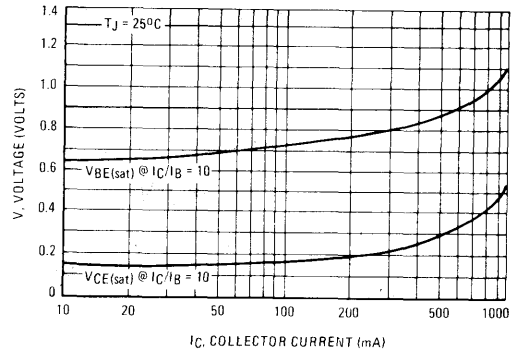


FIGURE 10 – TEMPERATURE COEFFICIENTS

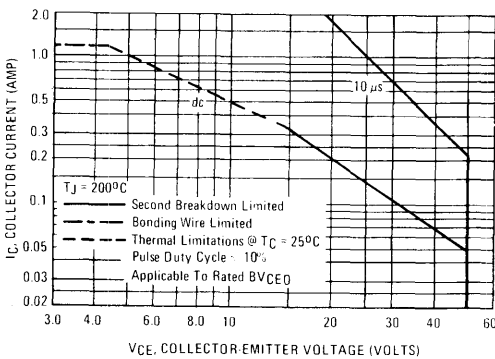
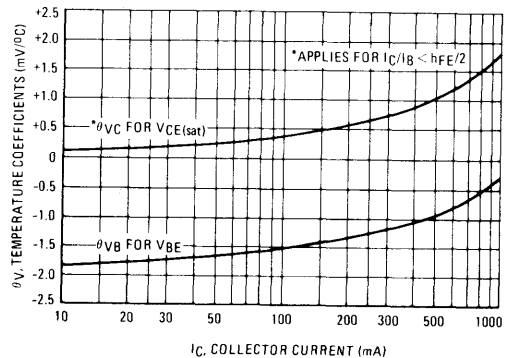


FIGURE 11 – TEMPERATURE COEFFICIENTS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 9 is based on $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

2N6430 2N6431

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	2N6430	2N6431	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	Vdc
Collector-Base Voltage	V_{CBO}	200	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	50		mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	500	2.86	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8	10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	200 300	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	200 300	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 160$ Vdc) ($V_{CB} = 200$ Vdc)	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25 40 50	— — 200	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, $f = 100$ MHz)	f_T	50	500	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	4.0	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N6432 2N6433

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N6432	2N6433	Unit
Collector-Emitter Voltage	V_{CE0}	200	300	Vdc
Collector-Base Voltage	V_{CBO}	200	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	500	2.86	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8	10.3	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

Refer to 2N3743 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	2N6432 2N6433	$V_{(BR)CEO}$	200 300	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}, I_E = 0$)	2N6432 2N6433	$V_{(BR)CBO}$	200 300	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}, I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 160 \text{ Vdc}$) ($V_{CB} = 200 \text{ Vdc}$)	2N6432 2N6433	I_{CBO}	— —	0.25 0.25	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0 \text{ Vdc}, I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 30 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)		h_{FE}	25 40 30	— — 150	—
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 20 \text{ MHz}$)		f_T	50	500	MHz
Collector-Base Capacitance ($V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)		C_{cb}	—	6.0	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	BC 107	BC 108	BC 109	Unit
Collector-Emitter Voltage	V _{CEO}	45	25	25	Vdc
Collector-Base Voltage	V _{CBO}	50	30	30	Vdc
Emitter-Base Voltage	V _{EBO}	6	5	5	Vdc
Collector Current - Continuous	I _C	0.2			Amp
Total Device Dissipation ^a T _A = 25°C Derate above 25°C	P _D	0.6 2.28			Watt mW/°C
Total Device Dissipation ^a T _C = 25°C T _C = 100°C Derate above 25°C	P _D	1 6.67			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	175	°C/W

**BC107
BC108
BC109**

**CASE 22-03, STYLE 1
TO-18 (TO-206AA)**

TRANSISTOR

NPN SILICON

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector Base Leakage Current (I _E = 0, V _{CB} = 45 V) (I _E = 0, V _{CB} = 45 V, T _{Amb} = 125°C) (I _E = 0, V _{CB} = 25 V) (I _E = 0, V _{CB} = 25 V, T _{Amb} = 125°C)	BC107 BC107 BC108/109 BC108/109	I _{CBO}		15 4 15 4	nA μA nA μA
Emitter Base Breakdown Voltage (I _E = 10 μA, I _C = 0)	BC107 BC108/109	V _{(BR)EBO}	6 5		V
Collector Emitter Breakdown Voltage (I _C = 2 mA, I _E = 0)	BC107 BC108/109	V _{(BR)CEO}	45 25		V

ON CHARACTERISTICS

DC Current gain (V _{CE} = 5 V, I _C = 2 mA) (V _{CE} = 5 V, I _C = 10 μA)	BC107 BC108 BC109 A group B group C group B group C group	h _{FE}	110 110 200 110 200 420 40 100		450 800 800 220 450 800	
Base Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.5 mA) (I _C = 100 mA, I _B = 5 mA)		V _{BE(sat)}		0.7 1.0	0.83 1.05	V
Collector Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.5 mA) (I _C = 100 mA, I _B = 5 mA)		V _{CE(sat)}			0.25 0.60	V
Base Emitter on Voltage (I _C = 2 mA, V _{CE} = 5 V) (I _C = 10 mA, V _{CE} = 5 V)		V _{BE(on)}	0.55		0.70 0.77	V
Collector Knee Voltage (I _C = 10 mA, I _B = the value for which I _C = 11 mA at V _{CE} = 1 V)		V _{CE(K)}		0.4	0.6	V

DYNAMIC CHARACTERISTICS

Transition Frequency (I _C = 10 mA, f = 100 MHz, V _{CE} = 5 V)		f _T	150	300		MHz
Noise Figure (V _{CE} = 5 V, I _C = 0.2 mA, R _g = 2 KΩ) F = 30 Hz to 15 kHz F = 1 kHz, ΔF = 200 Hz	BC109 BC109 BC107/108	NF			4 4 10	dB

BC107, BC108, BC109

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Capacitance ($V_{CB} = 10\text{ V}$, $f = 1\text{ MHz}$)	C_{ob0}			4.5	pF
h_{21e} Parameters ($V_{CE} = 5\text{ V}$, $I_C = 2\text{ mA}$, $f = 1\text{ kHz}$)	h_{21e}	125 240		500 900	
BC107/108 BC109					
A group		125		260	
B group		240		500	
C group		450		900	
h_{11e} Parameters ($V_{CE} = 5\text{ V}$, $I_C = 2\text{ mA}$, $f = 1\text{ kHz}$)	h_{11e}	1.6 3.2 6.0		4.5 8.5 15	K Ω
A group		1.6		4.5	
B group		3.2		8.5	
C group		6.0		15	
h_{22e} Parameters ($V_{CE} = 5\text{ V}$, $I_C = 2\text{ mA}$, $f = 1\text{ kHz}$)	h_{22e}			30 60 110	μhos
A group				30	
B group				60	
C group				110	

**FIGURE 1 – EMITTER-BASE CAPACITANCE
COLLECTOR-BASE CAPACITANCE**

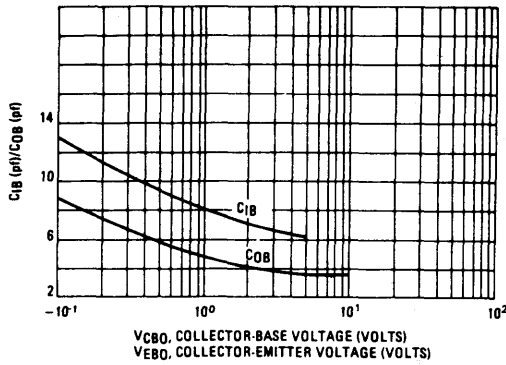


FIGURE 2 – CURRENT GAIN – BANDWIDTH PRODUCT

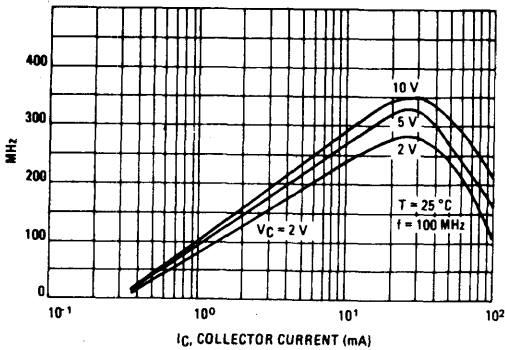
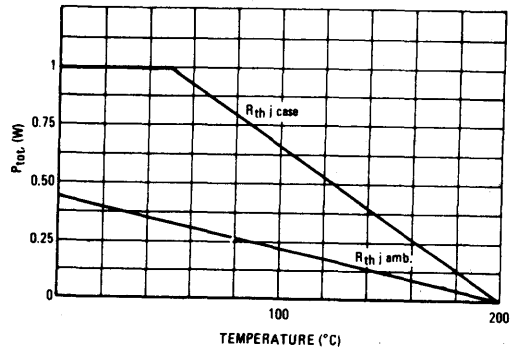


FIGURE 3 – TOTAL PERMISSIBLE POWER DISSIPATION



MAXIMUM RATINGS

Rating	Symbol	BC 140	BC 141	Unit
Collector-Emitter Voltage	V _{CEO}	40	60	Vdc
Collector-Base Voltage	V _{CBO}	80	100	Vdc
Emitter-Base Voltage	V _{EBO}	7		Vdc
Collector Current – Continuous	I _C	1		Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.8 4.6		Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	3.7 20		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

BC140 BC141

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

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Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector Cutoff Current (I _E = 0, V _{CE} = 60 V)	I _{CES}		100 100	nA μA
Collector-Emitter Breakdown Voltage (I _{CES} = 100 μA, I _E = 0)	V _{(BR)CES}	80 100		V
Collector-Emitter Breakdown Voltage(1) (I _C = 30 mA, I _B = 0)	V _{(BR)CEO}	40 60		V
Emitter-Base Breakdown Voltage (I _E = 100 μA, I _C = 0)	V _{(BR)EBO}	7		V

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 100 mA, V _{CE} = 1 V)	h _{FE}		40 40 63 100	400 100 160 250
Collector-Emitter Saturation Voltage(1) (I _C = 1 A, I _B = 0.1 A)	V _{CE(sat)}		1	V
Base-Emitter Voltage(1) (I _C = 1 A, V _{CE} = 1 V)	V _{BE(on)}		2	V

SMALL SIGNAL CHARACTERISTICS

Gain Bandwidth Product (I _C = 50 mA, V _{CE} = 10 V, f = 20 MHz)	f _T	50		MHz
Input Capacitance (V _{EB} = 0.5 V, I _C = 0, f = 1 MHz)	C _{ib}		80	pF
Capacitance (I _E = 0, V _{CB} = 10 V, f = 1 MHz)	C _{ob}		25	pF
Turn On Time (I _C = 150 mA, I _{B1} = 7.5 mA)	t _{on}		250	ns
Turn Off Time (I _C = 150 mA, I _{B1} = I _{B2} = 7.5 mA)	t _{off}		850	ns

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

BC160 BC161

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 160	BC 161	Unit
Collector-Emitter Voltage	V_{CE0}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	40	60	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current - Continuous	I_C	1		Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8	4.6	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.7	20	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^\circ\text{C/W}$

Refer to 2N4033 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector Cutoff Current $I_E = 0, V_{CES} = -40\text{ V}$ for BC160 $V_{CES} = -60\text{ V}$ for BC161 $V_{CES} = -40\text{ V}$ for BC160 $T_{Amb} = 150^\circ\text{C}$ $V_{CES} = -60\text{ V}$ for BC161 $T_{Amb} = 150^\circ\text{C}$	I_{CES}		-100 -100 -100 -100	nA μA
Collector-Emitter Breakdown Voltage $I_C = -100\ \mu\text{A}, I_E = 0$	$V_{(BR)CES}$	-40 -60		V
Collector-Emitter Breakdown Voltage(1) $I_C = -10\text{ mA}, I_B = 0$	$V_{(BR)CEO}$	-40 -60		V
Emitter-Base Breakdown Voltage $I_E = -100\ \mu\text{A}, I_C = 0$	$V_{(BR)EBO}$	-5		V

ON CHARACTERISTICS

DC Current Gain(1) $I_C = -100\text{ mA}, V_{CE} = -1\text{ V}$ for BC160, BC161 for BC160, BC161 Group 6 for BC160, BC161 Group 10 for BC160, BC161 Group 16	h_{FE}	40 40 63 100	400 100 160 250	
Collector-Emitter Saturation Voltage(1) ($I_C = -1\text{ A}, I_B = -0.1\text{ A}$)	$V_{CE(sat)}$		-1	V
Base-Emitter Voltage(1) ($I_C = -1\text{ A}, V_{CE} = -1\text{ V}$)	$V_{BE(on)}$		-1.7	V

SMALL SIGNAL CHARACTERISTICS

Gain Bandwidth Product ($I_C = -50\text{ mA}, V_{CE} = -10\text{ V}, f = 20\text{ MHz}$)	f_T	50		MHz
Input Capacitance ($V_{EB} = -10\text{ V}, f = 1\text{ MHz}$)	C_{ib}		180	pF
Output Capacitance ($V_{CB} = -10\text{ V}, I_E = 0, f = 1\text{ MHz}$)	C_{obo}		30	pF
Turn On Time ($I_C = -100\text{ mA}, I_{B1} = -5\ \mu\text{A}$)	T_{on}		500	ns
Turn Off Time ($I_C = -100\text{ mA}, I_{B1} = I_{B2} = -5\ \mu\text{A}$)	T_{off}		650	ns

(1) Pulsed: Pulse Duration = 300 μs , Duty Cycle = 1%.

MAXIMUM RATINGS

Rating	Symbol	BC 177	BC 178	BC 179	Unit
Collector-Emitter Voltage	V _{CEO}	45	25	20	Vdc
Collector-Emitter Voltage	V _{CES}	50	30	25	Vdc
Collector-Base Voltage	V _{CBO}	50	30	25	Vdc
Emitter-Base Voltage	V _{EBO}	5			Vdc
Collector Current - Continuous	I _C	0.2			Amp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.6		2.28	Watt mW/°C
Total Device Dissipation @ T _C = 25°C T _C = 100°C Derate above 25°C	P _D	1		6.67	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	175	°C/W

**BC177
BC178
BC179**

**CASE 22-03, STYLE 1
TO-18 (TO-206AA)**

TRANSISTOR

PNP SILICON

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector Emitter Leakage Current (V _{CE} = 20 V, I _E = 0) (V _{CE} = 20 V, I _E = 0, T _{Amb} = 125°C)	I _{CES}			100 4	nA μA
Collector Base Breakdown Voltage (I _C = 10 μA)	V _{(BR)CBO}	50 30 25			V
Collector Emitter Breakdown Voltage (I _C = 2 mA, I _E = 0)	V _{(BR)CEO}	45 25 20			V
Emitter Base Breakdown Voltage (I _E = 10 μA, I _C = 0)	V _{(BR)EBO}	5			V

ON CHARACTERISTICS

DC Current Gain (I _C = 2 mA, V _{CE} = 5 V)	BC177 BC178 BC179 V1 Group A Group B Group C Group	h _{FE}	120 120 180 70 120 180 380		460 800 800 140 220 460 800	
Collector Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.5 mA) (I _C = 100 mA, I _B = 5 mA)		V _{CE(sat)}			0.2 0.6	V
Base Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.5 mA) (I _C = 100 mA, I _B = 5 mA)		V _{BE(sat)}		0.7 0.9	0.8	V
Base Emitter on Voltage (I _C = 2 mA, V _{CE} = 5 V)		V _{BE(on)}	0.6		0.75	V
Collector Knee Voltage (I _C = 10 mA, I _B = the value for which I _C = 11 mA, at V _{CE} = 1V)		V _{CE(K)}		0.4	0.6	V

DYNAMIC CHARACTERISTICS

Transition Frequency (V _{CE} = 5 V, I _C = 10 mA, f _β = 50 MHz)		f _T	200	300		MHz
Noise Figure (V _{CE} = 5 V, I _C = 0.2 mA, R _g = 2 KΩ) F = 30 Hz to 15 kHz F = 1 kHz, F = 200 Hz	BC179 BC179 BC177/178	NF			4 4 10	dB

BC177, BC178, BC179

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance ($V_{CB} = 10\text{ V}$, $f = 1\text{ MHz}$)		C_{obo}		3.5	4	pF
h21e Parameters ($V_{CE} = 5\text{ V}$, $I_C = 2\text{ mA}$, $f = 1\text{ kHz}$)	BC177	h21e	125		500	
	BC178		125		900	
	BC179		240		900	
	V1 Group		75		150	
	A Group		125		260	
	B Group		240		500	
C Group	450		900			
h11e Parameters ($V_{CE} = 5\text{ V}$, $I_C = 2\text{ mA}$, $f = 1\text{ kHz}$)	V1 Group	h11e	1.0		2.2	k Ω
	A Group		1.6		4.5	
	B Group		3.2		8.5	
	C Group		6.0		15.0	
h22e Parameters ($V_{GE} = 5\text{ V}$, $I_C = 2\text{ mA}$, $f = 1\text{ kHz}$)	V1 Group	h22e			25	μmhos
	A Group				30	
	B Group				60	
	C Group				110	

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MAXIMUM RATINGS

Rating	Symbol	BC 393	BC 394	Unit
Collector-Emitter Voltage	V _{CEO}	180	180	V _{dc}
Collector-Base Voltage	V _{CBO}	180	180	V _{dc}
Emitter-Base Voltage	V _{EBO}	6	6	V _{dc}
Collector Current - Continuous	I _C	0.5		Amp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.4	2.66	Watt mW/°C
Total Device Dissipation @ T _C = 25°C T _C = 100°C Derate above 25°C	P _D	1.5		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	125	°C/W

BC393

PNP

BC394

NPN

**CASE 22-03, STYLE 1
TO-18 (TO-206AA)**
HIGH VOLTAGE TRANSISTOR
4
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)	V _{(BR)CEO}	180			V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	180			V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	6			V _{dc}
Collector Cutoff Current (V _{CB} = 100 V, I _E = 0)	I _{CBO}			50	nA
Collector-Emitter Cutoff (V _{CE} = 100 V, I _B = 0) (T _{Amb} = 150°C)	I _{CEO}			50	μA
ON CHARACTERISTICS (I)					
DC Current Gain (I _C = 10 mA, V _{CE} = 10 V)	h _{FE}	50	100		
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1 mAdc)	V _{CE(sat)}		0.15	0.3	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1 mAdc)	V _{BE(sat)}		0.7	0.9	V _{dc}
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I _C = 20 mAdc, V _{CE} = 20 Vdc, f = 20 MHz)	f _T	50	110	200	MHz
Output Capacitance (I _E = 0, V _{CB} = 20 Vdc, f = 1 MHz)	C _{obo}	—	3.5	7	pF
Input Capacitance (I _C = 0, V _{EB} = 0.5 Vdc, f = 1 MHz)	C _{ib}	—	75	—	pF
Turn-On Time (I _{B1} = 10 mA, I _C = 50 mAdc, V _{CC} = 100 Vdc)	t _{on}	—	100	—	ns
Turn-Off Time (I _{B2} = 10 mAdc, I _C = 50 mAdc, V _{CC} = 100 Vdc)	t _{off}	—	400	—	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

BCY58 BCY59

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

TRANSISTOR
NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BCY 58	BCY 59	Unit
Collector-Emitter Voltage	V _{CEO}	32	45	Vdc
Collector-Emitter Voltage (R _{BE} = 10 Ohms)	V _{CES}	32	45	Vdc
Emitter-Base Voltage	V _{EBO}	7		Vdc
Collector Current - Continuous	I _C	0.2		Amp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.6 2.28		Watt mW/°C
Total Device Dissipation @ T _C = 25°C T _C = 100°C Derate above 25°C	P _D	1 6.67		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	150	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	450	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _E = 0)	BCY58 BCY59	V _{(BR)CEO}	32 45			Vdc
Emitter-Base Breakdown Voltage (I _E = 1μAdc, I _C = 0)	all	V _{(BR)EBO}	7			Vdc
Collector Cutoff Current (V _{CE} = 32 V) (V _{CE} = 45 V) (V _{CE} = 32 V, T _A = 100°C, V _{BE} = 0.2 V) (V _{CE} = 45 V, T _A = 100°C, V _{BE} = 0.2 V) (V _{CE} = 32 V, T _A = 150°) (V _{CE} = 45 V, T _A = 150°)	BCY58 BCY59 BCY58 BCY59 BCY58 BCY59	I _{CES} I _{CEX} I _{CES}		0.2 0.2 0.2 0.5	10 10 20 20 10 10	nAdc μAdc μAdc
Emitter Base Cutoff Current (V _{EB} = 5 V)	all	I _{EBO}			10	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 Vdc)	BCY59-VII, BCY58-VII BCY59-VIII, BCY58-VIII BCY59-IX, BCY58-IX BCY59-X, BCY58-X BCY59-VII, BCY58-VII BCY59-VIII, BCY58-VIII BCY59-IX, BCY58-IX BCY59-X, BCY58-X BCY59-VII, BCY58-VII BCY59-VIII, BCY58-VIII BCY59-IX, BCY58-IX BCY59-X, BCY58-X BCY59-VII, BCY58-VII BCY59-VIII, BCY58-VIII BCY59-IX, BCY58-IX BCY59-X, BCY58-X	h _{FE}	20	145		
(I _C = 2 mAdc, V _{CE} = 5 Vdc)			40	220		
			100	300		
(I _C = 10 mAdc, V _{CE} = 1 Vdc)			120	170	220	
			180	250	310	
			250	350	460	
			380	500	630	
(I _C = 100 mAdc, V _{CE} = 1 Vdc)			80	190		
			120	260	400	
			160	380	630	
	240	550	1000			
(I _C = 100 mAdc, V _{CE} = 1 Vdc)	40					
	45					
	60					
	60					
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 2.5 mAdc) (I _C = 10 mAdc, I _B = 0.25 mA)	all	V _{CE(sat)}	0.15 0.05	0.30 0.12	0.70 0.35	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.25 mA) (I _C = 100 mA, I _B = 2.5 mA)	all	V _{BE(sat)}	0.6 0.75	0.70 0.90	0.85 1.2	Vdc
Base-Emitter on Voltage (I _C = 2 mAdc, V _{CE} = 5 Vdc)	all	V _{BE(on)}	0.55	0.62	0.70	Vdc

BCY58, BCY59

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS SMALL SIGNAL CHARACTERISTICS						
Current Gain-Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5 \text{ V}$, $f = 100 \text{ MHz}$)	all	f_T	125	200		MHz
Output Capacitance ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0$, $f = 1 \text{ MHz}$)	all	C_{ob}		3.5	6	pF
Input Capacitance ($V_{BE} = 0.5 \text{ V}$, $I_C = 0$, $f = 1 \text{ MHz}$)	all	C_{ib}		8	15	pF
Small Signal Current Gain ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	BCY58-VII, BCY59-VII BCY58-VIII, BCY59-VIII BCY58-IX, BCY59-IX BCY58-X, BCY59-X	h_{fe} (h_{21e})	125 175 250 350	200 260 330 520	250 350 500 700	
Output Admittance ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	BCY58-VII, BCY59-VII BCY58-VIII, BCY59-VIII BCY58-IX, BCY59-IX BCY58-X, BCY59-X	h_{oe} (h_{22e})			30 50 60 100	μhos
Input Impedance ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	BCY58-VII, BCY59-VII BCY58-VIII, BCY59-VIII BCY58-IX, BCY59-IX BCY58-X, BCY59-X	h_{ie} (h_{11e})	1.6 2.5 3.2 4.5		4.5 6 8.5 12	Kohms
Voltage Feedback Ratio ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = \text{kHz}$)	BCY58-VII, BCY59-VII BCY58-VIII, BCY59-VIII BCY58-IX, BCY59-IX BCY58-X, BCY59-X	h_{re} (h_{12e})		1.5 2 2 3		$\times 10^{-4}$
Noise Figure ($I_C = 0.2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $R_S = 2 \text{ Kohms}$, $f = 1 \text{ kHz}$)	all	NF		2	6	dB

SWITCHING CHARACTERISTICS

$I_C = 10 \text{ mA}$, $I_{B1} = 1 \text{ mA}$, $I_{B2} = 1 \text{ mA}$ $V_{BB} = 3.6 \text{ V}$, $R_1 = R_2 = 5 \text{ K}\Omega$ $R_L = 990 \text{ ohms}$ * See test circuit.	t_d	35		150	nS	
	t_r	50				
	t_{on}	85				
	t_s	400		800		
	t_f	80				
	t_{off}	480				
$I_C = 100 \text{ mA}$, $I_{B1} = 10 \text{ mA}$, $I_{B2} = 10 \text{ mA}$ $V_{BB} = 5 \text{ V}$, $R_1 = 500 \Omega$, $R_2 = 700 \Omega$ $R_L = 98 \text{ ohms}$ * See test circuit.	t_d	5		150	nS	
	t_r	50				
	t_{on}	55				
		t_s	250			800
		t_f	200			
	t_{off}	450				

TEST CIRCUIT

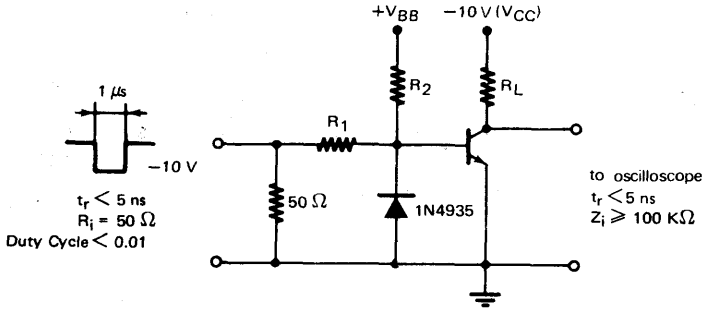


FIGURE 1 – CURRENT GAIN
(BCY58-VII/BCY59-VII)

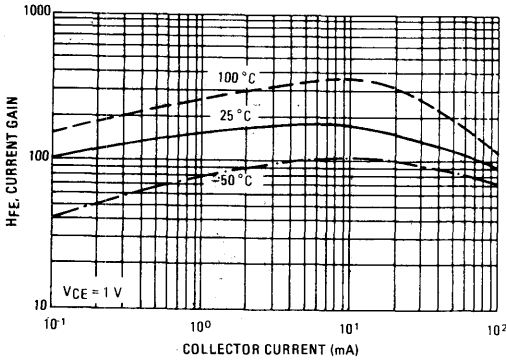


FIGURE 2 – CURRENT GAIN
(BCY58-VIII/BCY59-VIII)

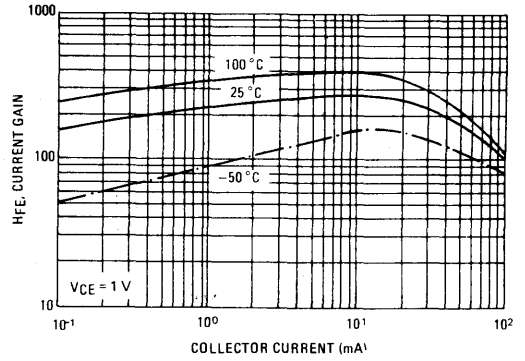


FIGURE 3 – CURRENT GAIN
(BCY58-IX/BCY59-IX)

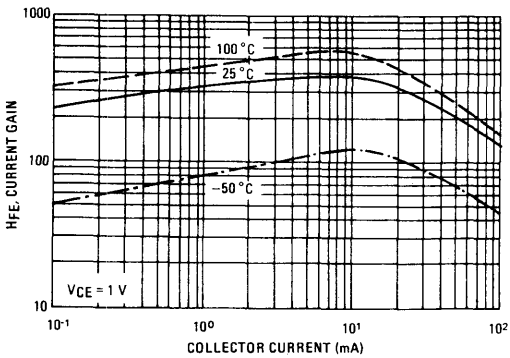


FIGURE 4 – CURRENT GAIN
(BCY58-X/BCY59-X)

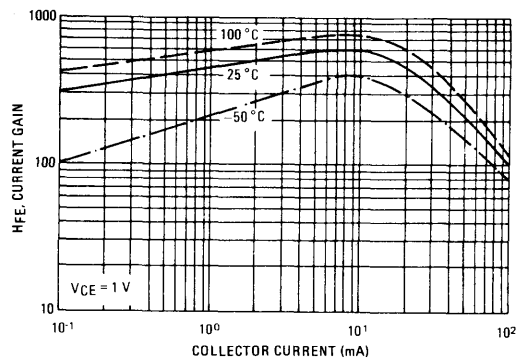


FIGURE 5 – SATURATION VOLTAGE

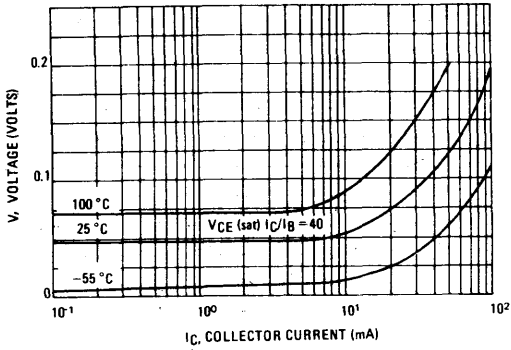


FIGURE 6 – SATURATION VOLTAGE

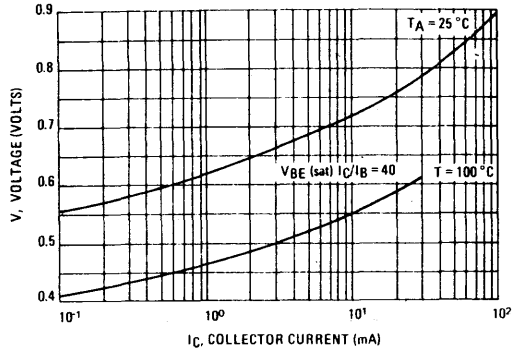


FIGURE 7 – INPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

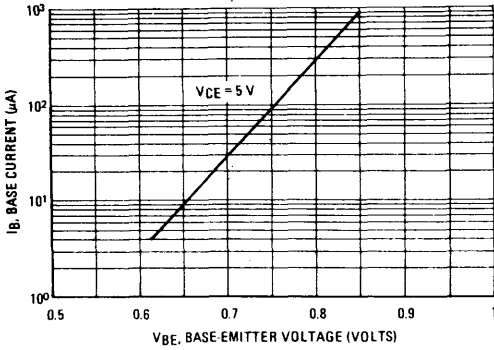


FIGURE 8 – OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

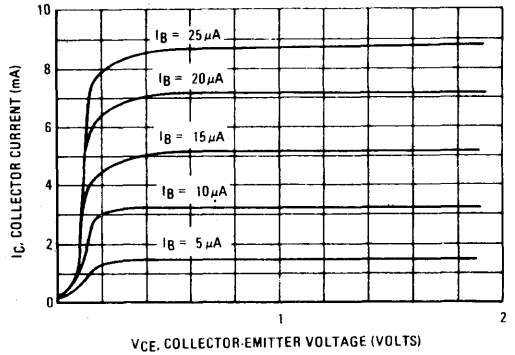


FIGURE 9 – OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

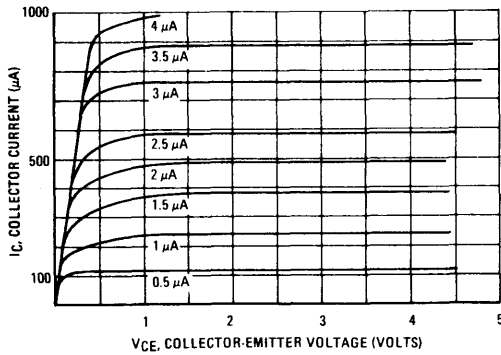
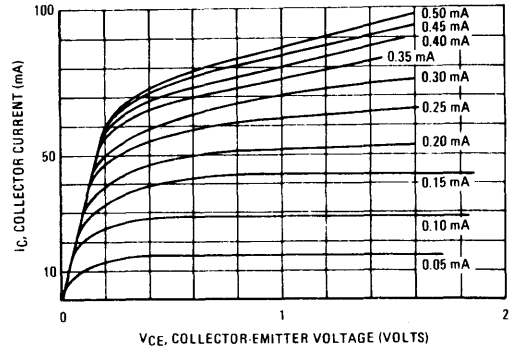
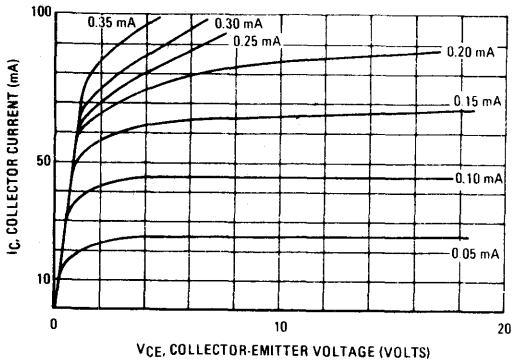


FIGURE 10 – OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)



BCY58, BCY59

**FIGURE 11 – OUTPUT CHARACTERISTIC
(COMMON EMITTER CIRCUIT)**



**FIGURE 12 – EMITTER-BASE CAPACITANCE
COLLECTOR-BASE CAPACITANCE**

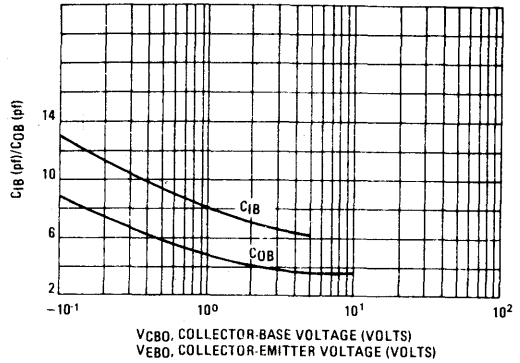
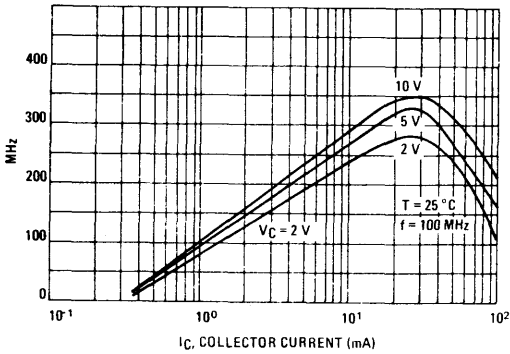
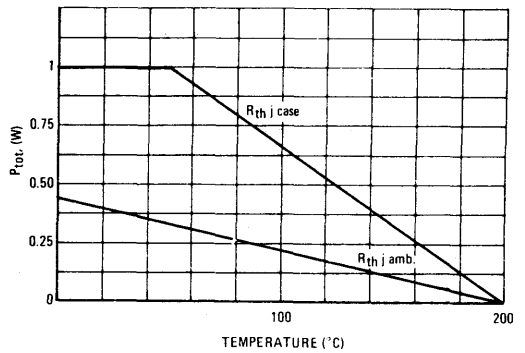


FIGURE 13 – CURRENT GAIN – BANDWIDTH PRODUCT



**FIGURE 14 – TOTAL PERMISSIBLE POWER
DISSIPATION (BCY58/BCY59)**



MAXIMUM RATINGS

Rating	Symbol	BCY70	BCY71	BCY72	Unit
Collector-Emitter Voltage	V _{CEO}	40	45	25	V _{dc}
Collector-Base Voltage	V _{CBO}	50	45	25	V _{dc}
Emitter-Base Voltage	V _{EBO}	5			V _{dc}
Collector Current - Continuous	I _C	0.2			Amp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	360	2.06		mWatt mW/°C
Total Device Dissipation @ T _C = 25°C T _C = 100°C Derate above 25°C	P _D	0.6		4.0	mWatt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	175	°C/W

**BCY70
BCY71
BCY72**

**CASE 22-03, STYLE 1
TO-18 (TO-206AA)**

TRANSISTOR

PNP SILICON

4

Refer to 2N3798 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector Emitter Breakdown Voltage (I _C = 2 mA, I _B = 0)	BCY70 BCY71 BCY72	V _{(BR)CEO}	40 45 25		V _{dc}
Collector Base Leakage Current (I _E = 0, V _{CB} = 50 V) (I _E = 0, V _{CB} = 45 V) (I _E = 0, V _{CB} = 25 V) (I _E = 0, V _{CB} = 40 V, T _{Amb} = 100°C) (I _E = 0, V _{CB} = 40 V, T _{Amb} = 100°C) (I _E = 0, V _{CB} = 20 V, T _{Amb} = 100°C) (I _E = 0, V _{CB} = 40 V) (I _E = 0, V _{CB} = 40 V) (I _E = 0, V _{CB} = 20 V)	BCY70 BCY71 BCY72 BCY70 BCY71 BCY72 BCY70 BCY71 BCY72	I _{CBO}		0.5 0.5 0.5 2 2 2 10 50 50	μA nA
Emitter Base Leakage Current (V _{EB} = 5 V, I _C = 0) (V _{EB} = 4 V, I _C = 0) (V _{EB} = 4 V, I _C = 0, T _{Amb} = 100°C)		I _{EBO}		0.5 10 2	μA nA μA
Collector Emitter Leakage Current (V _{CE} = 50 V, V _{BE} = 3 V)	BCY70	I _{CEx}		20	nA

ON CHARACTERISTICS

DC Current Gain (V _{CE} = 1 V, I _C = 10 μA) (V _{CE} = 1 V, I _C = 100 μA) (V _{CE} = 1 V, I _C = 1 mA) (V _{CE} = 1 V, I _C = 10 mA) (V _{CE} = 1 V, I _C = 50 mA)	BCY71 BCY70 BCY71 BCY70 BCY71 BCY72 BCY70 BCY71 BCY72 BCY70	HFE	40 40 80 45 90 40 50 100 50 15		600
Base Emitter Saturation Voltage (I _C = 50 mA, I _B = 5 mA) (I _C = 10 mA, I _B = 1 mA)	BCY70/71 BCY70/71	V _{BE(sat)}	0.6		1.2 0.9 V
Collector Emitter Saturation Voltage (I _C = 50 mA, I _B = 5 mA) (I _C = 10 mA, I _B = 1 mA)		V _{CE(sat)}			0.50 0.25 V

BCY70, BCY71, BCY72

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Transition Frequency (I _C = 10 mA, f = 100 MHz, V _{CE} = 20 V) All types (I _C = 100 μA, f = 10.7 MHz, V _{CE} = 20 V) BCY71 only	f _T	250 15			MHz
Noise Figure (V _{CE} = 5 V, I _C = 100 μA, R _g = 2 KΩ, 30 to 15 kHz at -3 dB points) BCY70/72 BCY71	NF			6 2	dB
Switching Times (I _C = 10 mA, I _{B1} = I _{B2} = 1 mA) BCY70/72 BCY70/72 BCY70/72 BCY70/72 BCY70/72 BCY70/72	ton toff td tr ts tf			65 420 35 35 350 80	ns
h parameters (V _{CE} = 10 V, I _C = 1 mA, f = 1 kHz) BCY71	h _{12e} h _{21e} h _{22e} h _{11e}	— 100 10 2		20 × 10 ⁻⁴ 400 60 12	— — μs KΩ
Common Base Output Capacitance (V _{CB} = 10 V, I _E = 0, f = 1 MHz)	C _{ob}			6	pF
Input Capacitance (V _{BE} = 1 V, I _C = 0, f = 1 MHz)	C _{ib}			8	pF

4

MAXIMUM RATINGS

Rating	Symbol	BCY 78	BCY 79	Unit
Collector-Emitter Voltage	V _{CEO}	32	45	V _{dc}
Collector-Emitter Voltage (R _{BE} = 10 Ohms)	V _{CES}	32	45	V _{dc}
Emitter-Base Voltage	V _{EBO}	5		V _{dc}
Collector Current - Continuous	I _C	0.2		Amp
Total Device Dissipation @ T _A = 25°C	P _D	0.6	2.28	Watt
Derate above 25°C				mW/°C
Total Device Dissipation @ T _C = 25°C	P _D	1		Watt
Derate above 25°C				mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	150	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	450	°C/W

BCY78 BCY79

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

TRANSISTOR

PNP SILICON

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _E = 0)	BCY78 BCY79	V _{(BR)CEO}	32 45			V _{dc}
Emitter-Base Breakdown Voltage (I _E = 2 μAdc, I _C = 0)	all	V _{(BR)EBO}	5			V _{dc}
Collector Cutoff Current (V _{CE} = 32 V)	BCY78	I _{CES}		0.2	100	nA
(V _{CE} = 45 V)	BCY79			0.2	100	
(V _{CE} = 32 V, T _A = 100°C, V _{BE} = 0.2 V)	BCY78	I _{CEX}			20	μAdc
(V _{CE} = 45 V, T _A = 100°C, V _{BE} = 0.2 V)	BCY79				20	
(V _{CE} = 25 V, T _A = 150°)	BCY78	I _{CES}		0.2	10	μAdc
(V _{CE} = 35 V, T _A = 150°)	BCY79			0.5	10	
Emitter Base Cutoff Current (V _{EB} = 4 V)	all	I _{EBO}			20	nA

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 Vdc)	BCY79-VII, BCY78-VII BCY79-VIII, BCY78-VIII BCY79-IX, BCY78-IX BCY79-X, BCY78-X	h _{FE}	30 40 100 120	145 220 300 170		
(I _C = 2 mAdc, V _{CE} = 5 Vdc)	BCY79-VII, BCY78-VII BCY79-VIII, BCY78-VIII BCY79-IX, BCY78-IX BCY79-X, BCY78-X		180 250 380	250 350 500	220 310 460 630	
(I _C = 10 mAdc, V _{CE} = 1 Vdc)	BCY79-VII, BCY78-VII BCY79-VIII, BCY78-VIII BCY79-IX, BCY78-IX BCY79-X, BCY78-X		80 120 160 240	190 260 380 550	400 630 1000	
(I _C = 100 mAdc, V _{CE} = 1 Vdc)	BCY79-VII, BCY78-VII BCY79-VIII, BCY78-VIII BCY79-IX, BCY78-IX BCY79-X, BCY78-X		40 45 60 60			
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 2.5 mAdc)	all	V _{CE(sat)}	0.15 0.05	0.30 0.12	0.80 0.25	V _{dc}
(I _C = 10 mAdc, I _B = 0.25 mA)						
Base-Emitter Saturation Voltage (I _C = 10 mA, I _B = 0.25 mA)	all	V _{BE(sat)}	0.6 0.75	0.70 0.90	0.85 1.2	V _{dc}
(I _C = 100 mA, I _B = 2.5 mA)						
Base-Emitter on Voltage (I _C = 2 mAdc, V _{CE} = 5 Vdc)	all	V _{BE(on)}	0.60	0.62	0.75	V _{dc}

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS SMALL SIGNAL CHARACTERISTICS						
Current Gain-Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5 \text{ V}$, $f = 100 \text{ MHz}$)	all	f_T	180	300		MHz
Output Capacitance ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0$, $f = 1 \text{ MHz}$)	all	C_{ob}		3.5	7	pF
Input Capacitance ($V_{BE} = 0.5 \text{ V}$, $I_C = 0$, $f = 1 \text{ MHz}$)	all	C_{ib}		8	15	pF
Small Signal Current Gain ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	BCY78-VII, BCY79-VII BCY78-VIII, BCY79-VIII BCY78-IX, BCY79-IX BCY78-X, BCY79-X	h_{fe} (h_{21e})		200 260 330 520		
Input Impedance ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	BCY78-VII, BCY79-VII BCY78-VIII, BCY79-VIII BCY78-IX, BCY79-IX BCY78-X, BCY79-X	h_{ie} (h_{11e})	1.6 2.5 3.2 7.5		4.5 6 8.5 12	Kohms
Voltage Feedback Ratio ($I_C = 2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	BCY78-VII, BCY79-VII BCY78-VIII, BCY79-VIII BCY78-IX, BCY79-IX BCY78-X, BCY79-X	h_{re} (h_{12e})		1.5 2 2 3		$\times 10^{-4}$
Noise Figure ($I_C = 0.2 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $R_S = 2 \text{ Kohms}$, $f = 1 \text{ kHz}$)	all	NF		2	6	dB
SWITCHING CHARACTERISTICS						
$I_C = 10 \text{ mA}$, $I_{B1} = 1 \text{ mA}$, $I_{B2} = 1 \text{ mA}$ $V_{BB} = 3.6 \text{ V}$, $R_1 = R_2 = 5 \text{ K}\Omega$ $R_L = 990 \text{ ohms}$ * See test circuit.		t_d t_r t_{on} t_s t_f t_{off}		35 50 85 400 80 480	150 800	nS
$I_C = 100 \text{ mA}$, $I_{B1} = 10 \text{ mA}$, $I_{B2} = 10 \text{ mA}$ $V_{BB} = 5 \text{ V}$, $R_1 = 500 \Omega$, $R_2 = 700 \Omega$ $R_L = 98 \text{ ohms}$ * See test circuit.		t_d t_r t_{on} t_s t_f t_{off}		5 50 55 250 200 450	150 800	nS

TEST CIRCUIT

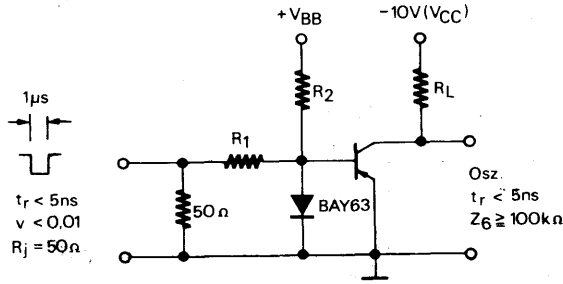


FIGURE 1 - CURRENT GAIN
(BCY78-VII/BCY79-VII)

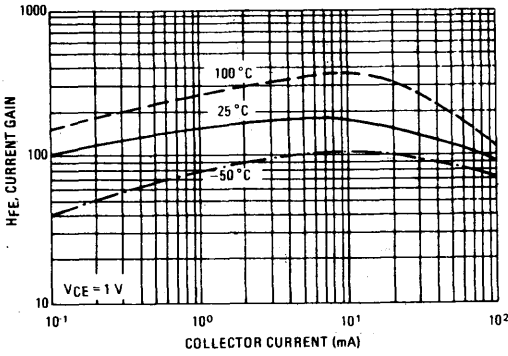


FIGURE 2 - CURRENT GAIN
(BCY78-VIII/BCY79-VIII)

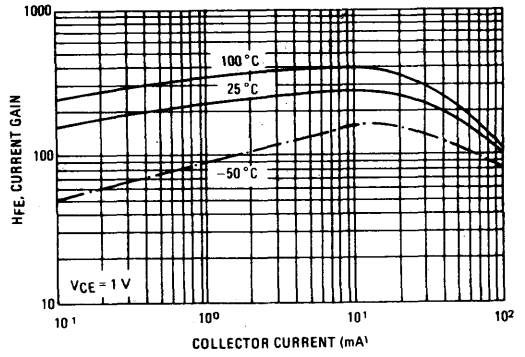


FIGURE 3 - CURRENT GAIN
(BCY78-IX/BCY79-IX)

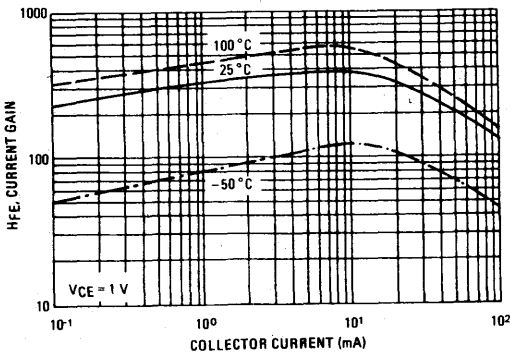
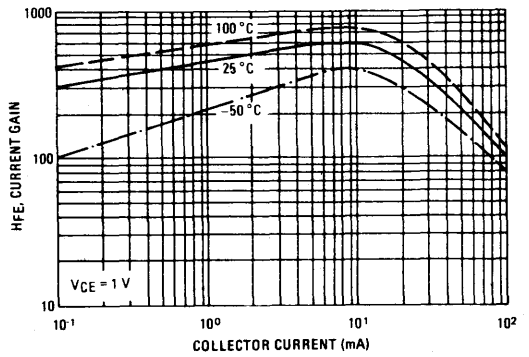


FIGURE 4 - CURRENT GAIN
(BCY78-X/BCY79-X)



BCY78, BCY79

FIGURE 5 – SATURATION VOLTAGE

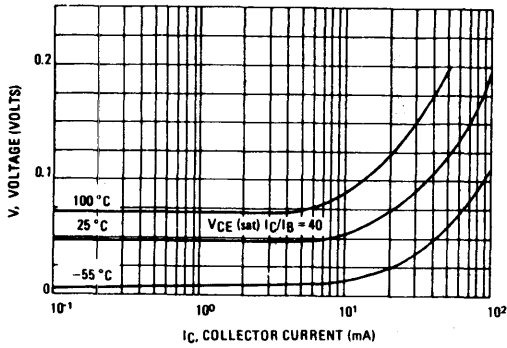


FIGURE 6 – SATURATION VOLTAGE

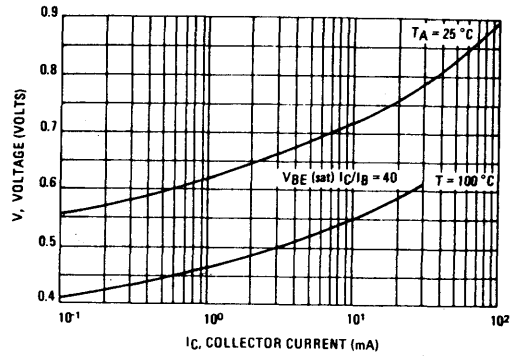


FIGURE 7 – INPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

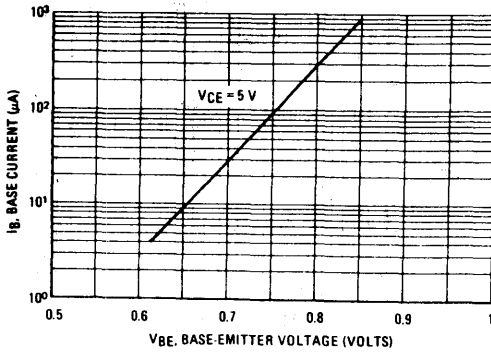


FIGURE 8 – TOTAL PERMISSIBLE POWER DISSIPATION (BCY78/BCY79)

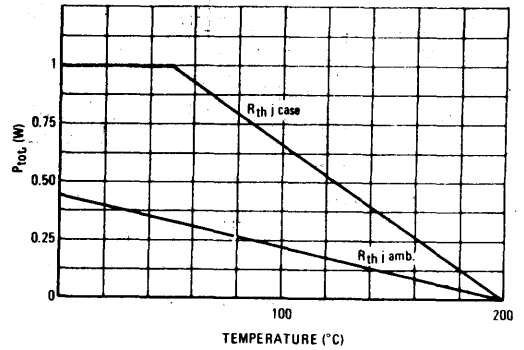


FIGURE 9 – CURRENT GAIN BANDWIDTH PRODUCT

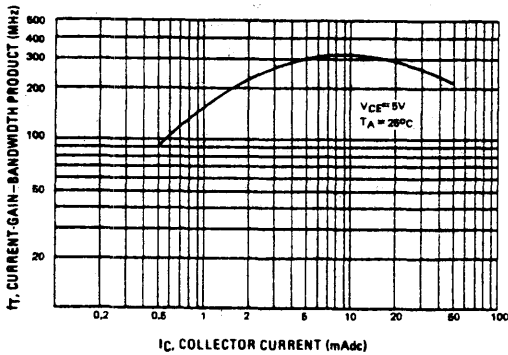
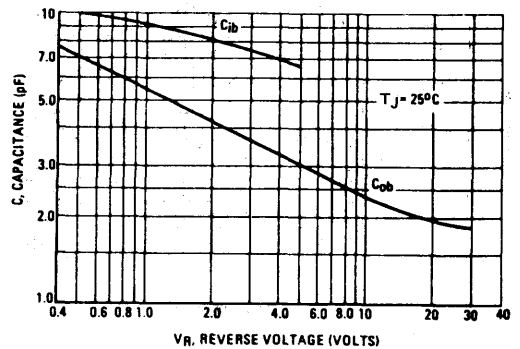


FIGURE 10 – CAPACITANCES



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MAXIMUM RATINGS

Rating	Symbol	BF 257	BF 258	BF 259	Unit
Collector-Emitter Voltage	V _{CEO}	160	250	300	V _{dc}
Collector-Emitter Voltage	V _{CER}	160	250	300	V _{dc}
Collector-Base Voltage	V _{CBQ}	160	250	300	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	0.1			Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	PD	0.8 4.57			Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	PD	5.0 28.6			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W

BF257
BF258
BF259

CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 30 mA _{dc} , I _B = 0)	BF257 BF258 BF259	V _{(BR)CEO}	160 250 300	— — —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	BF257 BF258 BF259	V _{(BR)CBO}	160 250 300	— — —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μA _{dc} , I _C = 0)		V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 100 V _{dc} , I _E = 0) (V _{CB} = 200 V _{dc} , I _E = 0) (V _{CB} = 250 V _{dc} , I _E = 0)	BF257 BF258 BF259	I _{CBO}	— — —	1 1 1	50 50 50 nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 30 mA _{dc} , V _{CE} = 10 V _{dc})		h _{FE}	25	80	—
Collector-Emitter Saturation Voltage (I _C = 30 mA _{dc} , I _B = 6.0 mA _{dc})		V _{CE(sat)}	—	0.1	1.0 V _{dc}
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I _C = 30 mA _{dc} , V _{CE} = 10 V _{dc} , f = 100 MHz)		f _T	—	110	— MHz
Reverse Transfer Capacitance (V _{CB} = 30 V _{dc} , I _E = 0, f = 500 kHz)		C _{re}	—	3.5	— pF
Collector-Base Capacitance (V _{CB} = 10 V _{dc} , I _E = 0, f = 500 kHz)		C _{cb}	—	5.5	— pF

BFW43

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

BFW44

CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BFW 43	BFW 44	Unit
Collector-Emitter Voltage	V_{CE0}	150	150	Vdc
Collector-Base Voltage	V_{CBO}	150	150	Vdc
Emitter-Base Voltage	V_{EBO}	6	6	Vdc
Collector Current - Continuous	I_C	0.1		Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.4 2.66	0.7 4.0	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.4 8.0	2.5 14.3	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	70°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	438	250°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 2\text{ mA}, I_B = 0$)	$V_{(BR)CEO}$	150			Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	150			Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	6			Vdc
Collector Cutoff Current ($V_{CB} = 100\text{ V}, I_E = 0$)	I_{CBO}			10	nA
Collector-Emitter Cutoff Current ($V_{CB} = 100\text{ V}, I_B = 0, T_A = 125^\circ\text{C}$)	I_{CEO}			10	μA

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 1\text{ mA}, V_{CE} = 10\text{ V}$) ($I_C = 10\text{ mA}, V_{CE} = 10\text{ V}$) ($I_C = 10\ \mu\text{A}, V_{CE} = 10\text{ V}, T_A = -55^\circ\text{C}$)	h_{FE}	40 40	30		
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}, I_B = 1\text{ mAdc}$)	$V_{CE(sat)}$		0.15	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}, I_B = 1\text{ mAdc}$)	$V_{BE(sat)}$		0.7	0.9	Vdc

DYNAMIC CHARACTERISTICS

Current Gain Bandwidth Product ($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 10\text{ MHz}$)	f_T	60	110	200	MHz
Output Capacitance ($I_E = 0, V_{CB} = 20\text{ Vdc}, f = 1\text{ MHz}$)	C_{obo}	—	3.5	7	pF
Turn On Time ($I_{B1} = 10\text{ mA}, I_C = 50\text{ mAdc}, V_{CC} = 100\text{ Vdc}$)	t_{on}	—	100	—	ns
Turn Off Time ($I_{B2} = 10\text{ mAdc}, I_C = 50\text{ mAdc}, V_{CC} = 100\text{ Vdc}$)	t_{off}	—	400	—	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2\%$.

BFW43, BFW44

FIGURE 1 - CURRENT-GAIN-BANDWIDTH PRODUCT

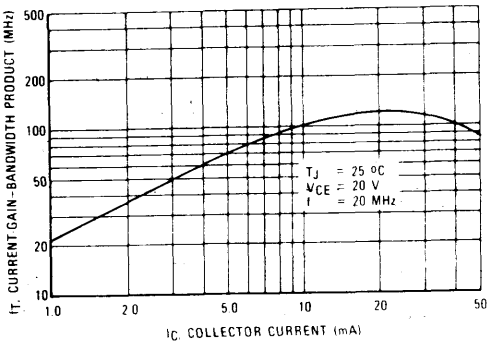


FIGURE 2 - TURN-ON TIME

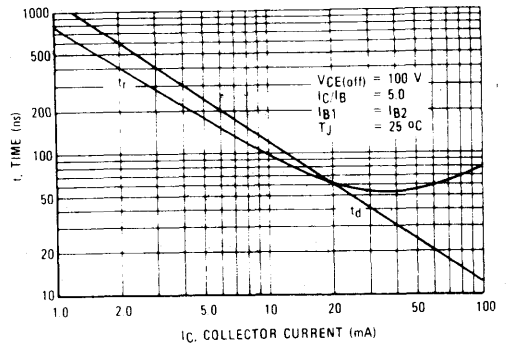


FIGURE 3 - TURN-OFF TIME

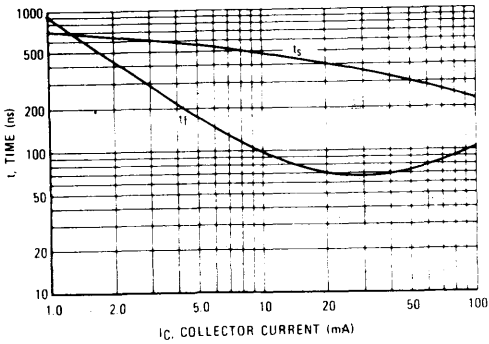
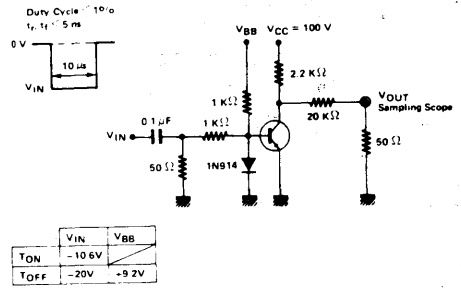


FIGURE 4 - SWITCHING TIME TEST CIRCUIT



BFX38,39,40,41

CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH CURRENT TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BFX38 BFX39	BFX40 BFX41	Unit
Collector-Emitter Voltage	V _{CEO}	55	75	V _{dc}
Collector-Base Voltage	V _{CBO}	55	75	V _{dc}
Emitter-Base Voltage	V _{EBO}	5		V _{dc}
Collector Current - Continuous	I _C	1		A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.25	7.15	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	7	40	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	20	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	140	°C/W

Refer to 2N4405 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mA)(1)	BFX38-39 BFX40-41	V _{(BR)CEO}	55 75	V
Collector-Base Breakdown Voltage (I _C = 10 μA)	BFX38-39 BFX40-41	V _{(BR)CBO}	55 75	V
Emitter-Base Breakdown Voltage (I _E = 10 μA)		V _{(BR)EBO}	5	V
Collector Cutoff Current (V _{CB} = 40 V) (V _{CB} = 50 V) (V _{CB} = 40 V, T _A = 125°C) (V _{CB} = 50 V, T _A = 125°C)	BFX38-39 BFX40-41 BFX38-39 BFX40-41	I _{CBO}	50 50 50 50	nA μA

ON CHARACTERISTICS

Collector-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA)(1) (I _C = 500 mA, I _B = 50 mA)(1)		V _{CE(sat)}	0.15 0.5	V
DC Current Gain (I _C = 100 μA, V _{CE} = 5 V)(1)	BFX38-40 BFX39-41	h _{FE}	60 30	
(I _C = 100 mA, V _{CE} = 5 V)(1)	BFX38-40 BFX39-41		85 40	
(I _C = 500 mA, V _{CE} = 5 V)(1)	BFX38-40 BFX39-41		60 25	
(I _C = 1 A, V _{CE} = 5 V)(1)	BFX38 BFX39 BFX40 BFX41		30 15 25 10	
Emitter-Base Saturation Voltage (I _C = 150 mA, I _B = 15 mA)(1) (I _C = 500 mA, I _B = 15 mA)(1)		V _{BE(sat)}	0.9 1.1	V
DC Current Gain (I _C = 100 mA, V _{CE} = 5 V, T _A = 125°C)(1)	BFX38-40 BFX39-41	h _{FE}	30 15	

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

BFX38,39,40,41

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Current Gain — Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 100\text{ MHz}$)	f_T	100		MHz
Output Capacitance ($V_{CB} = 10\text{ V}$)	C_{ob}		20	pF
Input Capacitance ($V_{EB} = 0.5\text{ V}$)	C_{ib}		120	pF
Turn On Time ($I_C = 500\text{ mA}$, $I_{B1} = 50\text{ mA}$)	t_{on}		100	ns
Turn Off Time ($I_C = 500\text{ mA}$, $I_{B1} = I_{B2} = 50\text{ mA}$)	t_{off}		350	ns
Fall Time ($I_C = 500\text{ mA}$, $I_{B1} = I_{B2} = 50\text{ mA}$)	t_f		50	ns

4

BFX48

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	30	V _{dc}
Collector-Base Voltage	V _{CBO}	30	V _{dc}
Emitter-Base Voltage	V _{EBO}	5	V _{dc}
Collector Current - Continuous	I _C	0.1	Amp
Total Device Dissipation (1) T _A = 25°C Derate above 25°C	P _D	0.36 2.06	Watt mW/°C
Total Device Dissipation (1) T _C = 25°C Derate above 25°C T _C = 100°C	P _D	1.2 0.686 6.86	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	146	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	486	°C/W

Refer to 2N869A for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mA)(1)	V _{(BR)CEO}	30		V
Collector-Base Breakdown Voltage (I _C = 10 μA)	V _{(BR)CBO}	30		V
Emitter-Base Breakdown Voltage (I _E = 10 μA)	V _{(BR)EBO}	5		V
Collector Cutoff Current (V _{CE} = 20 V) (V _{CE} = 20 V, T _A = 125°C)	I _{CES}		15 15	nA μA

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μA, V _{CE} = 1 V) (I _C = 100 μA, V _{CE} = 1 V) (I _C = 10 mA, V _{CE} = 1 V) (I _C = 50 mA, V _{CE} = 1 V) (I _C = 10 mA, V _{CE} = 1 V, T _A = -55°C)	h _{FE}	40 70 90 20 30		
Collector-Emitter Saturation Voltage (I _C = 1 mA, I _B = 0.1 mA) (I _C = 10 mA, I _B = 1 mA) (I _C = 50 mA, I _B = 5 mA)(1)	V _{CE(sat)}		0.13 0.14 0.3	V
Emitter-Base Saturation Voltage (I _C = 1 mA, I _B = 0.1 mA) (I _C = 10 mA, I _B = 1 mA) (I _C = 50 mA, I _B = 5 mA)(1)	V _{BE(sat)}		0.75 0.9 1.1	V

SMALL SIGNAL CHARACTERISTICS

Current Gain — Bandwidth Product (I _C = 10 mA, V _{CE} = 20 V, f = 100 MHz)	f _T	400		MHz
Output Capacitance (V _{CB} = 10 V)	C _{ob}		3.5	pF
Input Capacitance (V _{EB} = 0.5 V)	C _{ib}		5.5	pF
Noise Figure (I _C = 1 mA, V _{CE} = 20 V, f = 100 MHz)	NF		6	dB
Turn On Time (I _C = 50 mA, I _{B1} = 5 mA)	t _{on}		50	ns
Turn Off Time (I _C = 50 mA, I _{B1} = I _{B2} = 5 mA)	t _{off}		160	ns
Collector-Base Time Constant (I _C = 10 mA, V _{CE} = 20 V, f = 80 MHz)	τ _{b'Cc}		40	ps

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

BFX85

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	60	Vdc
Collector-Base Voltage	V _{CBO}	100	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current - Continuous	I _C	1.0	Amp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	PD	0.8 4.57	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	220	°C/W

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, V _{BE} = 0)	V _{(BR)CEO}	60		Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _B = 0)	V _{(BR)CBO}	100		Vdc
Collector Cutoff Current (V _{CB} = 80 Vdc, I _E = 0) (V _{CB} = 80 Vdc, I _E = 0, T _J = 100°C) (V _{CB} = 100 Vdc, I _E = 0) (V _{CB} = 100 Vdc, I _E = 0, T _J = 100°C)	I _{CBO}		50 2.5 500 2.5	nAdc μAdc nAdc μAdc
Emitter Cutoff Current (V _{EB} = 5 Vdc, I _C = 0) (V _{EB} = 5 Vdc, I _C = 0, T _J = 100°C) (V _{EB} = 6 Vdc, I _C = 0)	I _{EBO}		50 2.5 500	nAdc μAdc nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 150 mAdc, V _{CE} = 10 Vdc) (I _C = 500 mAdc, V _{CE} = 10 Vdc) (I _C = 1.0 Adc, V _{CE} = 10 Vdc)	h _{FE}	50 70 30 15		
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc) (I _C = 1.0 Adc, I _B = 100 mAdc)	V _{CE(sat)}		0.15 0.35 1.00 1.60	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc) (I _C = 1.0 Adc, I _B = 100 mAdc)	V _{BE(sat)}		1.2 1.3 1.5 2.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 35 \text{ MHz}$)	f_T	50		MHz
Collector Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1 \text{ MHz}$)	C_{obo}		12	pF
Small Signal Current Gain ($I_C = 1 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	20 25		
Input Impedance ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	h_{ie}		750	Ω
Voltage Feedback Ratio ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	h_{re}		5.0	$\times 10^{-4}$
Output Admittance ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	h_{oe}		80	μmhos

MAXIMUM RATINGS

Rating	Symbol	BFY 50	BFY 51	BFY 52	Unit
Collector-Emitter Voltage	V _{CEO}	35	30	20	V _{dc}
Collector-Base Voltage	V _{CBO}	80	60	40	V _{dc}
Emitter-Base Voltage	V _{EBO}	6			V _{dc}
Collector Current - Continuous	I _C	1			A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.8		4.6	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5		28.6	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	16.5	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	89.5	°C/W

**BFY50
BFY51
BFY52**

**CASE 79, STYLE 1
TO-39 (TO-205AD)**

**GENERAL PURPOSE
TRANSISTOR**

NPN SILICON

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Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mA)	BFY50 BFY51 BFY52	V _{(BR)CEO}	35 30 20	V
Collector-Base Breakdown Voltage (I _C = 10 μA)	BFY50 BFY51 BFY52	V _{(BR)CBO}	80 60 40	V
Emitter-Base Breakdown Voltage (I _E = 10 μA)		V _{(BR)EBO}	6	V
Collector Cutoff Current (V _{CB} = 60 V) (V _{CB} = 40 V) (V _{CB} = 30 V)	BFY50 BFY51 BFY52	I _{CBO}	50	nA
Collector Cutoff Current (V _{CB} = 60 V, T _J = 100°C) (V _{CB} = 40 V, T _J = 100°C) (V _{CB} = 30 V, T _J = 100°C)	BFY50 BFY51 BFY52	I _{CBO}	2.5	μA
Emitter Cutoff Current (V _{EB} = 5 V) (V _{EB} = 5 V, T _J = 100°C)		I _{EBO}	50 2.8	nA μA

ON CHARACTERISTICS

DC Current Gain (I _C = 10 mA, V _{CE} = 6 V)	BFY50 BFY51-52	h _{FE}	20 30	
(I _C = 150 mA, V _{CE} = 6 V)	BFY50 BFY51 BFY52		30 40 60	
(I _C = 1 A, V _{CE} = 6 V)			15	
Collector-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA(1))	BFY50 BFY51-52	V _{CE(sat)}	0.2 0.35	V
(I _C = 1 A, I _B = 100 mA(1))	BFY50 BFY51-52		1 1.6	
Emitter-Base Saturation Voltage (I _C = 1 A, I _B = 100 mA(1))		V _{BE(sat)}	2	V

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

BFY50, BFY51, BFY52**ELECTRICAL CHARACTERISTICS** (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Small Signal Current Gain ($I_C = 1\text{ mA}$, $V_{CE} = 6\text{ V}$, $f = 1\text{ kHz}$)	BFY50 BFY51-52 h_{fe}	10 30		
Output Capacitance ($V_{CB} = 12\text{ V}$, $f = 500\text{ kHz}$)	C_{ob}		12	μF
Current Gain Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 6\text{ V}$, $f = 20\text{ MHz}$)	BFY50 BFY51-52 f_T	60 50		MHz

MAXIMUM RATINGS

Rating	Symbol	BSS50	BSS51	BSS52	Unit
Collector-Emitter Voltage	V _{CEO}	45	60	80	V _{dc}
Collector-Emitter Voltage	V _{CER}	45	60	80	V _{dc}
Collector-Base Voltage	V _{CBO}	60	80	100	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	1.0			Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.8 5.3			Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5 28.6			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	220	°C/W

BSS50
BSS51
BSS52

CASE 79, STYLE 1
TO-39 (TO-205AD)

DARLINGTON TRANSISTOR

NPN SILICON

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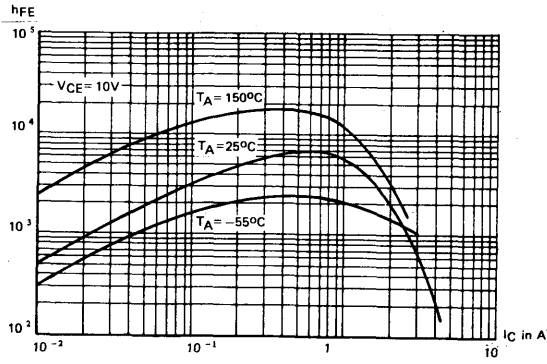
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Cutoff Current (V _{CB} = 45 V, I _E = 0) (V _{CB} = 60 V, I _E = 0) (V _{CB} = 80 V, I _E = 0)	I _{CBO}			50 50 50	nA
Emitter-Cutoff Current (V _{EB} = 4 V, I _C = 0)	I _{EBO}			50	nA
Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)	V _{(BR)CEO}	45 60 80			V
Emitter-Base Breakdown Voltage (I _B = 100 μA, I _C = 0)	V _{(BR)EBO}	5			V
ON CHARACTERISTICS					
DC Current Gain(1) (I _C = 150 mA, V _{CE} = 10 V) (I _C = 500 mA, V _{CE} = 10 V)	h _{FE}	1500 2000			
Base-Emitter Voltage(1) (I _C = 150 mA, V _{CE} = 10 V) (I _C = 500 mA, V _{CE} = 10 V)	V _{BE(on)}	1.4 1.5		1.55 1.65	V
Saturation Voltage(1) (I _C = 500 mA, I _B = 0.5 mA) (I _C = 500 mA, I _B = 0.5 mA) (I _C = 1 A, I _B = 1 mA) (I _C = 1 A, I _B = 1 mA) (I _C = 1 A, I _B = 4 mA) (I _C = 1 A, I _B = 4 mA)	V _{CE(sat)} V _{BE(sat)} V _{CE(sat)} V _{BE(sat)} V _{CE(sat)} V _{BE(sat)}			1.3 1.9 1.6 2.2 1.6 2.2	V
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I _C = 500 mA, V _{CE} = 5, f = 20 MHz)	f _T		70		MHz
Output Capacitance (V _{CB} = 10 V, I _E = 0, f = 1 MHz)	C _{ob}		11	25	pf
Turn On Time (I _C = 500 mA, I _{B1} = -I _{B2} = 0.5 mA) Turn Off Time (I _C = 500 mA, I _{B1} = -I _{B2} = 0.5 mA)	t _{on} t _{off}		400 1500		ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%, unless otherwise specified.

BSS50, BSS51, BSS52

FIGURE 1 – CURRENT GAIN versus COLLECTOR CURRENT



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MAXIMUM RATINGS

Rating	Symbol	BSS60	BSS61	BSS62	Unit
Collector-Emitter Voltage	V _{CEO}	45	60	80	V _{dc}
Collector-Emitter Voltage	V _{CER}	45	60	80	V _{dc}
Collector-Base Voltage	V _{CBO}	60	80	100	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	1.0			A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.8 5.3			Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5 28.6			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	220	°C/W

BSS60
BSS61
BSS62

CASE 79, STYLE 1
TO-39 (TO-205AD)

DARLINGTON TRANSISTOR

PNP SILICON

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Cutoff Current (V _{CB} = 45 V, I _E = 0) (V _{CB} = 60 V, I _E = 0) (V _{CB} = 80 V, I _E = 0)	BSS60 BSS61 BSS62	I _{CBO}		50 50 50	nA
Emitter-Cutoff Current (V _{EB} = 4 V, I _C = 0)		I _{EBO}		100	nA
Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)	BSS60 BSS61 BSS62	V _{(BR)CEO}	45 60 80		V
Emitter-Base Breakdown Voltage (I _B = 100 μA, I _C = 0)		V _{(BR)EBO}	5		V
ON CHARACTERISTICS					
DC Current Gain(1) (I _C = 150 mA, V _{CE} = 10 V) (I _C = 500 mA, V _{CE} = 10 V)		h _{FE}	1500 2000		
Saturation Voltage(1) (I _C = 500 mA, I _B = 0.5 mA) (I _C = 500 mA, I _B = 0.5 mA) (I _C = 1 A, I _B = 1 mA) (I _C = 1 A, I _B = 1 mA) (I _C = 1 A, I _B = 4 mA) (I _C = 1 A, I _B = 4 mA)	BSS61 BSS61 BSS60-62 BSS60-62	V _{CE(sat)} V _{BE(sat)} V _{CE(sat)} V _{BE(sat)} V _{CE(sat)} V _{BE(sat)}		1.3 1.9 1.6 2.2 1.6 2.2	V
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I _C = 500 mA, V _{CE} = 5 V, f = 20 MHz)		f _T	70		MHz
Output Capacitance (V _{CB} = 10 V, I _E = 0, f = 1 MHz)		C _{ob}		25	pf
Turn On Time (I _C = 500 mA, I _{B1} = -I _{B2} = 0.5 mA)		t _{on}	400		ns
Turn Off Time (I _C = 500 mA, I _{B1} = -I _{B2} = 0.5 mA)		t _{off}	1500		ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%, unless otherwise specified.

BSS71 BSS72 BSS73

CASE 79, STYLE 1
TO-18 (TO-206AA)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BSS71	BSS72	BSS73	Unit
Collector-Emitter Voltage	V _{CEO}	200	250	300	V _{dc}
Collector-Base Voltage	V _{CBO}	200	250	300	V _{dc}
Emitter-Base Voltage	V _{EBO}	6.0			V _{dc}
Collector Current - Continuous	I _C	0.5			Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.5 2.86			Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 14.3			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	70	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)	BSS71 BSS72 BSS73	V _{(BR)CEO}	200 250 300	— — —	— — —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	BSS71 BSS72 BSS73	V _{(BR)CBO}	200 250 300	— — —	— — —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	BSS71 BSS72 BSS73	V _{(BR)EBO}	6 6 6	— — —	— — —	V _{dc}
Collector Cutoff Current (V _{CB} = 150 V, I _E = 0) (V _{CB} = 200 V, I _E = 0) (V _{CB} = 250 V, I _E = 0)	BSS71 BSS72 BSS73	I _{CBO}	— — —	— — —	50 50 50	nA
Collector-Emitter Cutoff Current (V _{CE} = 150 V, I _B = 0) (V _{CE} = 200 V, I _B = 0) (V _{CE} = 300 V, I _B = 0)	BSS71 BSS72 BSS73	I _{CEO}	— — —	— — —	500 500 500	nA
Emitter-Cutoff Current (V _{BE} = 5 Vdc, I _C = 0)	ALL	I _{EBO}	—	—	50	nA
ON CHARACTERISTICS (1)						
DC Current Gain (I _C = 0.1 mA, V _{CE} = 1 V) (I _C = 1 mA, V _{CE} = 10 V) (I _C = 10 mA, V _{CE} = 10 V) (I _C = 30 mA, V _{CE} = 10 V) (I _C = 100 mA, V _{CE} = 10 V)	BSS71 ALL ALL ALL BSS73	h _{FE}	20 30 50 40 —	40 45 120 140 35	— — — 250 —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1 mAdc) (I _C = 30 mAdc, I _B = 3 mAdc) (I _C = 50 mAdc, I _B = 5 mAdc) (I _C = 100 mAdc, I _B = 20 mAdc)	ALL ALL ALL BSS73	V _{CE(sat)}	— — — —	0.15 0.25 0.35 0.25	0.3 0.4 0.5 —	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1 mAdc) (I _C = 30 mAdc, I _B = 3 mAdc) (I _C = 50 mAdc, I _B = 5 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc)	ALL ALL ALL BSS73	V _{BE(sat)}	— — — —	0.7 0.8 0.85 0.9	0.8 0.9 1.0 —	V _{dc}

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

BSS71, BSS72, BSS73

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product ($I_C = 20\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 20\text{ MHz}$)	f_t	50	70	200	MHz
Output Capacitance ($I_E = 0$, $V_{CB} = 20\text{ Vdc}$, $f = 1\text{ MHz}$)	C_{ob}	—	3.5	—	pF
Input Capacitance ($I_C = 0$, $V_{EB} = 0.5\text{ Vdc}$, $f = 1\text{ MHz}$)	C_{ib}	—	45	—	pF
Turn On Time ($I_{B1} = 10\text{ mA}$, $I_C = 50\text{ mAdc}$, $V_{CC} = 100\text{ Vdc}$)	t_{on}	—	100	—	ns
Turn Off Time ($I_{B2} = 10\text{ mAdc}$, $I_C = 50\text{ mAdc}$, $V_{CC} = 100\text{ Vdc}$)	t_{off}	—	400	—	ns

FIGURE 1 — DC CURRENT GAIN

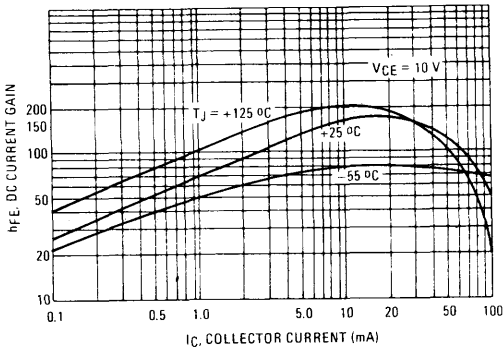


FIGURE 2 — CAPACITANCES

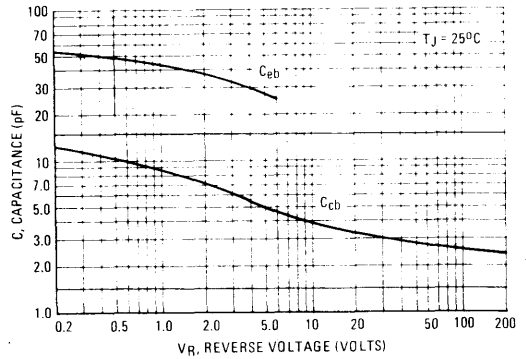


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT

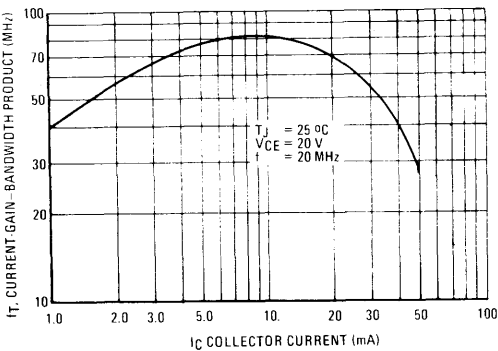
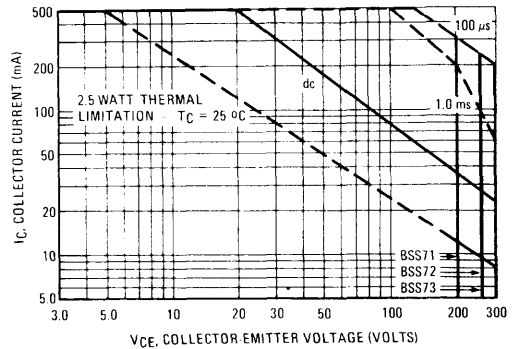


FIGURE 4 — ACTIVE-REGION SAFE OPERATING AREA



BSS71, BSS72, BSS73

FIGURE 5 - "ON" VOLTAGES

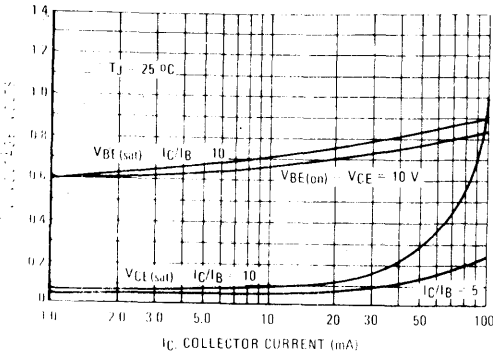


FIGURE 6 - TEMPERATURE COEFFICIENTS

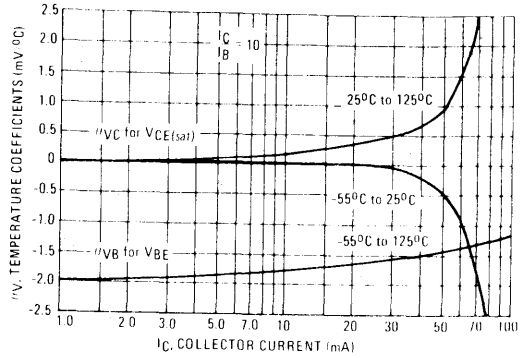


FIGURE 7 - TURN-ON TIME

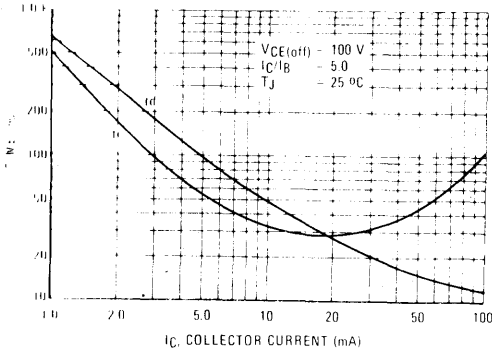


FIGURE 8 - TURN-OFF TIME

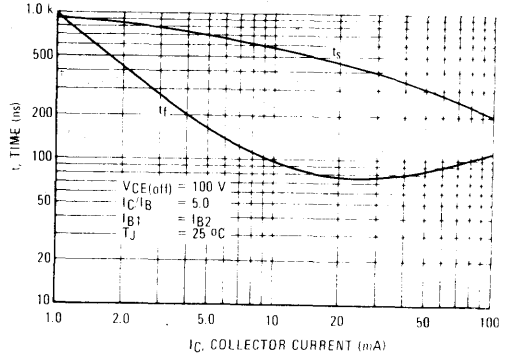
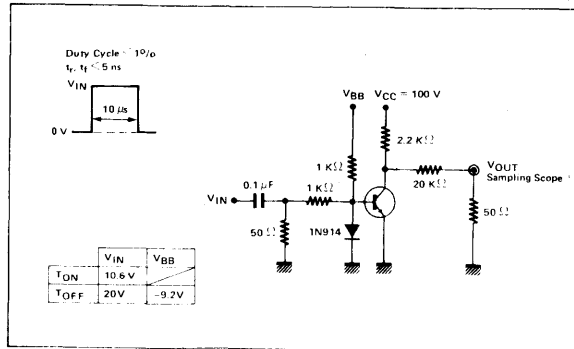


FIGURE 9 - SWITCHING TIME TEST CIRCUIT



MAXIMUM RATINGS

Rating	Symbol	BSS74	BSS75	BSS76	Unit
Collector-Emitter Voltage	V _{CEO}	200	250	300	V _{dc}
Collector-Base Voltage	V _{CBO}	200	250	300	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current - Continuous	I _C	0.5			A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.5	2.86		Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5	14.3		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	70	°C/W

BSS74 BSS75 BSS76

CASE 79, STYLE 1
TO-18 (TO-206AA)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)	BSS74 BSS75 BSS76	V _{(BR)CEO}	200 250 300	— — —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	BSS74 BSS75 BSS76	V _{(BR)CBO}	200 250 300	— — —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	BSS74 BSS75 BSS76	V _{(BR)EBO}	6 6 6	— — —	V _{dc}
Collector Cutoff Current (V _{CB} = 150 V, I _E = 0) (V _{CB} = 200 V, I _E = 0) (V _{CB} = 250 V, I _E = 0)	BSS74 BSS75 BSS76	I _{CBO}	— — —	— — —	nA
Collector-Emitter Cutoff Current (V _{CE} = 150 V, I _B = 0) (V _{CE} = 200 V, I _B = 0) (V _{CE} = 300 V, I _B = 0)	BSS74 BSS75 BSS76	I _{CEO}	— — —	— — —	nA
Emitter-Cutoff Current (V _{BE} = 5 Vdc, I _C = 0)	ALL	I _{EBO}	—	—	nA
ON CHARACTERISTICS (1)					
DC Current Gain (I _C = 0.1 mA, V _{CE} = 1 V) (I _C = 1 mA, V _{CE} = 10 V) (I _C = 10 mA, V _{CE} = 10 V) (I _C = 30 mA, V _{CE} = 10 V) (I _C = 100 mA, V _{CE} = 10 V)	BSS74 ALL ALL ALL BSS76	h _{FE}	20 30 35 35 —	40 45 50 55 40	— — — 150 —
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1 mAdc) (I _C = 30 mAdc, I _B = 3 mAdc) (I _C = 50 mAdc, I _B = 5 mAdc) (I _C = 100 mAdc, I _B = 20 mAdc)	ALL ALL ALL BSS76	V _{CE(sat)}	— — — —	0.15 0.25 0.35 0.40	0.3 0.4 0.5 —
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1 mAdc) (I _C = 30 mAdc, I _B = 3 mAdc) (I _C = 50 mAdc, I _B = 5 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc)	ALL ALL ALL BSS76	V _{BE(sat)}	— — — —	0.7 0.8 0.85 0.9	0.8 0.9 1.0 —

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

BSS74, BSS75, BSS76

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth product ($I_C = 20\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 20\text{ MHz}$)	f_t	50	110	200	MHz
Output Capacitance ($I_E = 0$, $V_{CB} = 20\text{ Vdc}$, $f = 1\text{ MHz}$)	C_{ob}	—	3.5	—	pF
Input Capacitance ($I_C = 0$, $V_{EB} = 0.5\text{ Vdc}$, $f = 1\text{ MHz}$)	C_{ib}	—	45	—	pF
Turn On Time ($I_{B1} = 10\text{ mA}$, $I_C = 50\text{ mA}$, $V_{CC} = 100\text{ Vdc}$)	t_{on}	—	100	—	ns
Turn Off Time ($I_{B2} = 10\text{ mA}$, $I_C = 50\text{ mA}$, $V_{CC} = 100\text{ Vdc}$)	t_{off}	—	400	—	ns

FIGURE 1 – DC CURRENT GAIN

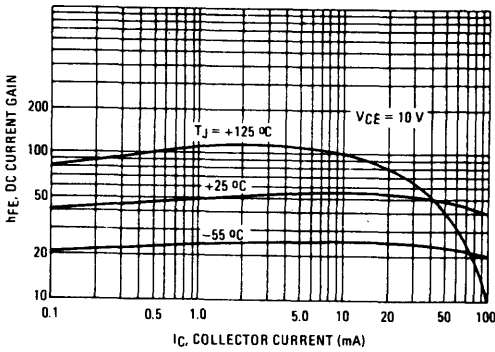


FIGURE 2 – CAPACITANCES

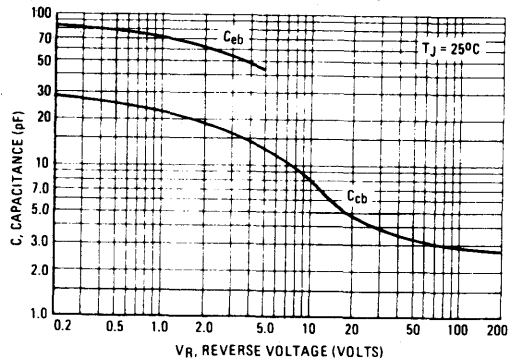


FIGURE 3 – "ON" VOLTAGES

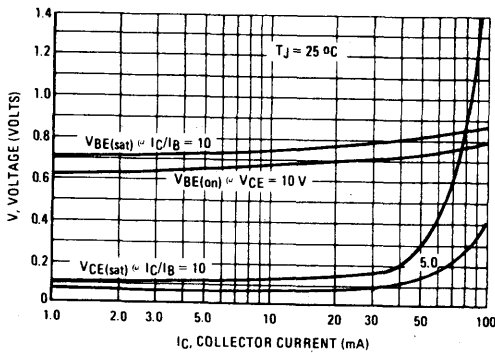
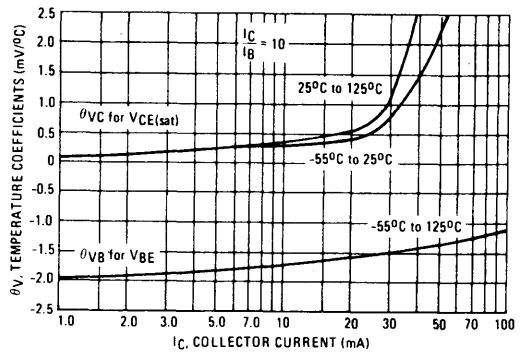


FIGURE 4 – TEMPERATURE COEFFICIENTS



BSS74, BSS75, BSS76

FIGURE 5 – CURRENT-GAIN-BANDWIDTH PRODUCT

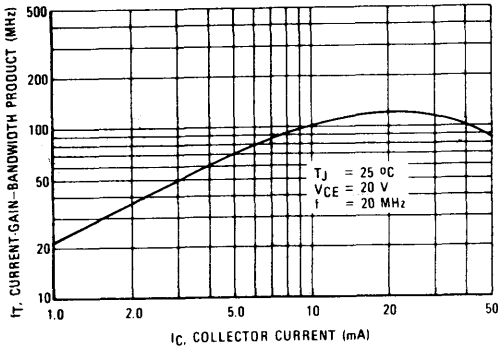


FIGURE 6 – TURN-ON TIME

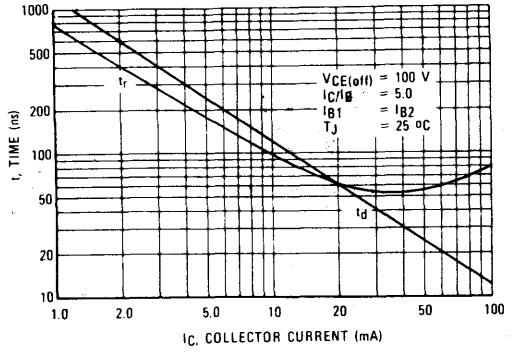


FIGURE 7 – TURN-OFF TIME

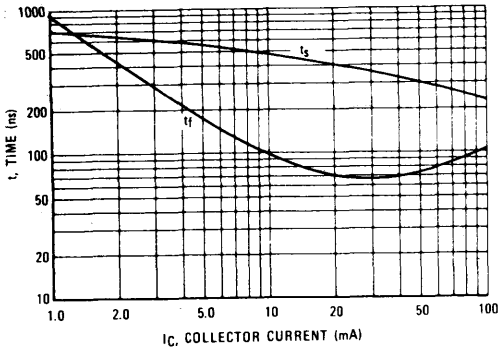


FIGURE 8 – SWITCHING TIME TEST CIRCUIT

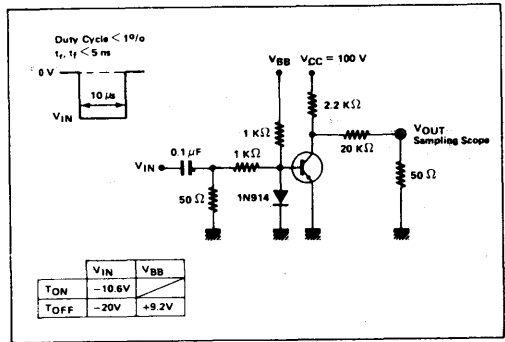
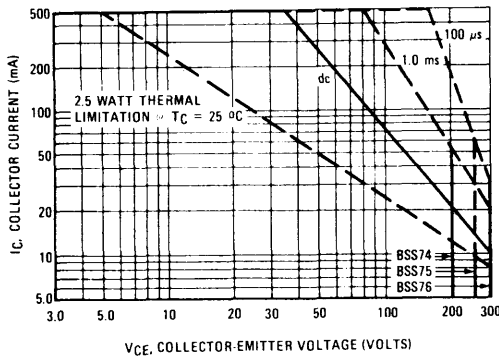


FIGURE 9 – ACTIVE-REGION SAFE OPERATING AREA



BSS77 BSS78

CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BSS 77	BSS 78	Unit
Collector-Emitter Voltage	V _{CEO}	200	250	V _{dc}
Collector-Base Voltage	V _{CBO}	200	250	V _{dc}
Emitter-Base Voltage	V _{EBO}	6		V _{dc}
Collector Current - Continuous	I _C	1		Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.8	4.57	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0	28.6	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)	BSS77 BSS78	V _{(BR)CEO}	200 250	— —	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	BSS77 BSS78	V _{(BR)CBO}	200 250	— —	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	BSS77 BSS78	V _{(BR)EBO}	6 6	— —	— —	V _{dc}
Collector Cutoff Current (V _{CB} = 150 V, I _E = 0) (V _{CB} = 200 V, I _E = 0)	BSS77 BSS78	I _{CBO}	— —	— —	50 50	nA
Collector-Emitter Cutoff Current (V _{CE} = 150 V, I _B = 0) (V _{CE} = 200 V, I _B = 0)	BSS77 BSS78	I _{CEO}	— —	— —	500 500	nA
Emitter-Base Cutoff Current (V _{BE} = 5 Vdc, I _C = 0) (V _{BE} = 5 Vdc, I _C = 0)	BSS77 BSS78	I _{EBO}	— —	— —	50 50	nA

ON CHARACTERISTICS (1)

DC Current Gain (I _C = 0.1 mA, V _{CE} = 1 V) (I _C = 1 mA, V _{CE} = 10 V) (I _C = 10 mA, V _{CE} = 10 V) (I _C = 30 mA, V _{CE} = 10 V) (I _C = 100 mA, V _{CE} = 10 V)	Both types	h _{FE}	20 30 50 40	40 45 120 140	— — — 250	— —
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1 mAdc) (I _C = 30 mAdc, I _B = 3 mAdc) (I _C = 50 mAdc, I _B = 5 mAdc) (I _C = 100 mAdc, I _B = 20 mAdc)	Both types	V _{CE(sat)}	— — — —	0.15 0.25 0.35 0.25	0.3 0.4 0.5 —	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1 mAdc) (I _C = 30 mAdc, I _B = 3 mAdc) (I _C = 50 mAdc, I _B = 5 mAdc) (I _C = 100 mAdc, I _B = 10 mAdc)	Both types	V _{BE(sat)}	— — — —	0.7 0.8 0.85 0.9	0.8 0.9 1.0 —	V _{dc}

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

BSS77, BSS78**ELECTRICAL CHARACTERISTICS** (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product ($I_C = 20\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 20\text{ MHz}$)	f_t	50	70	200	MHz
Output Capacitance ($I_E = 0$, $V_{CB} = 20\text{ Vdc}$, $f = 1\text{ MHz}$)	C_{ob}	—	3.5	—	pF
Input Capacitance ($I_C = 0$, $V_{EB} = 0.5\text{ Vdc}$, $f = 1\text{ MHz}$)	C_{ib}	—	45	—	pF
Turn On Time ($I_{B1} = 10\text{ mA}$, $I_C = 50\text{ mA}$, $V_{CC} = 100\text{ Vdc}$)	t_{on}	—	100	—	ns
Turn Off Time ($I_{B2} = 10\text{ mA}$, $I_C = 50\text{ mA}$, $V_{CC} = 100\text{ Vdc}$)	t_{off}	—	400	—	ns

BSV15 BSV16 BSV17

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BSV 15	BSV 16	BSV 17	Unit
Collector-Emitter Voltage	V _{CEO}	40	60	80	V _{dc}
Collector-Emitter Voltage	V _{CES}	40	60	90	V _{dc}
Collector-Base Voltage	V _{CBO}	40	60	90	V _{dc}
Emitter-Base Voltage	V _{EBO}	5			V _{dc}
Collector Current - Continuous	I _C	1			Adc
Total Device Dissipation @ T _A = 25°C	P _D	1.25			Watt
Derate above 25°C		7.15			mW/°C
Total Device Dissipation @ T _C = 25°C	P _D	7			Watt
Derate above 25°C		40			mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	20	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	140	°C/W

Refer to 2N4405 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current (V _{CE} = 40 V) (V _{CE} = 40 V, T _A = 150°C) (V _{CE} = 60 V) (V _{CE} = 60 V, T _A = 150°C) (V _{CE} = 80 V) (V _{CE} = 80 V, T _A = 150°C)	BSV15 BSV16 BSV17	IC _{ES}	50 50 50 50 50	nA μA nA μA nA μA
Collector Cutoff Current (V _{CE} = 40 V, V _{BE} = -0.2 V, T _A = 100°C) (V _{CE} = 60 V, V _{BE} = -0.2 V, T _A = 100°C) (V _{CE} = 80 V, V _{BE} = -0.2 V, T _A = 100°C)	BSV15 BSV16 BSV17	IC _{EX}	50 50 50	μA μA μA
Emitter Cutoff Current (V _{EB} = 4 V)		I _{EBO}	50	nA
Collector-Emitter Breakdown Voltage (I _C = 50 mA(1))	BSV15 BSV16 BSV17	V _{(BR)CEO}	40 60 80	V
Collector-Emitter Breakdown Voltage (I _C = 10 μA)	BSV15 BSV16 BSV17	V _{(BR)CES}	40 60 90	V
Emitter-Base Breakdown Voltage (I _E = 10 μA)		V _{(BR)EBO}	5	V
Emitter Cutoff Current (V _{EB} = 4 V)		I _{EBO}	50	nA

ON CHARACTERISTICS

DC Current Gain (V _{CE} = 1 V, I _C = 0.1 mA)	BSV15,16,17 - 6 - 10 BSV15,16 - 16	h _{FE}	15 20 30		
(V _{CE} = 1 V, I _C = 100 mA)(1)	BSV15,16,17 - 6 - 10 BSV15,16 - 16		40 63 100	100 160 250	
(V _{CE} = 1 V, I _C = 500 mA)(1)	BSV15,16,17 - 6 - 10 BSV15,16 - 16		20 25 35		
Base-Emitter Voltage (V _{CE} = 1 V, I _C = 100 mA)(1) (V _{CE} = 1 V, I _C = 500 mA)(1)		V _{BE(on)}	0.7	1 1.4	V

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

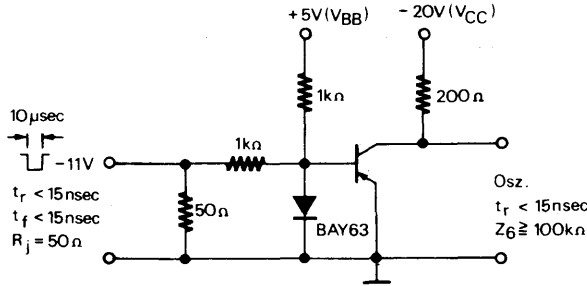
BSV15, BSV16, BSV17

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 20\text{ MHz}$)	f_T	50		MHz
Output Capacitance ($V_{CB} = 10\text{ V}$, $I_E = 0$, $f = 1\text{ MHz}$)	C_{ob}		25	pF
Small Signal Current Gain ($I_C = 1\text{ mA}$, $V_{CE} = 5\text{ V}$, $f = 1\text{ MHz}$)	h_{fe}	20		
Turn On Time (Fig. 1) ($I_C = 100\text{ mA}$, $I_{B1} = I_{B2} = 5\text{ mA}$)	t_{on}		500	ns
Storage Time (Fig. 1) ($I_C = 100\text{ mA}$, $I_{B1} = I_{B2} = 5\text{ mA}$)	t_s		500	ns
Fall Time (Fig. 1) ($I_C = 100\text{ mA}$, $I_{B1} = I_{B2} = 5\text{ mA}$)	t_f		150	ns

4

FIGURE 1 — SWITCHING TIME CIRCUIT



BSW66A BSW67A BSW68A

CASE 79, STYLE 1
TO-39 (TO-205AD)

TRANSISTOR
NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BSW 66A	BSW 67A	BSW 68A	Unit
Collector-Emitter Voltage	V _{CEO}	100	120	150	V _{dc}
Collector-Base Voltage	V _{CBO}	100	120	150	V _{dc}
Emitter-Base Voltage	V _{EBO}	6.0			V _{dc}
Collector Current - Continuous	I _C	2.0			Amp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.8 4.57			Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0 28.6			Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	220	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	100 120 150		V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc)	V _{(BR)CBO}	100 120 150		V _{dc}
Collector-Base Cutoff Current (V _{CB} = 50 V, I _E = 0) (V _{CB} = 60 V, I _E = 0) (V _{CB} = 75 V, I _E = 0) (V _{CB} = 50 V, I _E = 0, T _J = 150°C) (V _{CB} = 60 V, I _E = 0, T _J = 150°C) (V _{CB} = 75 V, I _E = 0, T _J = 150°C)	I _{CBO}		100 100 100 100 100 100	nAdc μAdc
Emitter-Base Cutoff Current (V _{EB} = 3 V, I _C = 0) (V _{EB} = 6 V, I _C = 0)	I _{EBO}		100 100	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 10 mA, V _{CE} = 5 V) (I _C = 100 mA, V _{CE} = 5 V) (I _C = 500 mA, V _{CE} = 5 V) (I _C = 1.0 A, V _{CE} = 5 V)	h _{FE}	30 40 30 15		
Collector-Emitter Saturation Voltage (I _C = 100 mA, I _B = 10 mA) (I _C = 500 mA, I _B = 50 mA) (I _C = 1.0 A, I _B = 150 mA)	V _{CE(sat)}		0.15 0.40 1.0	V _{dc}
Emitter-Base Saturation Voltage (I _C = 100 mA, I _B = 10 mA) (I _C = 500 mA, I _B = 50 mA) (I _C = 1.0 A, I _B = 150 mA)	V _{BE(sat)}		0.9 1.1 1.4	V _{dc}
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I _C = 100 mA, V _{CE} = 20 V, f = 35 MHz)	f _t	50		MHz
Output Capacitance (V _{CB} = 10 V, I _E = 0, f = 1 MHz)	C _{obo}		20	pF
Input Capacitance (V _{EB} = 0, I _C = 0, f = 1 MHz)	C _{ibo}		300	pF

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	15	Vdc
Collector-Emitter Voltage (R _{BE} = 10 Ohms)	V _{CER}	20	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	4.5	Vdc
Collector Current – Continuous	I _C		mAmp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	360 2.06	mWatt mW/°C
Total Device Dissipation @ T _C = 25°C T _C = 100°C Derate above 25°C	P _D	1.2 6.85	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	146	°C/W

BSX20

**CASE 22-03, STYLE 1
TO-18 (TO-206AA)**

TRANSISTOR

NPN SILICON

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA _{dc} , I _B = 0) (I _C = 10 mA _{dc} , R _{BE} = 10 Ω)	V _{(BR)CEO}	15		Vdc
	V _{(BR)CER}	20		Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	4.5		Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0) (V _{CB} = 20 Vdc, I _E = 0, T _J = 150°C)	I _{CBO}		400	nA _{dc}
			30	μA _{dc}
Collector Cutoff Current (V _{CE} = 15 Vdc, V _{BE} = 0, T _J = 55°C) (V _{CE} = 40 Vdc, V _{BE} = 0)	I _{CES}		0.4	μA _{dc}
			1.0	μA _{dc}
Cutoff Current (V _{CE} = 15 Vdc, V _{BE} = -3 V, T _J = 55°C)	I _{CEX} I _{BEX}		0.6	μA _{dc}
			0.6	μA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 10 mA _{dc} , V _{CE} = 1 Vdc) (I _C = 10 mA _{dc} , V _{CE} = 1 Vdc, T _J = -55°C) (I _C = 100 mA _{dc} , V _{CE} = 2 Vdc)	h _{FE}	40 20 10	120		
	Base-Emitter On Voltage (I _C = 30 μA _{dc} , V _{CE} = 20 Vdc, T _J = 100°C)	V _{BE(on)}		0.35	Vdc
	Emitter-Collector Saturation Voltage (I _C = 10 mA _{dc} , I _B = 0.3 mA _{dc}) (I _C = 10 mA _{dc} , I _B = 1 mA _{dc}) (I _C = 100 mA _{dc} , I _B = 10 mA _{dc})	V _{CE(sat)}		0.3	Vdc
			0.25	Vdc	
			0.60	Vdc	
Emitter-Base Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1 mA _{dc}) (I _C = 100 mA _{dc} , I _B = 10 mA _{dc})	V _{BE(sat)}	0.7	0.85	Vdc	
			1.50	Vdc	

BSX20

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ V}$)	f_T	500		MHz
Output Capacitance ($V_{CB} = 5\text{ V}$, $I_E = 0$, $f = 1\text{ MHz}$)	C_{obo}		4	pF
Input Capacitance ($V_{EB} = 1\text{ V}$, $I_C = 0$, $f = 1\text{ MHz}$)	C_{ibo}		4.5	pF
Time ($I_C = 10\text{ mA}$, $I_{B1} = I_{B2} = 10\text{ mA}$)	t_s		13	ns
Turn-On Time ($I_C = 10\text{ mA}$, $I_{B1} = 3\text{ mA}$) ($I_C = 100\text{ mA}$, $I_{B1} = 40\text{ mA}$)	t_{on}		12 7	ns
Turn-Off Time ($I_C = 10\text{ mA}$, $I_{B1} = 3\text{ mA}$, $I_{B2} = -1.5\text{ mA}$) ($I_C = 100\text{ mA}$, $I_{B1} = 40\text{ mA}$, $I_{B2} = -20\text{ mA}$)	t_{off}		18 21	ns

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	12	Vdc
Collector-Base Voltage	V _{CBO}	12	Vdc
Emitter-Base Voltage	V _{EBO}	5	Vdc
Collector Current – Continuous	I _C	200	Amp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	.36	Watt mW/°C
Total Device Dissipation @ T _C = 25°C T _C = 100°C Derate above 25°C	P _D	1.2 0.686 6.86	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	146	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	486	°C/W

BSX29

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

Refer to 2N869A for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mA)(1)	V(BR)CEO	12		V
Collector-Emitter Breakdown Voltage (I _C = 10 μA)	V(BR)CES	12		V
Collector-Base Breakdown Voltage (I _C = 10 μA)	V(BR)CBO	12		V
Emitter-Base Breakdown Voltage (I _E = 100 μA)	V(BR)EBO	4		V
Collector Cutoff Current (V _{CE} = 6 V, V _{BE} = 0) (V _{CE} = 6 V, V _{BE} = 0, T _A = 85°C)	I _{CES}		80 5	nA μA

ON CHARACTERISTICS

Collector-Emitter Saturation Voltage (I _C = 10 mA, I _B = 1 mA) (I _C = 30 mA, I _B = 3 mA) (I _C = 100 mA, I _B = 10 mA)	V _{CE(sat)}		0.15 0.2 0.5	V
Emitter-Base Saturation Voltage (I _C = 10 mA, I _B = 1 mA) (I _C = 30 mA, I _B = 3 mA) (I _C = 100 mA, I _B = 10 mA)	V _{BE(sat)}	0.78 0.85	0.98 1.2 1.7	V
DC Current Gain (I _C = 10 mA, V _{CE} = 0.3 V)(1) (I _C = 30 mA, V _{CE} = 0.5 V)(1) (I _C = 100 mA, V _{CE} = 1 V)(1)	h _{FE}	25 30 20	120	
Collector-Emitter Saturation Voltage (I _C = 30 mA, I _B = 3 mA, T _A = 85°C)	V _{CE(sat)}		0.4	V

SMALL SIGNAL CHARACTERISTICS

Small Signal Current Gain (I _C = 30 mA, V _{CE} = 10 V, f = 100 MHz)	h _{fe}	4		
Output Capacitance (V _{CB} = 5 V)	C _{ob}		6	pF
Input Capacitance (V _{EB} = 0.5 V)	C _{ib}		6	pF
Turn On Time (I _C = 30 mA, I _{B1} = 1.5 mA)	t _{on}		60	ns
Turn Off Time (I _C = 30 mA, I _{B1} = I _{B2} = 1.5 mA)	t _{off}		90	ns

* Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

BSX32

CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	6	Vdc
Collector Current - Continuous	I_C	1	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8 4.6	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.5 2.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

Refer to 2N3725 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10\text{ mA}, I_B = 0$)(1)	$V_{(BR)CEO}$	40		V
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}, I_E = 0$)	$V_{(BR)CBO}$	65		V
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}, I_C = 0$)	$V_{(BR)EBO}$	6		V
Collector Cutoff Current ($V_{CB} = 50\text{ V}, I_E = 0$)	I_{CBO}		4	μA

ON CHARACTERISTICS

DC Current Gain ($V_{CE} = 1\text{ V}, I_C = 10\text{ mA}$)(1) ($V_{CE} = 1\text{ V}, I_C = 100\text{ mA}$)(1) ($V_{CE} = 1\text{ V}, I_C = 500\text{ mA}$)(1) ($V_{CE} = 5\text{ V}, I_C = 1\text{ A}$)(1) ($V_{CE} = 1\text{ V}, I_C = 100\text{ mA}, T_A = -55^\circ\text{C}$)(1) ($V_{CE} = 1\text{ V}, I_C = 500\text{ mA}$)(1)	h_{FE}	30 60 25 20 30 15	150	
Collector-Emitter Saturation Voltage ($I_C = 100\text{ mA}, I_B = 10\text{ mA}$)(1) ($I_C = 500\text{ mA}, I_B = 50\text{ mA}$)(1) ($I_C = 1\text{ A}, I_B = 100\text{ mA}$)(1)	$V_{CE(sat)}$		0.25 0.5 0.85	V
Base-Emitter Saturation Voltage ($I_C = 100\text{ mA}, I_B = 10\text{ mA}$)(1) ($I_C = 500\text{ mA}, I_B = 50\text{ mA}$)(1) ($I_C = 1\text{ A}, I_B = 100\text{ mA}$)(1)	$V_{BE(sat)}$		0.9 1.5 2	V

SMALL SIGNAL CHARACTERISTICS

Small Signal Current Gain ($I_C = 50\text{ mA}, V_{CE} = 10\text{ V}, f = 100\text{ MHz}$)	h_{fe}	3		
Output Capacitance ($V_{CB} = 10\text{ V}$)	C_{ob}		10	pF
Input Capacitance ($V_{EB} = 0.5\text{ V}$)	C_{ib}		60	pF
Turn On Time ($I_C = 500\text{ mA}, I_{B1} = 50\text{ mA}$)	t_{on}		60	ns
Turn Off Time ($I_C = 500\text{ mA}, I_{B1} = I_{B2} = 50\text{ mA}$)	t_{off}		60	ns

* Pulsed: Pulse Duration = 300 μs , Duty Cycle = 1%.

MAXIMUM RATINGS

Rating	Symbol	BSX 45	BSX 46	BSX 47	Unit
Collector-Emitter Voltage	V _{CEO}	40	60	80	V _{dc}
Collector-Emitter Voltage	V _{CES}	80	100	120	V _{dc}
Emitter-Base Voltage	V _{EBO}	7			V _{dc}
Collector Current - Continuous	I _C	1			A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1	5.71		Watt mW/°C
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	5	28.6		Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

**BSX45
BSX46
BSX47**

**CASE 79, STYLE 1
TO-39 (TO-205AD)**

AMPLIFIER TRANSISTOR

NPN SILICON

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Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 30 mAdc, I _B = 0)	BSX45 BSX46 BSX47	V _{(BR)CEO}	40 60 80	V _{dc}
Collector-Emitter Breakdown Voltage (I _C = 100 μAdc, V _{BE} = 0)	BSX45 BSX46 BSX47	V _{(BR)CES}	80 100 120	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)		V _{(BR)EBO}	7	V _{dc}
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)		I _{EBO}		10 nAdc
Collector Cutoff Current (V _{CE} = 60 V, V _{BE} = 0) (V _{CE} = 80 V, V _{BE} = 0) (V _{CE} = 60 V, V _{BE} = 0, T _C = 150°C) (V _{CE} = 80 V, V _{BE} = 0, T _C = 150°C)	BSX45,46 BSX47 BSX45,46 BSX47	I _{CES}		10 10 10 10 μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc)	Gr. 6 Gr. 10 Gr. 16	h _{FE}	10 15 25	
(I _C = 100 mAdc, V _{CE} = 1.0 Vdc) (1)	Gr. 6 Gr. 10 Gr. 16		40 63 100	100 160 250
(I _C = 500 mAdc, V _{CE} = 1.0 Vdc) (1)	Gr. 6 Gr. 10 Gr. 16		15 25 35	
Base-Emitter On Voltage (I _C = 100 mAdc, V _{CE} = 1.0 Vdc) (I _C = 500 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1 A, V _{CE} = 1.0 Vdc)		V _{BE(on)}	0.75	1 1.5 2 V _{dc}
Collector-Emitter Saturation Voltage (I _C = 1 Adc, I _B = 100 mAdc)		V _{EC(sat)}		1 V _{dc}

SMALL SIGNAL CHARACTERISTICS

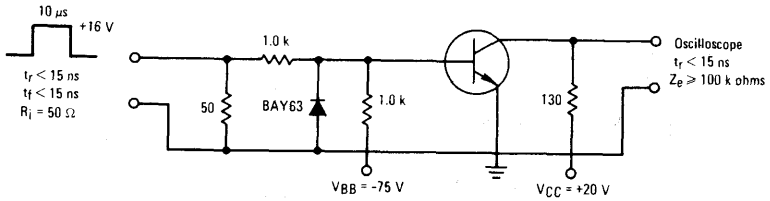
Transition Frequency (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	50		MHz
Emitter-Base Capacitance (V _{BE} = 0.5 V, f = 1 MHz)	C _{ib}		80	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Capacitance ($V_{CB} = 10\text{ V}$, $f = 1\text{ MHz}$)	BSX45	C_{ob}		25	pF
	BSX46			20	
	BSX47			15	
Turn On Time	See Figure 1 ($I_C = 100\text{ mA dc}$)	t_{on}		200	ns
Turn Off Time				$I_{B1} = -I_{B2} = 5\text{ mA dc}$	

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



BSX59 BSX60

CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	BSX 59	BSX 60	Unit
Collector-Emitter Voltage	V_{CE0}	45	30	Vdc
Collector-Emitter Voltage	V_{CES}	60	60	Vdc
Collector-Base Voltage	V_{CBO}	70	70	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current - Continuous	I_C	1		Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8	4.57	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.5	20	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

Refer to 2N3725 for graphs.

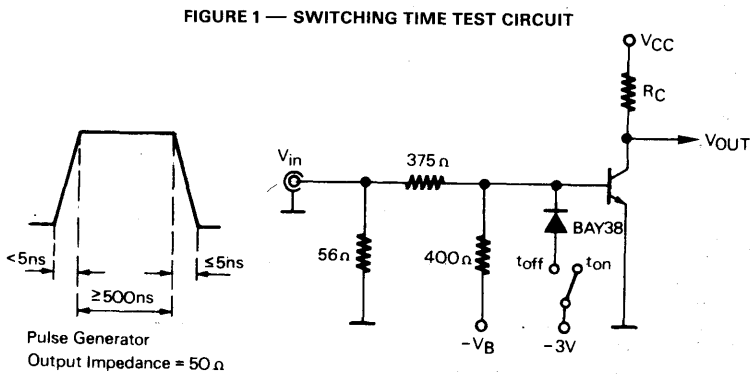
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$ [BSX59] [BSX60]	45 30		V
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}, I_E = 0$)	$V_{(BR)CBO}$	70		V
Collector Cutoff Current ($V_{CB} = 40 \text{ V}, I_E = 0$) ($V_{CB} = 40 \text{ V}, I_E = 0, T_J = 150^\circ\text{C}$)	I_{CBO}		500 300	nA μA
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ V}, I_C = 0$) ($V_{EB} = 4.0 \text{ V}, I_E = 0, T_J = 150^\circ\text{C}$)	I_{EBO}		300 50	nA μA
Collector Cutoff Current ($V_{CE} = 40 \text{ V}, -V_{BE} = 4.0 \text{ V}$) ($V_{CE} = 40 \text{ V}, -V_{BE} = 4.0 \text{ V}, T_J = 150^\circ\text{C}$)	I_{CEX}		500 300	nA μA
Emitter Cutoff Current ($V_{CE} = 40 \text{ V}, -V_{BE} = 4.0 \text{ V}$) ($V_{CE} = 40 \text{ V}, -V_{BE} = 4.0 \text{ V}, T_J = 150^\circ\text{C}$)	I_{BEX}		500 300	nA μA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mA}, I_B = 15 \text{ mA}$) ($I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$) ($I_C = 1.0 \text{ A}, I_B = 100 \text{ mA}$)	$V_{CE(sat)}$		0.3 0.5 1.0	V
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mA}, I_B = 15 \text{ mA}$) ($I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$) ($I_C = 1.0 \text{ A}, I_B = 100 \text{ mA}$)	$V_{BE(sat)}$ [BSX59] [BSX60]		1.0 1.2 1.3 1.8	V
DC Current Gain ($I_C = 150 \text{ mA}, V_{CE} = 1.0 \text{ V}$) ($I_C = 500 \text{ mA}, V_{CE} = 1.0 \text{ V}$) ($I_C = 1.0 \text{ A}, V_{CE} = 5.0 \text{ V}$)	h_{FE} [BSX59] [BSX60] [BSX59] [BSX60]	30 25 30	90	
SMALL SIGNAL CHARACTERISTICS				
Small Signal Current Gain ($I_C = 50 \text{ mA}, V_{CE} = 10 \text{ V}, f = 100 \text{ MHz}$)	$ h_{fe} $	2.5		
Input Capacitance ($-V_{BE} = 0.5 \text{ V}, I_C = 0, f = 1.0 \text{ MHz}$)	C_{ib}		60	pF

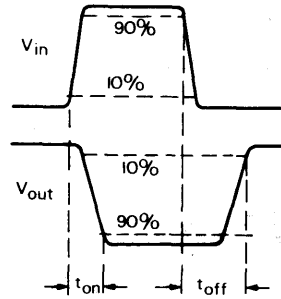
BSX59, BSX60

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 10\text{ V}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}		10	pF
Turn On Time (See Figure 1) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$, $-V_{BE} = 2.0\text{ V}$) ($V_{CC} = 50\text{ V}$) [BSX59] ($V_{CC} = 30\text{ V}$) [BSX60]	t_{on}		35 40	ns
Turn Off Time (See Figure 1) ($I_C = 500\text{ mA}$, $I_{B1} = I_{B2} = 50\text{ mA}$) ($V_{CC} = 50\text{ V}$) [BSX59] ($V_{CC} = 30\text{ V}$) [BSX60]	T_{off}		60 70	ns



Measurement	V_{CC}	BSX59 BSX61		V
		50	30	
t_{on}	R_C	100	60	Ω
	$-V_B$		4.0	V
	V_{in}		24.75	V
t_{off}	$-V_B$		16.7	V
	V_{in}		37.5	V



CV8616

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	V _{dc}
Collector-Base Voltage	V _{CBO}	20	V _{dc}
Emitter-Base Voltage	V _{EBO}	5	V _{dc}
Collector Current - Continuous	I _C	100	mAmp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.3 2.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +175	°C

THERMAL CHARACTERISTICS

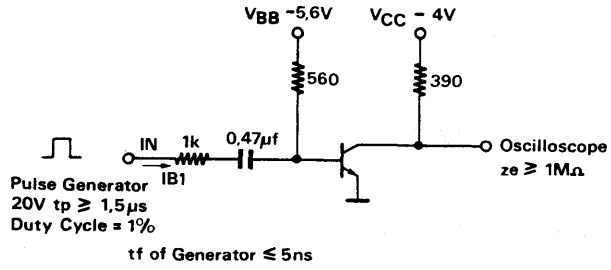
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I _C = 10 mA, I _B = 0)	V _{CEO(sus)}	20		V
Collector Cutoff Current (V _{CE} = 20 V, I _E = 0) (V _{CE} = 20 V, I _E = 0, T _A = 100°C)	I _{CBO}		50 20	nA μA
Emitter Cutoff Current (V _{EB} = 5.0 V, I _C = 0) (V _{EB} = 1.5 V, I _C = 0) (V _{EB} = 1.5 V, I _C = 0, T _A = 100°C)	I _{EBO}		10 25 20	μA nA μA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage(1) (I _C = 30 mA, I _B = 1.5 mA)	V _{CE(sat)}		0.4	V
Base-Emitter Saturation Voltage(1) (I _C = 10 mA, I _B = 1 mA) (I _C = 50 mA, I _B = 2.5 mA)	V _{BE(sat)}		0.9 1.6	V
DC Current Gain(1) (I _C = 1 mA, V _{CE} = 0.4 V) (I _C = 10 mA, V _{CE} = 0.4 V) (I _C = 30 mA, V _{CE} = 0.4 V) (I _C = 50 mA, V _{CE} = 0.75 V)	h _{FE}	30 35 20 20		
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I _C = 10 mA, V _{CE} = 12 V, f = 20 MHz)	f _T	50		MHz
Output Capacitance (V _{CB} = 10 V, f = 1 MHz)	C _{obo}		10	pF
Input Capacitance (V _{EB} = 0.5 V, f = 1 MHz)	C _{ibo}	6	25	pF
Storage Time (See Figure 1) (V _{CC} = 10 V, I _C = 10 mA) (I _{B1} = I _{B2} = 10 mA)	t _s		50	ns

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



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CV9507

(CECC 50004-050)
CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	65	V _{dc}
Collector-Base Voltage	V _{CBO}	65	V _{dc}
Emitter-Base Voltage	V _{EBO}	5	V _{dc}
Collector Current - Continuous	I _C	0.6	A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	PD	0.5 3.33	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W

Refer to 2N2904 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (I _C = 10 mA, I _B = 0)	V _{CEO(sus)}	65		V _{dc}
Collector Cutoff Current (V _{CB} = 50 V, I _E = 0) (V _{CB} = 50 V, I _E = 0, T _A = 100°C)	I _{CBO}		75 1	nA μA
Emitter Cutoff Current (V _{EB} = 3 V, I _C = 0) (V _{EB} = 5 V, I _C = 0)	I _{EBO}		100 10	nA μA

ON CHARACTERISTICS

Collector-Emitter Saturation Voltage(1) (I _C = 150 mA, I _B = 15 mA)	V _{CE(sat)}		0.4	V _{dc}
Base-Emitter Saturation Voltage(1) (I _C = 150 mA, I _B = 15 mA) (I _C = 30 mA, I _B = 1 mA)	V _{BE(sat)}		1.3 0.9	V _{dc}
DC Current Gain (I _C = 1 mA, V _{CE} = 0.4 V) (I _C = 10 mA, V _{CE} = 0.4 V) (I _C = 50 mA, V _{CE} = 0.4 V) (I _C = 150 mA, V _{CE} = 0.4 V)	h _{FE}	40 50 20 10	200	

SMALL SIGNAL CHARACTERISTICS

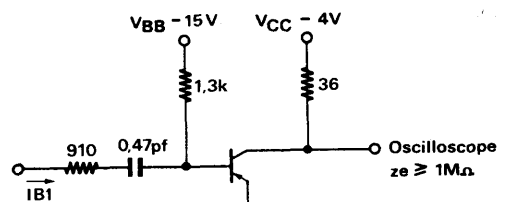
Current Gain Bandwidth Product (I _C = 50 mA, V _{CE} = 10 V, f = 20 MHz)	f _T	50		MHz
Output Capacitance (V _{CB} = 10 V, f = 1 MHz)	C _{obo}		12	pF

SWITCHING CHARACTERISTICS

Storage Time (See Figure 1) (V _{CC} = -4 V, I _C = -100 mA) (I _{B1} = I _{B2} = 10 mA)	t _s		250	ns
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(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

FIGURE 1 - SWITCHING TIME TEST CIRCUIT



CV9543

(CECC 50004-067)
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N3251 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	V _{dc}
Collector-Base Voltage	V _{CBO}	25	V _{dc}
Emitter-Base Voltage	V _{EBO}	5	V _{dc}
Collector Current - Continuous	I _C	100	mAmp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.3 2.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) (I _C = 10 mA, I _B = 0)	V _{CEO(sus)}	20			V
Collector Cutoff Current (V _{CB} = 20 V, I _B = 0) (V _{CB} = 25 V, I _B = 0)	I _{CBO}			50 10	nA μA
Collector Cutoff Current (V _{CE} = 13 V, I _B = 0, T _A = 100°C)	I _{CEO}			45	μA
Emitter Cutoff Current (V _{CB} = 1.5 V, I _C = 0) (V _{CB} = 5 V, I _C = 0) (V _{CB} = 1.5 V, I _C = 0, T _A = 100°C)	I _{EBO}			25 10 15	nA μA μA

ON CHARACTERISTICS

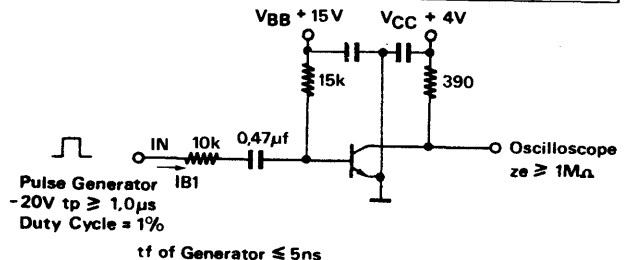
Collector-Emitter Saturation Voltage(1) (I _C = 30 mA, I _B = 1.5 mA)	V _{CE(sat)}			0.4	V
Base-Emitter Saturation Voltage(1) (I _C = 10 mA, I _B = 1.0 mA) (I _C = 50 mA, I _B = 2.5 mA)	V _{BE(sat)}			0.9 1.6	V
DC Current Gain (I _C = 1 mA, V _{CE} = 0.4 V) (I _C = 10 mA, V _{CE} = 0.4 V) (I _C = 30 mA, V _{CE} = 0.4 V) (I _C = 50 mA, V _{CE} = 0.75 V)	h _{FE}	30 35 20 20			

DYNAMIC CHARACTERISTICS

Current Gain Bandwidth Product (I _C = 10 mA, V _{CE} = 12 V, f = 20 MHz)	f _T	100			MHz
Output Capacitance (V _{CB} = 10 V, f = 1 MHz)	C _{ob}			10	pF
Storage Time (See Figure 1) (I _C = 10 mA, I _{B1} = I _{B2} = 1 mA)	t _s			200	ns

(1) Pulsed - Pulse Duration = 300 μs, Duty Cycle = 1%.

FIGURE 1 - SWITCHING TIME TEST CIRCUIT



CV9790

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	60	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	5	Vdc
Collector Current - Continuous	I _C	0.6	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	PD	0.5 3.43	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +175	°C

Refer to 2N2904 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _B = 0)(1)	V(BR)CEO	60		V
Collector Cutoff Current (V _{CB} = 50 V, I _E = 0) (V _{CB} = 50 V, I _E = 0, T _A = 100°C)	I _{CBO}		75 1	nA μA
Emitter-Base Cutoff Current (V _{EB} = 3 V, I _C = 0) (V _{EB} = 5 V, I _C = 0)	I _{EBO}		100 10	nA μA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I _C = 150 mA, I _B = 15 mA)(1)	V _{CE(sat)}		0.4	V
Emitter-Base Saturation Voltage (I _C = 30 mA, I _B = 1 mA)(1) (I _C = 150 mA, I _B = 15 mA)(1)	V _{BE(sat)}		0.9 1.3	V
DC Current Gain (V _{CE} = 10 V, I _C = 10 mA)(1) I _C = 150 mA)(1) I _C = 1 mA) I _C = 50 mA)	h _{FE}	50 40 40 50	200	
SMALL SIGNAL CHARACTERISTICS				
Transition Frequency (V _{CE} = 20 V, I _C = 50 mA, f = 100 MHz)	f _T	100		MHz
Output Capacitance (V _{CB} = 10 V, I _E = 0, f = 1 MHz)	C _{ob}		12	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

CV10253 CV12253

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	65	V _{dc}
Collector-Base Voltage	V _{CBO}	65	V _{dc}
Emitter-Base Voltage	V _{EBO}	5	V _{dc}
Collector Current - Continuous	I _C	0.6	A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.6 4.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	250	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (I _C = 10 mA, I _B = 0)	V _{CEO(sus)}	65		V
Collector Cutoff Current (V _{CB} = 50 V, I _E = 0)	I _{CBO}		20	nA
Emitter Cutoff Current (I _{EBO} (1) V _{EB} = 3 V, I _C = 0) (I _{EBO} (2) V _{EB} = 5 V, I _C = 0)	I _{EBO}		20 2	nA μA
Collector Cutoff Current (V _{CE} = 50 V, T _A = 100°C)	I _{CEO}		80	μA

ON CHARACTERISTICS

DC Current Gain (h _{21e} (1) I _C = 1.0 mA, V _{CE} = 0.4 V) (h _{21e} (2) I _C = 10 mA, V _{CE} = 0.4 V) (h _{21e} (3) I _C = 150 mA, V _{CE} = 0.75 V)(1) (h _{21e} (4) I _C = 50 mA, V _{CE} = 0.4 V)	h _{FE}	40 50 25 35	— 200 — —	
Base-Emitter Saturation Voltage(1) (I _C = 30 mA, I _B = 1 mA) (I _C = 150 mA, I _B = 15 mA)	V _{BE(sat)}		0.9 1.3	V

SMALL SIGNAL CHARACTERISTICS

Current Gain Bandwidth Product (I _C = 50 mA, V _{CE} = 10 V, f = 35 MHz)	f _T	60		MHz
Storage Time (V _{CC} = 45 V, I _C = 100 mA, I _{B1} = I _{B2} = 10 mA)	CV10253 CV12253	t _s	172	250
				550
Output Capacitance (V _{CB} = 10 V, f = 1 MHz)	C _{ob}		20	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

CV10440

(CECC 50004-087)
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	45	V _{dc}
Collector-Base Voltage	V _{CBO}	45	V _{dc}
Emitter-Base Voltage	V _{EBO}	5	V _{dc}
Collector Current - Continuous	I _C	250	mAmp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	PD	0.3 2.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +175	°C

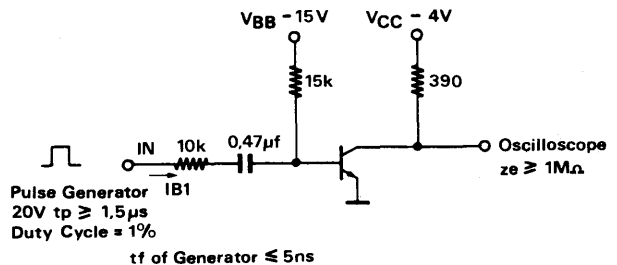
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I _C = 10 mA, I _B = 0)	V _{CEO(sus)}	45		V _{dc}
Collector Cutoff Current (Emitter Open) (V _{CB} = 30 V, I _B = 0) (V _{CB} = 30 V, I _B = 0, T _A = 100°C)	I _{CBO}		100 15	nA μA
Emitter Cutoff Current (V _{EB} = 5 V, I _C = 0)	I _{EBO}		500	nA
ON CHARACTERISTICS				
Base-Emitter Saturation Voltage (I _C = 10 mA, I _B = 1 mA) (I _C = 50 mA, I _B = 2.5 mA)	V _{BE(sat)}		0.9 1.6	V _{dc} V _{dc}
DC Current Gain (I _C = 10 μA, V _{CE} = 0.4 V) (I _C = 1 mA, V _{CE} = 0.4 V) (I _C = 10 mA, V _{CE} = 0.4 V)	h _{fe}	40 175 225	500 550	
Collector-Emitter Saturation Voltage (I _C = 10 mA, I _B = 1 mA)	V _{CE(sat)}		0.3	V _{dc}
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I _C = 10 mA, V _{CE} = 5 V, f = 35 MHz)	f _T	200		MHz
Output Capacitance (V _{CB} = 5 V, I _E = 0, f = 1 MHz)	C _{ob}		8	pF
SWITCHING CHARACTERISTICS				
Storage Time (See Figure 1) (V _{CC} = 4 V, V _{BB} = 15 V, I _C = 10 mA, I _{B1} = I _{B2} = 1 mA)	t _s		750	ns

FIGURE 1 - SWITCHING TIME TEST CIRCUIT



CV10814

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	V _{dc}
Collector-Base Voltage	V _{CB0}	40	V _{dc}
Emitter-Base Voltage	V _{EB0}	5	V _{dc}
Collector Current - Continuous	I _C	100	mAmp
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	300 2.0	mWatt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	200	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I _C = 2 mA, I _B = 0)	V _{CEO(sus)}	40		V
Collector Cutoff Current (Emitter Open) (V _{CB} = 30 V, I _E = 0) (V _{CB} = 30 V, I _E = 0, T _A = 100°C)	I _{CBO}		100 4	nA μA
Emitter Cutoff Current (Collector Open) (V _{EB} = 5 V, I _C = 0)	I _{EBO}		500	nA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I _C = 10 mA, I _B = 1 mA)	V _{CE(sat)}		0.3	V
DC Current Gain (I _C = 10 μA, V _{CE} = 5 V) (I _C = 2 mA, V _{CE} = 5 V)	h _{FE}	40 125	400	
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I _C = 10 mA, V _{CE} = 5 V, f = 100 MHz)	f _T	200		MHz
Small Signal Current Gain (I _C = 1 mA, V _{CE} = 10 V, f = 1 kHz)	h _{fe}	100	400	
Noise Figure (R _g = 2 KΩ, V _{CE} = 5 V, I _E = 200 μA, f = 30 Hz to 15 kHz)	NF		2	dB
Output Capacitance (V _{CB} = 5 V, f = 1 MHz)	C _{obo}		8	pF

MM420 MM421

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	MM420	MM421	Unit
Collector-Emitter Voltage	V_{CEO}	250	325	Vdc
Collector-Base Voltage	V_{CBO}	275	350	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Base Current	I_B	100	100	mA
Collector Current — Continuous	I_C	100	500	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	800 5.3		mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_A = 75^\circ\text{C}$ Derate above 75°C	P_D	2.5 25		Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 65 to + 175		$^\circ\text{C}$

Refer to 2N3439 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 10\text{ mA}, I_B = 0$)	$V_{CEO(sus)}$	250 325	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$)	$V_{(BR)CBO}$	275 350	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}$)	$V_{(BR)EBO}$	6	—	Vdc
Collector Cutoff Current ($V_{CE} = 250\text{ Vdc}, I_B = 0$) ($V_{CE} = 325\text{ Vdc}, I_B = 0$)	I_{CEO}	— —	1.0 1.0	mAdc
Collector Cutoff Current ($V_{BE} = 275\text{ Vdc}, I_E = 0$) ($V_{BE} = 350\text{ Vdc}, I_E = 0$)	I_{CBO}	— —	100 100	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0\text{ mAdc}, V_{CE} = 20\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 20\text{ Vdc}$) ($I_C = 30\text{ mAdc}, V_{CE} = 20\text{ Vdc}$)	h_{FE}	15 25 25	— — 250	—
Collector-Emitter Saturation Voltage ($I_C = 30\text{ mAdc}, I_B = 3.0\text{ mAdc}$)	$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter On Voltage ($I_C = 30\text{ mA}, V_{CE} = 20\text{ V}$)	$V_{BE(on)}$	—	1.0	V
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10\text{ mA}, V_{CE} = 20\text{ V}, f = 10\text{ MHz}$)	f_T	15	—	MHz
Output Capacitance ($V_{CB} = 20\text{ V}, f = 100\text{ kHz}$) (Common Base)	C_{obo}	—	12	pF

(1) $PW \leq 300\ \mu\text{sec}$, Duty Cycle $\leq 2.0\%$.

MM3000 thru MM3003

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MM3000	MM3001	MM3002	MM3003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0				Vdc
Collector Current — Continuous	I_C	200	200	50	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71				Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6				Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_E = 0$)	$V_{(BR)CEO}$	100 100 150 200 250	— — — — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$) ($V_{CB} = 75 \text{ Vdc}, I_E = 0$) ($V_{CB} = 100 \text{ Vdc}, I_E = 0$)	I_{CBO}	— — —	1.0 1.0 5.0	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	150	—	MHz
Output Capacitance ($V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	— —	7.0 15	pF

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	MM3005	MM3006	MM3007	Unit
Collector-Emitter Voltage	V _{CEO}	60	80	100	Vdc
Collector-Base Voltage	V _{CBO}	80	100	120	Vdc
Emitter-Base Voltage	V _{EBO}	5.0			Vdc
Collector Current — Continuous	I _C	2.5			Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 5.71			Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	8.0 45.6			Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

**MM3005
MM3006
MM3007**

**CASE 79-02, STYLE 1
TO-39 (TO-205AD)**

AUDIO TRANSISTOR

NPN SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	60 80 100	— — —	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	80 100 120	— — —	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 80 Vdc, I _E = 0) (V _{CB} = 100 Vdc, I _E = 0)	I _{CBO}	— — —	100 100 100	nAdc
Emitter Cutoff Current (V _{BE} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc) (I _C = 150 mAdc, V _{CE} = 1.0 Vdc) (I _C = 200 mAdc, V _{CE} = 1.0 Vdc) (I _C = 250 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	40 50 50 50	— 250 250 250	—
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{CE(sat)}	—	0.35	Vdc
Base-Emitter On Voltage (I _C = 150 mAdc, V _{CE} = 1.0 Vdc)	V _{BE(on)}	0.60	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	50	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	15	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3008 MM3009

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MM3008	MM3009	Unit
Collector-Emitter Voltage	V_{CEO}	120	180	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	400		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	5.71	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	4.0	22.8	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MM3008 MM3009	$V_{(BR)CEO}$	120 180	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 180$ Vdc, $I_E = 0$)	MM3008 MM3009	I_{CBO}	— —	0.1 0.1	μ Adc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}		0.1	μ Adc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	30 40 30	— — —	—
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SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, $f = 20$ MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, $f = 1.0$ MHz)		C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 1.0$ MHz)		C_{ibo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V _{CB0}	50	Vdc
Emitter-Base Voltage	V _{EB0}	5.0	Vdc
Collector Current — Continuous	I _C	1.5	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

MM3726

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

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THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	175	°C/W

Refer to 2N3467 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	50	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0)	I _{CBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I _C = 500 mAdc, V _{CE} = 2.0 Vdc) (I _C = 1.0 Adc, V _{CE} = 5.0 Vdc)	h _{FE}	30 15	120 —	—
Collector-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc) (I _C = 1.0 Adc, I _B = 100 mAdc)	V _{CE(sat)}	—	0.6 1.2	Vdc
Base-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc) (I _C = 1.0 Adc, I _B = 100 mAdc)	V _{BE(sat)}	0.8	1.1 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	200	—	MHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz, emitter guarded)	C _{cb}	—	10	pF
Emitter-Base Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz, collector guarded)	C _{eb}	—	80	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V _{CC} = 30 Vdc, V _{BE(off)} = 2.0 Vdc, I _C = 500 mAdc, I _{B1} = 50 mAdc, R _B = 200 ohms, R _L = 60 ohms)	t _{on}	—	30	ns
Turn-Off Time (V _{CC} = 30 Vdc, I _C = 500 mAdc, I _{B1} = I _{B2} = 50 mAdc, R _B = 200 ohms, R _L = 60 ohms)	t _{off}	—	90	ns
Turn-On Time (V _{CC} = 30 Vdc, V _{BE} = 2.0 Vdc, I _C = 1.0 Adc, I _{B1} = 100 mAdc, R _B = 100 ohms, R _L = 30 ohms)	t _{on}	—	35	ns
Turn-Off Time (V _{CC} = 30 Vdc, I _C = 1.0 Adc, I _{B1} = I _{B2} = 100 mAdc, R _B = 100 ohms, R _L = 30 ohms)	t _{off}	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM4000 thru MM4003

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3494 for graphs for MM4000.*

MAXIMUM RATINGS

Rating	Symbol	MM4000	MM4001	MM4002	MM4003	Unit
Collector-Emitter Voltage	V_{CE0}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 3.42	1.0 5.71	1.0 5.71	1.0 5.71	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.2	5.0 28.6	5.0 28.6	5.0 28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	100 150 200 250	—	Vdc
Collector-Base Breakdown Voltage ($I_E = 0, I_C = 100 \mu\text{Adc}$)	$V_{(BR)CBO}$	100 150 200 250	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$) ($V_{CB} = 75 \text{ Vdc}, I_E = 0$) ($V_{CB} = 150 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	1.0 1.0 5.0	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.6 5.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	6.0 10 20	pF

(1) Pulse Test: $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

*Refer to 2N3634 for graphs for MM4001.

Refer to 2N3743 for graphs for MM4002 and MM4003.

MAXIMUM RATINGS

Rating	Symbol	MM4005	MM4006	MM4007	Unit
Collector-Emitter Voltage	V _{CEO}	60	80	100	Vdc
Collector-Base Voltage	V _{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V _{EBO}	5.0			Vdc
Collector Current — Continuous	I _C	1.0			A dc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 5.71			Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	7.0 40			Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	25	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	175	°C/W

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

MM4005 thru MM4007

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

4

Refer to 2N4405 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mA dc, I _E = 0)	V _{(BR)CEO}	60 80 100	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA dc, I _E = 0)	V _{(BR)CBO}	60 80 100	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μA dc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 80 Vdc, I _E = 0)	I _{CBO}	— — —	— — —	100 100 100	nA dc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	100	nA dc
ON CHARACTERISTICS(2)					
DC Current Gain (I _C = 1.0 mA dc, V _{CE} = 1.0 Vdc) (I _C = 150 mA dc, V _{CE} = 1.0 Vdc)	h _{FE}	40 50	90 150	— —	—
Collector-Emitter Saturation Voltage (I _C = 150 mA dc, I _B = 15 mA dc)	V _{CE(sat)}	—	0.1	—	Vdc
Base-Emitter Saturation Voltage (I _C = 150 mA dc, I _B = 15 mA dc)	V _{BE(sat)}	—	0.7	—	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I _C = 50 mA dc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	50	250	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	10	—	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	100	—	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM4036 MM4037

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	65	Vdc
		40	
Collector-Base Voltage	V _{CBO}	90	Vdc
		60	
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Base Current	I _B	500	mAcd
Collector Current — Continuous	I _C	1.0	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0	Watt
		5.71	mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	7.0	Watts
		40	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	25	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	175	°C/W

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAcd, I _B = 0)	MM4036 MM4037	V _{(BR)CEO}	65 40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0) (I _C = 10 μAdc, I _E = 0)	MM4036 MM4037	V _{(BR)CBO}	90 60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0) (I _E = 1.0 μAdc, I _C = 0)	MM4036 MM4037	V _{(BR)EBO}	5.0 5.0	—	—	Vdc
Collector Cutoff Current(1) (V _{CE} = 60 Vdc, V _{BE(off)} = 1.5 Vdc) (V _{CE} = 30 Vdc, V _{BE(off)} = 1.5 Vdc, T _C = 150°C)	MM4036 MM4036	I _{CEV}	— —	—	250 100	nAdc μAdc
Collector Cutoff Current (V _{CB} = 60 Vdc, I _E = 0)	MM4036, MM4037	I _{CBO}	—	—	250	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0) (V _{BE} = 5.0 Vdc, I _C = 0)	MM4036 MM4037	I _{EBO}	— —	—	250 1.0	μAdc

ON CHARACTERISTICS(2)

DC Current Gain (I _C = 100 μAdc, V _{CE} = 10 Vdc) (I _C = 150 mAcd, V _{CE} = 2.0 Vdc) (I _C = 150 mAcd, V _{CE} = 10 Vdc) (I _C = 500 mAcd, V _{CE} = 10 Vdc) (I _C = 1.0 mAcd, V _{CE} = 10 Vdc) (I _C = 150 mAcd, V _{CE} = 10 Vdc)	MM4036 MM4036 MM4036 MM4036 MM4037 MM4037	h _{FE}	20 20 40 20 15 50	50 60 90 40 50 75	— 200 140 — — 250	—
Collector-Emitter Saturation Voltage (I _C = 150 mAcd, I _B = 15 mAcd)	MM4036 MM4037	V _{CE(sat)}	—	0.3 0.3	0.65 1.4	Vdc
Base-Emitter Saturation Voltage (I _C = 150 mAcd, I _B = 15 mAcd)		V _{BE(sat)}	—	1.0	1.4	Vdc

MM4036, MM4037

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	60	100	—	MHz
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ibo}	—	60	—	pF
Collector-Base Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{cb}	—	20	—	pF
		—	20	30	

SWITCHING CHARACTERISTICS

Turn-On Time	($V_{CC} = 30\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = 15\text{ mAdc}$)	t_{on}	—	40	75	ns
Turn-Off Time	($V_{CC} = 6.0\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = I_{B2} = 15\text{ mAdc}$)	t_{off}	—	110	175	ns

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

**MM5005
MM5006
MM5007**

**CASE 79-02, STYLE 1
TO-39 (TO-205AD)**

AUDIO TRANSISTOR

PNP SILICON

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MAXIMUM RATINGS

Rating	Symbol	MM5005	MM5006	MM5007	Unit
Collector-Emitter Voltage	V _{CEO}	60	80	100	Vdc
Collector-Base Voltage	V _{CBO}	80	100	120	Vdc
Emitter-Base Voltage	V _{EBO}	5.0			Vdc
Collector Current — Continuous	I _C	2.0			Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	PD	1.5 8.57			Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	PD	8.0 45.7			Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	MM5005 MM5006 MM5007 V _{(BR)CEO}	60 80 100	— — —	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	MM5005 MM5006 MM5007 V _{(BR)CBO}	80 100 120	— — —	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 80 Vdc, I _E = 0) (V _{CB} = 100 Vdc, I _E = 0)	MM5005 MM5006 MM5007 I _{CBO}	— — —	200 200 200	nAdc
Emitter Cutoff Current (V _{EB} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc) (I _C = 150 mAdc, V _{CE} = 2.5 Vdc) (I _C = 200 mAdc, V _{CE} = 2.5 Vdc) (I _C = 250 mAdc, V _{CE} = 2.5 Vdc)	All Types MM5005 MM5006 MM5007 h _{FE}	40 50 50 50	— 250 250 250	—
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{CE(sat)}	—	0.5	Vdc
Base-Emitter On Voltage (I _C = 150 mAdc, V _{CE} = 2.5 Vdc)	V _{BE(on)}	0.65	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	30	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	MM5415	MM5416	Unit
Collector-Emitter Voltage	V _{CEO}	200	300	Vdc
Collector-Base Voltage	V _{CBO}	200	350	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	7.0	Vdc
Base Current	I _B	0.5		Adc
Collector Current — Continuous	I _C	1.0		.Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0	6.7	Watt W/°C
Total Power Dissipation @ T _C = 50°C Linear Derating Factor	P _D	10	0.057	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	17.5	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	150	°C/W

MM5415 MM5416

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

TRANSISTOR

PNP SILICON

4

Refer to 2N5415 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (I _C = 10 mA, I _B = 0)	V _{CEO(sus)}	200 300	—	Vdc
Collector Cutoff Current (V _{CE} = 150 Vdc, I _B = 0)	I _{CEO}	—	50	μAdc
Collector Cutoff Current (V _{CE} = 175 Vdc, I _E = 0)	I _{CBO}	—	50	μAdc
Collector Cutoff Current (V _{CE} = 280 Vdc, I _E = 0)	I _{CBO}	—	50	μAdc
Emitter Cutoff Current (V _{BE} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	20	μAdc
Emitter Cutoff Current (V _{BE} = 7.0 Vdc, I _C = 0)	I _{EBO}	—	20	μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 50 mAdc, V _{CE} = 10 Vdc)	h _{FE}	30 30	150 120	—
Collector-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 5.0 mAdc)	V _{CE(sat)}	—	2.5	Vdc
Base-Emitter On Voltage (I _C = 50 mAdc, V _{CE} = 10 V)	V _{BE(on)}	—	1.5	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 5.0 MHz)	f _T	15	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, f = 1.0 MHz)	C _{obo}	—	25	pF
Current Gain — High Frequency (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	25	—	—
Real Part of Input Impedance (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 MHz)	Re(h _{ie})	—	300	Ohms

MM6427

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	300	mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	375 2.14	mW W/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.25 7.15	Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	140	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	467	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mA}_{dc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}_{dc}, I_E = 0$)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}_{dc}, I_C = 0$)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	100	nA _{dc}
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	100	nA _{dc}
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 10 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 100 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	5000 10,000	—	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mA}_{dc}, I_B = 0.1 \text{ mA}_{dc}$)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	15	pF
Small-Signal Current Gain(1) ($I_C = 10 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}, f = 100 \text{ MHz}$)	h_{fe}	1.25	—	—

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

P038

(CECC 50002-169)
CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	300	V _{dc}
Collector-Base Voltage	V _{CBO}	300	V _{dc}
Emitter-Base Voltage	V _{EBO}	5	V _{dc}
Collector Current - Continuous	I _C	0.5	A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	PD	0.8 4.57	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) (I _C = 10 mA, I _B = 0)	V _{CEO(sus)}	300		V
Collector Cutoff Current (V _{CB} = 300 V, I _E = 0) (V _{CB} = 240 V, I _E = 0) (V _{CB} = 240 V, I _E = 0)	I _{CBO}		50 10 100	μA μA nA
Collector Cutoff Current (V _{CE} = 240 V, I _B = 0)	I _{CEO}		500	nA
Emitter Cutoff Current (V _{EB} = 3 V, I _C = 0)	I _{EBO}		100	nA

ON CHARACTERISTICS

Collector-Emitter Saturation Voltage (I _C = 1 mA, I _B = 40 μA)	V _{CE(sat)}		0.5	V
Base-Emitter Saturation Voltage (I _C = 1 mA, I _B = 10 μA)	V _{BE(sat)}		0.8	V
Common Emitter Static Value of the Forward Current Transfer Ratio (h _{21E} (1) I _C = 20 μA, V _{CE} = 0.5 V) (h _{21E} (2) I _C = 200 μA, V _{CE} = 0.5 V)	h _{FE}	25 25	200 200	

SMALL SIGNAL CHARACTERISTICS

Transition Frequency (I _C = 15 mA, V _{CB} = 10 V)	f _T	35		MHz
Collector-Base Capacitance (V _{CB} = 5 V, f = 1 MHz)	C _{obo}		25	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

P039

(CECC 50002-170)
CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

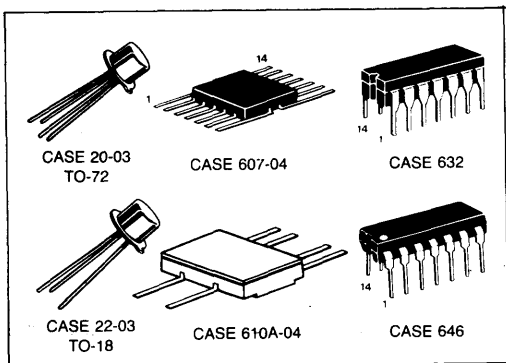
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	300	V _{dc}
Collector-Base Voltage	V _{CBO}	300	V _{dc}
Emitter-Base Voltage	V _{EBO}	5	V _{dc}
Collector Current - Continuous	I _C	0.5	A _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.6 4.0	Watt mW/°C
Total Device Dissipation T _A = 25°C Derate above 25°C	P _D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

Refer to 2N3439 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I _C = 10 mA, I _B = 0)	V _{CEO(sus)}	300		V
Collector-Emitter Cutoff Current (V _{CE} = 240 V)	I _{CEO}		10	μA
Collector-Base Cutoff Current (V _{CB} = 240 V) (V _{CB} = 240 V, T _{Amb} = 100°C)	I _{CBO}		500 5	nA μA
Emitter-Base Cutoff Current (V _{EB} = 3 V)	I _{EBO}		1	μA
ON CHARACTERISTICS				
Static Forward Current Transfer(1) (I _C = 100 mA, V _{CE} = 1 V) (I _C = 1.0 mA, V _{CE} = 1 V) (I _C = 25 mA, V _{CE} = 1 V)	h _{FE}	25 30 30	150 200	
Collector-Emitter Saturation Voltage(1) (I _C = 200 mA, I _B = 20 mA) (I _C = 25 mA, I _B = 1.25 mA)	V _{CE(sat)}		3.0 0.2	V
Base-Emitter Saturation Voltage(1) (I _C = 25 mA, I _B = 1.25 mA)	V _{BE(sat)}		0.9	V
SMALL SIGNAL CHARACTERISTICS				
Transition Frequency (I _C = 50 mA, V _{CB} = 10 V, f = 5 MHz)	f _T	10		MHz
Output Capacitance (V _{CB} = 10 V, f = 1 MHz)	C _{obo}		25	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.



Motorola's multiple (Duals and Quads) transistors have been implemented with discrete transistor chips that have proven to be the most popular for all-around performance at low cost.

Packaging options include plastic and ceramic DIP's, ceramic flat pak, and various metal-can outlines.

Multiple Transistors

5

2N998

CASE 20-03, STYLE 8
TO72 (TO206AF)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	60	V _{dc}
Collector-Base Voltage	V _{CBO}	100	V _{dc}
Emitter-Base Voltage	V _{EBO}	15	V _{dc}
Collector Current - Continuous	I _C	500	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	500 2.86	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

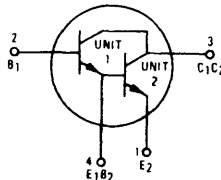
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) I _C = 30 mAdc, I _B = 0	V _{CEO(sus)}	60		V _{dc}
Collector-Base Breakdown Voltage I _C = 100 μAdc, I _E = 0	V(BR)CBO	100		V _{dc}
Emitter-Base Breakdown Voltage I _E = 100 μAdc, I _C = 0	V(BR)EBO	15		V _{dc}
Collector Cutoff Current V _{CB} = 90 V, I _E = 0	I _{CBO}		0.01 15	μAdc
Emitter Cutoff Current V _{BE} = 10 V, I _C = 0	I _{EBO}		0.01	μAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 1 mAdc, V _{CE} = 5 Vdc) (I _C = 10 mAdc, V _{CE} = 5 Vdc) (I _C = 100 mAdc, V _{CE} = 5 Vdc) (I _C = 10 mAdc, V _{CE} = 5 Vdc) (2)	h _{FE}	800 1600 2000 25	8000	

SMALL-SIGNAL CHARACTERISTICS

Small-Signal Current Gain (I _C = 1 mAdc, V _{CE} = 5 Vdc, f = 1 kHz)	h _{fe}	1000		—
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}		30	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}		50	pF
Noise Figure (I _C = 100 μAdc, V _{CE} = 10 Vdc, R _S = 5 kohms, f = 1 kHz, Δf = 200 Hz)	NF		6	dB

(1) Pulse Test: Pulse Width < 300 μs, Duty Cycle ≤ 2%

(2) Measured across each transistor within the device



The input unit is identified as Unit 1 regardless of terminal numbering.

MAXIMUM RATINGS

Rating	Symbol	2N2060,A 2N2223,A	2N2480	2N2480A	Unit
Collector-Emitter Voltage	V _{CEO}	60	40	40	Vdc
Collector-Emitter Voltage	V _{CER}	80	—	—	Vdc
Collector-Base Voltage	V _{CB0}	100	75	80	Vdc
Emitter-Base Voltage	V _{EBO}	7.0	5.0	5.0	Vdc
Collector Current — Continuous	I _C	500			mAdc
			One Die	All Die Equal Power	
Total Device Dissipation @ T _A = 25°C 2N2060,A 2N2223,A 2N2480,A	P _D	0.5	0.6	0.6	mW
Derate above 25°C 2N2060,A 2N2223,A 2N2480,A		2.86	3.43	3.43	mW/°C
Total Device Dissipation @ T _C = 25°C 2N2060,A 2N2223,A 2N2480,A	P _D	1.5	3.0	3.0	Watts
Derate above 25°C 2N2060,A 2N2223,A 2N2480,A		8.6	17.2	11.4	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200			°C

**2N2060,A
2N2223,A
2N2480,A**

**2N2060 JAN, JTX, JTXV
AVAILABLE
CASE 654-07, STYLE 1**

**DUAL
AMPLIFIER TRANSISTOR**

NPN SILICON

Refer to MD2218 for graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 100 mAdc, R _{BE} ≤ 10 ohms)	V _{CER(sus)}	80	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I _C = 20 mAdc, I _B = 0)	V _{CEO(sus)}	40	—	Vdc
(I _C = 30 mAdc, I _B = 0)		60	—	
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	100	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	7.0	—	Vdc
		5.0	—	
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	15	μAdc
(V _{CB} = 60 Vdc, I _E = 0)		—	0.050	
(V _{CB} = 80 Vdc, I _E = 0)		—	0.002	
(V _{CB} = 80 Vdc, I _E = 0, T _A = 150°C)		—	10	
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)		I _{EBO}	—	

2N2060,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit		
ON CHARACTERISTICS						
DC Current Gain ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$)	2N2060, 2N2060A 2N2223, 2N2223A	h _{FE}	25	75	—	
			15	—		
		(I _C = 100 μAdc , V _{CE} = 5.0 Vdc)	2N2060, 2N2060A 2N2223, 2N2223A 2N2480 2N2480A	30	90	—
				25	150	
20	—					
(I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)	2N2060, 2N2060A 2N2480 2N2480A	40	120	—		
		30	350			
		50	200			
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	2N2060, 2N2060A 2N2223, 2N2223A	50	150	—		
		50	200			
Collector-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 5.0 mAdc)	2N2060A 2N2060, 2N2223, 2N2223A, 2N2480A 2N2480	V _{CE(sat)}	—	0.6	Vdc	
			—	1.2		
			—	1.3		
Base-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 5.0 mAdc)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A 2N2480	V _{BE(sat)}	—	0.9	Vdc	
			—	1.0		
			—	—		

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	2N2223, 2N2223A 2N2480, 2N2480A 2N2060, 2N2060A	f _T	50	—	MHz
			60	—	
			—	—	
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A 2N2480A 2N2480	C _{obo}	—	15	pF
			—	18	
			—	20	
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A	C _{ibo}	—	85	pF
			—	—	
Input Impedance (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A 2N2480A	h _{ie}	1000	4000	ohms
			1000	5000	
Input Impedance (I _C = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A, 2N2223, 2N2223A 2N2480A	h _{ib}	20	30	ohms
			20	35	
Voltage Feedback Ratio (I _C = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A	h _{rb}	—	3.0	X 10 ⁻⁴
			—	—	
Small-Signal Current Gain (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A 2N2223, 2N2223A 2N2480A	h _{fe}	50	150	—
			40	200	
			50	300	
			—	—	
Output Admittance (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A, 2N2480A	h _{oe}	—	16	μmhos
			—	—	
Output Admittance (I _C = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A	h _{ob}	—	0.5	μmhos
			—	—	
Noise Figure (I _C = 0.3 mAdc, V _{CE} = 10 Vdc, R _S = 510 Ω , f = 1.0 kHz, BW = 1.0 Hz) (I _C = 0.3 mAdc, V _{CE} = 10 Vdc,	2N2480, 2N2480A	NF	—	8.0	dB
			—	—	

2N2060,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
$R_S = 510 \Omega$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$ ($I_C = 0.3 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 1.0 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$, $BW = 15.7 \text{ kHz}$)(2)	2N2060, 2N2060A	—	8.0	
		—	8.0	

MATCHING CHARACTERISTICS

DC Current Gain Ratio(3) ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$)	2N2060, 2N2060A, 2N2223A 2N2223, 2N2480, 2N2480A	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	—
($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$)	2N2060, 2N2060A 2N2480, 2N2480		0.9 0.8	1.0 1.0	
Base-Emitter Voltage Differential ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$)	2N2060A 2N2060, 2N2223A, 2N2480A 2N2480 2N2223	$ V_{BE1} - V_{BE2} $	— — — —	3.0 5.0 10 15	mVdc
($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$)	2N2060, 2N2060A, 2N2480A 2N2480		— —	5.0 10	
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$)	2N2060A 2N2060 2N2223, 2N2223A 2N2480, 2N2480A	$\Delta(V_{BE1} - V_{BE2}) / \Delta T$	— — — —	5.0 10 25 15	$\mu\text{V}/^\circ\text{C}$

- (1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.
- (2) Amplifier: 3.0 Db points at 25 Hz and 10 kHz with a roll-off of 6.9 dB per octave.
- (3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

FIGURE 1 — DC CURRENT GAIN versus COLLECTOR CURRENT

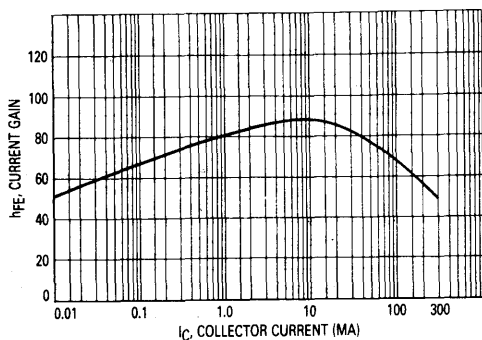
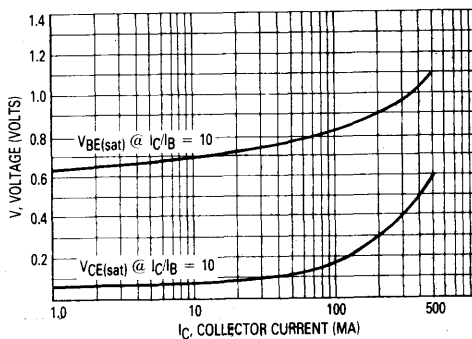


FIGURE 2 — "ON" VOLTAGES



2N2453,A

CASE 654-07, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N2453	2N2453A	Unit
Collector-Emitter Voltage	V_{CE0}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	300 1.71	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	600 3.43	1200 6.86	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

Refer to 2N2920 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{CE0(sus)}$	30 50	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	60 80	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.005 10	μ Adc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.002	μ Adc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10$ μ Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ μ Adc, $V_{CE} = 5.0$ Vdc, $T_A = -55^\circ\text{C}$) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55^\circ\text{C}$)	h_{FE}	80 40 150 75	— — 600 —	—
Collector-Emitter Saturation Voltage ($I_C = 5.0$ mAdc, $I_B = 0.5$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 5.0$ mAdc, $I_B = 0.5$ mAdc)	$V_{BE(sat)}$	—	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 30$ MHz)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 140$ kHz)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 140$ kHz)	C_{ibo}	—	10	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz)	h_{ie}	5.0	—	kohms
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, $f = 1.0$ kHz)	h_{ib}	20	30	Ohms

2N2453,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Voltage Feedback Ratio ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{re}	—	6.0	$\times 10^{-4}$
Voltage Feedback Ratio ($I_C = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{rb}	—	5.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	150	600	—
Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	5.0	30	μmhos
Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ob}	—	0.2	μmho
Noise Figure ($I_C = 10 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 10 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$)	NF	—	7.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$)	h_{FE1}/h_{FE2}	0.90 0.90 0.85	1.0 1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 10 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$)	$ V_{BE1} - V_{BE2} $	— —	3.0 5.0	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 10 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	— —	10 5.0	$\mu\text{V}/^\circ\text{C}$

- (1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.
 (2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

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2N2639 thru 2N2644

CASE 654-07, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CE0}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.72	600 3.43	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	600 3.43	1200 6.87	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

Refer to 2N2913 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{CE0(sus)}$	45	—	Vdc
Collector Cutoff Current ($V_{CE} = 5.0 \text{ Vdc}, I_B = 0$)	I_{CEO}	—	0.010	μAdc
Collector Cutoff Current ($V_{CB} = 45 \text{ Vdc}, I_E = 0$) ($V_{CB} = 45 \text{ Vdc}, I_E = 0, T_A = +150^\circ\text{C}$)	I_{CBO}	— —	0.010 10	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 10 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		—
		50 100	300 300	
($I_C = 10 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}, T_A = -55^\circ\text{C}$)		2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		— —
		10 20	— —	
($I_C = 100 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)		2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		— —
	55 110	— —		
($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		— —	
	65 130	— —		
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 0.5 \text{ mAdc}$)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 0.5 \text{ mAdc}$)	$V_{BE(sat)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	40	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	8.0	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}, I_E = -1.0 \text{ mA}$)	h_{ib}	25	32	ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}, V_{CB} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}, I_E = -1.0 \text{ mA}$)	h_{rb}	—	600	$\times 10^{-6}$

2N2639 thru 2N2644

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Small-Signal Current Gain ($I_C = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	65 130	600 600	—
Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $I_E = -1.0 \text{ mA}$)	h_{ob}	—	1.0	μmhos
Noise Figure ($I_C = 10 \mu\text{A}$, $V_{CB} = 5.0 \text{ Vdc}$, $R_S = 10 \text{ k}\Omega$, Bandwidth = 10 Hz to 15 kHz)	NF	—	4.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) ($I_C = 10 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 10 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$)	$ V_{BE1} - V_{BE2} $	— —	5.0 10	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 10 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55 \text{ to } +125^\circ\text{C}$)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	— —	10 20	$\mu\text{V}/^\circ\text{C}$

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

2N2652,A

CASE 654-07, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage	V _{CEO}	60	Vdc	
Collector-Base Voltage	V _{CBO}	100	Vdc	
Emitter-Base Voltage	V _{EBO}	7.0	Vdc	
Collector Current — Continuous	I _C	500	mAdc	
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.3 1.72	0.6 3.43	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 5.7	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

Refer to 2N2060,A for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 20 mAdc, I _B = 0)	V _{(BR)CEO}	60	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	100	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	7.0	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	0.010 15	μAdc
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	0.010	μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 100 μAdc, V _{CE} = 5.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, T _A = -55°C)	h _{FE}	35 50 15	— 200 —	—
Collector-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 5.0 mAdc)	V _{CE(sat)}	—	1.2	Vdc
Base-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 5.0 mAdc)	V _{BE(sat)}	—	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	60	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	15	pF
Input Capacitance (V _{BE} = 0, 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	85	pF
Input Impedance (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz)	h _{ie}	1.0	10.5	kohms
Input Impedance (I _C = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{ib}	20	35	ohms
Small-Signal Current Gain (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz)	h _{fe}	50	300	—
Output Admittance (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz)	h _{oe}	—	50	μmhos
Noise Figure (I _C = 0.3 mAdc, V _{CE} = 10 Vdc, R _S = 610 ohms, B. W. = 1.0 Hz, f = 1.0 kHz)	NF	—	8.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) (I _C = 100 μAdc, V _{CE} = 5.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)	2N2652 2N2652	h _{FE1} /h _{FE2}	0.85 0.85	1.0 1.0	—
Base-Emitter Voltage Differential (I _C = 100 μAdc, V _{CE} = 5.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)		V _{BE1} - V _{BE2}	—	3.0 3.0	mVdc
Base-Emitter Voltage Differential Gradient (I _C = 100 μAdc, V _{CE} = 5.0 Vdc, T _A = -55 to +125°C)		$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) The lowest of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2720 2N2721

CASE 654-07, STYLE 1

**DUAL
AMPLIFIER TRANSISTOR**

NPN SILICON

Refer to 2N2060 for graphs.

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MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	60		Vdc
Collector-Base Voltage	V _{CBO}	80		Vdc
Emitter-Base Voltage	V _{EBO}	6.0		Vdc
Collector Current — Continuous	I _C	40		mAdc
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.3 1.71	0.6 3.4	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.6 3.4	1.2 6.8	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	60	—	Vdc
Collector Cutoff Current (V _{CE} = 5.0 Vdc, I _B = 0)	I _{CEO}	—	10	nAdc
Collector Cutoff Current (V _{CB} = 60 Vdc, I _E = 0)	I _{CBO}	—	0.01	μAdc
Collector Cutoff Current (V _{CB} = 60 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	10	μAdc
Emitter Cutoff Current (V _{EB} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 100 μAdc, V _{CE} = 5.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	30 35 42	120 — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	1.0	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	80	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	6.0	pF
Input Impedance (I _E = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{ib}	25	32	ohms
Voltage Feedback Ratio (I _E = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{rb}	—	500	X 10 ⁻⁶
Small-Signal Current Gain (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz)	h _{fe}	30	200	—
Output Admittance (I _E = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{ob}	—	1.0	μmhos

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) (I _C = 100 μAdc, V _{CE} = 5.0 Vdc)	2N2720 2N2721	h _{FE1} /h _{FE2}	0.9 0.8	1.0 1.0	—
Base-Emitter Voltage Differential (I _C = 100 μAdc, V _{CE} = 5.0 Vdc)	2N2720 2N2721	V _{BE1} - V _{BE2}	— —	5.0 10	mVdc
Base-Emitter Voltage Differential Change Due to Temperature (I _C = 100 μAdc, V _{CE} = 5.0 Vdc, T _A = -55 to +25°C)	2N2720 2N2721	Δ(V _{BE1} - V _{BE2})	— —	0.8 1.6	mV
(I _C = 100 μAdc, V _{CE} = 5.0 Vdc, T _A = +25 to +125°C)	2N2720 2N2721		— —	1.0 2.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2722

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	45		Vdc
Collector-Base Voltage	V _{CBO}	45		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	40		mAdc
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.3	0.6	Watt mW/°C
		1.7	3.4	
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.6	1.2	Watts mW/°C
		3.4	6.8	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

Refer to 2N2920 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	45	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	45	—	Vdc
Collector Cutoff Current (V _{CE} = 5.0 Vdc, I _B = 0)	I _{CEO}	—	2.0	nAdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 30 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	0.001 1.0	μAdc
Emitter Cutoff Current (V _{EB} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 1.0 μAdc, V _{CE} = 5.0 Vdc) (I _C = 10 μAdc, V _{CE} = 5.0 Vdc) (I _C = 0.1 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	50 100 125	250 — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc)	V _{CE(sat)}	—	1.0	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc)	V _{BE(sat)}	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	100	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	6.0	pF
Input Impedance (I _E = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{ib}	25	32	ohms
Voltage Feedback Ratio (I _E = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{rb}	—	600	X 10 ⁻⁶
Small-Signal Current Gain (I _E = 0.1 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 kHz)	h _{fe}	100	700	—
Output Admittance (I _E = 1.0 mAdc, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{ob}	—	1.0	μmhos
Noise Figure (I _C = 10 μAdc, V _{CE} = 5.0 Vdc, R _S = 10 kΩ, f = 10 Hz to 15.7 kHz)	NF	—	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) (I _C = 1.0 μAdc, V _{CE} = 5.0 Vdc)	h _{FE1} /h _{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential (I _C = 10 μAdc, V _{CE} = 5.0 Vdc)	V _{BE1} - V _{BE2}	—	5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature (I _C = 10 μAdc, V _{CE} = 5.0 Vdc, T _A = -55 to +25°C) (I _C = 10 μAdc, V _{CE} = 5.0 Vdc, T _A = +25 to +125°C)	Δ(V _{BE1} - V _{BE2})	—	0.8	mVdc
		—	1.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2723

CASE 20-03, STYLE 8
TO-72 (TO-206AF)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V _{CE2O}	60	Vdc
Collector-Base Voltage	V _{CB1}	80	Vdc
Emitter-Base Voltage	V _{E2B1}	12	Vdc
Collector Current — Continuous	I _C	40	Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.5 2.9	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.8 10.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _{B1} = 0)	V _{(BR)CE2O}	60	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _{E2} = 0)	V _{(BR)CB1O}	80	—	Vdc
Emitter-Base Breakdown Voltage (I _{E2} = 10 μAdc, I _C = 0)	V _{(BR)E2B1O}	12	—	Vdc
Collector Cutoff Current (V _{CB1} = 60 Vdc, I _E = 0) (V _{CB1} = 60 Vdc, I _E = 0, T _A = 150°C)	I _{CB1O}	—	0.01 10	μAdc
Emitter Cutoff Current (V _{B1E2} = 10 Vdc, I _C = 0)	I _{E2B1O}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 10 mAdc, V _{CE2} = 5.0 Vdc, I _{B2} = 0)	h _{FE}	2000	10,000	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _{B1} = 1.0 mAdc)	V _{CE2(sat)}	—	1.0	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _{B1} = 1.0 mAdc)	V _{BE2(sat)}	—	1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V _{CB1} = 10 Vdc, I _{E2} = 0, f = 140 kHz)	C _{ob1o}	—	10	pF
Small-Signal Current Gain (I _C = 10 mAdc, V _{CE2} = 5.0 Vdc, f = 1.0 kHz)	h _{fe}	1500	15,000	—
Current Gain — Bandwidth Product (Each Unit) (I _C = 10 mAdc, V _{CE1} or V _{CE2} = 10 Vdc, f = 20 MHz)	h _{fe} f	5.0	—	—
Noise Figure (Input Stage Only) (I _C = 50 μAdc, V _{CE} = 5.0 Vdc, R _S = 3.0 kohms, f = 1.0 kHz, BW = 100 Hz)	NF	—	10	dB

(1) Pulse Test: Pulse Width ≤ 12 ms, Duty Cycle ≤ 2.0%.

2N2785

CASE 20-03, STYLE 8
TO-72 (TO-206AF)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V _{CE2O}	40	V _{dc}
Collector-Base Voltage	V _{CB1O}	60	V _{dc}
Emitter-Base Voltage (Pin 4 to Pin 2)	V _{E2B1O}	15 7.5	V _{dc}
Collector Current — Continuous	I _C	200	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.5 2.9	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.8 10.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 20 mAdc, I _{B1} = 0)	V _{(BR)CEO2O}	40	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _{E2} = 0)	V _{(BR)CBO1O}	60	—	V _{dc}
Emitter-Base Breakdown Voltage (I _{E2} = 100 μAdc, I _C = 0)	V _{(BR)E2BO1O}	15	—	V _{dc}
Collector Cutoff Current (V _{CE} = 20 Vdc, I _B = 0)	I _{CEO}	—	500	nAdc
Collector Cutoff Current (V _{CB1} = 30 Vdc, I _E = 0) (V _{CB1} = 30 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	— —	0.05 10	μAdc
Emitter Cutoff Current (V _{E2B1} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 1.0 mAdc, V _{CE2} = 4.0 Vdc) (I _C = 10 mAdc, V _{CE2} = 5.0 Vdc) (I _C = 100 mAdc, V _{CE2} = 5.0 Vdc)	h _{FE}	600 1200 2000	— — 20,000	—
Collector-Emitter Saturation Voltage (I _C = 15 mAdc, I _{B1} = 3.0 mAdc)	V _{CE(sat)}	—	1.0	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance (V _{CB1} = 10 Vdc, I _{E2} = 0, f = 1.0 MHz)	C _{ob1o}	—	30	pF
Input Impedance (I _C = 1.0 mAdc, V _{CB1} = 5.0 Vdc, f = 1.0 kHz)	h _{ib}	30	80	Ωms
Voltage Feedback Ratio (I _C = 1.0 mAdc, V _{CE2} = 5.0 Vdc, f = 1.0 kHz)	h _{rb}	—	10	X 10 ⁻⁴
Small-Signal Current Gain (I _C = 1.0 mAdc, V _{CE2} = 5.0 Vdc, f = 1.0 kHz)	h _{fe}	600	—	—
Current Gain — High Frequency (I _C = 1.0 mAdc, V _{CE2} = 5.0 Vdc, f = 10 MHz)	h _{fe}	1.0	—	—
Output Admittance (I _C = 1.0 mAdc, V _{CB1} = 5.0 Vdc, f = 1.0 kHz)	h _{ob}	—	0.5	μmhos

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2903,A

CASE 654-07, STYLE 1

**DUAL
AMPLIFIER TRANSISTOR**

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	300 1.71	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 3.43	1.2 6.86	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

Refer to 2N2920 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) ($I_C = 10\text{ mAdc}, I_B = 0$)	$V_{CEO(sus)}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}, I_E = 0$) ($V_{CB} = 50\text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	—	0.01 15	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.01	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10\ \mu\text{Adc}, V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\ \mu\text{Adc}, V_{CE} = 5.0\text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 1.0\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}, T_A = -55^\circ\text{C}$)	h_{FE}	60 25 125 60	— — 625 —	—
Collector-Emitter Saturation Voltage ($I_C = 5.0\text{ mAdc}, I_B = 0.5\text{ mAdc}$)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 5.0\text{ mAdc}, I_B = 0.5\text{ mAdc}$)	$V_{BE(sat)}$	—	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 5.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 30\text{ MHz}$)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 140\text{ kHz}$)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 140\text{ kHz}$)	C_{ibo}	—	10	pF
Input Impedance ($I_C = 1.0\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{ie}	1.0	—	kohm
Input Impedance ($I_C = 1.0\text{ mAdc}, V_{CB} = 5.0\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{ib}	20	30	ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{re}	—	6.0	$\times 10^{-4}$
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}, V_{CB} = 5.0\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{rb}	—	5.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{fe}	150	600	—
Output Admittance ($I_C = 1.0\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{oe}	5.0	30	μmhos
Output Admittance ($I_C = 1.0\text{ mAdc}, V_{CB} = 5.0\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{ob}	—	0.2	μmho
Noise Figure ($I_C = 10\ \mu\text{Adc}, V_{CE} = 5.0\text{ Vdc}, R_S = 10\text{ kohms}, f = 1.0\text{ kHz}$)	NF	—	7.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) ($I_C = 1.0\text{ mAdc}, V_{CE} = 5.0\text{ Vdc}$)	2N2903 2N2903A	h_{FE1}/h_{FE2}	0.8 0.9	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 10\ \mu\text{Adc}, V_{CE} = 5.0\text{ Vdc}$)	2N2903 2N2903A	$ V_{BE1} - V_{BE2} $	—	10 5.0	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 10\ \mu\text{Adc}, V_{CE} = 5.0\text{ Vdc}, T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$)	2N2903 2N2903A	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	20 10	$\mu\text{V}/^\circ\text{C}$

- (1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.
 (2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2913 thru 2N2920

**JAN, JTX, JTXV, JANS AVAILABLE
CASE 654-07, STYLE 1**

**DUAL
AMPLIFIER TRANSISTOR**

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N2913 thru 2N2918	2N2919 2N2920	Unit
Collector-Emitter Voltage	V_{CE0}	45	60	Vdc
Collector-Base Voltage	V_{CB0}	45	60	Vdc
Emitter-Base Voltage	V_{EB0}	6.0		Vdc
Collector Current — Continuous	I_C	30		mA _{dc}
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	500 2.86	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	750 4.3	1500 8.6	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mA}_{dc}, I_B = 0$)	2N2913 thru 18, 2N2919, 2N2920	$V_{(BR)CEO(sus)}$	45 60	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}_{dc}, I_E = 0$)	2N2913 thru 18, 2N2919, 2N2920	$V_{(BR)CBO}$	45 60	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}_{dc}, I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 5.0 \text{ Vdc}, I_B = 0$)		I_{CEO}	—	—	0.002	μA_{dc}
Collector Cutoff Current ($V_{CB} = 45 \text{ Vdc}, I_E = 0$)	2N2913 thru 18, 2N2919, 2N2920	I_{CBO}	— —	— —	0.010 0.002	μA_{dc}
($V_{CB} = 45 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	All Types		—	—	10	
Emitter Cutoff Current ($V_{EB} = 5.0 \text{ Vdc}, I_C = 0$)		I_{EBO}	—	—	0.002	μA_{dc}

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10 \mu\text{A}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	2N2913,15,17,19, 2N2914,16,18,20	hFE	60 150	— —	240 600	—
($I_C = 10 \mu\text{A}_{dc}, V_{CE} = 5.0 \text{ Vdc}, T_A = -55^\circ\text{C}$)	2N2913,15,17,19, 2N2914,16,18, 2N2920		15 30 40	— — —	— — —	
($I_C = 100 \mu\text{A}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	2N2913,15,17,19, 2N2914,16,18,20		100 225	— —	— —	
($I_C = 1.0 \text{ mA}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)	2N2913,15,17,19, 2N2914,16,18,20		150 300	— —	— —	
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ mA}_{dc}, I_B = 0.1 \text{ mA}_{dc}$)		$V_{CE(sat)}$	—	—	0.35	Vdc
Base-Emitter On Voltage ($I_C = 100 \mu\text{A}_{dc}, V_{CE} = 5.0 \text{ Vdc}$)		$V_{BE(on)}$	—	—	0.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 500 \mu\text{A}_{dc}, V_{CE} = 5.0 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	60	—	—	MHz
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2N2913 thru 2N2920

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{obo}	—	4.0	6.0	pF
Input Impedance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	25	28	32	ohms
Output Admittance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	—	—	1.0	μmhos
Noise Figure ($I_C = 10\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k}\Omega$, $f = 1.0\text{ kHz}$, $BW = 200\text{ Hz}$)	NF	—	2.0	3.0	dB
($I_C = 10\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k}\Omega$, $f = 10\text{ Hz to }15.7\text{ kHz}$, $BW = 10\text{ kHz}$)		—	3.0	4.0	
		—	2.0	3.0	
		—	3.0	4.0	

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$)	2N2917,18, 2N2915,16,19,20	h_{FE1}/h_{FE2}	0.8 0.9	— —	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 10\text{ }\mu\text{A}$ to 1.0 mA , $V_{CE} = 5.0\text{ Vdc}$)	2N2917,18, 2N2915,16,19,20	$ V_{BE1} - V_{BE2} $	— —	— —	10 5.0	mVdc
($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$)	2N2917,18, 2N2915,16,19,20		— —	— —	5.0 3.0	
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55^\circ\text{C to }+25^\circ\text{C}$)	2N2917,18, 2N2915,16,19,20	$\Delta(V_{BE1} - V_{BE2})$	— —	— —	1.6 0.8	mVdc
($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = +25^\circ\text{C to }+125^\circ\text{C}$)	2N2917,18, 2N2915,16,19,20		— —	— —	2.0 1.0	

- (1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.
 (2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

FIGURE 1 — DC CURRENT GAIN versus COLLECTOR CURRENT

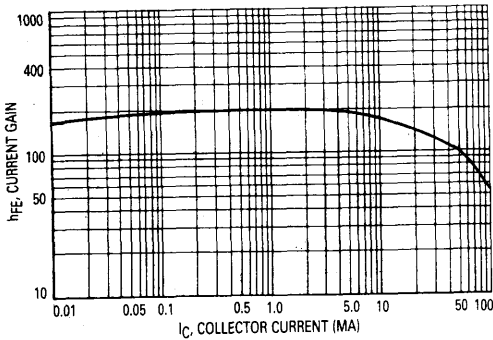


FIGURE 3 — "ON" VOLTAGES

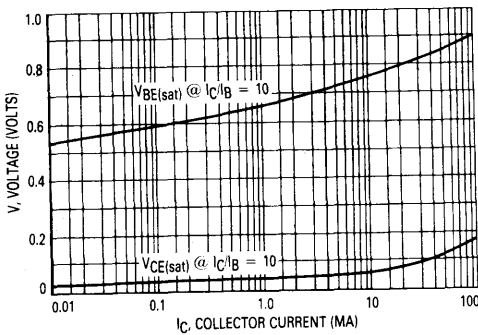


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT

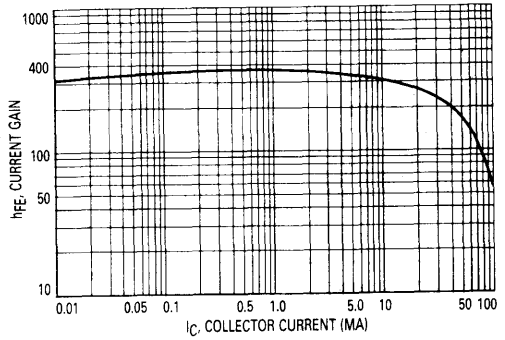
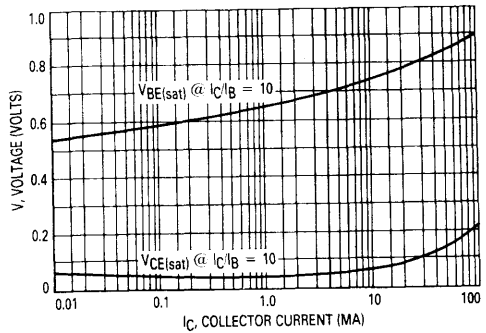


FIGURE 4 — "ON" VOLTAGES



2N3043 thru 2N3048

CASE 610A-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage	V_{CE0}	45	Vdc	
Collector-Base Voltage	V_{CBO}	45	Vdc	
Emitter-Base Voltage	V_{EBO}	5.0	Vdc	
Collector Current — Continuous	I_C	30	mAdc	
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	250 1.67	350 2.33	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	0.7 4.67	1.4 9.33	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$	

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 45 \text{ Vdc}, I_E = 0$) ($V_{CB} = 45 \text{ Vdc}, I_E = 0, T_A = +150^\circ\text{C}$)	I_{CBO}	—	0.010 10	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 10 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	100 50 130 65	300 200 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 0.5 \text{ mAdc}$)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage ($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	V_{BE}	0.6	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	30	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	8.0	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ie}	3.2k 1.6k	19k 13k	Ohms
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	130 65	600 400	—
Output Admittance ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{oe}	— —	100 70	μmhos
Noise Figure ($I_C = 10 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}, R_S = 10 \text{ kohms}, \text{Bandwidth} = 10 \text{ Hz to } 15.7 \text{ kHz}$)	NF	—	5.0	dB

2N3043 thru 2N3048

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2) ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{Vdc}$)	2N3043, 2N3046	h_{FE1}/h_{FE2}	0.9	1.0	—
	2N3044, 2N3047		0.8	1.0	
Base-Emitter Voltage Differential ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{Vdc}$)	2N3043, 2N3046	$ V_{BE1} - V_{BE2} $	—	5.0	mVdc
	2N3044, 2N3047		—	10	
Base-Emitter Voltage Differential Temperature Gradient ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{Vdc}$, $T_A = -55$ to $+125^\circ\text{C}$)	2N3043, 2N3046	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	$\mu\text{V}/^\circ\text{C}$
	2N3044, 2N3047		—	20	

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

2N3425

CASE 654-07, STYLE 1
DUAL
AMPLIFIER TRANSISTORS
 NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	15		Vdc
Collector-Emitter Voltage	V _{CER}	20		Vdc
Collector-Base Voltage	V _{CBO}	40		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.3 1.72	0.4 2.28	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.75 4.3	1.5 8.55	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

Refer to MD2369,A,B for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 30 mAdc, R _{BE} ≤ 10 ohms)	V _{CER(sus)}	20	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{CEO(sus)}	15	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CE} = 20 Vdc, V _{EB(off)} = 0.25 Vdc, T _A = 125°C)	I _{CEX}	—	15	μAdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0) (V _{CB} = 20 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	0.025 15	μAdc
Emitter Cutoff Current (V _{EB} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	0.2	μAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 0.5 mAdc, V _{CE} = 1.0 Vdc) (I _C = 10 mAdc, V _{CE} = 1.0 Vdc) (I _C = 10 mAdc, V _{CE} = 1.0 Vdc, T _A = -55°C)	h _{FE}	12 30 12	— 120 —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 7.0 mAdc, I _B = 0.7 mAdc, T _A = -55°C to +125°C)	V _{CE(sat)}	— —	0.4 0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc) (I _C = 7.0 mAdc, I _B = 0.7 mAdc, T _A = -55°C)	V _{BE(sat)}	0.7 —	0.85 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	300	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	6.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 140 kHz)	C _{ibo}	—	9.0	pF
Small-Signal Current Gain (I _C = 10 mAdc, V _{CE} = 1.0 Vdc, f = 1.0 kHz)	h _{fe}	20	—	—
Real Part of Input Impedance (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 300 MHz)	Re(h _{ie})	—	50	Ohms
SWITCHING CHARACTERISTICS				
Storage Time (I _C = 10 mAdc, I _{B1} = 10 mAdc, I _{B2} = 10 mAdc)	t _s	—	40	ns
Turn-On Time (V _{CC} = 3.0 Vdc, V _{EB(off)} = 2.0 Vdc, I _C = 10 mAdc, I _{B1} = 3.0 mAdc)	t _{on}	—	50	ns
Turn-Off Time (V _{CC} = 3.0 Vdc, I _C = 10 mAdc, I _{B1} = 3.0 mAdc, I _{B2} = 1.0 mAdc)	t _{off}	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	45		Vdc
Collector-Base Voltage	V _{CBO}	45		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Base Current	I _B	100		mAdc
Collector Current — Continuous	I _C	300		mAdc
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	400 2.29	500 2.86	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.85 4.85	1.4 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C
Collector ₁ to Collector ₂ Voltage Voltage rating any lead to case	V _{C1} V _{C2}	±200 ±200		Vdc Vdc

2N3726
2N3727

CASE 654-07, STYLE 1

**DUAL
AMPLIFIER TRANSISTOR**

PNP SILICON

Refer to MD2905,A for graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	45	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.01 mAdc, I _E = 0)	V _{(BR)CBO}	45	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.01 mAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 30 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	10 10	nAdc μAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 0.01 mAdc, V _{CE} = 5.0 Vdc) (I _C = 0.1 mAdc, V _{CE} = 5.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc) (I _C = 50 mAdc, V _{CE} = 5.0 Vdc)(1)	h _{FE}	80 120 135 115	— — 350 —	—
Collector-Emitter Saturation Voltage(1) (I _C = 50 mAdc, I _B = 2.5 mAdc)	V _{CE(sat)}	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 50 mAdc, I _B = 2.5 mAdc)	V _{BE(sat)}	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 20 MHz) (I _C = 50 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	60 200	— 600	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	8.0	pF
Input Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	30	pF
Input Impedance (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{ie}	—	11.5	kohm
Voltage Feedback Ratio (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{re}	—	1500	X 10 ⁻⁶
Small-Signal Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	135	420	—

2N3726, 2N3727

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	—	80	μmhos
Noise Figure ($I_C = 30 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 10 \text{ kohms}$, $f = 1.0 \text{ kHz}$, B.W. = 200 Hz)	NF	—	4.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio(3) ($I_C = 0.1 \text{ mAdc}$ to 1.0 mAdc , $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential ($I_C = 0.1 \text{ mAdc}$ to 1.0 mAdc , $V_{CE} = 5.0 \text{ Vdc}$)	2N3726	—	5.0	mVdc
	2N3727	—	2.5	
Base-Emitter Differential Change Due to Temperature ($I_C = 0.1 \text{ mAdc}$ to 1.0 mAdc , $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$ to $+25^\circ\text{C}$)	2N3726	—	1.6	mVdc
			2N3727	
	2N3726	—	2.0	
			2N3727	

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

(3) For purposes of this ratio, the lowest h_{FE} reading is taken as h_{FE1} .

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	60		Vdc
Collector-Base Voltage	V _{CBO}	60		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	50		mAdc
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Metal Can (2N3806 thru 2N3810,A, 2N3811,A) Derate above 25°C	P _D	500	600	mW
		2.86	3.43	mW/°C
Total Device Dissipation @ T _C = 25°C Flat Package (2N3812 thru 2N3816,A, 2N3817,A) Derate above 25°C	P _D	250	350	mW
		1.5	2.06	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

**2N3806 thru
2N3810,A
2N3811,A**

CASE 610A-04, STYLE 1

**2N3812 thru
2N3816,A
2N3817,A**

CASE 654-07, STYLE 1

**2N3810, 2N3811 — JAN, JTX, JTXV
AVAILABLE**

**DUAL
AMPLIFIER TRANSISTOR**

PNP SILICON

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	60	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	0.01 10	μAdc
Emitter Cutoff Current (V _{BE} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I _C = 1.0 μAdc, V _{CE} = 5.0 Vdc)	h _{FE}	2N3807,9,11,A,13,15,17,A		
(I _C = 10 μAdc, V _{CE} = 5.0 Vdc)		2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A		
(I _C = 100 μAdc, V _{CE} = 5.0 Vdc)		2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A		
(I _C = 100 μAdc, V _{CE} = 5.0 Vdc, T _A = -55°C)		2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A		
(I _C = 500 μAdc, V _{CE} = 5.0 Vdc)		2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A		
(I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)		2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A		
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)		2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A		
Collector-Emitter Saturation Voltage(1) (I _C = 100 μAdc, I _B = 1.0 μA) (I _C = 1.0 mAdc, I _B = 100 μAdc)		V _{CE(sat)}	—	0.2 0.25
Base-Emitter Saturation Voltage(1) (I _C = 100 μAdc, I _B = 10 μAdc) (I _C = 1.0 mAdc, I _B = 100 μAdc)	V _{BE(sat)}	—	0.7 0.8	Vdc

2N3806 thru 2N3810,A, 2N3811,A, 2N3812,A, 2N3816,A, 2N3817,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Base-Emitter On Voltage ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	0.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 500 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 30 \text{ MHz}$) ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	30 100	— 500	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	8.0	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$; $f = 1.0 \text{ kHz}$)	h_{ie}	3.0 10	30 40	Ω
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{re}	—	25	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	150 300	600 900	—
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	5.0	60	μmhos
Noise Figure ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 10 \text{ Vdc}$, $R_G = 3.0 \text{ kohms}$ $f = 100 \text{ Hz}$, $BW = 20 \text{ Hz}$)	NF	—	7.0 4.0	dB
Spot Noise $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$		—	3.0 1.5	
$f = 10 \text{ kHz}$, $BW = 2.0 \text{ kHz}$		—	2.5 1.5	
Broadband Noise Bandwidth 10 Hz to 15.7 kHz		—	3.5 2.5	

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE1}/h_{FE2}	0.8 0.9 0.95	1.0 1.0 1.0	—
($I_C = 100 \mu\text{Adc}$, $V_{CE} = 50 \text{ Vdc}$, $T_A = -55 \text{ to } +125^\circ\text{C}$)		0.85	1.0	
Base-Emitter Voltage Differential ($I_C = 10 \mu\text{Adc}$ to 10 mAdc , $V_{CE} = 5.0 \text{ Vdc}$)	$ V_{BE1} - V_{BE2} $	— —	8.0 5.0	mVdc
($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$)		— — —	5.0 3.0 1.5	
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55 \text{ to } +25^\circ\text{C}$)	$\Delta(V_{BE1} - V_{BE2})$	— — —	1.6 0.8 0.4	mVdc
($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = +25 \text{ to } +125^\circ\text{C}$)		— — —	2.0 1.0 0.5	

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N3806 thru 2N3810,A, 2N3811,A, 2N3812,A, 2N3816,A, 2N3817,A

FIGURE 1 — DC CURRENT GAIN versus COLLECTOR CURRENT

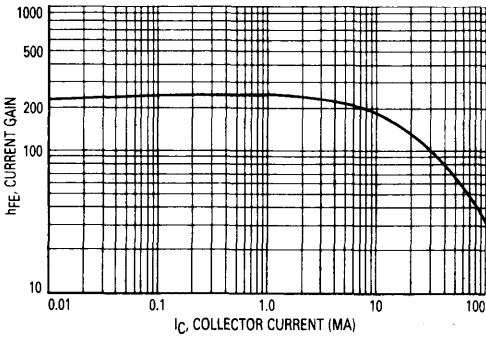


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT

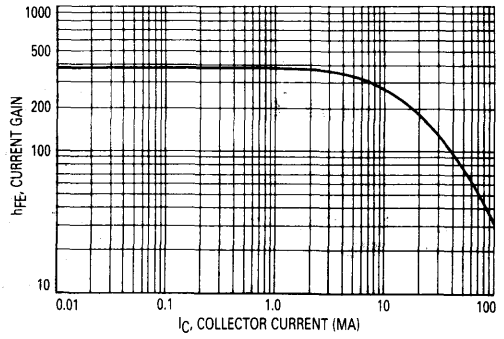


FIGURE 3 — "ON" VOLTAGES

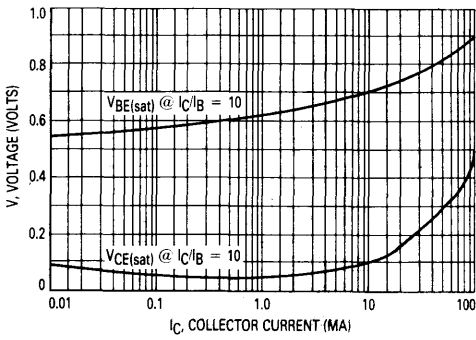
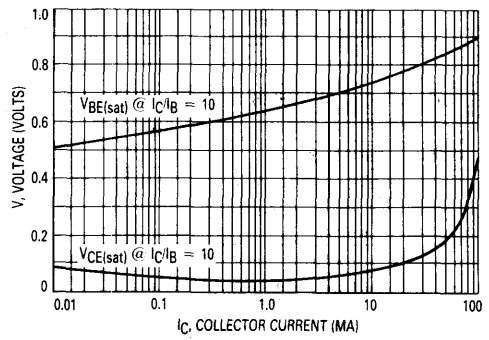


FIGURE 4 — "ON" VOLTAGES



2N3838

CASE 610A-04, STYLE 1

COMPLEMENTARY DUAL AMPLIFIER TRANSISTOR

NPN/PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage	V _{CEO}	40	Vdc	
Collector 1 to Collector 2 Voltage Voltage Rating any Lead to Case	V _{C1C2}	± 120 ± 120	Vdc	
Collector-Base Voltage	V _{CBO}	60	Vdc	
Emitter-Base Voltage	V _{EBO}	5.0	Vdc	
Collector Current — Continuous	I _C	600	mAdc	
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.25 1.67	0.35 2.34	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.7 4.67	1.4 9.34	Watts
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc	
Collector-Emitter Nonmatching Voltage (I _{C(on)} = 600 mAdc, I _{B(on)} = 120 mAdc, I _{B(off)} = 0)	V _{CEO(NL)} †	40	—	Vdc	
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc	
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc	
Base Cutoff Current (V _{CE} = 50 Vdc, V _{BE(off)} = 0.5 Vdc)	I _{BEV}	—	10	nAdc	
Collector Cutoff Current (V _{CE} = 50 Vdc, V _{BE(off)} = 0.5 Vdc) (V _{CE} = 50 Vdc, V _{BE(off)} = 0.5 Vdc, T _A = 150°C)	I _{CEV}	—	0.01 10	μAdc	
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	10	nAdc	
ON CHARACTERISTICS					
DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 10 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc)(1) (I _C = 150 mAdc, V _{CE} = 10 Vdc)(1) (I _C = 150 mAdc, V _{CE} = 1.0 Vdc)(1)	h _{FE}	35 50 75 100 50	— — — 300 —	—	
Collector-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc)	V _{CE(sat)}	—	0.4	Vdc	
Base-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc)	V _{BE(sat)}	0.85	1.3	Vdc	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	200	—	MHz	
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	8.0	pF	
Input Impedance (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{ie}	1.6	9.0	kohms	
Small-Signal Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	60	300	—	
Output Admittance (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{oe}	—	50	μmho	
Noise Figure (I _C = 100 μAdc, V _{CE} = 10 Vdc, R _S = 1.0 kohm, f = 1.0 kHz)	NF	—	8.0	dB	
SWITCHING CHARACTERISTICS					
Delay Time	V _{CC} = 10 Vdc, V _{BE(off)} = 0 Vdc, I _C = 150 mAdc, I _{B1} = 15 mAdc)	t _d	—	10	ns
Rise Time		t _r	—	40	ns
Storage Time	V _{CC} = 10 Vdc, I _C = 150 mAdc, I _{B1} = I _{B2} = 15 mAdc)	t _s	—	250	ns
Fall Time		t _f	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

† The highest value of collector supply voltage that may be safely used with a resistive load switching circuit in which the collector current is 600 mAdc.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	60	Vdc
Collector 1 to Collector 2 Voltage Voltage Rating and Lead to Case	V_{C1C2}	± 200 ± 200	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	100	mAdc
Collector Current — Continuous	I_C	300	mAdc
		One Die	Both Die
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	400 2.29	500 2.86 mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	0.85 4.85	1.4 8.0 Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 65 to + 200	$^\circ\text{C}$

2N4015
2N4016

CASE 654-07, STYLE 1

**DUAL
AMPLIFIER TRANSISTOR**

PNP SILICON

Refer to MD2905.A for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$) ($V_{CB} = 50 \text{ Vdc}, I_E = 0, T_A = +150^\circ\text{C}$)	I_{CBO}	—	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 3.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.01 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 0.1 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 50 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)(1)	h_{FE}	80 120 135 115	— — 350 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}, I_B = 2.5 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}, V_{CE} = 2.5 \text{ Vdc}$)	$V_{BE(sat)}$	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 50 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	200 60	600 —	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$)	C_{ibo}	—	25	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{ie}	—	11.5	kohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{re}	—	15	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	135	420	—

2N4015, 2N4016

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	—	80	μmhos
Noise Figure ($I_C = 0.03 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 10 \text{ kohms}$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$)	NF	—	4.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio ($I_C = 0.1 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential ($I_C = 0.1 \text{ to } 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	$ V_{BE1} - V_{BE2} $	—	5.0	mVdc
		—	2.5	
Base-Emitter Voltage Differential Gradient ($I_C = 0.1 \text{ to } 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55 \text{ to } +25^\circ\text{C}$)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	1.6	mVdc
		—	0.8	
($I_C = 0.1 \text{ to } 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = +25^\circ\text{C}$ to $+125^\circ\text{C}$)		—	2.0	
		—	1.0	

- (1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 1.0\%$.
 (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N4854 2N4855

2N4854 — JAN, JTX, JTXV
AVAILABLE
CASE 654-07, STYLE 5

COMPLEMENTARY DUAL
AMPLIFIER TRANSISTOR

NPN/PNP SILICON

Refer to MD6001 for graphs.

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector 1 to Collector 2 Voltage Voltage Rating any Lead to Case	V _{C1C2}	± 200 ± 200	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	600	mAdc
		One Die	Both Die
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	300 2.0	600 4.0 mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 6.67	2.0 13.33 Watts
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	10	μAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 10 Vdc)	h _{FE}	2N4854	35	—
		2N4855	20	—
(I _C = 1.0 mAdc, V _{CE} = 10 Vdc)		2N4854	50	—
		2N4855	25	—
(I _C = 10 mAdc, V _{CE} = 10 Vdc)(1)		2N4854	75	—
		2N4855	35	—
(I _C = 150 mAdc, V _{CE} = 10 Vdc)(1)		2N4854	100	300
		2N4855	40	120
(I _C = 150 mAdc, V _{CE} = 1.0 Vdc)(1)		2N4854	50	—
		2N4855	20	—
(I _C = 300 mAdc, V _{CE} = 10 Vdc)(1)		2N4854	35	—
		2N4855	20	—
Collector-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc)	V _{CE(sat)}	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc)	V _{BE(sat)}	0.75	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	200	—	MHz

2N4854, 2N4855

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)		C_{cb}	—	8.0	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N4854 2N4855	h_{ie}	1.5 0.75	9.0 4.5	kohms
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N4854 2N4855	h_{fe}	60 30	300 150	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N4854 2N4855	h_{oe}	— —	50 25	μmhos
Noise Figure ($I_C = 100\ \mu\text{A}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 1.0\text{ kohm}$, $f = 1.0\text{ kHz}$)		NF	—	8.0	dB

SWITCHING CHARACTERISTICS

Delay Time	$V_{CC} = 30\text{ Vdc}$, $V_{BE(\text{off})} = 0.5\text{ Vdc}$, $I_C = 150\text{ mA}$, $I_{B1} = 15\text{ mA}$	t_d	—	20	ns
Rise Time		t_r	—	40	ns
Storage Time	$V_{CC} = 30\text{ Vdc}$, $I_C = 150\text{ mA}$, $I_{B1} = I_{B2} = 15\text{ mA}$	t_s	—	280	ns
Fall Time		t_f	—	70	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage	V _{CEO}	40	Vdc	
Collector 1 to Collector 2 Voltage Voltage Rating and Lead to Case	V _{C1C2}	±200 ±200	Vdc	
Collector-Base Voltage	V _{CBO}	50	Vdc	
Emitter-Base Voltage	V _{EBO}	5.0	Vdc	
Base Current	I _B	10	mAdc	
Collector Current — Continuous	I _C	50	mAdc	
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C — Ceramic Metal Can	P _D	250 500	350 600	mW mW/°C
Derate above 25°C — Ceramic Metal Can		1.5 2.9	2.0 3.4	
Total Device Dissipation @ T _C = 25°C Derate above 25°C Metal Can	P _D	1.2 6.85	2.0 11.42	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C	

2N4937 thru 2N4942

2N4937, 2N4938, 2N4939
CASE 654-07, STYLE 1
2N4440, 2N4441, 2N4442
CASE 610A-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MD3250,A for graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	50	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0)	I _{CBO}	—	20	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 100 μAdc, V _{CE} = 10 Vdc) (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc)	h _{FE}	40 50 50	200 250 250	—
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SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 100 Mhz)	f _T	300	900	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 140 kHz) Emitter Guarded	C _{cb}	—	5.0	pF
Input Impedance (I _{BE} = 0.5 Vdc, I _C = 0, f = 140 kHz) Collector Guarded	C _{eb}	—	10	pF
Input Impedance (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{ie}	1.0	10	kΩ
Voltage Feedback Ratio (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{re}	—	10	X 10 ⁻⁴
Small-Signal Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	50	—	—
Output Admittance (I _C = 1.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{oe}	5.0	50	μmhos
Noise Figure (I _C = 100 μAdc, V _{CE} = 10 Vdc, R _S = 3.0 kΩ, f = 10 Hz to 15.7 kHz)	NF	—	4.0	dB

2N4937 thru 2N4942

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(1) ($I_C = 100 \mu\text{A}$ dc to 1.0 mA dc, $V_{CE} = 10 \text{ V}$ dc)	2N4937, 2N4941	h_{FE1}/h_{FE2}	0.9	1.0	—
	2N4938, 2N4940		0.8	1.0	
($I_C = 100 \mu\text{A}$ dc to 1.0 mA dc, $V_{CE} = 10 \text{ V}$ dc, $T_A = -55^\circ\text{C}$ to 125°C)	2N4937, 2N4941		0.85	1.0	
	2N4938, 2N4940		0.7	1.0	
Base-Emitter Voltage Differential ($I_C = 100 \mu\text{A}$ dc to 1.0 mA dc, $V_{CE} = 10 \text{ V}$ dc)	2N4937, 2N4941	$ V_{BE1} - V_{BE2} $	—	3.0	mVdc
	2N4938, 2N4940		—	5.0	
Base-Emitter Voltage Differential Gradient ($I_C = 100 \mu\text{A}$ dc to 1.0 mA dc, $V_{CE} = 10 \text{ V}$ dc, $T_A = 25^\circ\text{C}$ to $+125^\circ\text{C}$)	2N4937, 2N4941	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	1.0	mVdc
	2N4938, 2N4940		—	2.0	
($I_C = 100 \mu\text{A}$ dc to 1.0 mA dc, $V_{CE} = 10 \text{ V}$ dc, $T_A = -55^\circ\text{C}$ to 25°C)	2N4937, 2N4941		—	0.8	
	2N4938, 2N4940		—	1.6	

(1) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N5793 2N5794

JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 1

DUAL TRANSISTOR

NPN SILICON

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Refer to MD2218,A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	40		Vdc
Collector-Base Voltage	V _{CBO}	75		Vdc
Emitter-Base Voltage	V _{EBO}	6.0		Vdc
Collector Current — Continuous	I _C	600		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	500 2.9	600 3.4	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.2 6.9	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	75	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0)	I _{CBO}	—	10	nAdc
Emitter Cutoff Current (V _{EB} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	10	nAdc
Collector 1 to Collector 2 Leakage Current (V _{I_C-2_C} = ± 50 Vdc)	I _{C1-C2}	—	± 1.0	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 100 μAdc, V _{CE} = 10 Vdc)		h _{FE}	20	—	—
(I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	2N5793	h _{FE}	35	—	—
	2N5794	h _{FE}	25	—	—
(I _C = 10 mAdc, V _{CE} = 10 Vdc)(1)	2N5793	h _{FE}	50	—	—
	2N5794	h _{FE}	35	—	—
(I _C = 150 mAdc, V _{CE} = 1.0 Vdc)(1)	2N5793	h _{FE}	75	—	—
	2N5794	h _{FE}	20	—	—
(I _C = 150 mAdc, V _{CE} = 10 Vdc)(1)	2N5793	h _{FE}	50	—	—
	2N5794	h _{FE}	40	120	—
(I _C = 300 mAdc, V _{CE} = 10 Vdc)(1)	2N5793	h _{FE}	100	300	—
	2N5794	h _{FE}	25	—	—
	2N5794	h _{FE}	40	—	—
Collector-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc)	V _{CE(sat)}	—	0.3	—	Vdc
(I _C = 300 mAdc, I _B = 30 mAdc)	V _{CE(sat)}	—	0.9	—	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc)	V _{BE(sat)}	0.6	1.2	—	Vdc
(I _C = 300 mAdc, I _B = 30 mAdc)	V _{BE(sat)}	—	1.8	—	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) (I _C = 20 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	250	—	MHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{cb}	—	8.0	pF
Emitter-Base Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{eb}	—	25	pF

SWITCHING CHARACTERISTICS

Delay Time	(V _{CC} = 30 Vdc, V _{BE(off)} = 0.5 Vdc, I _C = 150 mAdc, I _{B1} = 15 mAdc)	t _d	—	15	ns
Rise Time		t _r	—	30	ns
Storage Time	(V _{CC} = 30 Vdc, I _C = 150 mAdc, I _{B1} = I _{B2} = 15 mAdc)	t _s	—	250	ns
Fall Time		t _f	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) f_T is defined as the frequency at which |h_{fe}| extrapolates to unity.

2N5795 2N5796

JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 1

DUAL TRANSISTOR

PNP SILICON

Refer to MD2904,A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	60		Vdc
Collector-Base Voltage	V _{CBO}	60		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	600		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	500 2.9	600 3.4	mW mW/°C
Total Power Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.2 6.9	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	60	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0)	I _{CBO}	—	20	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	100	nAdc
Collector 1 to Collector 2 Leakage Current (V _{I_C-2_C} = ±50 Vdc)	I _{C1-C2}	—	±1.0	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 100 μAdc, V _{CE} = 10 Vdc)	2N5795	h _{FE}	40	—	—
	2N5796		75	—	
(I _C = 1.0 mAdc, V _{CE} = 10 Vdc)	2N5795		40	—	
	2N5796		100	—	
(I _C = 10 mAdc, V _{CE} = 10 Vdc)(1)	2N5795		40	—	
	2N5796		100	—	
(I _C = 150 mAdc, V _{CE} = 1.0 Vdc)(1)	2N5795		20	—	
	2N5796		50	—	
(I _C = 150 mAdc, V _{CE} = 10 Vdc)(1)	2N5795		40	120	
	2N5796		100	300	
(I _C = 500 mAdc, V _{CE} = 10 Vdc)(1)	2N5795		40	—	
	2N5796		50	—	
Collector-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	—	0.4 1.6		Vdc
Base-Emitter Saturation Voltage(1) (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{BE(sat)}	—	1.3 2.6		Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) (I _C = 50 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	200	—	MHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{cb}	—	8.0	pF
Emitter-Base Capacitance (V _{EB} = 2.0 Vdc, I _C = 0, f = 100 kHz)	C _{eb}	—	30	pF

SWITCHING CHARACTERISTICS (See Figure 1)

Delay Time	(V _{CC} = 30 Vdc, V _{BE(off)} = 0.5 Vdc, I _C = 150 mAdc, I _{B1} = 15 mAdc)	t _d	—	12	ns
Rise Time		t _r	—	35	ns
Storage Time	(V _{CC} = 30 Vdc, I _C = 150 mAdc, I _{B1} = I _{B2} = 15 mAdc)	t _s	—	100	ns
Fall Time		t _f	—	40	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) f_T is defined as the frequency at which |h_{fe}| extrapolates to unity.

BFX11

CASE 654-07, STYLE 1
**DUAL
 AMPLIFIER TRANSISTOR**
 PNP SILICON

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MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	45		V _{dc}
Collector-Base Voltage	V _{CBO}	45		V _{dc}
Emitter-Base Voltage	V _{EBO}	4.5		V _{dc}
Collector Current - Continuous	I _C	100		mAdc
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	400	500	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.85	1.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) (I _C = 10 mA, I _B = 0)	V _{CEO(sus)}		45	V _{dc}
Collector-Base Breakdown Voltage (I _C = 10 μA, I _E = 0)	V _{(BR)CBO}		45	V _{dc}
Emitter-Base Breakdown Voltage (I _C = 0, I _E = 10 μA)	V _{(BR)EBO}		4.5	V _{dc}
Collector Cutoff Current (V _{CB} = 30 V _{dc} , I _E = 0) (V _{CB} = 30 V _{dc} , I _E = 0, T _A = 150°C)	I _{CBO}		10 10	nAdc μAdc
Emitter Cutoff Current (I _C = 0, V _{EB} = 3 V _{dc})	I _{EBO}		100	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 10 μA, V _{CE} = 5 V _{dc}) (I _C = 100 μA, V _{CE} = 5 V _{dc}) (I _C = 1 mA, V _{CE} = 5 V _{dc}) (I _C = 50 mA, V _{CE} = 5 V _{dc})	h _{FE}	50 80 90 80	— — — —	— — — —
Collector-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 2.5 mAdc)	V _{CE(sat)}	—	0.25	V _{dc}
Base-Emitter Saturation Voltage (I _C = 50 mAdc, I _B = 2.5 mAdc)	V _{BE(sat)}	—	1.0	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain - Bandwidth Product (I _C = 50 mAdc, V _{CE} = 20 V _{dc} , f = 100 MHz)	f _T	130	—	MHz
Output Capacitance (V _{CB} = 10 V _{dc} , I _E = 0, f = 140 kHz)	C _{obo}	—	8	pF
Input Capacitance (V _{EB} = 0.5 V _{dc} , I _C = 0, f = 140 kHz)	C _{ibo}	—	25	pF
Noise Figure (I _C = 30 μAdc, V _{CE} = 5 V _{dc} , R _S = 10 kohms, f = 1 kHz)	NF	—	5	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) (I _C = 100 μAdc, V _{CE} = 5 V _{dc})	h _{FE1} /h _{FE2}	0.8	1	—
Base-Emitter Voltage Differential (I _C = 100 μAdc, V _{CE} = 5 V _{dc})	V _{BE1} - V _{BE2}	—	5	mV _{dc}
Base-Emitter Voltage Differential Gradient (I _C = 100 μAdc, V _{CE} = 5 V _{dc} , T _A = -55°C to +125°C)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	20	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

BFX15

CASE 645-07, STYLE 1
DUAL
AMPLIFIER TRANSISTOR
 NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage	V _{CEO}	40	Vdc	
Collector-Base Voltage	V _{CBO}	80	Vdc	
Emitter-Base Voltage	V _{EBO}	5	Vdc	
Collector Current - Continuous	I _C	200	mAdc	
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	500	600	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.2	1.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I _C = 30 mAdc, I _B = 0)	V _{CEO(sus)}	40		Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	80		Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	5.0		Vdc
Collector-Emitter Sustaining Voltage(1) (I _C = 100 mAdc, R _{BE} = 10 Ω)	V _{CER(sus)}	60		Vdc
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0) (V _{CB} = 40 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}		10 10	nAdc μAdc
Emitter Cutoff Current (V _{EB} = 4.0 Vdc, I _C = 0)	I _{EBO}		10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 10 μAdc, V _{CE} = 5 Vdc) (I _C = 0.1 mAdc, V _{CE} = 5.0 Vdc) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	30 60 90	— — —	— — —
Collector-Emitter Saturation Voltage (I _C = 1 mAdc, I _B = 0.1 mAdc)	V _{CE(sat)}	—	1.0	Vdc
Base-Emitter Saturation Voltage (I _C = 1 mAdc, I _B = 0.1 mAdc)	V _{BE(sat)}	—	0.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain - Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 20 MHz)	f _T	50	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1 kHz)	C _{obo}	—	15	pF
Input Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 1 kHz)	C _{TE}	—	85	pF
Small-Signal Current Gain (I _C = 1 mAdc, V _{CE} = 5.0 Vdc, f = 1 kHz)	h _{FE}	30	—	—
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) (I _C = 0.1 mAdc, V _{CE} = 5.0 Vdc)	h _{FE1} /h _{FE2}	0.9	1	—
Base-Emitter Voltage Differential (I _C = 100 μAdc, V _{CE} = 5.0 Vdc)	V _{BE1} - V _{BE2}	—	5.0	mVdc
Base-Emitter Voltage Differential Gradient (I _C = 100 μAdc, V _{CE} = 5.0 Vdc, T _A = -55°C to +125°C) (I _{C1} + I _{C2} = 200 μAdc, T _A = 0°C to +70°C)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

BFX36

CASE 654-07, STYLE 1

**DUAL
AMPLIFIER TRANSISTOR**

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage	V _{CEO}	60	Vdc	
Collector-Base Voltage	V _{CBO}	60	Vdc	
Emitter-Base Voltage	V _{EBO}	6	Vdc	
Collector Current - Continuous	I _C	100	mAdc	
		One Die	Both Die	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	400	600	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.8	1.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) (I _C = 5 mA, I _B = 0)	V _{CEO(sus)}		60	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA, I _E = 0)	V _{(BR)CBO}		60	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA, I _C = 0)	V _{(BR)EBO}		6	Vdc
Collector Cutoff Current (V _{CB} = 50 V, I _E = 0)	I _{CBO}		10	nAdc
			10	μAdc
Emitter Cutoff Current (V _{EB} = 4 V, I _C = 0)	I _{EBO}		10	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 1 μAdc, V _{CE} = 5 V) (I _C = 10 μAdc, V _{CE} = 5 Vdc) (I _C = 100 μAdc, V _{CE} = 5 Vdc) (I _C = 1 mAdc, V _{CE} = 5 Vdc) (I _C = 50 mAdc, V _{CE} = 5 Vdc) (I _C = 10 μAdc, V _{CE} = 5 Vdc, T _A = -55°C)	h _{FE}	60 100 100 100 90 40	— 300 — — — —	— — — — — —
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 0.5 mAdc)	V _{CE(sat)}	—	0.25	Vdc
Base-Emitter Saturation Voltage	V _{BE(sat)}	—	0.9	Vdc
Collector-Emitter Saturation Voltage (I _C = 50 mAdc, I _R = 5 mAdc)	V _{CE(sat)}	—	0.4	Vdc
Base-Emitter Saturation Voltage	V _{BE(sat)}	—	0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain - Bandwidth Product (I _C = 1 mAdc, V _{CE} = 5 Vdc, f = 20 MHz)	f _T	40	—	MHz
Output Capacitance (V _{CB} = 5 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	6	pF
Input Impedance (I _C = 1 mAdc, V _{CE} = 5 Vdc, f = 1 kHz)	h _{ie}	2.5	20	kohm
Voltage Feedback Ratio (I _C = 1 mAdc, V _{CE} = 5 Vdc, f = 1 kHz)	h _{re}	—	10	× 10 ⁻⁴
Output Admittance (I _C = 1 mAdc, V _{CE} = 5 Vdc, f = 1 kHz)	h _{oe}	5	50	μmhos
Noise Figure (3) (I _C = 20 μAdc, V _{CE} = 5 Vdc, R _S = 10 kohms, f = 1 kHz)	NF	—	3	dB
Noise Figure (4) (I _C = 20 μAdc, V _{CE} = 5 Vdc, R _S = 10 kohms, f = 1 kHz)	NF	—	10	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) (I _C = 100 μAdc, V _{CE} = 5 Vdc)	h _{FE1} /h _{FE2}	0.9	—	—
Base-Emitter Voltage Differential (I _C = 100 μAdc, V _{CE} = 5 Vdc)	V _{BE1} - V _{BE2}	—	3	mVdc
Base-Emitter Voltage Differential Gradient (I _C = 100 μAdc, V _{CE} = 5 Vdc, T _A = -55°C to +125°C)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

(3) BW = 200 Hz

(4) BW = 20 Hz

BFY81

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	45	Vdc
Collector-Base Voltage	V _{CBO}	45	Vdc
Emitter-Base Voltage	V _{EBO}	6	Vdc
Collector Current - Continuous	I _C	30	mAdc
		One Die	Both Die
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	575 3.29	625 3.57 mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.8 10.3	2.5 14.3 Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1)	V _{CEO(sus)}	45	—	Vdc
Collector-Base Breakdown Voltage	V _{(BR)CBO}	45	—	Vdc
Emitter-Base Breakdown Voltage	V _{(BR)EBO}	6	—	Vdc
Collector Cutoff Current (I _E = 0, V _{CB} = 40 Vdc) (I _E = 0, V _{CB} = 40 Vdc, T _A = 150°C)	I _{CBO}	—	10 10	nAdc μAdc
Emitter Cutoff Current (I _C = 0, V _{EB} = 5.0 Vdc)	I _{EBO}	—	10	nAdc
Collector to Emitter Cutoff Current (V _{CE} = 5.0 Vdc, I _B = 0)	I _{CEO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I _C = 10 μA, V _{CE} = 5.0 Vdc) (I _C = 100 μA, V _{CE} = 5.0 Vdc) (I _C = 1.0 mA, V _{CE} = 5.0 Vdc)	h _{FE}	60 100 150	— — —	— — —
Collector-Emitter Saturation Voltage (I _C = 1.0 mAdc, I _B = 0.1 mAdc)	V _{CE(sat)}	—	0.35	Vdc
Base-Emitter ON Voltage (I _C = 100 μAdc, V _{CE} = 5.0 Vdc)	V _{BE(ON)}	—	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain - Bandwidth Product (I _C = 500 μAdc, V _{CE} = 5.0 Vdc, f = 30 MHz)	f _T	60	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	6.0	pF
Noise Figure (I _C = 10 μAdc, V _{CE} = 5.0 Vdc, R _S = 2 kohms, f = 1 kHz)	NF	—	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2)	h _{FE1} /h _{FE2}	0.8	1	—
Base-Emitter Voltage Differential (I _C = 100 μAdc, V _{CE} = 5.0 Vdc)	V _{BE1} - V _{BE2}	—	10	mVdc
Base-Emitter Voltage Differential Gradient (I _C = 100 μAdc, V _{CE} = 5 Vdc, T _A = -55°C to +125°C)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	25	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

BFY84

CASE 654-07

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	12	Vdc
Collector-Base Voltage	V _{CBO}	30	Vdc
Emitter-Base Voltage	V _{EBO}	3	Vdc
Collector Current - Continuous	I _C	30	mAdc
		One Die	Both Die
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	575 3.29	625 3.57 mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.8 10.3	2.5 14.3 Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) (I _C = 3.0 mA, I _B = 0)	V _{CEO(sus)}	12	—	Vdc
Collector-Base Breakdown Voltage (I _C = 1.0 μA, I _E = 0)	V _{(BR)CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA, I _C = 0)	V _{(BR)EBO}	3.0	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0) (V _{CB} = 15 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	10 1	nAdc μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 3.0 mAdc, V _{CE} = 1 Vdc)	h _{FE}	20	—	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	0.4	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain - Bandwidth Product (I _C = 4 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	600	—	MHz
Output Capacitance (V _{CB} = 0 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	3.0	pF
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	1.7	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 140 kHz)	C _{TE}	—	2.0	pF
Noise Figure (I _C = 1 mA, V _{CE} = 6.0 Vdc, R _S = 0.4 kohms, f = 60 MHz)	NF	—	6.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio(2) (I _C = 3.0 mAdc, V _{CE} = 1.0 Vdc)	h _{FE1} /h _{FE2}	0.8	1	—
Base-Emitter Voltage Differential (I _C = 3.0 mAdc, V _{CE} = 1.0 Vdc)	V _{BE1} - V _{BE2}	—	15	mVdc
Base-Emitter Voltage Differential Gradient (I _C = 3.0 mAdc, V _{CE} = 1 Vdc, T _A = -55°C to +125°C)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	25	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD708,A,B

CASE 654-07, STYLE 1

MD708F,AF,BF

CASE 610A-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CE0}	15		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ MD708, MD708A, MD708B MD708F, MD708AF, MD708BF	P_D	550 350	600 400	mW
Derate above 25°C MD708, MD708A, MD708B MD708F, MD708AF, MD708BF		3.13 2.0	3.42 2.28	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ MD708, MD708A, MD708B MD708F, MD708AF, MD708BF	P_D	1.4 0.7	2.0 1.4	Watts
Derate above 25°C MD708, MD708A, MD708B MD708F, MD708AF, MD708BF		8.0 4.0	11.4 8.0	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

Refer to MD2369 for graphs.

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case MD708, MD708A, MD708B MD708F, MD708AF, MD708BF	$R_{\theta JC}$	125 250	87.5 125	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$	319 500	292 438	$^\circ\text{C/W}$
		Junction to Ambient	Junction to Case	
Coupling Factors MD708, MD708A, MD708B MD708F, MD708AF, MD708BF		83 75	40 0	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 30 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}, I_E = 0$) ($V_{CB} = 20 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	—	15 30	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 500 \mu\text{Adc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	40 40 35 20	— 200 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	$V_{CE(sat)}$	— — —	0.20 0.35 0.50	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	$V_{BE(sat)}$	0.65 — —	0.85 0.95 1.10	Vdc

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ MD918,A,B MD918F,AF,BF Derate above 25°C	P_D	550 350	600 400	mW
MD918,A,B MD918F,AF,BF		3.14 2.0	3.42 2.28	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ MD918,A,B MD918F,AF,BF Derate above 25°C	P_D	1.4 0.7	2.0 1.4	Watts
MD918,A,B MD918F,AF,BF		8.0 4.0	11.4 8.0	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

**MD918
MD918A
MD918B**

CASE 654-07, STYLE 1

**MD918F
MD918AF
MD918BF**

CASE 610A-04, STYLE 1

**DUAL
AMPLIFIER TRANSISTOR**

NPN SILICON

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THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case MD918,A,B MD918F,AF,BF	$R_{\theta JC}$	125 250	87.5 125	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient MD918,A,B MD918F,AF,BF	$R_{\theta JA}(1)$	319 500	292 438	$^\circ\text{C/W}$
		Junction to Ambient	Junction to Case	
Coupling Factors MD918,A,B MD918F,AF,BF		83 75	40 0	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	10 1.0	nAdc μ Adc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	50	165	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ Adc)	$V_{CE(sat)}$	—	0.09	0.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.86	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	600	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{obo}	—	1.1	1.7	pF

MD918,A,B,F,AF,BF

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ibo}	—	1.15	2.0	pF	
Noise Figure ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 6.0\text{ Vdc}$, $R_S = 400\Omega$, $f = 60\text{ MHz}$)	NF	—	—	6.0	dB	
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)	MD918B,BF MD918A,AF	h_{FE1}/h_{FE2}	0.8 0.9	— —	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)	MD918B,BF MD918A,AF	$ V_{BE1} - V_{BE2} $	— —	— —	10 5.0	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55\text{ to }+125^\circ\text{C}$)	MD918B,AF,BF MD918A	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	— —	— —	20 10	$\mu\text{V/dc}$ $^\circ\text{C}$

- (2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.
 (3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

FIGURE 1 - DC CURRENT GAIN

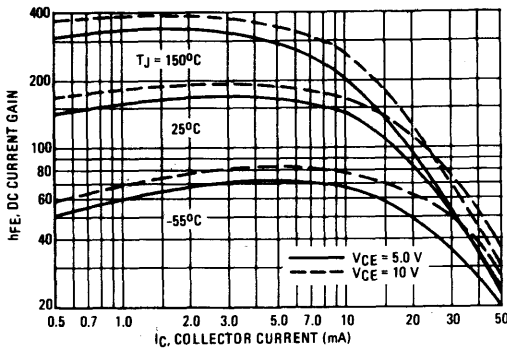


FIGURE 2 - "ON" VOLTAGES

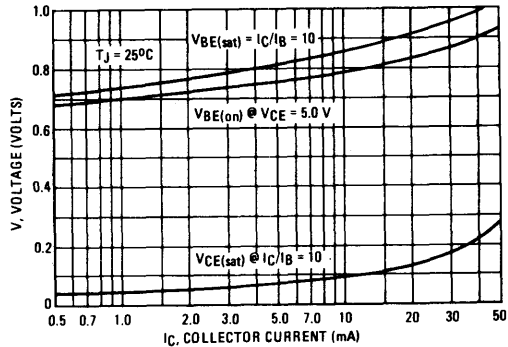


FIGURE 3 - BASE-EMITTER TEMPERATURE COEFFICIENT

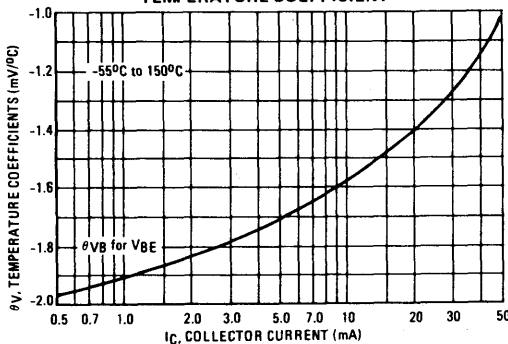


FIGURE 4 - CURRENT-GAIN BANDWIDTH PRODUCT

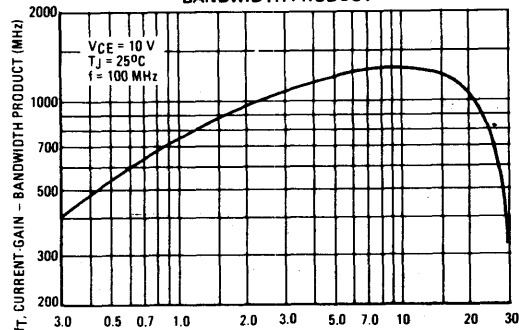
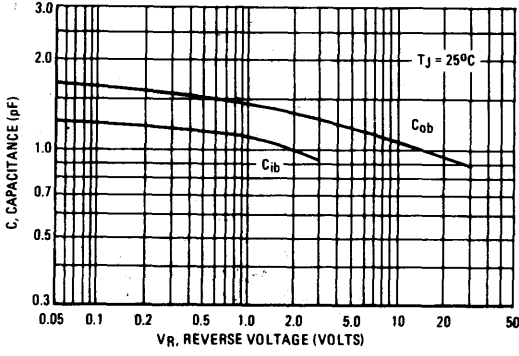


FIGURE 5 - CAPACITANCE



MD2218,A,F,AF
MD2219,A,F,AF
MQ2218,A
MQ2219,A

MD2218,A
 MD2219,A
 CASE 654-07, STYLE 1

MD2218F,AF
 MD2219F,AF
 CASE 610A-04, STYLE 1

MQ2218,A
 MQ2219,A
 CASE 607-04, STYLE 1

DUAL
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MAXIMUM RATINGS

Rating	Symbol	MD2218,A,F MD2219,A,F MQ2218,A MQ2219,A	MD2218AF MD2219AF	Unit
Collector-Emitter Voltage	V _{CEO}	30	40	V _{dc}
Collector-Base Voltage	V _{CBO}	60	75	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0	6.0	V _{dc}
Collector Current — Continuous	I _C	500		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ T _A = 25°C	P _D			mW
MD2218,A, MD2219,A		575	625	mW/°C
MD2218F,AF, MD2219F,AF		350	400	
MQ2218,A, MQ2219,A		400	600	
Derate above 25°C				
MD2218,A, MD2219,A		3.29	3.57	
MD2218F,AF, MD2219F,AF		2.0	2.28	
MQ2218,A, MQ2219,A		2.28	3.42	
Total Device Dissipation @ T _C = 25°C	P _D			Watts
MD2218,A, MD2219,A		1.8	2.5	mW/°C
MD2218F,AF, MD2219F,AF		1.0	2.0	
MQ2218,A, MQ2219,A		0.9	3.6	
Derate above 25°C				
MD2218,A, MD2219,A		10.3	14.3	
MD2218F,AF, MD2219F,AF		5.71	11.4	
MQ2218,A, MQ2219,A		5.13	20.5	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	R _{θJC}			°C/W
MD2218,A, MD2219,A		97	70	
MD2218F,AF, MD2219F,AF		175	87.5	
MQ2218,A, MQ2219,A		195	48.8	
Thermal Resistance, Junction to Ambient	R _{θJA} (1)			°C/W
MD2218,A, MD2219,A		304	280	
MD2218,F,AF, MD2219,F,AF		500	438	
MQ2218,A, MQ2219,A		438	292	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD2218,A, MD2219,A		84	44	
MD2218F,AF, MD2219F,AF		75	0	
MQ2218,A, MQ2219,A (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}				V _{dc}
MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		30	—	—	
MD2218AF, MD2219AF		40	—	—	
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}				V _{dc}
MD2218,A,F, MD2219,A,F, MQ2218,A, MD2219,A		60	—	—	
MD2218AF, MD2219AF		75	—	—	

MD2218,A,F,AF, MD2219,A,F,AF, MQ2218,A, MQ2219,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$				Vdc
MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		5.0	—	—	
MD2218AF, MD2219AF		6.0	—	—	
Collector Cutoff Current ($V_{CE} = 50 \text{ Vdc}$, $V_{EB(off)} = 3.0 \text{ Vdc}$)	I_{CEV}				nAdc
MD2218,F, MD2219,F, MQ2218,A, MD2218A,AF, MD2219A,AF, MQ2219,A		20 15	— —	— —	
Base Cutoff Current ($V_{CE} = 50 \text{ Vdc}$, $V_{EB(off)} = 3.0 \text{ Vdc}$)	I_{BL}	30	—	—	nAdc

ON CHARACTERISTICS(2)

DC Current Gain ($I_C = 0.1 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}				—
MD2218,A,F,AF, MQ2218,A MD2219,A,F,AF, MQ2219,A		20 35	50 45	— —	
($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)					
MD2218,A,F,AF, MQ2218,A MD2219,A,F,AF, MQ2219,A		25 50	55 55	— —	
($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)					
MD2218,A,F,AF, MQ2218,A MD2219,A,F,AF, MQ2219,A		35 75	65 85	— —	
($I_C = 150 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)					
MD2218,A,F,AF, MQ2218,A MD2219,A,F,AF, MQ2219,A		20 50	65 65	— —	
($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)					
MD2218,AF,AF, MQ2218,A MD2219,A,F,AF, MQ2219,A		40 100	30 120	120 300	
($I_C = 300 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)					
MD2218,A, MQ2218,A MD2219,A, MQ2219,A		25 30	75 75	— —	
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	$V_{CE(sat)}$				Vdc
MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	0.2	0.4	
MD2218AF, MD2219AF		—	—	0.3	
($I_C = 300 \text{ mAdc}$, $I_B = 30 \text{ mAdc}$)					
MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	0.35	1.2	
MD2218AF, MD2219AF		—	—	0.9	
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	$V_{BE(sat)}$				Vdc
MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		0.6	0.95	1.3	
MD2218AF, MD2219AF		0.6	1.0	1.2	
($I_C = 300 \text{ mAdc}$, $I_B = 30 \text{ mAdc}$)					
MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	—	2.0	
MD2218AF, MD2219AF		—	—	1.8	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	200	250	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	3.5	8.0	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}				pF
MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	15	20	
MD2218AF, MD2219AF		—	18	25	

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MD2218,A,F,AF, MD2219,A,F,AF, MQ2218,A, MQ2219,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS						
Delay Time	$(V_{CC} = 30\text{ Vdc}, I_C = 150\text{ mAdc}, V_{BE(off)} = 0.5\text{ Vdc}, I_{B1} = 15\text{ mAdc})$ MD2218,F, MD2219,F MD2218A,AF, MD2219A,AF	t_d	—	—	20	μs
			—	—	15	
Rise Time	MD2218,F, MD2219,F MD2218A,AF, MD2219A,AF	t_r	—	—	40	μs
			—	—	30	
Storage Time	$(V_{CC} = 30\text{ Vdc}, I_C = 150\text{ mAdc}, I_{B1} = I_{B2} = 15\text{ mAdc})$ MD2218,F, MD2219,F MD2218A,AF, MD2219A,AF	t_s	—	—	280	μs
			—	—	250	
Fall Time	MD2218,F, MD2219,F MD2218A,AF, MD2219A,AF	t_f	—	—	70	μs
			—	—	60	

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

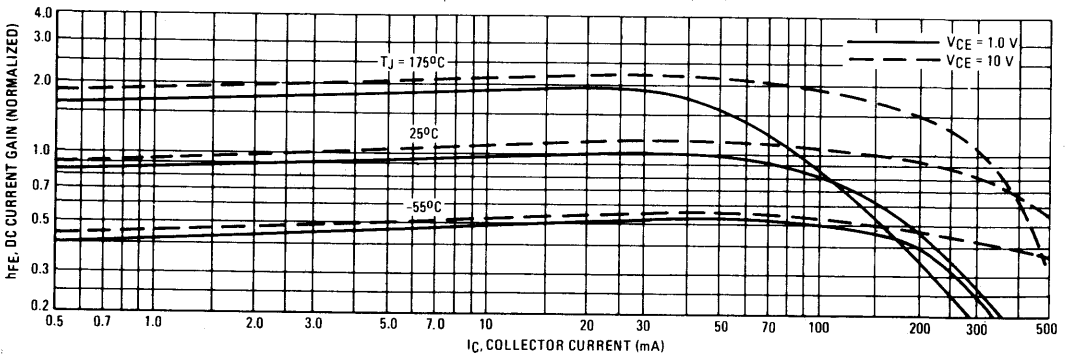


FIGURE 2 – "ON" VOLTAGES

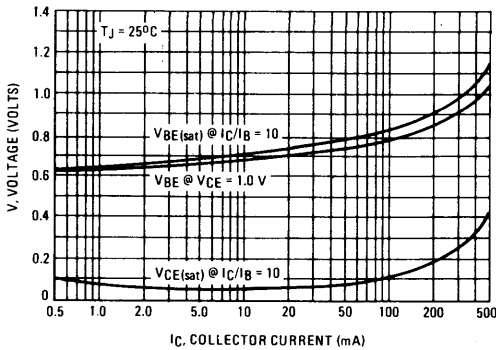
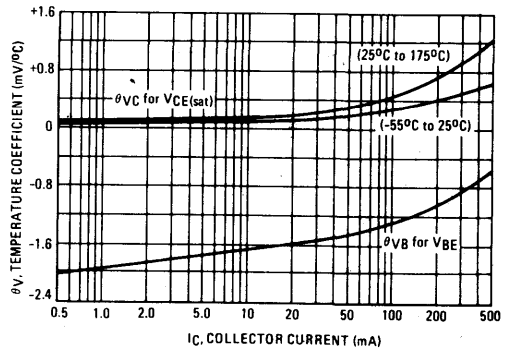


FIGURE 3 – TEMPERATURE COEFFICIENTS



MD2218,A,F,AF, MD2219,A,F,AF, MQ2218,A, MQ2219,A

NOISE FIGURE

($V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$)

FIGURE 4 - FREQUENCY EFFECTS

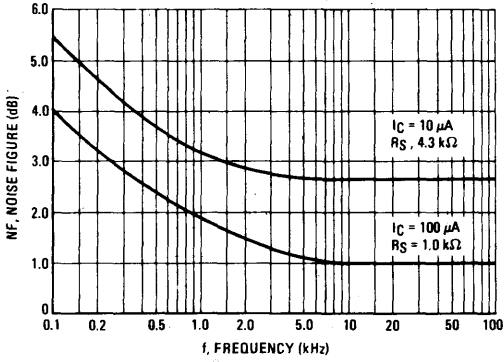


FIGURE 5 - SOURCE RESISTANCE EFFECTS

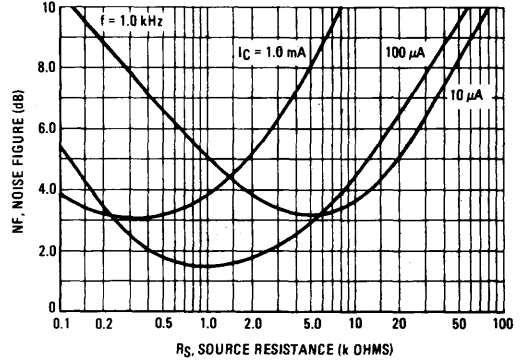


FIGURE 6 - CURRENT-GAIN-BANDWIDTH PRODUCT

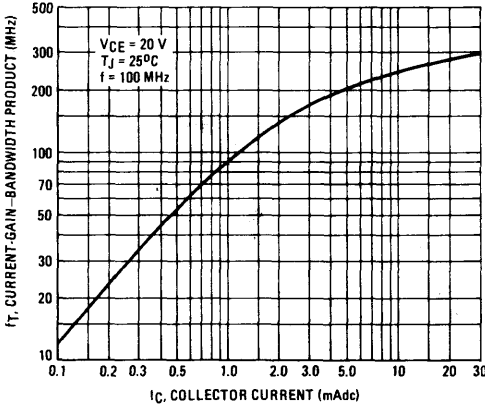
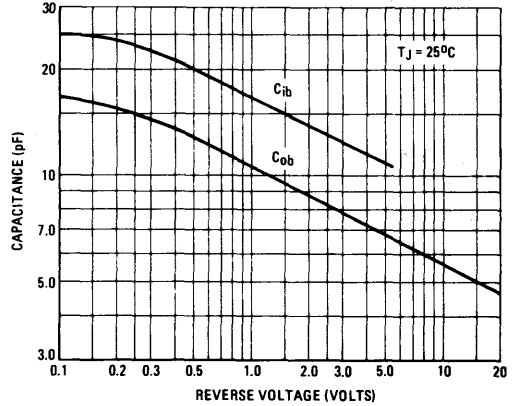


FIGURE 7 - CAPACITANCES



SWITCHING TIME CHARACTERISTICS

FIGURE 8 - TURN-ON TIME

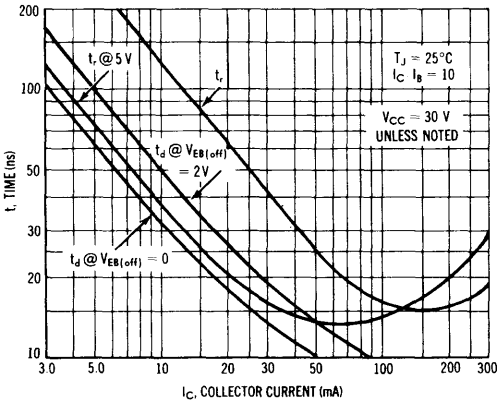
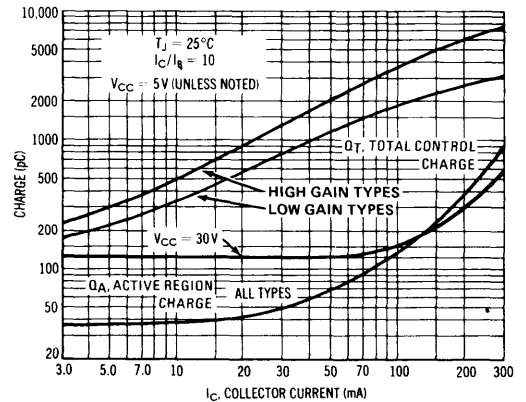


FIGURE 9 - CHARGE DATA



MD2218,A,F,AF, MD2219,A,F,AF, MQ2218,A, MQ2219,A

FIGURE 10 – TURN-OFF BEHAVIOR

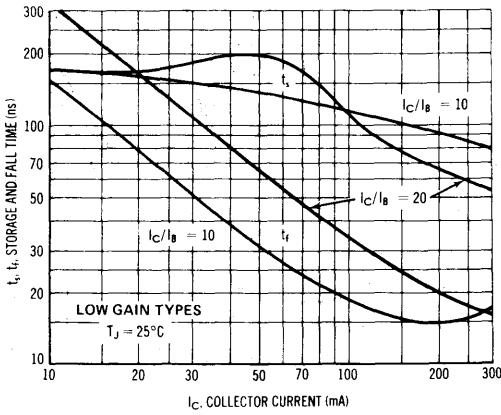


FIGURE 11 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

GENERATOR RISE TIME ≤ 2.0 ns
 PW ≤ 200 ns
 DUTY CYCLE = 2.0%

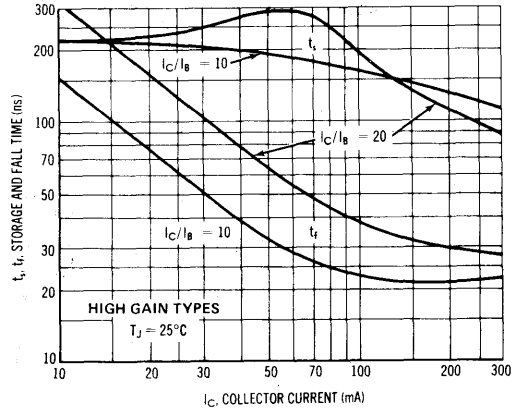
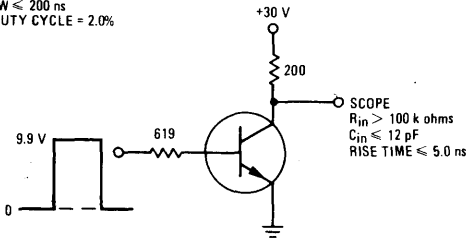
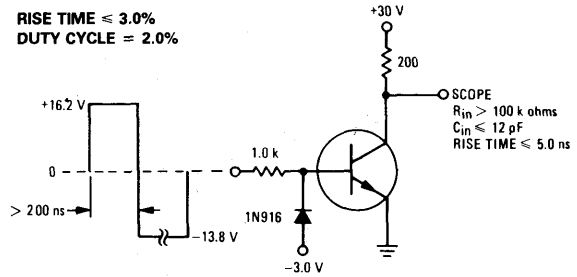


FIGURE 12 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT

RISE TIME $\leq 3.0\%$
 DUTY CYCLE = 2.0%



5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	15		Vdc
Collector-Base Voltage	V _{CBO}	40		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	500		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ T _A = 25°C	P _D			mW
MD2369,A,B		550	600	
MD2369F,AF,BF		350	400	
MQ2369		400	600	
Derate above 25°C				mW/°C
MD2369,A,B		3.14	3.42	
MD2369F,AF,BF		2.0	2.28	
MQ2369		2.28	3.42	
Total Device Dissipation @ T _C = 25°C	P _D			Watts
MD2369,A,B		1.4	2.0	
MD2369F,AF,BF		0.7	1.4	
MQ2369		0.7	2.8	
Derate above 25°C				mW/°C
MD2369,A,B		8.0	11.4	
MD2369F,AF,BF		4.0	8.0	
MQ2369		4.0	16	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200		°C

MD2369,A,B

MD2369F,AF,BF

MQ2369

MD2369,A,B
CASE 654-07, STYLE 1

MD2369F,AF,BF
CASE 610A-04, STYLE 1

MQ2369
CASE 607-04, STYLE 1

DUAL GENERAL PURPOSE TRANSISTOR

NPN SILICON

5

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	R _{θJC}			°C/W
		MD2369,A,B MD2369F,AF,BF MQ2369	125 250 250	87.5 125 62.6
Thermal Resistance, Junction to Ambient	R _{θJA} (1)			°C/W
		MD2369,A,B MD2369F,AF,BF MQ2369	319 500 438	292 438 292
			Junction to Ambient	Junction to Case
Coupling Factor		MD2369,A,B MD2369F,AF,BF MQ2369 (Q1-Q2) (Q1-Q3 or Q1-Q4)	83 75 57 55	40 0 0 0

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	15	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 20 Vdc, I _E = 0) (V _{CB} = 20 Vdc, I _E = 0, T _A = +150°C)	I _{CBO}	—	—	0.03 30	μAdc

ON CHARACTERISTICS(2)

DC Current Gain (I _C = 10 mAdc, V _{CE} = 1.0 Vdc) (I _C = 10 mAdc, V _{CE} = 1.0 Vdc, T _A = -55°C)	h _{FE}	40 20	95 —	140 —	—
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MD2369,A,B, MD2369F,AF,BF, MQ2369

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	0.7	—	0.85	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	500	800	—	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{obo}	—	—	4.0	pF
Input Capacitance ($V_{BE} = 1.0\text{ Vdc}$, $I_C = 0$, $f = 100\text{ MHz}$)	C_{ibo}	—	—	4.0	pF

SWITCHING CHARACTERISTICS

Storage Time ($V_{CC} = 10\text{ Vdc}$, $I_C = I_{B1} = I_{B2} = 10\text{ mAdc}$)	t_s	—	—	13	ns
Turn-On Time ($V_{CC} = 3.0\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$)	t_{on}	—	—	15	ns
Turn-Off Time ($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$, $I_{B2} = 1.5\text{ mAdc}$)	t_{off}	—	—	20	ns

MATCHING CHARACTERISTICS

DC Current Gain Ratio(3) ($I_C = 3.0\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	MD2369A, MD2369AF MD2369B, MD2369BF	h_{FE1}/h_{FE2}	0.9 0.8	— —	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 3.0\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	MD2369A, MD2369AF MD2369B, MD2369BF	$ V_{BE1} - V_{BE2} $	— —	— —	5.0 10	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 3.0\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55\text{ to } +125^\circ\text{C}$)	MD2369A, MD2369AF MD2369B, MD2369BF	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	— —	— —	10 20	$\mu\text{V}/^\circ\text{C}$

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(3) The lowest h_{FE} reading is taken as h_{FE1} for this test.

FIGURE 1 — STORAGE TIME TEST CIRCUIT

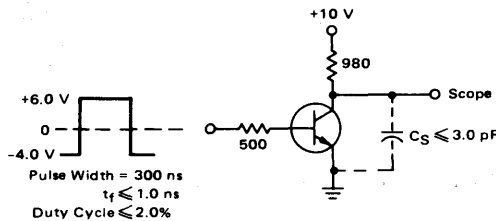


FIGURE 2 — TURN-ON TIME

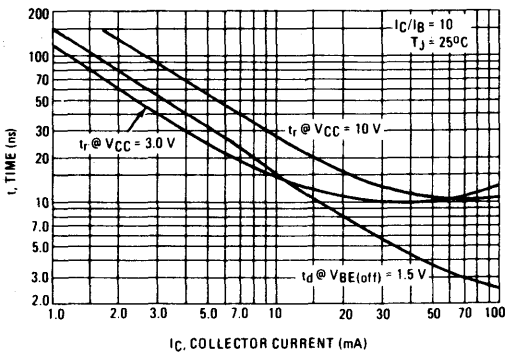
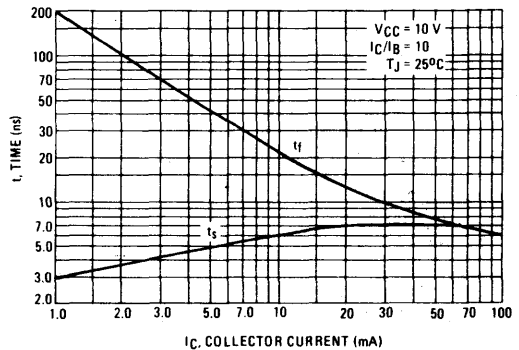


FIGURE 3 — TURN-OFF TIME



MD2369,A,B, MD2369F,AF,BF, MQ2369

FIGURE 4 - TURN-ON TEST CIRCUIT

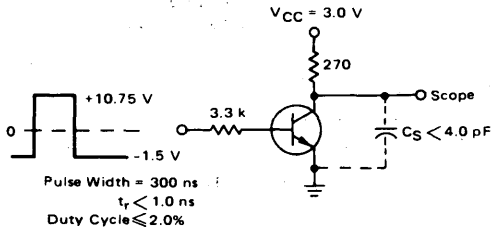


FIGURE 5 - TURN-OFF TEST CIRCUIT

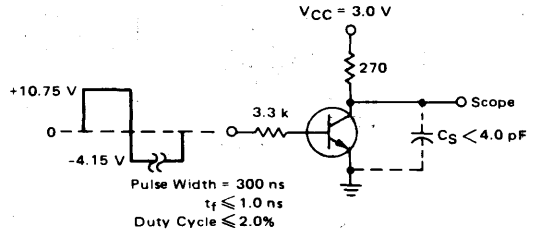


FIGURE 6 - CAPACITANCE

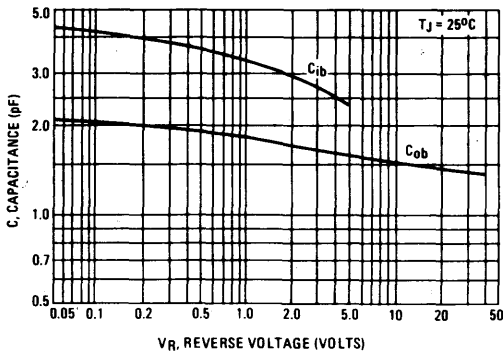


FIGURE 7 - CURRENT-GAIN-BANDWIDTH PRODUCT

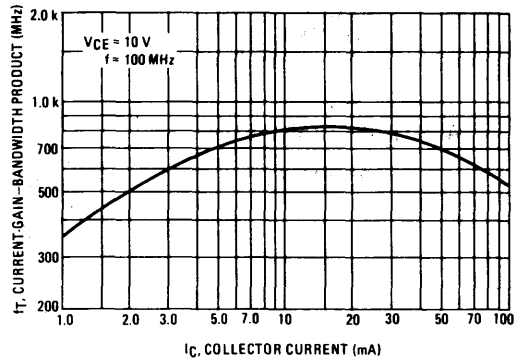


FIGURE 8 - DC CURRENT GAIN

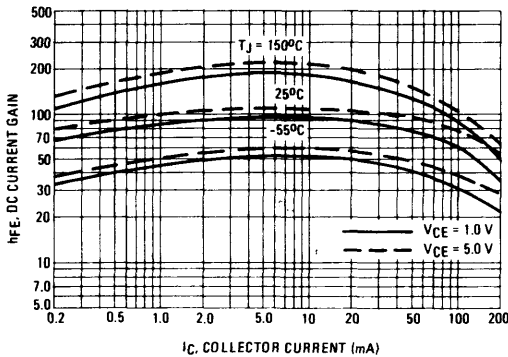


FIGURE 9 - "ON" VOLTAGES

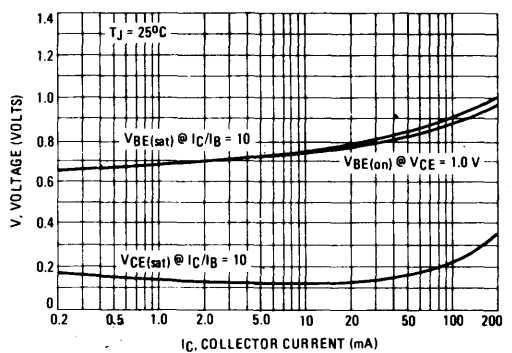


FIGURE 10 - COLLECTOR SATURATION REGION

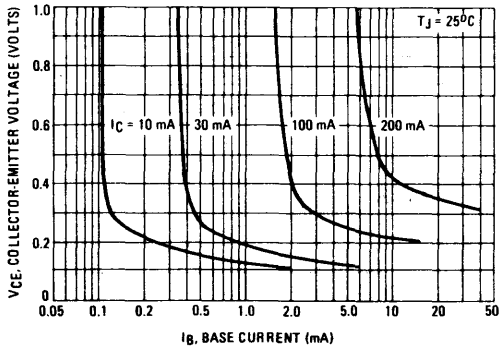
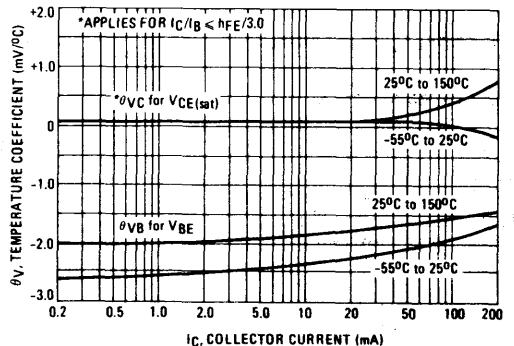


FIGURE 11 - TEMPERATURE COEFFICIENTS



MD2904,A,F,AF MD2905,A,F,AF MQ2904, MQ2905A

MD2904,A
MD2905,A
CASE 654-07, STYLE 1

MD2904F,AF
MD2905F,AF
CASE 610A-04, STYLE 1

MQ2904
MQ2905A
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MD2904,F MD2905,F MQ2904	MD2904A,AF MD2905A,AF MQ2905A	Unit
		One Die	All Die Equal Power	
Collector-Emitter Voltage	V _{CEO}	40	60	Vdc
Collector-Base Voltage	V _{CBO}	60		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	600		mA
Total Device Dissipation @ T _A = 25°C	P _D			mW
MD2904,A, MD2905,A		575	625	mW/°C
MD2904F,AF, MD2905F,AF		350	400	
MQ2904, MQ2905A		400	600	
Derate above 25°C				
MD2904,A, MD2905,A		3.29	3.57	
MD2904,F,AF, MD2905F,AF		2.0	2.28	
MQ2904, MQ2905A		2.28	3.42	
Total Device Dissipation @ T _C = 25°C	P _D			Watts
MD2904,A, MD2905,A		1.8	2.5	mW/°C
MD2904F,AF, MD2905F,AF		1.0	2.0	
MQ2904, MQ2905A		0.9	3.6	
Derate above 25°C				
MD2904,A, MD2905,A		10.3	14.3	
MD2904F,AF, MD2905F,AF		5.71	11.4	
MQ2904, MQ2905A		5.13	20.5	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case MD2904,A, MD2905,A MD2904F,AF, MD2905F,AF MQ2904, MQ2905A	R _{θJC}	97 175 195	70 87.5 48.8	°C/W
Thermal Resistance, Junction to Ambient MD2904,A, MD2905,A MD2904F,AF, MD2905F,AF MQ2904, MQ2905A	R _{θJA} (1)	304 500 438	280 438 292	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factor MD2904,A, MD2905,A MD2904F,AF, MD2905F,AF MQ2904, MQ2905A (Q1-Q2) (Q1-Q3 or Q1-Q4)		84 75 57 55	44 0 0 0	%

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mA, I _B = 0)	V _{(BR)CEO}	40 60	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA, I _E = 0)	V _{(BR)CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	— —	— —	0.020 30	μA

MD2904,A,F,AF, MD2905,A,F,AF, MQ2904, MQ2905A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	30	nAdc

ON CHARACTERISTICS(2)

DC Current Gain ($I_C = 0.1\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	MD2904 MD2904A MD2905 MD2905A	hFE	20 40 35 75	50 70 70 150	— — — —	—
($I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	MD2904 MD2904A MD2905 MD2905A		25 40 50 100	75 75 100 175	— — — —	
($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	MD2904 MD2904A MD2905 MD2905A		35 40 75 100	90 90 110 200	— — — —	
($I_C = 150\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	MD2904,A, MD2905,A		40 100	90 200	120 300	
($I_C = 500\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	MD2904 MD2904A MD2905 MD2905A		20 40 30 50	60 80 130 150	— — — —	
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$)		$V_{CE(sat)}$	— —	0.25 0.5	0.4 1.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$)		$V_{BE(sat)}$	— —	0.88 1.0	1.3 2.6	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(3) ($I_C = 50\text{ mAdc}, V_{CE} = 20\text{ Vdc}, f = 100\text{ MHz}$)	f_T	200	320	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 100\text{ kHz}$)	C_{obo}	—	5.8	8.0	pF
Input Capacitance ($V_{BE} = 2.0\text{ Vdc}, I_C = 0, f = 100\text{ kHz}$)	C_{ibo}	—	16	30	pF

SWITCHING CHARACTERISTICS

Turn-On Time	$(V_{CC} = 30\text{ Vdc}, V_{BE} = 0.5\text{ Vdc}, I_C = 150\text{ mAdc}, I_{B1} = 15\text{ mAdc})$	t_{on}	—	—	45	ns
Delay Time		t_d	—	—	12	ns
Rise Time		t_r	—	—	35	ns
Turn-Off Time	$(V_{CC} = 30\text{ Vdc}, I_C = 150\text{ mAdc}, I_{B1} = I_{B2} = 15\text{ mAdc})$	t_{off}	—	—	130	ns
Storage Time		t_s	—	—	100	ns
Fall Time		t_f	—	—	40	ns

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(3) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 - DC CURRENT GAIN

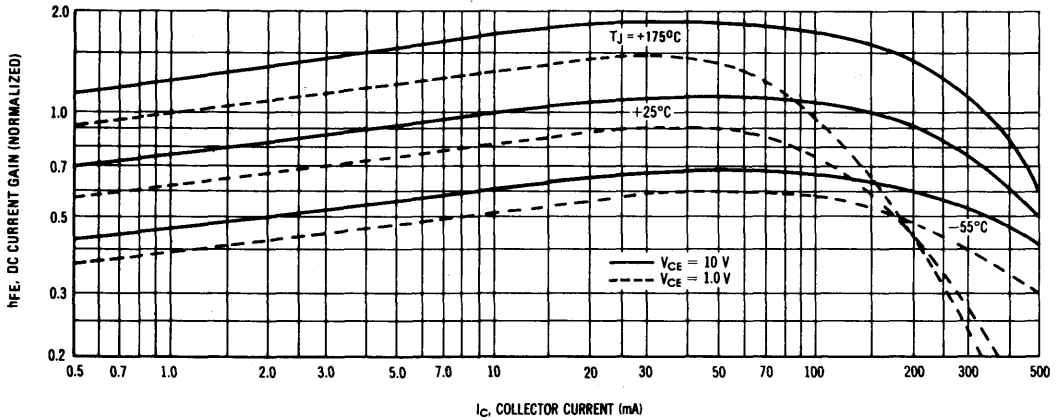


FIGURE 2 - "ON" VOLTAGES

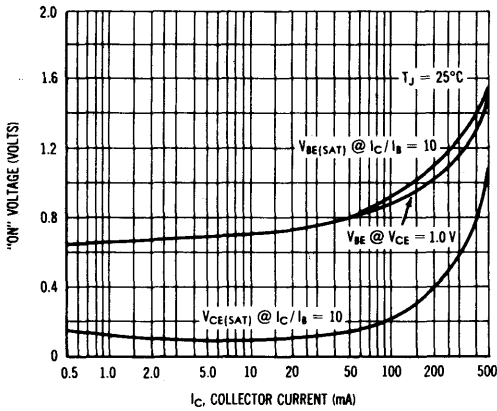
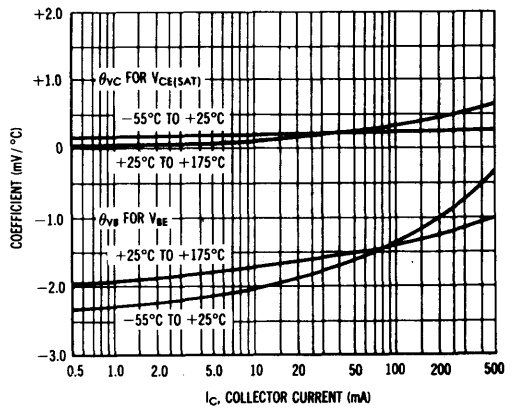


FIGURE 3 - TEMPERATURE COEFFICIENTS



NOISE FIGURE

$V_{CE} = 10\text{ V}$, $T_A = 25^\circ\text{C}$

FIGURE 4 - FREQUENCY EFFECTS

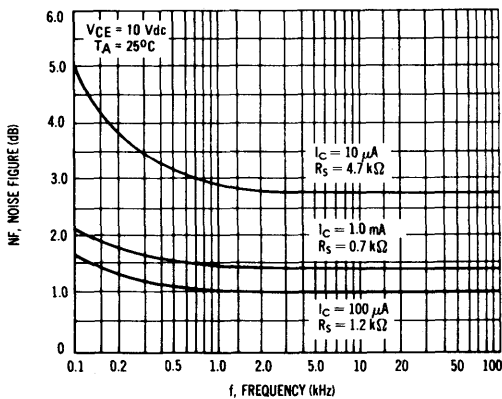
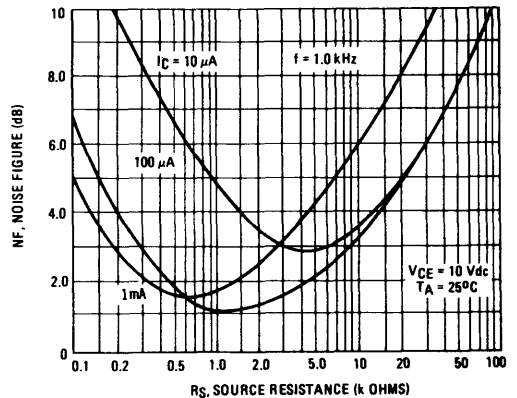


FIGURE 5 - SOURCE RESISTANCE EFFECTS



MD2904,A,F,AF, MD2905,A,F,AF, MQ2904, MQ2905A

FIGURE 6 - CURRENT-GAIN BANDWIDTH PRODUCT

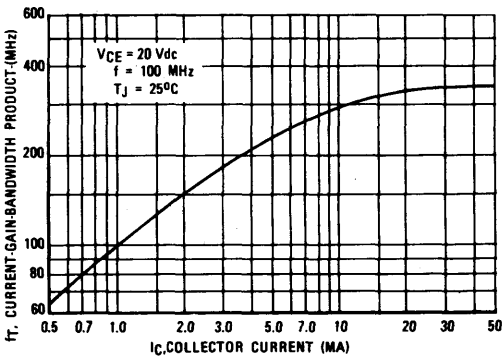


FIGURE 7 - CAPACITANCE

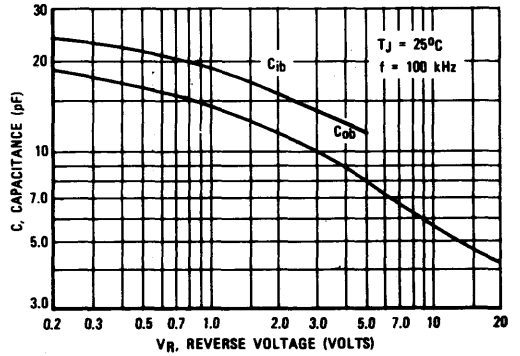


FIGURE 8 - TURN ON TIME

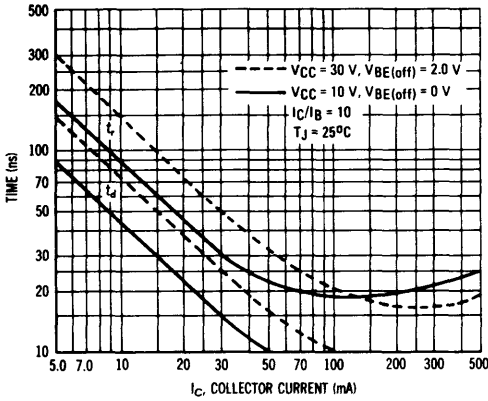


FIGURE 9 - CHARGE DATA

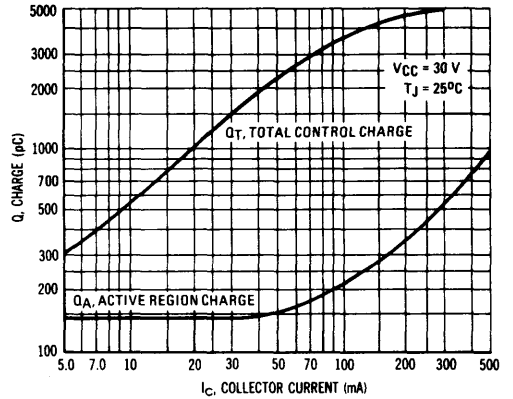


FIGURE 10 - STORAGE TIME

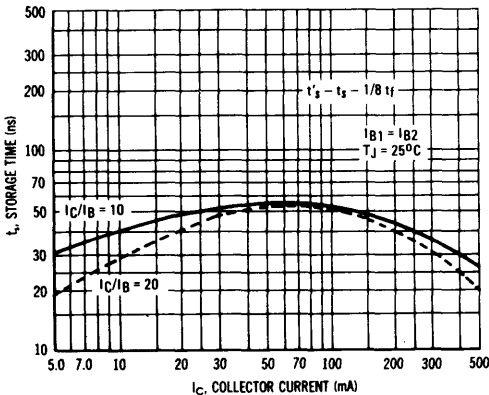
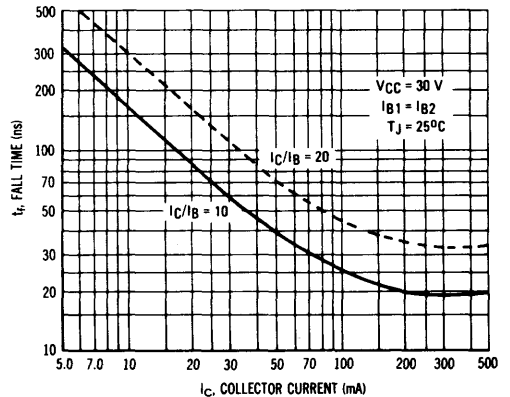


FIGURE 11 - FALL TIME



MD2904,A,F,AF, MD2905,A,F,AF, MQ2904, MQ2905A

FIGURE 12 - DELAY AND RISE TIME TEST CIRCUIT

P.W. > 200 ns
 $t_r < 2.0$ ns
Duty Cycle < 2.0%

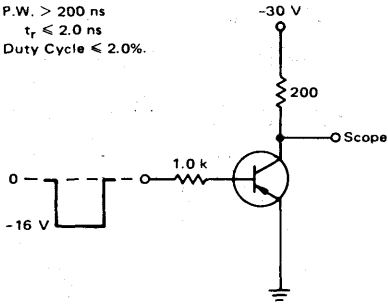
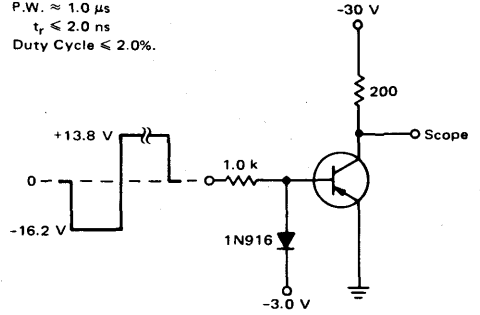


FIGURE 13 - STORAGE AND FALL TIME TEST CIRCUIT

P.W. ≈ 1.0 μ s
 $t_r < 2.0$ ns
Duty Cycle < 2.0%



5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	40		Vdc
Collector-Base Voltage	V _{CBO}	50		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	50		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ T _A = 25°C	P _D			mW
MD3250,A, MD3251,A		575	625	
MD3250F,AF, MD3251F,AF		350	400	
MQ3251		400	600	
Derate above 25°C				mW/°C
MD3250,A, MD3251,A		3.29	3.57	
MD3250F,AF, MD3251F,AF		2.0	2.28	
MQ3251		2.28	3.42	
Total Device Dissipation @ T _C = 25°C	P _D			Watts
MD3250,A, MD3251,A		1.8	2.5	
MD3250F,AF, MD3251F,AF		1.0	2.0	
MQ3251		0.9	3.6	
Derate above 25°C				mW/°C
MD3250,A, MD3251,A		10.3	14.3	
MD3250F,AF, MD3251F,AF		5.71	11.4	
MQ3251		5.13	20.5	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to +200		°C

**MD3250,A,F,AF
MD3251,A,F,AF
MQ3251**

**MD3250,A
MD3251,A
CASE 654-07, STYLE 1**

**MD3250F,AF
MD3251F,AF
CASE 610A-04, STYLE 1**

**MQ3251
CASE 607-04, STYLE 1**

**DUAL
AMPLIFIER TRANSISTOR**

PNP SILICON

5

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	R _{θJC}			°C/W
MD3251,A, MD3251,A		97	70	
MD3250F,AF, MD3251F,AF		175	87.5	
MQ3251		195	48.8	
Thermal Resistance, Junction to Ambient	R _{θJA} (1)			°C/W
MD3250,A, MD3251,A		304	280	
MD3250F,AF, MD3251F,AF		500	438	
MQ3251		438	292	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD3250,A, MD3251,A		84	44	
MD3250F,AF, MD3251F,AF		75	0	
MQ3251 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0)	I _{CBO}	—	—	10	nAdc
(V _{CB} = 40 Vdc, I _E = 0, T _A = 150°C)		—	—	10	μAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	10	nAdc

MD3250,A,F,AF, MD3251,A,F,AF, MQ3251

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
ON CHARACTERISTICS(2)						
DC Current Gain ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$)	MD3250,A,F,AF MD3251,A,F,AF	25 50	75 100	— —	—	
($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$)	MD3250,A,F,AF MD3251,A,F,AF MQ3251	50 80 80	82 170 170	150 300 —		
($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$)	MD3250,A,F,AF MD3251,A,F,AF	25 50	35 75	— —		
($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	MD3250,A,F,AF MD3251,A,F,AF MQ3251	50 100 100	87 180 180	150 300 —		
($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	MD3250,A,F,AF MD3251,A,F,AF MQ3251	50 100 100	92 190 190	— — 300		
($I_C = 50 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	MD3250,A,F,AF MD3251,A,F,AF MQ3251	15 30 30	50 90 90	— — —		
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)		$V_{CE(sat)}$	— —	0.11 0.18	0.25 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)		$V_{BE(sat)}$	0.6 —	0.78 0.88	0.9 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	MD3250,A,F,AF MD3251,A,F,AF MQ3251	f_T	200 250 300	600 600 600	— — —	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)		C_{obo}	—	2.5	6.0	pF
Input Capacitance ($V_{BE} = 1.0 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)		C_{ibo}	—	6.0	8.0	pF
MATCHING CHARACTERISTICS (MD3250,A,F,AF & MD3251,A,F,AF ONLY)						
DC Current Gain Ratio(3) ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)		h_{FE1}/h_{FE2}	0.9 0.9	— —	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)		$ V_{BE1} - V_{BE2} $	— — —	— — —	3.0 5.0 5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55$ to $+25^\circ\text{C}$) ($I_C = 100 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = +25$ to $+125^\circ\text{C}$)		$\Delta V_{BE1} - V_{BE2} $	— —	— —	0.8 1.0	mVdc

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD3250,A,F,AF, MD3251,A,F,AF, MQ3251

FIGURE 1 - CAPACITANCE

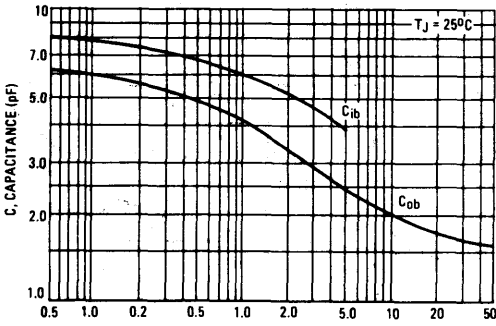
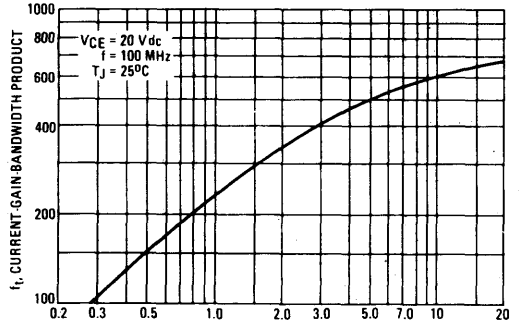


FIGURE 2 - CURRENT-GAIN BANDWIDTH PRODUCT



NOISE FIGURE VARIATIONS

($V_{CE} = 6.0\text{ V}$, $T_A = 25^\circ\text{C}$)

FIGURE 3 - EFFECTS OF FREQUENCY

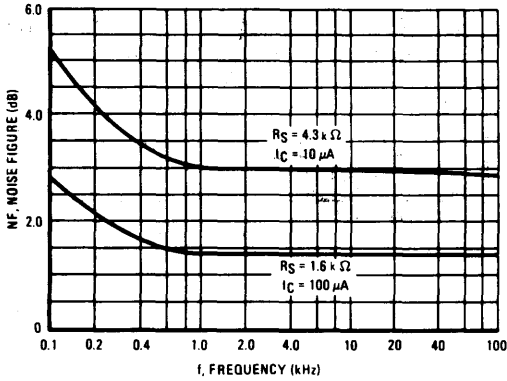


FIGURE 4 - EFFECTS OF SOURCE RESISTANCE

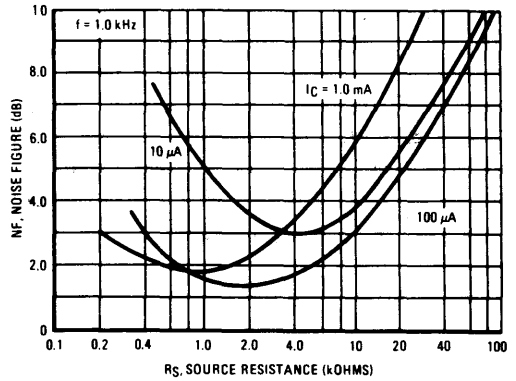
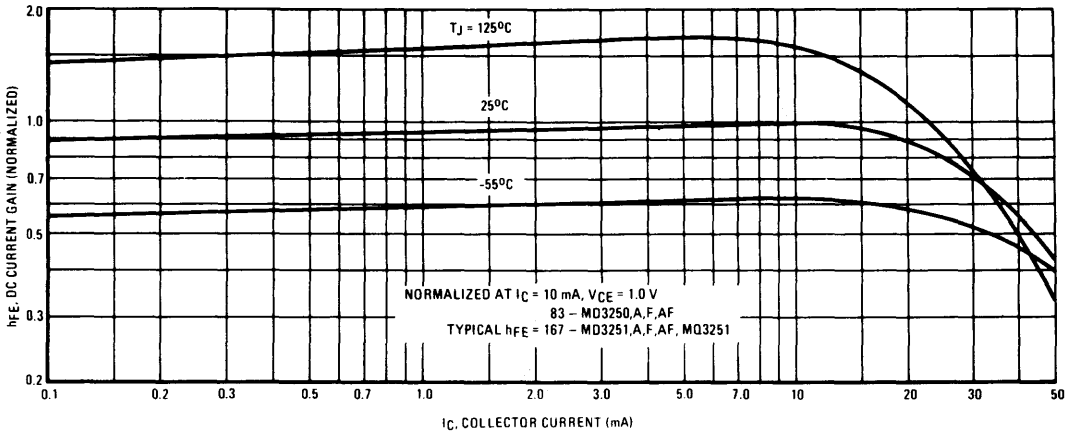


FIGURE 5 - DC CURRENT GAIN



MD3250,A,F,AF, MD3251,A,F,AF, MQ3251

FIGURE 6 – "ON" VOLTAGE

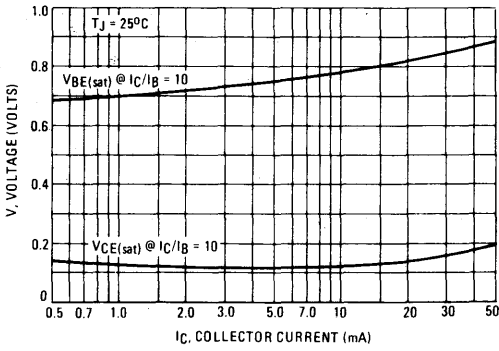
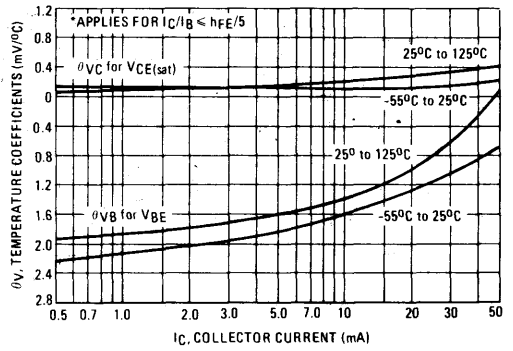


FIGURE 7 – TEMPERATURE COEFFICIENTS

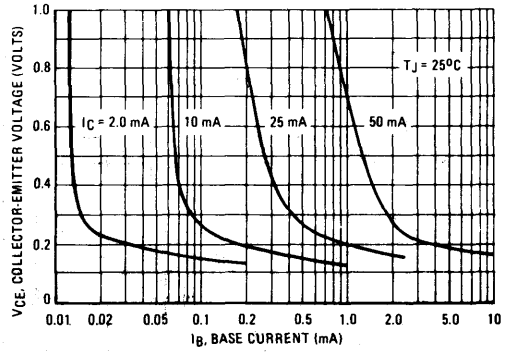
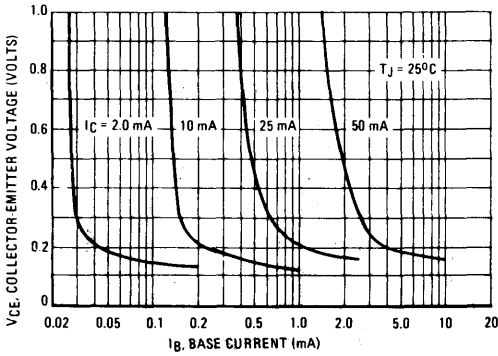


5

MD3250

FIGURE 8 – COLLECTOR SATURATION REGION

MD3251, MQ3251



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	40		Vdc
Collector-Base Voltage	V _{CBO}	40		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	1.5		Adc
		One Die	All Die Equal Power	
Total Device Dissipation @ T _A = 25°C	P _D			mW
MD3467		600	650	
MD3467F		350	400	
Derate above 25°C		400	600	mW/°C
MD3467		3.42	3.7	
MD3467F		2.0	2.28	
MQ3467		2.28	3.42	
Total Device Dissipation @ T _C = 25°C	P _D			Watts
MD3467		2.1	3.0	
MD3467F		1.25	2.5	
Derate above 25°C		1.0	4.0	mW/°C
MD3467		12	17.2	
MD3467F		7.15	14.3	
MQ3467		5.71	22.8	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

**MD3467,F
MQ3467**

**MD3467
CASE 654-07, STYLE 1
MD3467F
CASE 610A-04, STYLE 1
MQ3467
CASE 607-04, STYLE 1**

**DUAL
AMPLIFIER TRANSISTOR**

PNP SILICON

5

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	58.3	°C/W
MD3467		140	70	
MD3467F		175	43.8	
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	292	270	°C/W
MD3467		500	438	
MD3467F		438	292	
Coupling Factors		Junction to Ambient	Junction to Case	%
MD3467	85	40		
MD3467F	75	0		
MQ3467 (Q1-Q2)	57	0		
(Q1-Q3 or Q1-Q4)	55	0		

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mA _{dc} , I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{(BR)CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0, T _A = 100°C)	I _{CBO}	—	—	10	μA _{dc}
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	100	nA _{dc}

MD3467,F, MQ3467

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
ON CHARACTERISTICS						
DC Current Gain ($I_C = 500 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	20	—	—	—	
Collector-Emitter Saturation Voltage ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.32	0.5	Vdc	
Base-Emitter Saturation Voltage ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.95	1.2	Vdc	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$; $f = 100 \text{ MHz}$)	f_T	150	220	—	MHz	
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	C_{obo}	—	8.5	20	pF	
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$)	C_{ibo}	—	22	80	pF	
SWITCHING CHARACTERISTICS						
Delay Time	($V_{CC} = 30 \text{ Vdc}$, $V_{BE} = 2.0 \text{ Vdc}$, $I_C = 500 \text{ mAdc}$, $I_{B1} = 50 \text{ mAdc}$)	t_d	—	7.0	10	ns
Rise Time		t_r	—	17	30	ns
Storage Time	($V_{CC} = 30 \text{ Vdc}$, $I_C = 500 \text{ mAdc}$, $I_{B1} = I_{B2} = 50 \text{ mAdc}$)	t_s	—	58	80	ns
Fall Time		t_f	—	14	30	ns

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 — DC CURRENT GAIN

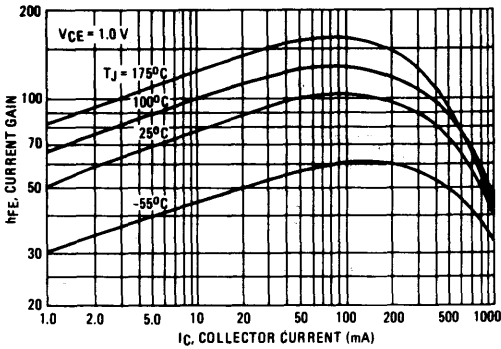


FIGURE 2 — COLLECTOR SATURATION REGION

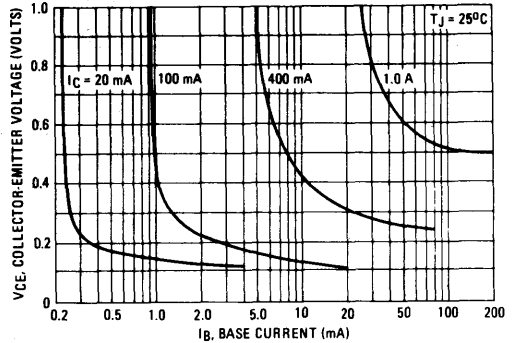


FIGURE 3 — "ON" VOLTAGE

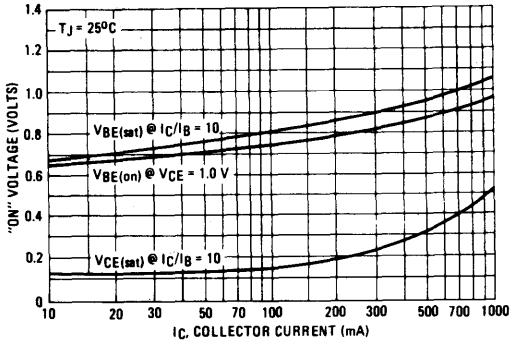


FIGURE 4 — TEMPERATURE COEFFICIENTS

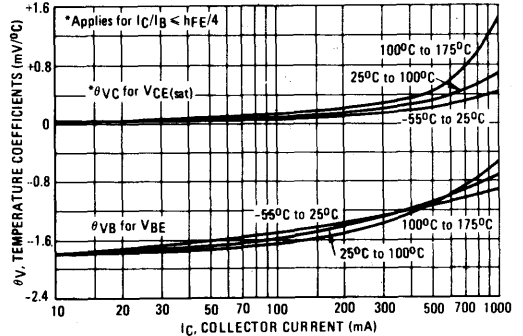


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

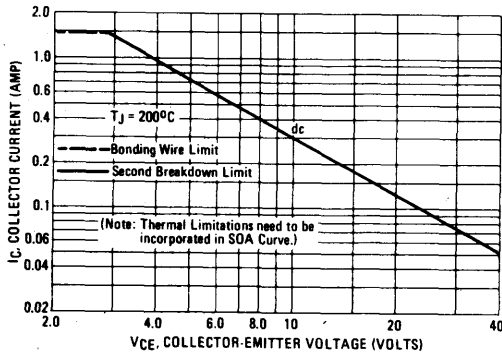


FIGURE 6 – TURN-ON TIME

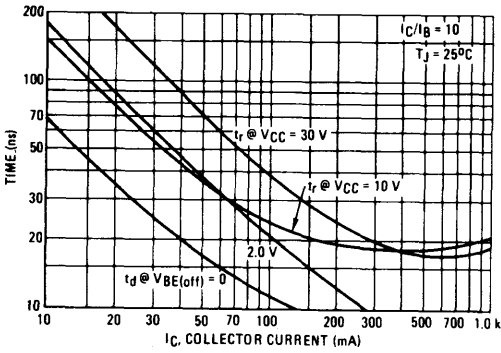


FIGURE 7 – RISE AND FALL TIME

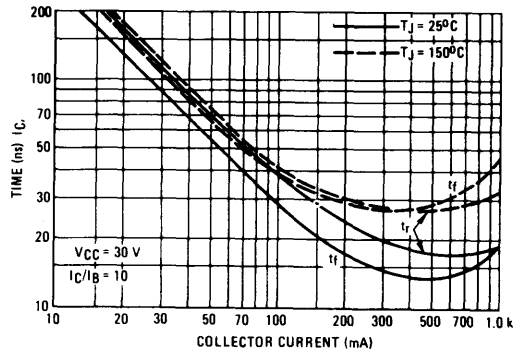


FIGURE 8 – STORAGE TIME

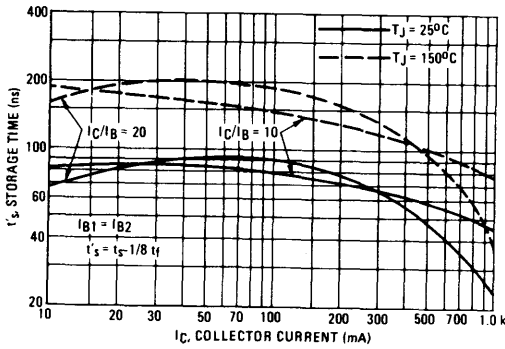
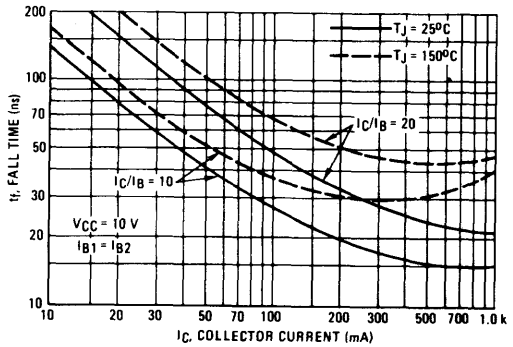


FIGURE 9 – FALL TIME



MD3467,F, MQ3467

FIGURE 10 – SWITCHING TIME TEST CIRCUIT

$I_C = 500 \text{ mA}$
 $I_{B1} = I_{B2} = 50 \text{ mA}$
 Rise Time $\leq 5 \text{ ns}$
 Pulse Width = $0.5 \mu\text{s}$
 Duty Cycle = 2%

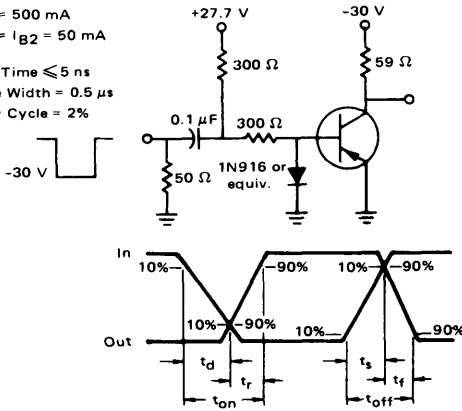
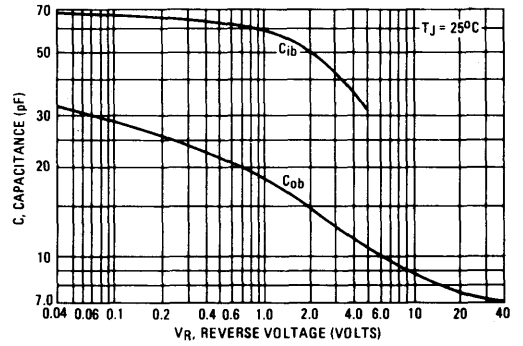


FIGURE 11 – CAPACITANCE



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	65		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ MD3725 MD3725F MQ3725	P_D	600 350 400	650 400 600	mW
Derate above 25°C MD3725 MD3725F MQ3725		3.42 2.0 2.28	3.7 2.28 3.42	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ MD3725 MD3725F MQ3725	P_D	2.1 1.25 1.0	3.0 2.5 4.0	Watts
Derate above 25°C MD3725 MD3725F MQ3725		12 7.15 5.71	17.2 14.3 22.8	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

MD3725,F MQ3725

MD3725
CASE 654-07, STYLE 1

MD3725F
CASE 610A-04, STYLE 1

MQ3725
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

5

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	MD3725 MD3725F MQ3725	83.3 140 175	58.3 70 43.8 $^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$	MD3725 MD3725F MQ3725	292 500 433	270 438 292 $^\circ\text{C/W}$
			Junction to Ambient	Junction to Case
Coupling Factor		MD3725 MD3725F MQ3725 (Q1-Q2) (Q1-Q3, Q1-Q4)	85 75 57 55	40 0 0 0 %

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{Adc}, V_{BE} = 0$)	$V_{(BR)CES}$	65	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 40 \text{ Vdc}, I_E = 0$) ($V_{CB} = 40 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$)	I_{CBO}	—	0.12	1.7	μAdc μAdc

MD3765,F, MQ3725

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)					
DC Current Gain ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	50 30	—	150 —	—
Collector-Emitter Saturation Voltage ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)	$V_{CE(sat)}$	—	0.19 0.30	0.26 0.45	Vdc
Base-Emitter Saturation Voltage ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)	$V_{BE(sat)}$	—	—	0.86 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	—	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{obo}	—	—	10	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ibo}	—	—	65	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30\text{ Vdc}$, $I_C = 500\text{ mAdc}$, $I_{B1} = 50\text{ mAdc}$, $V_{BE(off)} = 3.8\text{ Vdc}$)	t_{on}	—	20	45	ns
Turn-Off Time ($V_{CC} = 30\text{ Vdc}$, $I_C = 500\text{ mAdc}$, $I_{B1} = I_{B2} = 50\text{ mAdc}$)	t_{off}	—	50	75	ns

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

TYPICAL DC CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

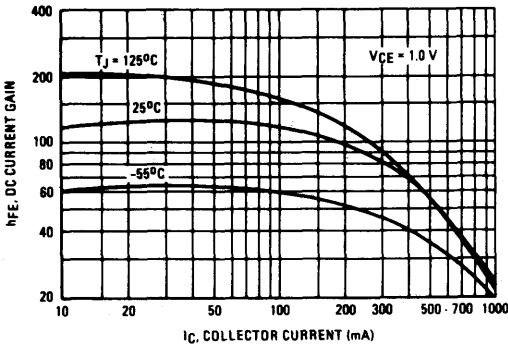


FIGURE 2 — "ON" VOLTAGES

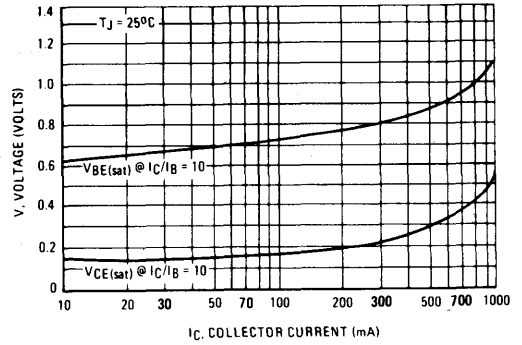


FIGURE 3 — COLLECTOR SATURATION REGION

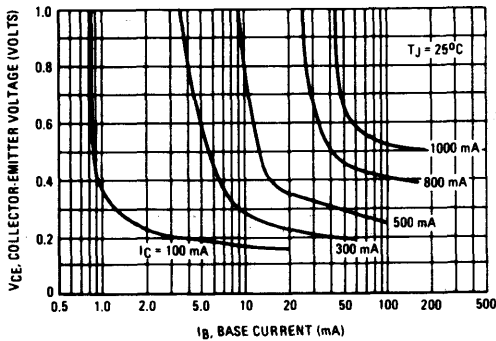
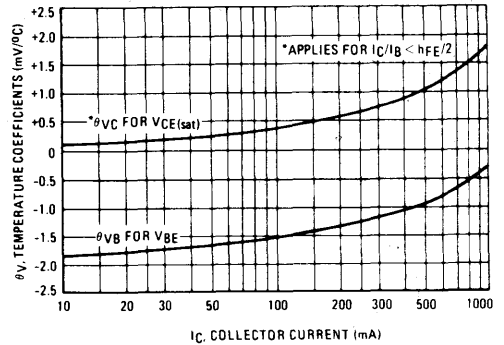


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 5 - CURRENT-GAIN - BANDWIDTH PRODUCT

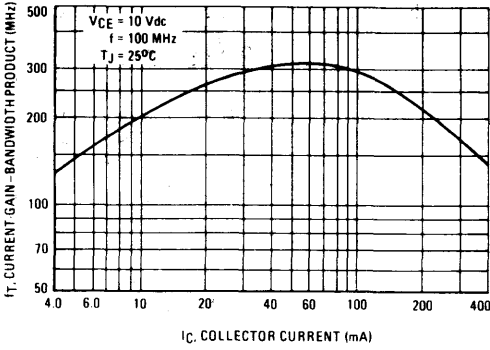


FIGURE 6 - CAPACITANCE

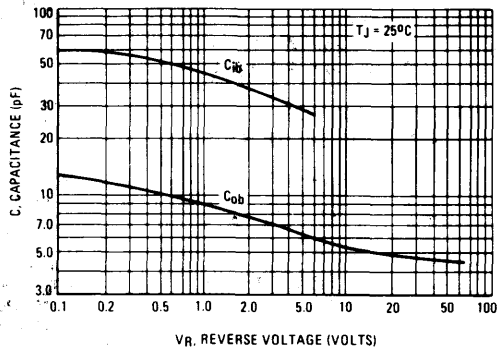


FIGURE 7 - TURN-ON TIME

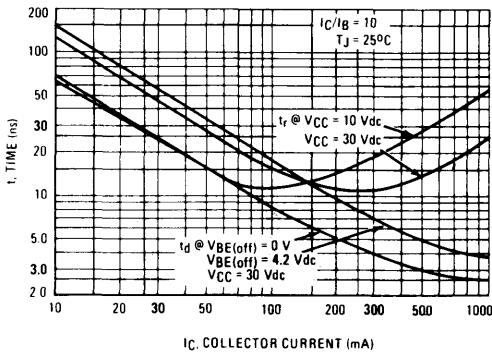


FIGURE 8 - TURN-OFF TIME

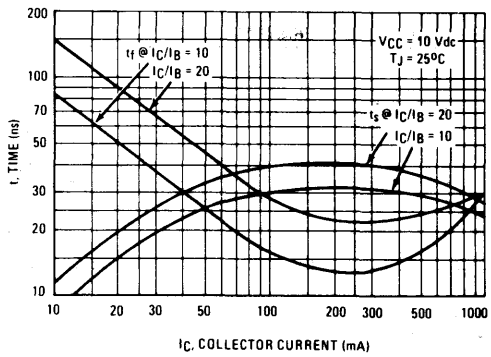


FIGURE 9 - SWITCHING TIME TEST CIRCUIT

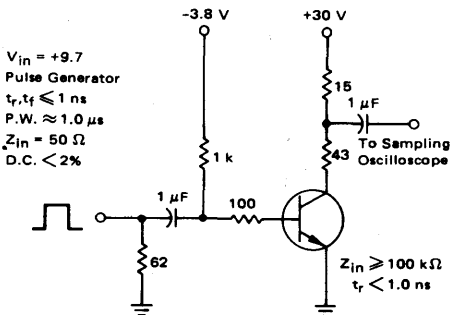
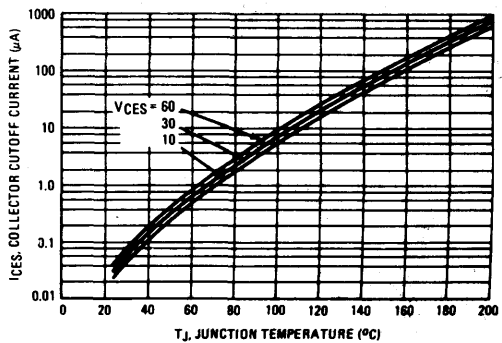


FIGURE 10 - COLLECTOR CUTOFF CURRENT



MD3762,F MQ3762

MD3762
CASE 654-07, STYLE 1

MD3762F
CASE 610A-04, STYLE 1

MQ3762
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	40		Vdc
Collector-Base Voltage	V _{CBO}	40		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	1.5		Adc
		One Die	All Die Equal Power	
Total Device Dissipation @ T _A = 25°C	P _D			mW
		MD3762	600	650
		MD3762F	350	400
		MQ3762	400	600
		Derate above 25°C		
		3.42	3.7	
		2.0	2.28	
		2.28	3.42	
Total Device Dissipation @ T _C = 25°C	P _D			Watts
		MD3762	2.1	3.0
		MD3762F	1.25	2.5
		MQ3762	1.0	4.0
		Derate above 25°C		
		12	17.2	
		7.15	14.3	
		5.71	22.8	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to + 200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit	
Thermal Resistance, Junction to Case	R _{θJC}	MD3762	83.3	58.3	°C/W
		MD3762F	140	70	
		MQ3762	175	43.8	
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	MD3762	292	270	°C/W
		MD3762F	500	438	
		MQ3762	438	292	
		Junction to Ambient	Junction to Case		
Coupling Factors		MD3762	85	40	%
		MD3762F	75	0	
		MQ3762 (Q1-Q2)	57	0	
		MQ3762 (Q1-Q3, Q1-Q4)	55	0	

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0) (V _{CB} = 30 Vdc, I _E = 0, T _A = 100°C)	I _{CBO}	—	—	100 10	nAdc μAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	100	nAdc

MD3762,F, MQ3762

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)					
DC Current Gain ($I_C = 1.0 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$)	h_{FE}	20	40	—	—
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ Adc}, I_B = 0.1 \text{ Adc}$)	$V_{CE(sat)}$	—	0.52	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ Adc}, I_B = 0.1 \text{ Adc}$)	$V_{BE(sat)}$	—	1.05	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	150	220	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{obo}	—	8.5	20	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{ibo}	—	22	80	pF
SWITCHING CHARACTERISTICS					
Delay Time ($V_{CC} = 30 \text{ Vdc}, V_{BE(off)} = 2.0 \text{ Vdc}, I_C = 1.0 \text{ Adc}, I_{B1} = 100 \text{ mAdc}$)	t_d	—	5.0	10	ns
Rise Time	t_r	—	18	30	ns
Storage Time ($V_{CC} = 30 \text{ Vdc}, I_C = 1.0 \text{ Adc}, I_{B1} = I_{B2} = 100 \text{ mAdc}$)	t_s	—	45	80	ns
Fall Time	t_f	—	18	30	ns

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(3) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — DC CURRENT GAIN

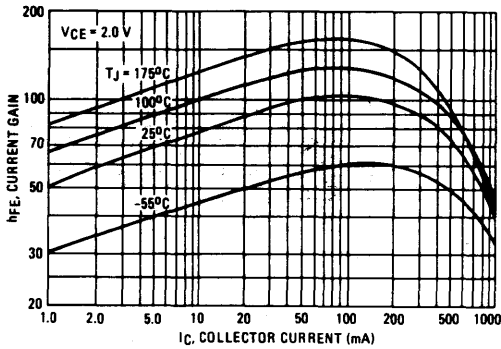


FIGURE 3 — "ON" VOLTAGE

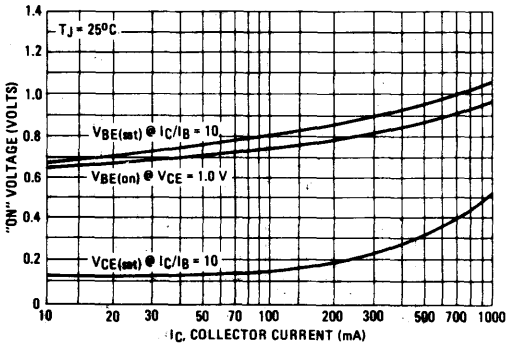


FIGURE 2 — COLLECTOR SATURATION REGION

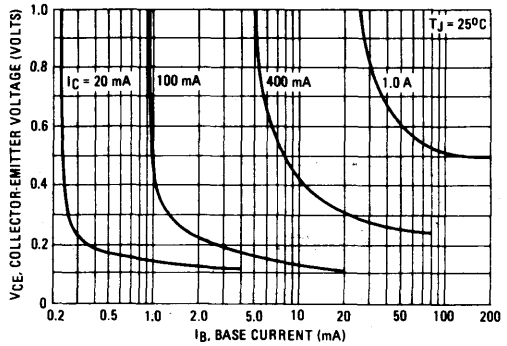


FIGURE 4 — TEMPERATURE COEFFICIENTS

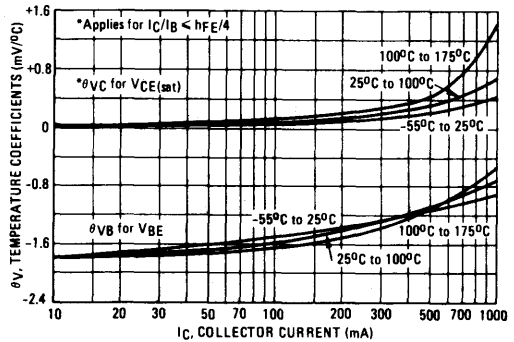


FIGURE 5 - ACTIVE REGION SAFE OPERATING AREA

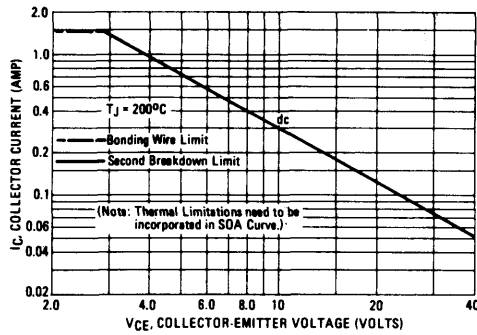


FIGURE 6 - TURN-ON TIME

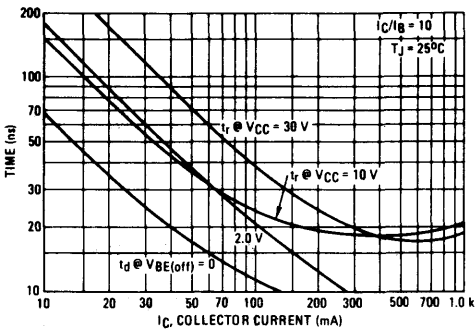


FIGURE 7 - RISE AND FALL TIME

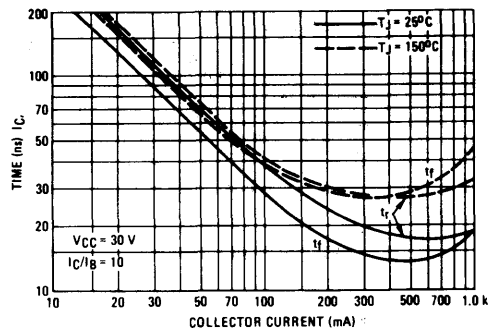


FIGURE 8 - STORAGE TIME

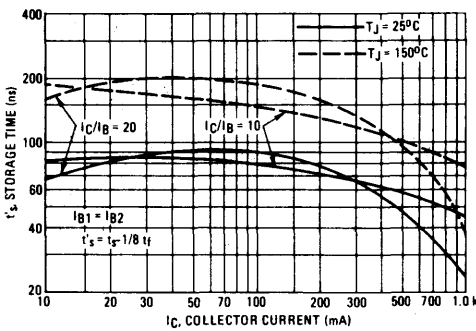


FIGURE 9 - FALL TIME

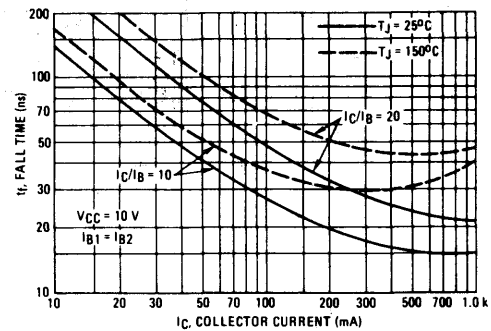


FIGURE 10 - SWITCHING TIME TEST CIRCUIT

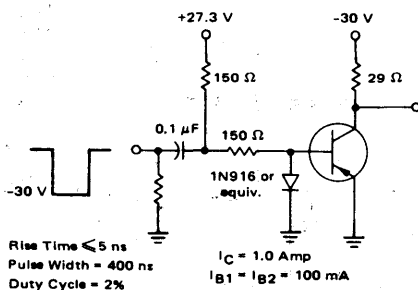
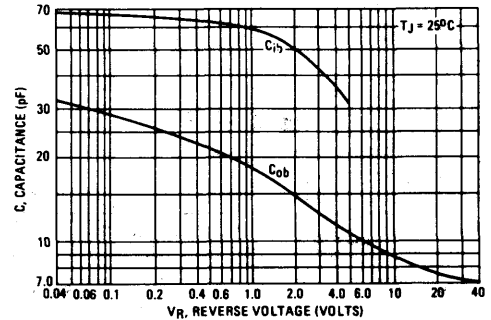


FIGURE 11 - CAPACITANCE



MD5000,A,B

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	20		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current Continuous	I_C	50		mAdc
		One Side	Both Sides	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	400 2.3	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

Refer to 2N3307 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 3.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}, I_E = 0$) ($V_{CB} = 15 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	—	—	0.010 1.0	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 3.0 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	20	50	—	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 4.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	600	900	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{obo}	—	—	1.7	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{ibo}	—	—	2.0	pF
Noise Figure ($I_C = 1.0 \text{ mAdc}, V_{CE} = 6.0 \text{ Vdc}, f = 60 \text{ MHz}, R_S = 400 \text{ ohms}$)	NF	—	3.0	6.0	dB

FUNCTIONAL TEST

Amplifier Power Gain ($I_C = 6.0 \text{ mAdc}, V_{CB} = 12 \text{ Vdc}, R_G = R_L = 50 \text{ ohms}, f = 200 \text{ MHz}$)	G_{pe}	15	20	—	dB
---	----------	----	----	---	----

MATCHING CHARACTERISTICS

DC Current Gain Ratio(1) ($I_C = 4.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MD5000 MD5000A MD5000B	h_{FE1}/h_{FE2}	— 0.9 0.8	0.7 — —	— 1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 4.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MD5000 MD5000A MD5000B	$ V_{BE1} - V_{BE2} $	— — —	5.0 — —	— 5.0 10	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 4.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, T_A = -55 \text{ to } +125^\circ\text{C}$)	MD5000 MD5000A MD5000B	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	— — —	10 — —	— 10 20	$\mu\text{V}/^\circ\text{C}$

(1) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

**MD6001,F
MD6002,F
MD6003,F
MQ6001, MQ6002**

MD6001

MD6002

MD6003

CASE 654-07, STYLE 5

MD6001F

MD6002F

MD6003F

CASE 610A-04, STYLE 1

MQ6001

MQ6002

CASE 607-04, STYLE 1

COMPLEMENTARY DUAL

GENERAL PURPOSE

TRANSISTOR

NPN/PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MD6003	MD6001,F	Unit
		MD6003F	MD6002,F	
Collector-Emitter Voltage	V _{CEO}	30		Vdc
Collector-Base Voltage	V _{CBO}	50	60	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	500		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ T _A = 25°C	P _D			mW
MD6001,2,3		575	625	
MD6001F,2F,3F		350	400	
MQ6001,2		400	600	
Derate above 25°C				mW/°C
MD6001,2,3		3.29	3.57	
MD6001F,2F,3F		2.0	2.28	
MQ6001,2		2.28	3.42	
Total Device Dissipation @ T _C = 25°C	P _D			Watts
MD6001,2,3		1.8	2.5	
MD6001F,2F,3F		1.0	2.0	
MQ6001,2		0.9	3.6	
Derate above 25°C				mW/°C
MD6001,2,3		10.3	14.3	
MD6001F,2F,3F		5.71	11.4	
MQ6001,2		5.13	20.5	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

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THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	R _{θJC}			°C/W
MD6001,2,3		97	70	
MD6001F,2F,3F		175	87.5	
MQ6001,2		195	48.8	
Thermal Resistance, Junction to Ambient	R _{θJA} (1)			°C/W
MD6001,2,3		304	280	
MD6001F,2F,3F		500	438	
MQ6001,2		438	292	
		Junction to Ambient	Junction to Class	
Coupling Factor				%
MD6001,2,3		84	44	
MD6001F,2F,3F		75	0	
MQ6001,2 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mA _{dc} , I _B = 0)	V _{(BR)CEO}	30	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 mA _{dc} , I _E = 0) MD6003,F MD6001,F, MD6002,F, MQ6001, MQ6002	V _{(BR)CBO}	50 60	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 mA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Base Cutoff Current (V _{CE} = 30 Vdc, V _{BE} = 3.0 Vdc) MD6003,F (V _{CE} = 50 Vdc, V _{EB} = 3.0 Vdc) MD6001,F,2,F, MQ6002,F	I _{BEV}	— —	— —	50 30	nAdc

MD6001,F, MD6002,F, MD6003,F, MQ6001, MQ6002

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

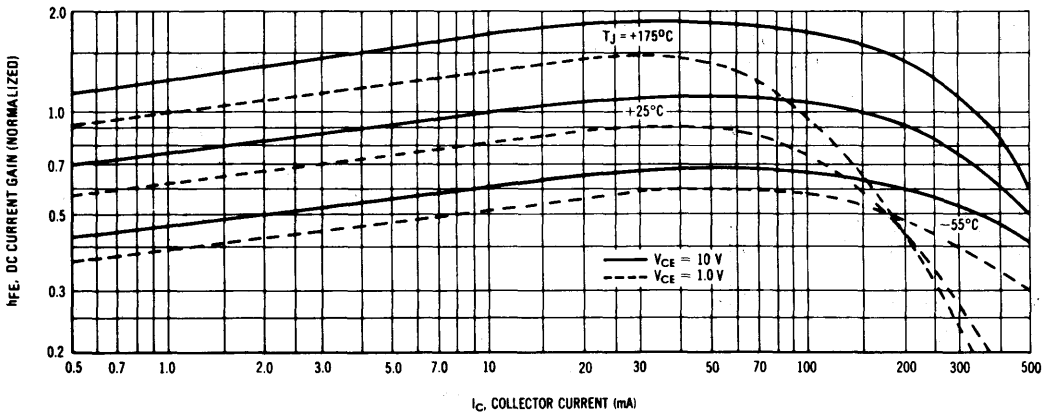
Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE(\text{off})} = 3.0\text{ Vdc}$) ($V_{CE} = 50\text{ Vdc}$, $V_{EB(\text{off})} = 3.0\text{ Vdc}$) ($V_{CE} = 50\text{ Vdc}$, $V_{EB(\text{off})} = 3.0\text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{CEV}	—	—	30 20 30	nAdc nAdc μAdc
Collector Cutoff Current ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	100	nA

ON CHARACTERISTICS(2)

DC Current Gain ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 300\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	Device	h_{FE}	Min	Typ	Max	Unit
	MD6001,F, MQ6001 MD6002,F, MQ6002		20 35	80 70	— —	—
	MD6001,F, MQ6001 MD6003,F MQ6002,F, MQ6002		25 40 50	90 70 100	— — —	—
	MD6001,F, MQ6001 MD6002,F, MQ6002		35 75	70 110	— —	—
	MD6001,F, MQ6001 MD6003,F MD6002,F, MQ6002		40 70 100	— 110 200	120 — 300	—
	MD6001,F, MQ6001 All Other Devices		20 30	— 90	— —	—
	MD6001,F, MQ6001 MD6002,F, MQ6002		20 50	80 —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$)	All Devices MD6001, MD6002,F, MQ6002,1	$V_{CE(\text{sat})}$	—	0.3 0.59	0.4 1.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$)	All Devices MD6001, MD6002,F, MQ6001,2	$V_{BE(\text{sat})}$	—	1.02 1.25	1.3 2.0	Vdc

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 - DC CURRENT GAIN



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FIGURE 2 - "ON" VOLTAGES

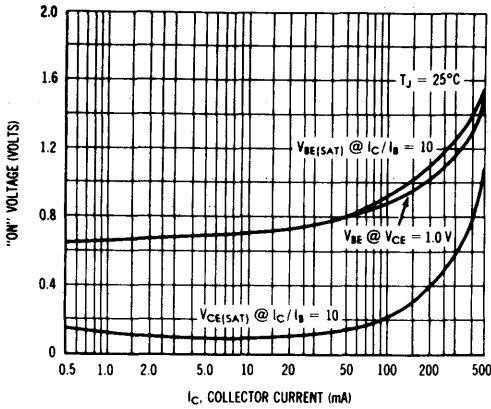
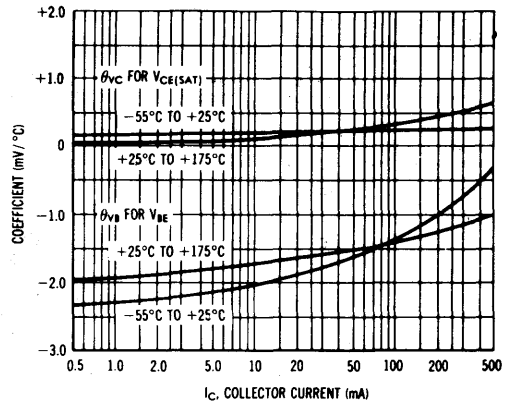


FIGURE 3 - TEMPERATURE COEFFICIENTS



5

NOISE FIGURE
 $V_{CE} = 10\text{ V}$, $T_A = 25^\circ\text{C}$

FIGURE 4 - FREQUENCY EFFECTS

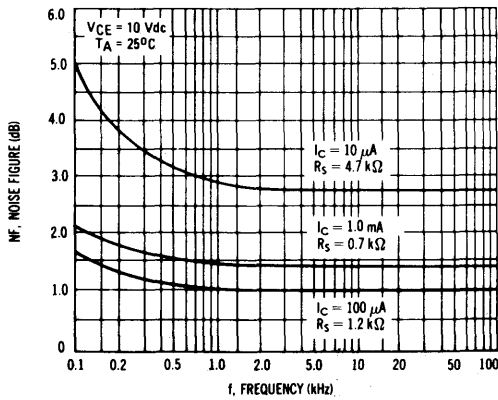


FIGURE 5 - SOURCE RESISTANCE EFFECTS

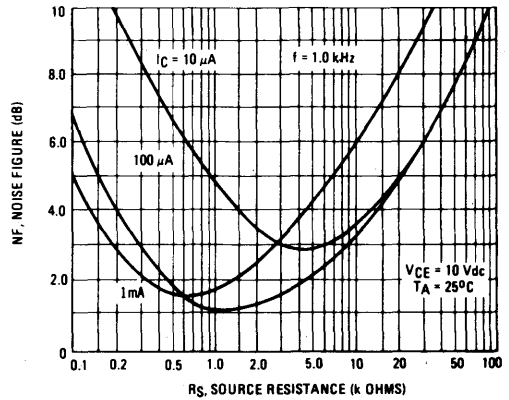


FIGURE 6 - CURRENT-GAIN BANDWIDTH PRODUCT

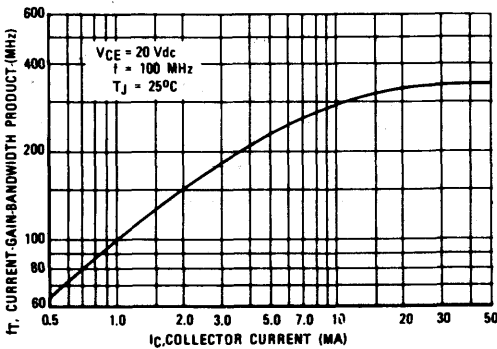


FIGURE 7 - CAPACITANCE

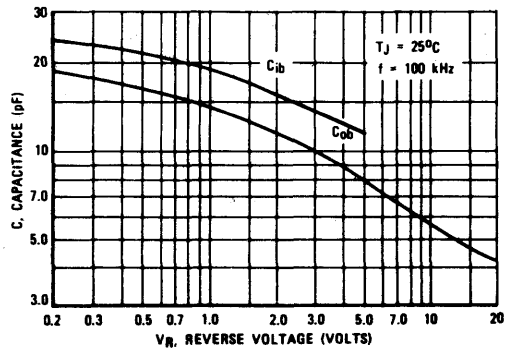


FIGURE 8 - TURN ON TIME

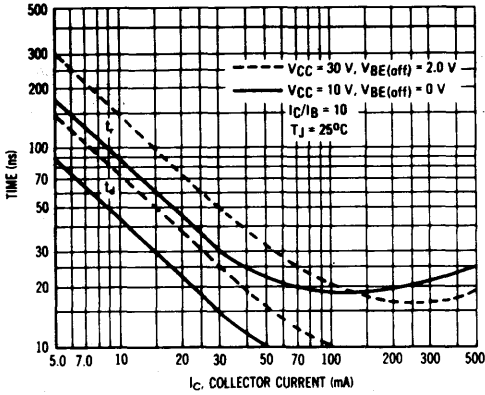


FIGURE 9 - CHARGE DATA

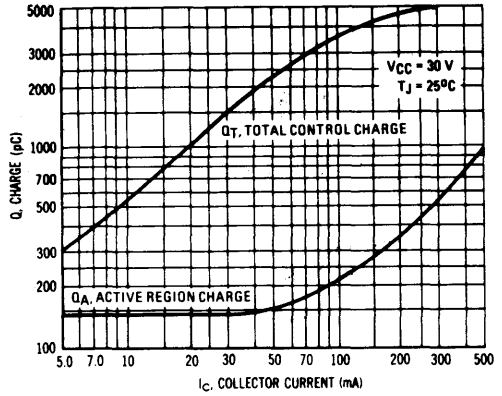


FIGURE 10 - STORAGE TIME

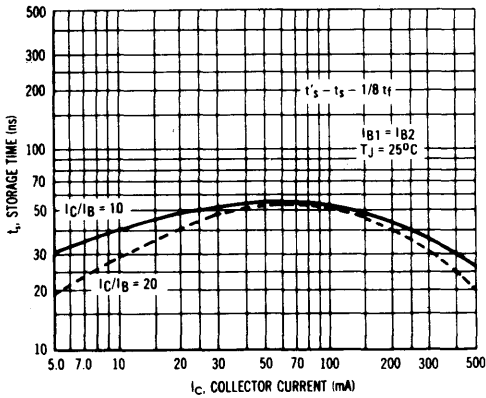


FIGURE 11 - FALL TIME

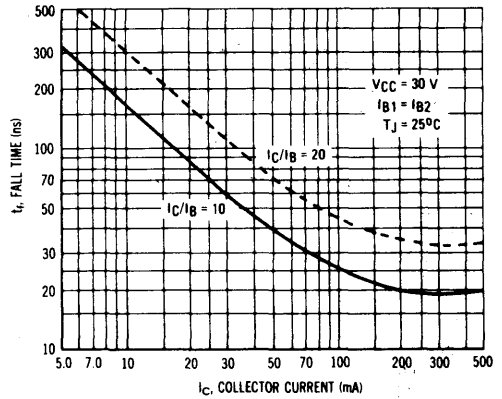


FIGURE 12 - DELAY AND RISE TIME TEST CIRCUIT

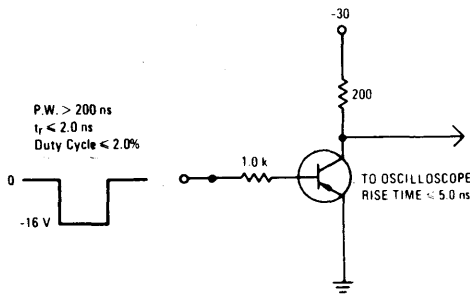
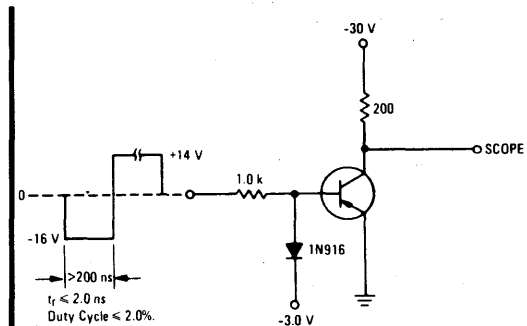


FIGURE 13 - STORAGE AND FALL TIME TEST CIRCUIT



For NPN Test Circuits, Reverse Diode and all Voltage Polarities.

MD7000

CASE 654-07, STYLE 1

DUAL GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to MD2218 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	575	625	mW
		3.29	3.57	
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8	2.5	Watts
		10.3	14.3	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$	304	280	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 40 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 300 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	40 70 30	60 80 50	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.2	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.95	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	200	250	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	3.5	8.0	pF
Input Capacitance ($V_{EB} = 2.0 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	15	30	pF

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	30		Vdc
Collector-Base Voltage	V _{CBO}	50		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	600		mAdc
		One Die	All Die	
Total Device Dissipation @ T _A = 25°C	P _D	600	650	mW
MD7001		350	400	
MD7001F		400	600	
MQ7001				
Derate above 25°C				mW/°C
MD7001		3.42	3.7	
MD7001F		2.0	2.28	
MQ7001		2.28	3.42	
Total Device Dissipation @ T _C = 25°C	P _D	2.1	3.8	Watts
MD7001		1.25	2.5	
MD7001F		1.0	4.0	
MQ7001				
Derate above 25°C				mW/°C
MD7001		12	17.2	
MD7001F		7.15	14.3	
MQ7001		5.71	22.8	
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

MD7001,F MQ7001

MD7001
CASE 654-07, STYLE 1

MD7001F
CASE 610A-04, STYLE 1

MQ7001
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

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THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	R _{θJC}			°C/W
		MD7001	58.3	
		MD7001F	70	
		MQ7001	43.8	
Thermal Resistance, Junction to Ambient	R _{θJA} (1)			°C/W
		MD7001	270	
		MD7001F	438	
		MQ7001	292	
			Junction to Ambient	Junction to Case
Coupling Factor				%
		MD7001	85	40
		MD7001F	75	0
		MQ7001 (Q1-Q2)	57	0
		(Q1-Q3 or Q1-Q4)	55	0

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	30	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0)	I _{CBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 150 mAdc, V _{CE} = 10 Vdc) (I _C = 300 mAdc, V _{CE} = 10 Vdc)	h _{FE}	40 70 30	50 90 60	— — —	—
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{CE(sat)}	—	0.25	0.4	Vdc

MD7001,F, MQ7001**ELECTRICAL CHARACTERISTICS** (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.88	1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 20 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	200	320	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	5.8	8.0	pF
Input Capacitance ($V_{BE} = 2.0 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	16	30	pF

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	304	280	$^\circ\text{C/W}$
		Junction to Ambient	Junction to Case	%
Coupling Factors		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	100	nAdc

ON CHARACTERISTICS

DC Current Gain(2) ($I_C = 100 \mu\text{Adc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	40 50	130 170	—	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.2	0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.8	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 5.0 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	200	260	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	2.6	6.0	pF
Input Capacitance ($V_{BE} = 2.0 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	2.3	8.0	pF

MATCHING CHARACTERISTICS

DC Current Gain Ratio(3) ($I_C = 100 \mu\text{Adc}, V_{CE} = 10 \text{ Vdc}$)	MD7002A MD7002B	h_{FE1}/h_{FE2}	0.75 0.85	— —	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 100 \mu\text{Adc}, V_{CE} = 10 \text{ Vdc}$)	MD7002A MD7002B	$ V_{BE1} - V_{BE2} $	— —	— —	25 15	mVdc

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD7002,A,B

CASE 654-07, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2919 for graphs.

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MD7003,A,B,F,AF MQ7003

MD7003,A,B
CASE 654-07, STYLE 1

MD7003F,AF
CASE 610A-04, STYLE 1

MQ7003
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3810 for curves.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit		
Collector-Emitter Voltage	V_{CEO}	40	Vdc		
Collector-Base Voltage	V_{CBO}	50	Vdc		
Emitter-Base Voltage	V_{EBO}	5.0	Vdc		
Collector Current — Continuous	I_C	50	mAdc		
		One Die	All Die Equal Power		
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D			mW	
		MD7003,A,B	550		600
		MD7003F,AF	350		400
		MQ7003	400		600
		Derate above 25°C			
MD7003,A,B	3.14	3.42			
MD7003F,AF	2.0	2.28			
MQ7003	2.28	3.42			
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D			Watts	
		MD7003,A,B	1.4		2.0
		MD7003F,AF	0.7		1.4
		MQ7003	0.7		2.8
		Derate above 25°C			
MD7003,A,B	8.0	11.4			
MD7003F,AF	4.0	8.0			
MQ7003	4.0	16			
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$		

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			$^\circ\text{C/W}$	
		MD7003,A,B	125		87.5
		MD7003F,AF	250		125
		MQ7003	250		62.6
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$			$^\circ\text{C/W}$	
		MD7003,A,B	319		292
		MD7003F,AF	500		438
		MQ7003	438		292
Coupling Factor		Junction to Ambient	Junction to Case	%	
		MD7003,A,B	83		40
		MD7003F,AF	75		0
		MQ7003 (Q1-Q2)	57		0
		(Q1-Q3 or Q1-Q4)	55		0

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 100 \mu\text{Adc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	40 50	350 350	— —	—

MD7003,A,B,F,AF, MQ7003

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{CE(sat)}$	—	0.25	0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	—	0.6	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	300	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{obo}	—	3.0	6.0	pF
Input Capacitance ($V_{BE} = 2.0\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ibo}	—	2.0	8.0	pF
Noise Figure ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 3.0\text{ kohms}$, $f = 10\text{ Hz to }15.7\text{ kHz}$)	NF	—	2.0	—	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio(3) ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 10\text{ Vdc}$)	MD7003A,AF MD7003B	h_{FE1}/h_{FE2}	0.75 0.85	— —	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 10\text{ Vdc}$)	MD7003A,AF MD7003B	$ V_{BE1} - V_{BE2} $	— —	— —	25 15	mV

(2) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

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MD7007,A,B,F,BF MQ7007

MD7007,A,B
CASE 654-07, STYLE 1

MD7007F,BF
CASE 610A-04, STYLE 1

MQ7007
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	50	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	200	mAdc
		One Die	All Die Equal Power
Total Device Dissipation @ T _A = 25°C	P _D		mW
MD7007,A,B		575	625
MD7007F,BF		350	400
MQ7007		400	600
Derate above 25°C			mW/°C
MD7007,A,B		3.29	3.57
MD7007F,BF		2.0	2.28
MQ7007		2.28	3.42
Total Device Dissipation @ T _C = 25°C	P _D		Watts
MD7007,A,B		1.8	2.5
MD7007F,BF		1.0	2.0
MQ7007		0.9	3.6
Derate above 25°C			mW/°C
MD7007,A,B		10.3	14.3
MD7007F,BF		5.71	11.4
MQ7007		5.13	20.5
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	R _{θJC}			°C/W
MD7007,A,B		97	70	
MD7007F,BF		175	87.5	
MQ7007		195	48.8	
Thermal Resistance, Junction to Ambient	R _{θJA} (1)			°C/W
MD7007,A,B		304	280	
MD7007F,BF		500	438	
MQ7007		438	292	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD7007,A,B		84	44	
MD7007F,BF		75	0	
MQ7007 (Q1-Q2)		57	0	
(Q1-Q2 or Q1-Q4)		55	0	

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain	h _{FE}				—
(I _C = 100 μAdc, V _{CE} = 10 Vdc)		30	110	—	
(I _C = 1.0 mAdc, V _{CE} = 10 Vdc)		30	130	—	
(I _C = 10 mAdc, V _{CE} = 10 Vdc)		30	75	—	
(I _C = 50 mAdc, V _{CE} = 10 Vdc)		15	25	—	

MD7007,A,B,F,BF, MQ7007

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.38	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.9	1.5	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	300	600	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	4.0	8.0	pF
Input Capacitance ($V_{BE} = 2.0 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	3.8	10	pF

MATCHING CHARACTERISTICS

DC Current Gain Ratio(3) ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	MD7007A	h_{FE1}/h_{FE2}	0.75	—	1.0	—
	MD7007B		0.85	—	1.0	—
Base-Emitter Voltage Differential ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	MD7007A	$ V_{BE1} - V_{BE2} $	—	—	20	mVdc
	MD7007B		—	—	10	

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD7021,F MQ7021

MD7021
CASE 654-07, STYLE 5

MD7021F
CASE 610A-04, STYLE 1

MQ7021
CASE 607-04, STYLE 1

COMPLEMENTARY
GENERAL PURPOSE TRANSISTOR

NPN/PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D			mW
MD7021		550	600	
MD7021F		350	400	
MQ7021		400	600	
Derate above 25°C				mW/ $^\circ\text{C}$
MD7021		3.14	3.42	
MD7021F		2.0	2.28	
MQ7021		2.28	3.42	
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D			Watts
MD7021		1.4	2.0	
MD7021F		0.7	1.4	
MQ7021		0.7	2.8	
Derate above 25°C				mW/ $^\circ\text{C}$
MD7021		8.0	11.4	
MD7021F		4.0	8.0	
MQ7021		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 65 to + 200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			$^\circ\text{C/W}$
MD7021		125	87.5	
MD7021F		250	125	
MQ7021		250	62.6	
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$			$^\circ\text{C/W}$
MD7021		319	292	
MD7021F		500	438	
MQ7021		438	292	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD7021		83	40	
MD7021F		75	0	
MQ7021 (Q1-Q2)		57	0	
MQ7021 (Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mAdc}, I_E = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100 \mu\text{Adc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	40 50	65 70	—	—

MD7021,F, MQ7021

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$)(2)	$V_{CE(sat)}$	—	—	0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	200	320	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	—	6.0	pF
Input Capacitance ($V_{BE} = 2.0 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	—	8.0	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 30 \text{ Vdc}$, $V_{BE(off)} = 0.5 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = 15 \text{ Adc}$)	t_{on}	—	28	—	ns
Turn-Off Time ($V_{CC} = 30 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = I_{B2} = 15 \text{ mAdc}$)	t_{off}	—	72	—	ns

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MD8001 MD8002 MD8003

CASE 654-07, STYLE 1
DUAL
AMPLIFIER TRANSISTOR
NPN SILICON

Refer to 2N2920 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage MD8001 MD8002 MD8003	V_{CEO}	40 50 60		Vdc
Collector Current — Continuous	I_C	30		mA _{dc}
		One Die	Both Die Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die Max	Both Die Equal Power Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$	304	280	$^\circ\text{C/W}$
		Junction to Ambient	Junction to Case	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mA}_{dc}, I_B = 0$)	$V_{(BR)CEO}$	40 50 60	— — —	— — —	Vdc
Collector Cutoff Current ($V_{CB} = 40 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	50	nA _{dc}
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	50	nA _{dc}
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0 \text{ mA}_{dc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	100	200	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 5.0 \text{ mA}_{dc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	—	260	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	2.6	—	pF
Input Capacitance ($V_{BE} = 2.0 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	2.3	—	pF
MATCHING CHARACTERISTICS					
Base-Emitter Voltage Differential ($I_C = 1.0 \text{ mA}_{dc}, V_{CE} = 10 \text{ Vdc}$)	$ V_{BE1} - V_{BE2} $	—	—	15	mVdc

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	15		Vdc
Collector-Base Voltage	V _{CBO}	30		Vdc
Emitter-Base Voltage	V _{EBO}	3.0		Vdc
Collector Current — Continuous	I _C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.65 3.72	1.9 10.88	Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.3 7.43	4.6 26.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 65 to +200		°C

MHQ918

**CASE 632-02, STYLE 1
TO-116**

**QUAD
AMPLIFIER TRANSISTOR**

NPN SILICON

Refer to MD918 for graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 3.0 mAdc, I _B = 0)	V _{(BR)CEO}	15	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 1.0 μAdc, I _E = 0)	V _{(BR)CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	—	10	nAdc

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc) (I _C = 3.0 mAdc, V _{CE} = 1.0 Vdc) (I _C = 10 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	— 20 —	110 80 50	— — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	0.11	0.4	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	—	0.84	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 4.0 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	600	850	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	0.75	2.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 140 kHz)	C _{ibo}	—	1.4	2.5	pF
Noise Figure (I _C = 1.0 mAdc, V _{CE} = 6.0 Vdc, R _S = 400 Ohms, f = 60 MHz)	NF	—	4.0	6.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ2221
MHQ2222
MPQ2221*
MPQ2222*

MHQ2221
MHQ2222
CASE 632-02, STYLE 1
TO-116

MPQ2221
MPQ2222
CASE 646, STYLE 1

QUAD
GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	5.0	Vdc
Collector Current — Continuous	I _C	500	mAdc
		Each Transistor	Total Device
Total Device Dissipation @ T _A = 25°C Derate above 25°C MHQ2221, MHQ2222 MPQ2221, MPQ2222	P _D	0.65 3.72 5.2	1.9 10.88 15.2
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200 -55 to +150	
			Watts mW/°C °C

Refer to MD2218 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 10 mAdc, V _{CE} = 10 Vdc)	h _{FE}	MHQ2221, MPQ2221	35	—	—	—
		MHQ2222, MPQ2222	75	—	—	
(I _C = 150 mAdc, V _{CE} = 10 Vdc)		MHQ2221, MPQ2221	40	—	—	
		MHQ2222, MPQ2222	100	—	—	
(I _C = 300 mAdc, V _{CE} = 10 Vdc)		MHQ2221, MPQ2221	20	—	—	
		MHQ2222, MPQ2222	30	—	—	
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{CE(sat)}		—	—	0.4	Vdc
(I _C = 300 mAdc, I _B = 30 mAdc)			—	—	1.6	
Base-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{BE(sat)}		—	—	1.3	Vdc
(I _C = 300 mAdc, I _B = 30 mAdc)			—	—	2.6	

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) (I _C = 20 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	200	350	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	4.5	8.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	17	30	pF

SWITCHING CHARACTERISTICS

Turn-On Time (V _{CC} = 30 Vdc, V _{BE(off)} = 0.5 Vdc, I _C = 150 mAdc, I _{B1} = 15 mAdc)	t _{on}	—	25	—	ns
Turn-Off Time (V _{CC} = 30 Vdc, I _C = 150 mAdc, I _{B1} = I _{B2} = 15 mAdc)	t _{off}	—	250	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

*MPQ2221A and MPQ2222A also available.

MHQ2221, MHQ2222, MPQ2221, MPQ2222

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

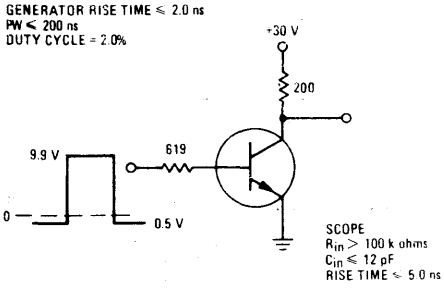
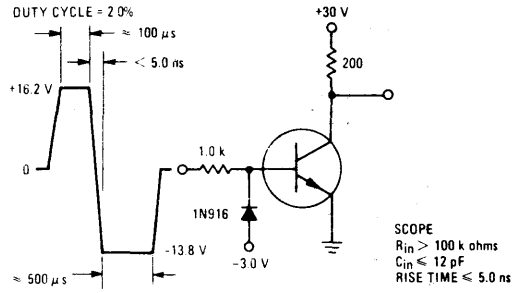


FIGURE 2 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



MHQ2369 MPQ2369

MHQ2369
CASE 632-02, STYLE 1

MPQ2369
CASE 646-05, STYLE 1
TO-116

QUAD SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage	V_{CE0}	15	Vdc	
Collector-Base Voltage	V_{CBO}	40	Vdc	
Emitter-Base Voltage	V_{EBO}	4.5	Vdc	
Collector Current — Continuous	I_C	500	mAdc	
		Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	PD	MHQ2369	1.5	Watts mW/ $^\circ\text{C}$
		MPQ2369	8.58	
			15	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200 -55 to +125	$^\circ\text{C}$	

Refer to MD2369 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	0.4	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$)	h_{FE}	40 20	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	450	550	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{obo}	—	2.5	4.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{ibo}	—	3.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 3.0 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}, I_C = 10 \text{ mAdc}, I_{B1} = 3.0 \text{ mAdc}$)	t_{on}	—	9.0	—	ns
Turn-Off Time ($V_{CC} = 3.0 \text{ Vdc}, I_C = 10 \text{ mAdc}, I_{B1} = 3.0 \text{ mAdc}, I_{B2} = 1.5 \text{ mAdc}$)	t_{off}	—	15	—	ns

(1) Pulse Test: Pulse Width $\leq 300 \text{ } \mu\text{s}$, Duty Cycle = 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — t_{on} CIRCUIT

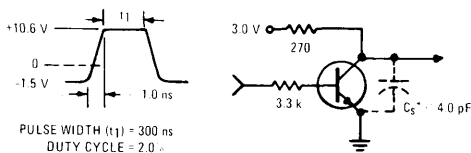
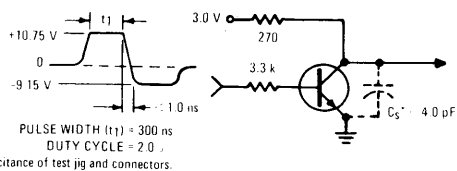


FIGURE 2 — t_{off} CIRCUIT



*Total Shunt Capacitance of test jig and connectors.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CBO}	60	Vdc
Emitter-Base Voltage	V _{EBO}	6.0	Vdc
Collector Current — Continuous	I _C	50	mAdc
		Each Transistor	Total Device
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.6	1.8
		3.42	10.3
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.2	4.2
		6.85	24
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

**MHQ2483
MHQ2484**

**CASE 632-02, STYLE 1
TO-116**

**QUAD
AMPLIFIER TRANSISTOR**

NPN SILICON

Refer to 2N2919 for graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 45 Vdc, I _E = 0)	I _{CBO}	—	—	20	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	MHQ2483	100	—	—
		MHQ2484	200	—	—
		(I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)	MHQ2483	150	—
		MHQ2484	300	—	—
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	MHQ2483	150	—	—	
		MHQ2484	300	—	—
Collector-Emitter Saturation Voltage (I _C = 1.0 mAdc, I _B = 0.1 mAdc) (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	0.13 0.15	0.35 0.5	Vdc
Base-Emitter On Voltage (I _C = 100 μAdc, V _{CE} = 5.0 Vdc) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	V _{BE(on)}	—	0.58 0.70	0.7 0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 500 μAdc, V _{CE} = 5.0 Vdc, f = 20 MHz)	f _T	50	100	—	MHz
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	4.0	8.0	pF
Collector-Base Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 100 kHz)	C _{cb}	—	1.8	6.0	pF
Noise Figure (I _C = 10 μAdc, V _{CE} = 5.0 Vdc, R _S = 10 kohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)	NF	—	3.0 2.0	—	dB
		MHQ2483			
		MHQ2484			

MHQ2906
MHQ2907
MPQ2906*
MPQ2907*

MHQ2906, MHQ2907
CASE 632-02, STYLE 1

MPQ2906
MPQ2907
CASE 646-05, STYLE 1
TO-116

QUAD
GENERAL PURPOSE
TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit		
Collector-Emitter Voltage	V_{CEO}	40	Vdc		
Collector-Base Voltage	V_{CBO}	60	Vdc		
Emitter-Base Voltage	V_{EBO}	5.0	Vdc		
Collector Current — Continuous	I_C	600	mAdc		
		Each Transistor	Total Device		
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.65	1.9	Watts	
		MHQ2906, MHQ2907	3.72	10.88	mW/ $^\circ\text{C}$
		MPQ29006, MPQ2907	6.5	19	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200 -55 to +125	$^\circ\text{C}$		

Refer to MD2904 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min.	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{CB} = 3.0 \text{ Vdc}, I_E = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	MHQ2906, MPQ2906	35	—	—
		MHQ2907, MPQ2907	75	—	—
($I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)		MHQ2906, MPQ2906	40	—	—
	MHQ2907, MPQ2907	100	—	—	
($I_C = 300 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MHQ2906, MPQ2906	30	—	—	
	MHQ2907, MPQ2907	50	—	—	
Collector-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 300 \text{ mAdc}, I_B = 30 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.4 1.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 300 \text{ mAdc}, I_B = 30 \text{ mAdc}$)	$V_{BE(sat)}$	—	—	1.3 2.6	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	200	350	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	6.0	8.0	pF
Input Capacitance ($V_{BE} = 2.0 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	20	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = 15 \text{ mAdc}$)	t_{on}	—	30	—	ns
Turn-Off Time ($V_{CC} = 6.0 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = I_{B2} = 15 \text{ mAdc}$)	t_{off}	—	100	—	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle = 2.0%.

*MPQ2906A and MPQ2907A also available.

FIGURE 1 - DELAY AND RISE TIME TEST CIRCUIT

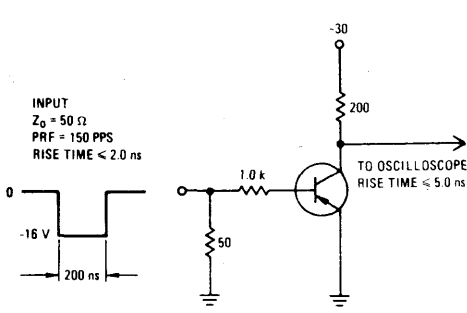
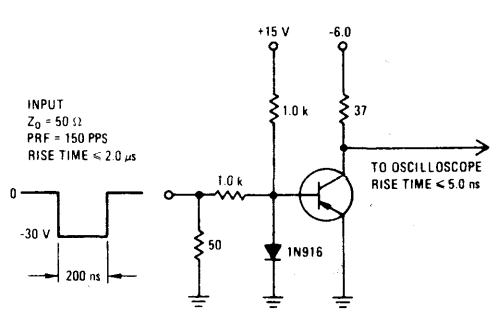


FIGURE 2 - STORAGE AND FALL TIME TEST CIRCUIT



MHQ3467

CASE 632-02, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage	V _{CEO}	40	Vdc	
Collector-Base Voltage	V _{CB0}	40	Vdc	
Emitter-Base Voltage	V _{EBO}	5.0	Vdc	
Collector Current — Continuous	I _C	1.0	Adc	
		Each Transistor	Total Device	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.9 5.14	2.7 15.4	Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.8 10.3	6.3 36	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +200	°C	

Refer to MD3467 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mA _{dc} , I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{(BR)CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	—	200	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	200	nAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 500 mA _{dc} , V _{CE} = 1.0 Vdc)	h _{FE}	20	—	—	—
Collector-Emitter Saturation Voltage(1) (I _C = 500 mA _{dc} , I _B = 50 mA _{dc})	V _{CE(sat)}	—	0.23	0.5	Vdc
Base-Emitter Saturation Voltage(1) (I _C = 500 mA _{dc} , I _B = 50 mA _{dc})	V _{BE(sat)}	—	0.9	1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) (I _C = 50 mA _{dc} , V _{CE} = 10 Vdc, f = 100 MHz)	f _T	125	190	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	10	25	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	55	80	pF

SWITCHING CHARACTERISTICS

Turn-On Time (I _C = 500 mA _{dc} , I _{B1} = 50 mA _{dc})	t _{on}	—	—	40	ns
Turn-Off Time (I _C = 500 mA _{dc} , I _{B1} = I _{B2} = 50 mA _{dc})	t _{off}	—	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ3546 MPQ3546

MHQ3546
CASE 632-02, STYLE 1
TO-116

MPQ3546
CASE 646-05, STYLE 1

QUAD
SWITCHING TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
		Each Transistor	Total Device
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 2.86 4.0	1.5 8.58 12 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200 -55 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30 15	— —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	—	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	600	1000	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	2.0	6.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$)	C_{ibo}	—	3.5	8.0	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 2.0 \text{ Vdc}, V_{BE(off)} = 3.0 \text{ Vdc},$ $I_C = 30 \text{ mAdc}, I_{B1} = 1.5 \text{ mAdc}$)	t_{on}	—	15	—	ns
Turn-Off Time ($V_{CC} = 2.0 \text{ Vdc}, I_C = 30 \text{ mAdc},$ $I_{B1} = I_{B2} = 1.5 \text{ mAdc}$)	t_{off}	—	25	—	ns

(1) Pulse Test: Pulse Width $\leq 300 \text{ } \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MHQ3798 MHQ3799

CASE 632-02, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MHQ3798	MHQ3799	Unit
Collector-Emitter Voltage	V _{CEO}	40	60	Vdc
Collector-Base Voltage	V _{CBO}	60		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.5 2.86	1.5 8.58	Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 5.71	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

Refer to 2N3810 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V(BR)CEO	40 60	—	—	Vdc
		MHQ3798 MHQ3799			
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V(BR)CBO	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V(BR)EBO	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0)	I _{CBO}	—	—	10	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 10 μAdc, V _{CE} = 5.0 Vdc)	h _{FE}	100 225	—	—	—
		MHQ3798 MHQ3799			
(I _C = 100 μAdc, V _{CE} = 5.0 Vdc)		150 300	—	—	
		MHQ3798 MHQ3799			
(I _C = 500 μAdc, V _{CE} = 5.0 Vdc)		150 300	—	—	
		MHQ3798 MHQ3799			
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)		125 250	—	—	
		MHQ3798 MHQ3799			
Collector-Emitter Saturation Voltage (I _C = 100 μAdc, I _B = 10 μAdc) (I _C = 1.0 mAdc, I _B = 100 μAdc)	V _{CE(sat)}	—	—	0.2 0.25	Vdc
Base-Emitter Saturation Voltage (I _C = 100 μAdc, I _B = 10 μAdc) (I _C = 1.0 mAdc, I _B = 100 μAdc)	V _{BE(sat)}	—	—	0.7 0.8	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)	f _T	—	130	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	2.3	—	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	5.5	—	pF
Noise Figure (I _C = 100 μAdc, V _{CE} = 10 Vdc, R _S = 3.0 kohms, f = 10 Hz to 15.7 kHz)	NF	—	2.5 1.5	—	dB
		MHQ3798 MHQ3799			

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	MHQ4001A	MHQ4002A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Collector-Base Voltage	V_{CBO}	60	70	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	750 4.3	2500 14.3	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.86	4.0 22.8	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		$^\circ\text{C}$

MHQ4001A MHQ4002A

CASE 632-02, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

NPN SILICON

5

Refer to MD3725 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	MHQ4001A MHQ4002A	$V_{(BR)CEO}$	40 45	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{Adc}, V_{BE} = 0$)	MHQ4001A MHQ4002A	$V_{(BR)CES}$	60 70	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	MHQ4001A MHQ4002A	$V_{(BR)CBO}$	60 70	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)		I_{CBO}	—	—	500	nAdc

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc}$)		h_{FE}	50 30 20	100 60 45	250 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$)		$V_{CE(sat)}$	— — —	0.14 0.23 0.36	0.26 0.52 0.95	Vdc
Base-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$)		$V_{BE(sat)}$	— 0.8 —	0.75 0.88 1.0	0.86 1.1 1.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)		f_T	200	275	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)		C_{obo}	—	5.0	10	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)		C_{ibo}	—	55	70	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 30 \text{ Vdc}, I_C = 0.5 \text{ Adc}, V_{BE} = 3.8 \text{ Vdc}, I_{B1} = 50 \text{ mAdc}$)		t_{on}	—	30	40	ns
Turn-Off Time ($V_{CC} = 30 \text{ Vdc}, I_C = 0.5 \text{ Adc}, I_{B1} = I_{B2} = 50 \text{ mAdc}$)		t_{off}	—	60	75	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MHQ4013 MHQ4014

CASE 632-02, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MHQ4013	MHQ4014	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Collector-Base Voltage	V_{CBO}	60	70	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	750 4.3	2500 14.3	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.86	4.0 22.8	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 55 to +200		$^\circ\text{C}$

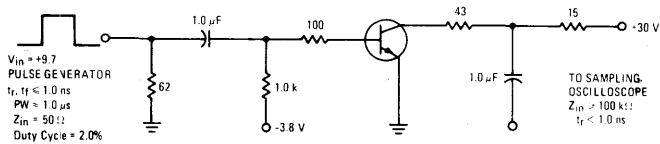
Refer to MD3725 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40 45	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{Adc}, V_{BE} = 0$)	$V_{(BR)CES}$	60 70	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60 70	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	500	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	60 35 25	100 65 50	250 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$)	$V_{CE(sat)}$	— — —	0.14 0.23 0.36	0.26 0.52 0.95	Vdc
Base-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}$)	$V_{BE(sat)}$	— 0.8 —	0.75 0.88 1.0	0.86 1.1 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 50 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	200	275	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	5.0	10	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	50	70	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30 \text{ Vdc}, I_C = 0.5 \text{ Adc}, V_{BE(off)} = 3.8 \text{ Vdc}, I_{B1} = 50 \text{ mAdc}$)	t_{on}	—	20	35	ns
Turn-Off Time ($V_{CC} = 30 \text{ Vdc}, I_C = 0.5 \text{ Adc}, I_{B1} = I_{B2} = 50 \text{ mAdc}$)	t_{off}	—	50	60	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



MHQ6001 MHQ6002

CASE 632-02, TYPE 1
TO-116

QUAD
COMPLEMENTARY TRANSISTOR

NPN/PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CE0}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.65 3.72	1.9 10.88	Watts $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.3 7.43	4.6 26.3	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	20	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MHQ6001 MHQ6002	25 50	— —	— —	—
($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MHQ6001 MHQ6002	35 75	— —	— —	—
($I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MHQ6001 MHQ6002	40 100	— —	— —	—
($I_C = 300 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	MHQ6001 MHQ6002	20 30	— —	— —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 300 \text{ mAdc}, I_B = 30 \text{ mAdc}$)	$V_{CE(sat)}$	— —	— —	0.4 1.4	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 300 \text{ mAdc}, I_B = 30 \text{ mAdc}$)	$V_{BE(sat)}$	— —	— —	1.3 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 50 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ kHz}$)	f_T	—	400	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	NPN PNP C_{obo}	— —	6.0 4.5	— —	pF
Input Capacitance ($V_{BE} = 2.0 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	NPN PNP C_{ibo}	— —	20 17	— —	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30 \text{ Vdc}, V_{BE} = 0.5 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = 15 \text{ mAdc}$)	t_{on}	—	30	—	ns
Turn-Off Time ($V_{CC} = 30 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = I_{B2} = 15 \text{ mAdc}$)	t_{off}	—	225	—	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MHQ6100,A

CASE 632-02, TYPE 2
TO-116

QUAD
COMPLEMENTARY PAIR
TRANSISTOR

NPN/PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MHQ6100	MHQ6100A	Unit
Collector-Emitter Voltage	V _{CEO}	40	45	Vdc
Collector-Base Voltage	V _{CBO}	60		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.5 2.86	1.5 8.58	Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 5.71	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

Refer to 2N2919 for NPN graphs.
Refer to 2N3810 for PNP graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	MHQ6100 MHQ6100A	V _{(BR)CEO}	40 45	— —	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)		V _{(BR)CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)		V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0)		I _{CBO}	—	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 100 μAdc, V _{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A	h _{FE}	50 100	— —	— —	—
(I _C = 500 μAdc, V _{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		75 150	— —	— —	
(I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		75 150	— —	— —	
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		60 125	— —	— —	
Collector-Emitter Saturation Voltage (I _C = 1.0 mAdc, I _B = 0.1 mAdc)		V _{CE(sat)}	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I _C = 1.0 mAdc, I _B = 0.1 mAdc)		V _{BE(sat)}	—	—	0.8	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 500 μAdc, V _{CE} = 5.0 Vdc, f = 20 MHz)	NPN PNP	f _T	— —	175 130	— —	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 100 kHz)	NPN PNP	C _{obo}	— —	4.5 2.3	— —	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	NPN PNP	C _{ibo}	— —	6.0 5.5	— —	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ918

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD918 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CE0}	15		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	6.7 0.825	2.4 19.2	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	$^\circ\text{C}/\text{W}$
	Effective, 4 Die	52	134	$^\circ\text{C}/\text{W}$
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 3.0\text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 0.1\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$) ($I_C = 3.0\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	—	110	—	—
		20	80	—	—
		—	50	—	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$)	$V_{CE(sat)}$	—	0.11	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}, I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	—	0.84	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 100\text{ MHz}$)	f_T	600	850	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 140\text{ kHz}$)	C_{obo}	—	0.75	1.7	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 140\text{ kHz}$)	C_{ibo}	—	1.1	2.0	pF
Noise Figure ($I_C = 1.0\text{ mAdc}, V_{CE} = 6.0\text{ Vdc}, R_G = 400\text{ Ohms}, f = 60\text{ MHz}$)	NF	—	4.0	6.0	dB

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	20		Vdc
Collector-Base Voltage	V _{CBO}	40		Vdc
Emitter-Base Voltage	V _{EBO}	4.0		Vdc
Collector Current — Continuous	I _C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	650 5.18	1250 10	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit	
Thermal Resistance(1) Each Die	125	193	°C/W	
Effective, 4 Die	41.6	100	°C/W	
Coupling Factors	Q1-Q4 or Q2-Q3	30	60	%
	Q1-Q2 or Q3-Q4	2.0	24	%

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	20	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V _{EB} = 2.0 Vdc, I _C = 0)	I _{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 50 mAdc, V _{CE} = 10 Vdc) (I _C = 150 mAdc, V _{CE} = 10 Vdc)	h _{FE}	50 50 40	— — —	— — —	—
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{CE(sat)}	—	—	0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{BE(sat)}	—	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 20 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	175	—	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	—	8.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	—	30	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ1000

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD2218 for graphs.

MPQ1500CASE 646-05, STYLE 1
TO-116

QUAD

PNP SILICON

Refer to MD2904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	Vdc
Collector Current — Continuous	I _C	500	mAdc
		Each Transistor	Four Transistors Equal Power
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.65 5.18	1.25 8.0 Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	3.0 24 Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1) Each Die	125	193	°C/W
Effective, 4 Die	41.6	100	
Coupling Factor Q1-Q4 or Q2-Q3	30	60	%
Q1-Q2 or Q3-Q4	2.0	24	

(1) Junction to ambient data applies for typical printed circuit board mounting.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	20	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V _{EB} = 2.0 Vdc, I _C = 0)	I _{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 50 mAdc, V _{CE} = 10 Vdc) (I _C = 150 mAdc, V _{CE} = 10 Vdc)	h _{FE}	50 50 40	100 120 80	—	—
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{CE(sat)}	—	0.22	0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc)	V _{BE(sat)}	—	0.89	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I _C = 20 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	150	300	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	4.5	8.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	17	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ2221, MPQ2222 For Specifications, See MHQ2221 Data.**MPQ2369** For Specifications, See MHQ2369 Data.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	40		Vdc
Collector-Base Voltage	V _{CBO}	60		Vdc
Emitter-Base Voltage	V _{EBO}	6.0		Vdc
Collector Current — Continuous	I _C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T _A = 25°C(1) Derate above 25°C	P _D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to + 150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	°C/W
	Effective, 4 Die	52	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	%
	Q1-Q2 or Q3-Q4	2.0	%

**MPQ2483
MPQ2484**

**CASE 646-05, STYLE 1
TO-116**

**QUAD
AMPLIFIER TRANSISTOR**

NPN SILICON

Refer to 2N2919 for graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 45 Vdc, I _E = 0)	I _{CBO}	—	—	20	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I _C = 0.1 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	MPQ2483	100	—	—
		MPQ2484	200	—	—
(I _C = 1.0 mAdc, V _{CE} = 5.0 Vdc)		MPQ2483	150	—	—
	MPQ2484	300	—	—	
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	MPQ2483	150	—	—	
	MPQ2484	300	—	—	
Collector-Emitter Saturation Voltage (I _C = 1.0 mAdc, I _B = 0.1 mAdc) (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	— —	0.13 0.15	0.35 0.5	Vdc
Base-Emitter Saturation Voltage(2) (I _C = 100 μAdc, V _{CE} = 5.0 Vdc) (I _C = 10 mAdc, V _{CE} = 5.0 Vdc)	V _{BE(sat)}	— —	0.58 0.70	0.7 0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 500 μAdc, V _{CE} = 5.0 Vdc, f = 20 MHz)	f _T	50	100	—	MHz
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	4.0	8.0	pF

MPQ2483, MPQ2484**ELECTRICAL CHARACTERISTICS** (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{cb}	—	1.8	6.0	pF
Noise Figure ($I_C = 10\ \mu\text{A}$ dc, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ kohms}$, $f = 10\text{ Hz to } 15.7\text{ kHz}$, $BW = 10\text{ kHz}$)	NF	—	3.0	—	dB
	MPQ2483	—	2.0	—	
	MPQ2484	—	—	—	

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.**MPQ2906, MPQ2907** For Specifications, See MHQ2906 Data.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	12		Vdc
Collector-Base Voltage	V _{CBO}	25		Vdc
Emitter-Base Voltage	V _{EBO}	4.0		Vdc
Collector Current — Continuous	I _C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	650 5.2	1250 10	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

MPQ3303

CASE 646-05, STYLE 1
TO-116

QUAD
SWITCHING TRANSISTOR

NPN SILICON

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	125	193*	°C/W
	Effective, 4 Die	41.6	100*	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	30	60	%
	Q1-Q2 or Q3-Q4	2.0	25	%

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	12	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V _{CE} = 15 Vdc, V _{BE} = 0)	I _{CES}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 100 mAdc, V _{CE} = 0.5 Vdc) (I _C = 300 mAdc, V _{CE} = 0.5 Vdc)	h _{FE}	30 40	45 55	— 200	—
Collector-Emitter Saturation Voltage (I _C = 300 mAdc, I _B = 30 mAdc) (I _C = 1.0 Adc, I _B = 0.1 Adc)	V _{CE(sat)}	— —	0.22 0.52	0.33 0.7	Vdc
Base-Emitter Saturation Voltage (I _C = 300 mAdc, I _B = 30 mAdc) (I _C = 1.0 Adc, I _B = 0.1 Adc)	V _{BE(sat)}	— —	0.87 1.04	1.1 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 100 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)	f _T	400	500	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	5.0	10	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{iBo}	—	22	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V _{CC} = 12 Vdc, I _C = 1.0 Adc, V _{BE(off)} = 4.0 Vdc, I _{B1} = 100 mAdc)	t _{on}	—	12	15	ns
Turn-Off Time (V _{CC} = 12 Vdc, I _C = 1.0 Adc, I _{B1} = I _{B2} = 100 mAdc)	t _{off}	—	18	25	ns

MPQ3467

CASE 646-05, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CE0}	40		Vdc
Collector-Base Voltage	V_{CB0}	40		Vdc
Emitter-Base Voltage	V_{EB0}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ (1) Derate above 25°C	P_D	650 5.2	1500 12	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.25 10	3.2 25.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

(1) Second Breakdown occurs at power levels greater than 2 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ Junction to Ambient	Unit
Thermal Resistance	Each Die	100	193	$^\circ\text{C}/\text{W}$
	Effective, 4 Die	39	83.2	$^\circ\text{C}/\text{W}$
Coupling Factors	Q1-Q4 or Q2-Q3	45	55	%
	Q1-Q2 or Q3-Q4	5.0	10	%

Refer to MD3467 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10\text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30\text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	200	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	200	nAdc

ON CHARACTERISTICS

DC Current Gain(2) ($I_C = 500\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage(2) ($I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$)	$V_{CE(sat)}$	—	0.23	0.5	Vdc
Base-Emitter Saturation Voltage(2) ($I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$)	$V_{BE(sat)}$	—	0.90	1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 100\text{ MHz}$)	f_T	125	190	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}, I_E = 0, f = 100\text{ kHz}$)	C_{obo}	—	10	25	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 100\text{ kHz}$)	C_{ibo}	—	55	80	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($I_C = 500\text{ mAdc}, I_{B1} = 50\text{ mAdc}$)	t_{on}	—	—	40	ns
Turn-Off Time ($I_C = 500\text{ mAdc}, I_{B1} = I_{B2} = 50\text{ mAdc}$)	t_{off}	—	—	90	ns

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MPQ3546

For Specifications, See MHQ3546 Data.

MAXIMUM RATINGS

Rating	Symbol	MPQ3725	MPQ3725A	Unit
Collector-Emitter Voltage	V _{CEO}	40	50	Vdc
Collector-Emitter Voltage	V _{CES}	60	70	Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	1.0		Adc
		One Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 8.0	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max		Unit
		One Transistor	Effective For Four Transistors	
Thermal Resistance, Junction to Ambient(1)	R _{θJA}	125	50	°C/W

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40 50	—	—	Vdc
Collector-Emitter Breakdown Voltage (I _C = 100 μAdc, V _{BE} = 0)	V _{(BR)CES}	60 70	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0)	I _{CBO}	—	—	0.5	μAdc

ON CHARACTERISTICS(2)

DC Current Gain (I _C = 100 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	35 40	75 80	200	—
(I _C = 500 mAdc, V _{CE} = 2.0 Vdc)		25 30	45 50	—	—
Collector-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	—	0.32	0.45	Vdc
Base-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc)	V _{BE(sat)}	0.8	0.9	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	250 200	275 250	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	5.1	10	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	62	80	pF

MPQ3725,A

CASE 646-05, STYLE 1
TO-116

QUAD
CORE DRIVER TRANSISTOR

NPN SILICON

Refer to MD3725 for graphs.

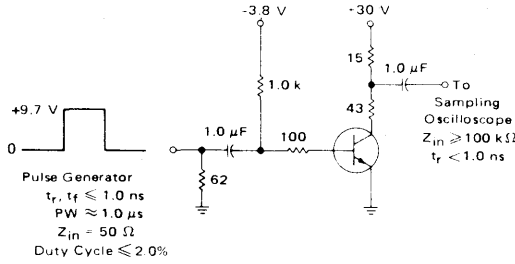
MPQ3725,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_C = 500 \text{ mAdc}$, $I_{B1} = 50 \text{ mAdc}$, $V_{BE(\text{off})} = 3.8 \text{ Vdc}$)	t_{on}	—	20	35	ns
Turn-Off Time ($I_C = 500 \text{ mAdc}$, $I_{B1} = I_{B2} = 50 \text{ mAdc}$)	t_{off}	—	50	60	ns

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	40		Vdc
Collector-Base Voltage	V _{CBO}	40		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	750 5.98	1700 13.6	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.25 10	3.2 25.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to + 150		°C

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1) Each Die	100	167	°C/W
Effective, 4 Die	39	73.5	°C/W
Coupling Factors Q1-Q4 or Q2-Q3	46	56	%
Q1-Q2 or Q3-Q4	5.0	10	%

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V _{EB} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	100	nAdc

ON CHARACTERISTICS(2)

DC Current Gain (I _C = 150 mAdc, V _{CE} = 1.0 Vdc) (I _C = 500 mAdc, V _{CE} = 2.0 Vdc) (I _C = 1.0 Adc, V _{CE} = 2.0 Vdc)	h _{FE}	35 30 20	70 65 35	— — —	—
Collector-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc) (I _C = 1.0 Adc, I _B = 100 mAdc)	V _{CE(sat)}	— —	0.3 0.6	0.55 0.9	Vdc
Base-Emitter Saturation Voltage (I _C = 500 mAdc, I _B = 50 mAdc) (I _C = 1.0 Adc, I _B = 100 mAdc)	V _{BE(sat)}	— —	0.9 1.0	1.25 1.4	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	150	275	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	9.0	15	pF
Input Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	55	80	pF

SWITCHING CHARACTERISTICS

Turn-On Time (V _{CC} = 30 Vdc, I _C = 1.0 Adc, I _{B1} = 100 mAdc, V _{BE(off)} = 2.0 Vdc)	t _{on}	—	—	50	ns
Turn-Off Time (V _{CC} = 30 Vdc, I _C = 1.0 Adc, I _{B1} = I _{B2} = 100 mAdc)	t _{off}	—	—	120	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ3762

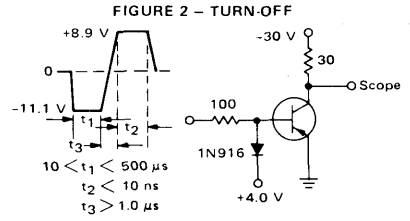
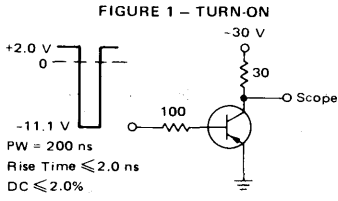
CASE 646-05, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

PNP SILICON

Refer to MD3467 for graphs.

EQUIVALENT TEST CIRCUITS



MAXIMUM RATINGS

Rating	Symbol	MPQ3798	MPQ3799	Unit
Collector-Emitter Voltage	V _{CEO}	40	60	Vdc
Collector-Base Voltage	V _{CBO}	60		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T _A = 25°C(1) Derate above 25°C	P _D	0.5 4.0	0.9 7.2	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.825 6.7	2.4 19.2	Watts m/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to + 150		°C

(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		R _{θJC} Junction to Case	R _{θJA} Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	139	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

MPQ3798 MPQ3799

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3810 for graphs.

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40 60	— —	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 50 Vdc, I _E = 0)	I _{CBO}	—	—	10	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	20	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I _C = 10 μAdc, V _{CE} = 5.0 Vdc)	h _{FE}	100 225	— —	— —	—
(I _C = 100 μAdc, V _{CE} = 5.0 Vdc)		150 300	— —	— —	
(I _C = 500 μAdc, V _{CE} = 5.0 Vdc)		150 300	— —	— —	
(I _C = 10 mAdc, V _{CE} = 5.0 Vdc)		125 250	— —	— —	
Collector-Emitter Saturation Voltage (I _C = 100 μAdc, I _B = 10 μAdc) (I _C = 1.0 mAdc, I _B = 100 μAdc)	V _{CE(sat)}	— —	0.12 0.07	0.2 0.25	Vdc
Base-Emitter Saturation Voltage (I _C = 100 μAdc, I _B = 10 μAdc) (I _C = 1.0 mAdc, I _B = 100 μAdc)	V _{BE(sat)}	— —	0.62 0.68	0.7 0.8	Vdc

MPQ3798,99

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ V}$, $f = 100 \text{ MHz}$)	f_T	60	250	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ V}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{obo}	—	2.1	4.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ V}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ibo}	—	5.5	8.0	pF
Noise Figure ($I_C = 100 \mu\text{A}$, $V_{CE} = 10 \text{ V}$, $R_S = 3.0 \text{ kohms}$, $f = 10 \text{ Hz to } 15.7 \text{ kHz}$)	NF	—	2.5	—	dB
		—	1.5	—	

(2) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	40		Vdc
Collector-Base Voltage	V _{CBO}	60		Vdc
Emitter-Base Voltage	V _{EBO}	6.0		Vdc
Collector Current — Continuous	I _C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	6.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V _{BE} = 40 Vdc, I _C = 0)	I _{EBO}	—	—	50	nAdc

ON CHARACTERISTICS(1)

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc) (I _C = 10 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	30 50 75	90 160 200	— — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	0.1	0.2	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	—	0.65	0.85	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	250	300	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 140 kHz)	C _{obo}	—	2.0	4.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 140 kHz)	C _{ibo}	—	4.0	8.0	pF

SWITCHING CHARACTERISTICS

Turn-On Time (I _C = 10 mAdc, V _{BE} = 0.5 Vdc, I _{B1} = 1.0 mAdc)	t _{on}	—	37	—	ns
Turn-Off Time (I _C = 10 mAdc, I _{B1} = I _{B2} = 1.0 mAdc)	t _{off}	—	136	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ3904

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER/SWITCHING
TRANSISTOR

NPN SILICON

Refer to 2N3904 for graphs.

MPQ3906

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER/SWITCH TRANSISTOR

PNP SILICON

Refer to 2N3906 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	825 6.7	2.4 19.2	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	$^\circ\text{C}/\text{W}$
	Effective, 4 Die	52	139	$^\circ\text{C}/\text{W}$
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	50	nAdc

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 0.1 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	40 60 75	160 180 200	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.1	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.65	0.85	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	200	250	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{obo}	—	3.3	4.5	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{ibo}	—	4.8	10	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($I_C = 10 \text{ mAdc}, V_{BE(off)} = 0.5 \text{ Vdc}, I_{B1} = 1.0 \text{ mAdc}$)	t_{on}	—	43	—	ns
Turn-Off Time ($I_C = 10 \text{ mAdc}, I_{B1} = I_{B2} = 1.0 \text{ mAdc}$)	t_{off}	—	155	—	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

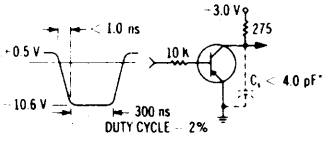
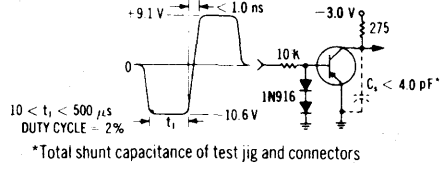


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



* Total shunt capacitance of test jig and connectors

**MPQ6001
MPQ6002**

TYPE 1

**MPQ6501
MPQ6502**

TYPE 2

CASE 646-05

QUAD
COMPLEMENTARY PAIR
TRANSISTOR

PNP/NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
		Each Transistor	Four Transistors Equal Power
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ (1) MPQ6001, MPQ6002, MPQ6501, MPQ6502	P_D	0.65	1.25
Derate above 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502		5.18	10
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ MPQ6001, MPQ6002, MPQ6501, MPQ6502	P_D	1.0	3.0
Derate above 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502		8.0	24
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance Each Die	125	193	$^\circ\text{C}/\text{W}$
Effective, 4 Die	41.6	100	
Coupling Factors	30	60	%
Q1-Q4 or Q2-Q3	30 30 30	60 60 60	
Q1-Q2 or Q3-Q4	20 20 20 2.0	24 24 24 24	

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10\text{ mAdc}, I_E = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	30	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0\text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	h_{FE}	25 50	—	—	—
($I_C = 10\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)		35 75	—	—	—
($I_C = 150\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)		40 100	—	—	—
($I_C = 300\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)		20 30	—	—	—

MPQ6001

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage(2) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.4 1.4	Vdc
Base-Emitter Saturation Voltage(2) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$)	$V_{BE(sat)}$	—	—	1.3 2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	350	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{obo}	—	6.0 4.5	8.0 8.0	pF
Input Capacitance ($V_{EB} = 2.0\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ibo}	—	20 17	30 30	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 30\text{ Vdc}$, $V_{BE} = 0.5\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = 15\text{ mAdc}$, Figure 1)	t_{on}	—	30	—	ns
Turn-Off Time ($V_{CC} = 30\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = I_{B2} = 15\text{ mAdc}$)	t_{off}	—	225	—	ns

- (1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.
 (2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

NPN DATA

FIGURE 1 — NORMALIZED DC CURRENT GAIN

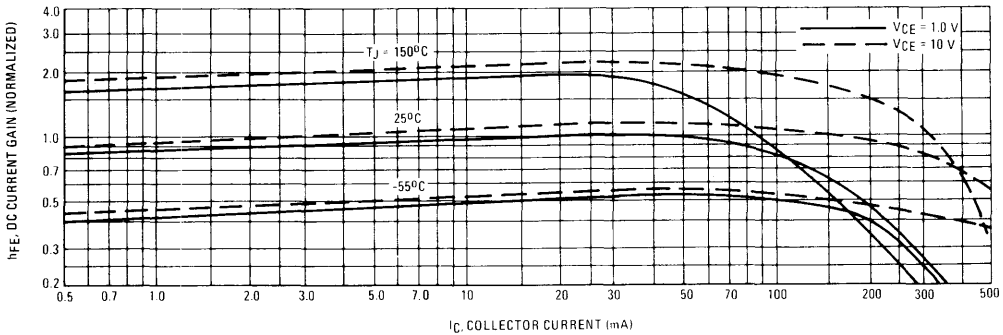


FIGURE 2 — "ON" VOLTAGES

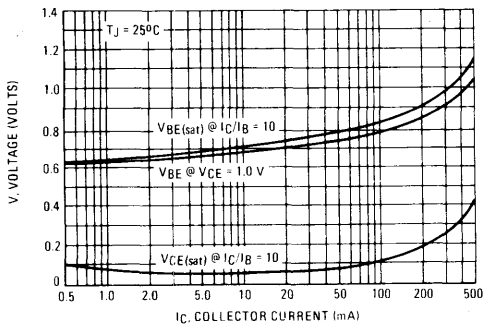
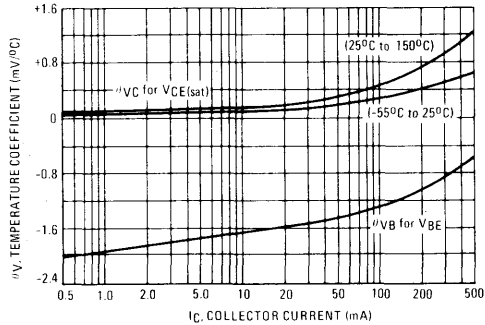


FIGURE 3 — TEMPERATURE COEFFICIENTS



NOISE FIGURE
($V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$)

FIGURE 4 — FREQUENCY EFFECTS

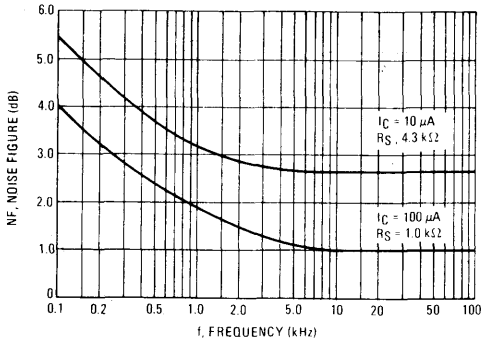
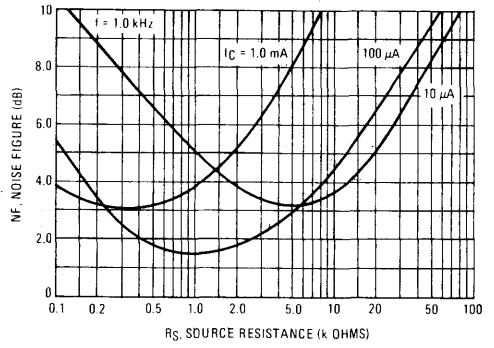


FIGURE 5 — SOURCE RESISTANCE EFFECTS



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MAXIMUM RATINGS

Rating	Symbol	MPQ6100 MPQ6600	MPQ6100A MPQ6600A	Unit
Collector-Emitter Voltage	V_{CE0}	40	45	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	0.825 6.7	2.4 19.2	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1) Each Die Effective, 4 Die		151	250	$^\circ\text{C}/\text{W}$
		52	139	$^\circ\text{C}/\text{W}$
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40 45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain ($I_C = 100 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	50 100	—	—	—
($I_C = 500 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}$)		75 150	—	—	
($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)		75 150	—	—	
($I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)		60 125	—	—	
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ mAdc}, I_B = 100 \mu\text{Adc}$)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ mAdc}, I_B = 100 \mu\text{Adc}$)	$V_{BE(sat)}$	—	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 500 \mu\text{Adc}, V_{CE} = 5.0 \text{ Vdc}, f = 20 \text{ MHz}$)	f_T	50	—	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	1.2 1.8	4.0 4.0	pF
					PNP NPN

**MPQ6100,A TYPE 1
MPQ6600,A TYPE 2**

CASE 646-05

TO-116

QUAD

**COMPLEMENTARY PAIR
TRANSISTOR**

PNP/NPN SILICON

Refer to 2N2919 for NPN Curves.

Refer to 2N3810 for PNP Curves.

MPQ6100,A, MPQ6600,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C _{ibo}	—	—	8.0	pF
PNP NPN		—	—	8.0	
Noise Figure ($I_C = 100\ \mu\text{A}$ dc, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ kohms}$, $f = 10\text{ Hz to }15.7\text{ kHz}$, $BW = 10\text{ kHz}$)	NF	—	4.0	—	dB

(2) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage MPQ6426 MPQ6427	V _{CEO}	30 40		Vdc
Collector-Base Voltage MPQ6426 MPQ6427	V _{CBO}	40 50		Vdc
Emitter-Base Voltage	V _{EBO}	12		Vdc
Collector Current — Continuous	I _C	500		mAdc
		Each Die	Four Die Equal Power	
Total Device Dissipation @ T _A = 25°C(1) Derate above 25°C	P _D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	825 6.7	2400 19.2	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance Each Die	151	250	°C/W
Effective, 4 Die	52	139	°C/W
Coupling Factors Q1-Q4 or Q2-Q3	34	70	%
Q1-Q2 or Q3-Q4	2.0	26	%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	MPQ6426 MPQ6427	V _{(BR)CEO}	30 40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	MPQ6426 MPQ6427	V _{(BR)CBO}	40 50	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)		V _{(BR)EBO}	12	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)		I _{CBO}	—	100	nAdc
Emitter Cutoff Current (V _{BE} = 10 Vdc, I _C = 0)		I _{EBO}	—	100	nAdc

ON CHARACTERISTICS(2)

DC Current Gain (I _C = 10 mAdc, V _{CE} = 5.0 Vdc) (I _C = 100 mAdc, V _{CE} = 5.0 Vdc)		h _{FE}	5000 10,000	—	—
Collector-Emitter Saturation Voltage (I _C = 100 mAdc, I _B = 0.1 mAdc)		V _{CE(sat)}	—	1.5	Vdc
Base-Emitter On Voltage (I _C = 100 mAdc, V _{CE} = 5.0 Vdc)		V _{BE(on)}	—	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 5.0 Vdc, f = 100 MHz)		f _T	125	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)		C _{obo}	—	8.0	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)		C _{ibo}	—	15	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ6426 MPQ6427

CASE 646-05, STYLE 1
TO-116

QUAD
DARLINGTON TRANSISTOR

NPN SILICON

NOISE CHARACTERISTICS
($V_{CE} = 5.0 \text{ Vdc}$, $T_A = 25^\circ\text{C}$)

FIGURE 1 – NOISE VOLTAGE

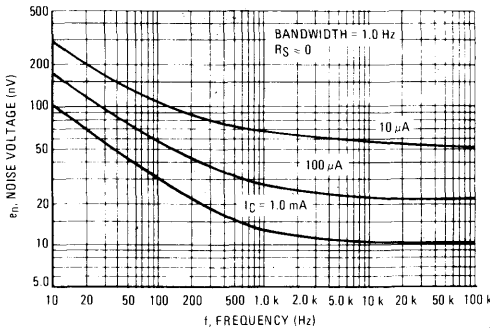


FIGURE 2 – NOISE CURRENT

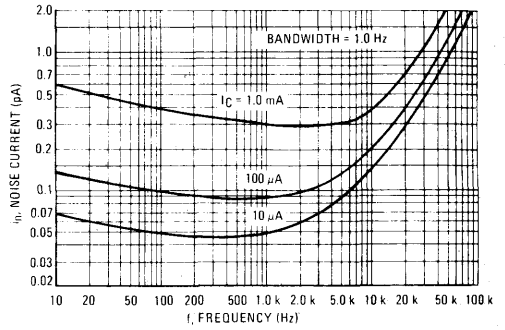


FIGURE 3 – TOTAL WIDEBAND NOISE VOLTAGE

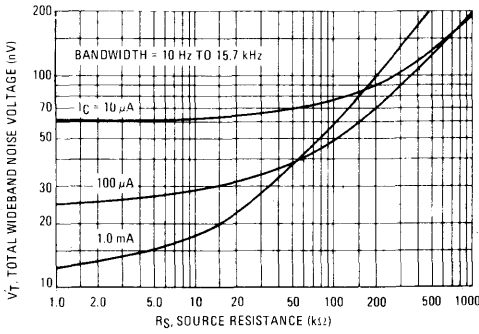
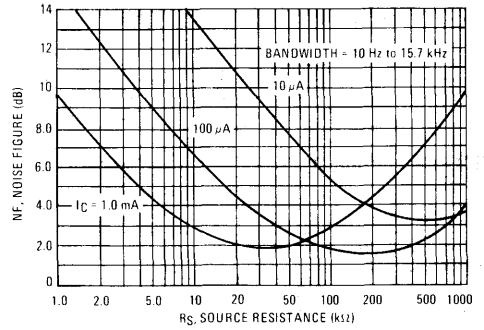


FIGURE 4 – WIDEBAND NOISE FIGURE



DYNAMIC CHARACTERISTICS

FIGURE 5 – CAPACITANCE

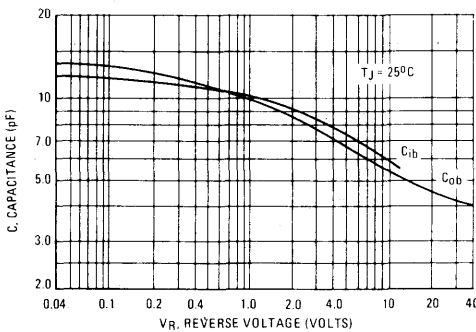
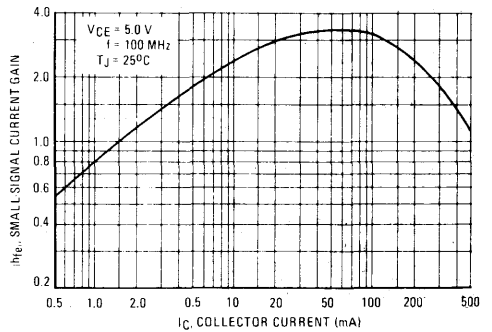


FIGURE 6 – HIGH FREQUENCY CURRENT GAIN



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	40		Vdc
Collector-Base Voltage	V _{CBO}	40		Vdc
Emitter-Base Voltage	V _{EBO}	5.0		Vdc
Collector Current — Continuous	I _C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T _A = 25°C(1) Derate above 25°C	P _D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	825 6.7	2400 19.2	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	139	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) (I _C = 10 mAdc, I _B = 0)	V _{(BR)CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μAdc, I _E = 0)	V _{(BR)CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μAdc, I _C = 0)	V _{(BR)EBO}	5.0	—	Vdc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0)	I _{CBO}	—	50	nAdc
Emitter Cutoff Current (V _{EB} = 4.0 Vdc, I _C = 0)	I _{EBO}	—	50	nAdc

ON CHARACTERISTICS(2)

DC Current Gain (I _C = 0.1 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1.0 mAdc, V _{CE} = 1.0 Vdc) (I _C = 10 mAdc, V _{CE} = 1.0 Vdc)	h _{FE}	30 50 70	— — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{CE(sat)}	—	0.25	Vdc
Base-Emitter Saturation Voltage (I _C = 10 mAdc, I _B = 1.0 mAdc)	V _{BE(sat)}	—	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	200	—	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 100 kHz)	C _{obo}	—	4.5	pF
Input Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 100 kHz)	C _{ibo}	—	10 8.0	pF
		PNP		
		NPN		

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ6700

CASE 646-05, TYPE 2
TO-116

QUAD
COMPLEMENTARY PAIR
TRANSISTOR

PNP/NPN SILICON

NPN

PNP

FIGURE 1 - DC CURRENT GAIN

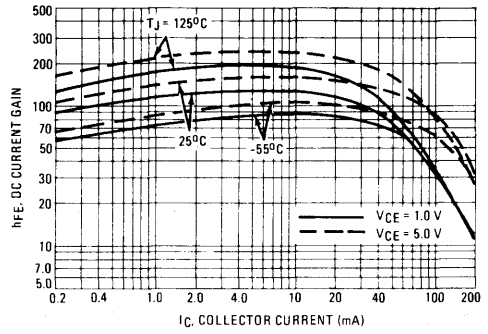
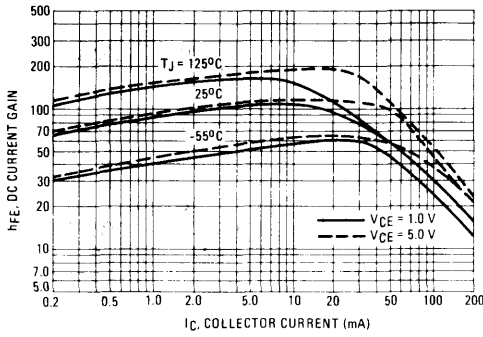


FIGURE 2 - "ON" VOLTAGE

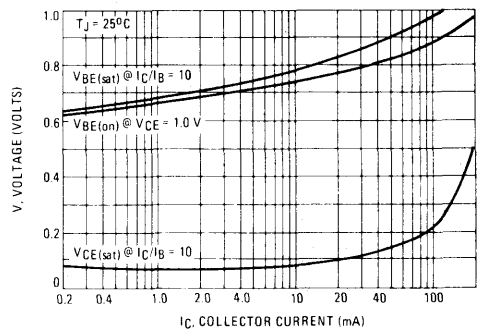
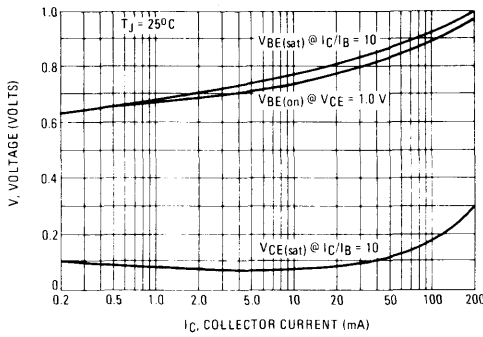
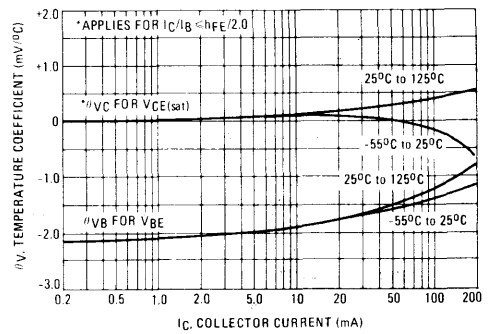
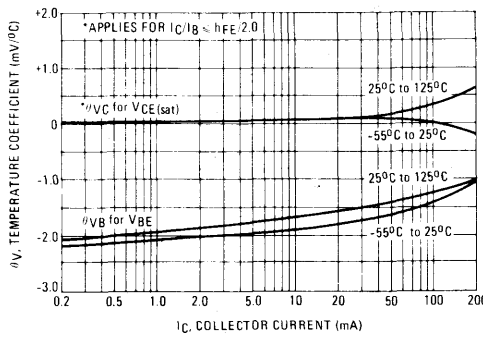


FIGURE 3 - TEMPERATURE COEFFICIENTS



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NPN

PNP

FIGURE 4 – COLLECTOR SATURATION REGION

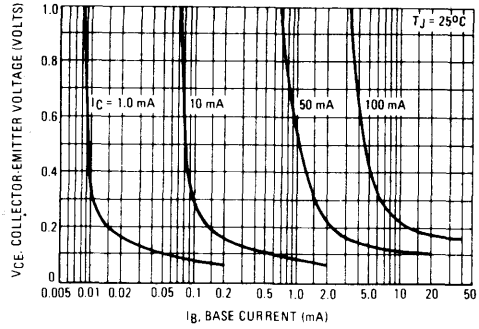
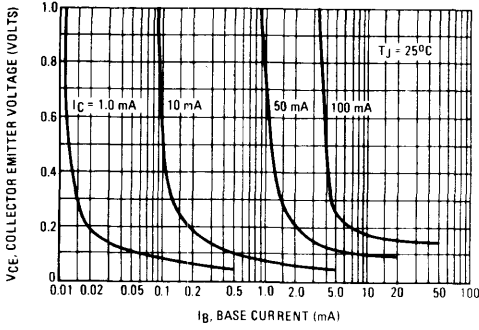


FIGURE 5 – TURN-ON TIME

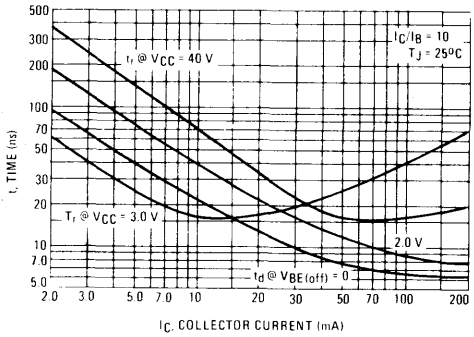
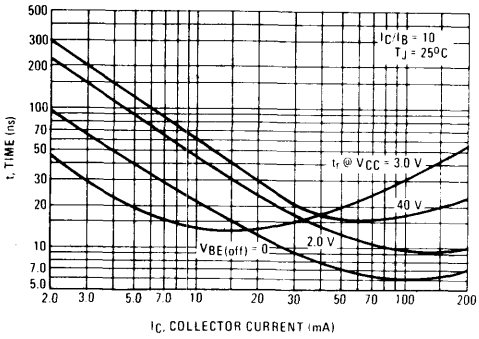
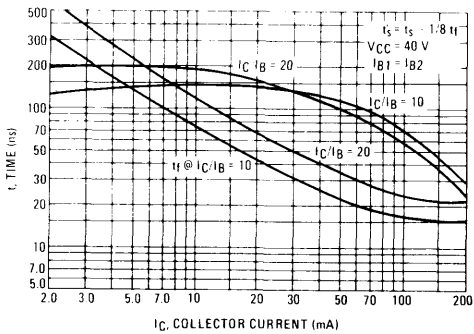
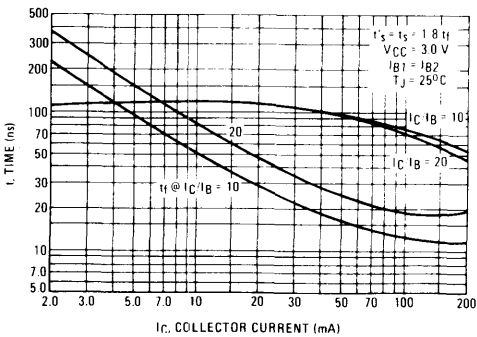


FIGURE 6 – TURN-OFF TIME



5

NPN

PNP

FIGURE 7 – CURRENT-GAIN – BANDWIDTH PRODUCT

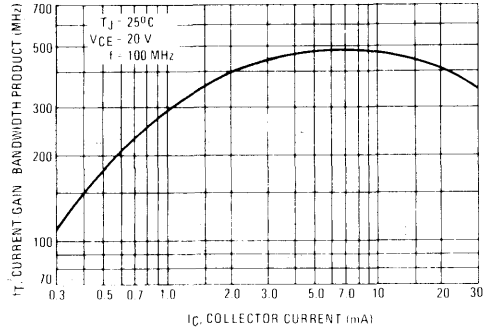
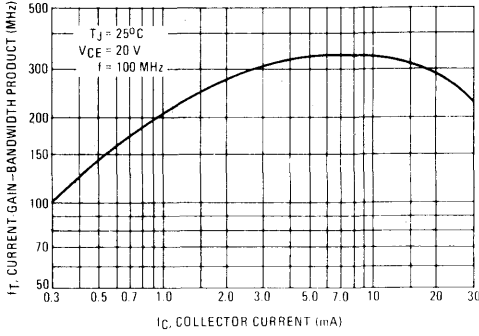
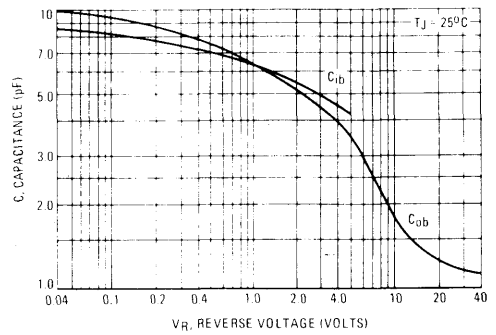
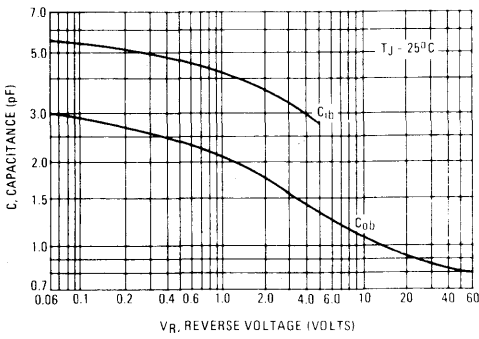


FIGURE 8 – CAPACITANCE



5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ (1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	825 6.7	2400 19.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 55 to + 150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	139	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	50	nAdc

ON CHARACTERISTICS(2)

DC Current Gain ($I_C = 0.5 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30 50 70	— — —	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 0.5 \text{ mAdc}, I_B = 0.05 \text{ mAdc}, 0^\circ\text{C} \leq T \leq 70^\circ\text{C}$)	$V_{CE(sat)}$	—	0.05	0.15	Vdc
Base-Emitter Saturation Voltage ($I_C = 0.5 \text{ mAdc}, I_B = 0.05 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.65	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(2) ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	200	350	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	3.0	4.5	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz}$)	C_{ibo}	—	5.0 4.0	10 8.0	pF
					PNP NPN

SWITCHING CHARACTERISTICS ($T_A = 25^\circ\text{C}, V_{CC} = 5.0 \text{ Vdc}$)

Propagation Delay Time (50% Points TP1 to TP3) (50% Points TP2 to TP4)	t_{PLH} t_{PHL}	— —	15 6.0	25 15	ns
Rise Time (0.3 V to 4.7 V, TP3 or TP4)	t_r	5.0	25	35	ns
Fall Time (4.7 V to 0.3 V, TP3 or TP4)	t_f	5.0	10	20	ns

(2) Pulse Test: Pulse Width $\leq 300 \text{ } \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MPQ6842

CASE 646-05, TYPE 2
TO-116

QUAD
COMPLEMENTARY PAIR
TRANSISTOR

PNP/NPN SILICON

5

NPN

PNP

FIGURE 1 - DC CURRENT GAIN

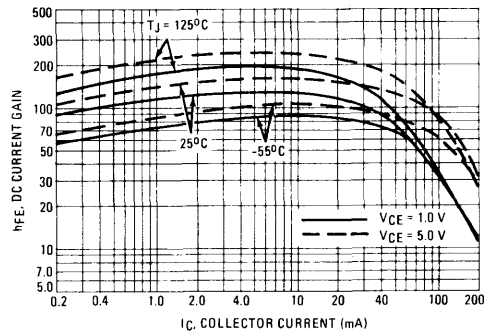
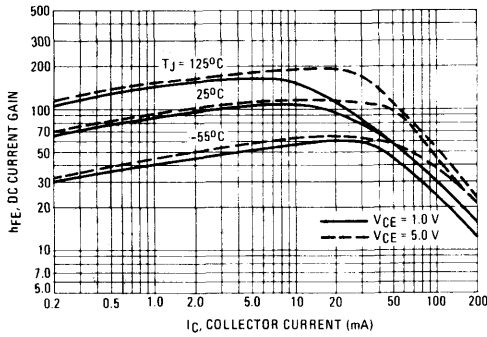


FIGURE 2 - "ON" VOLTAGE

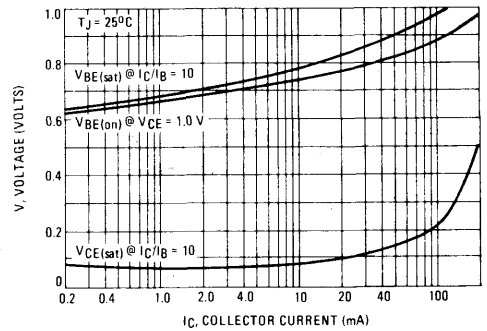
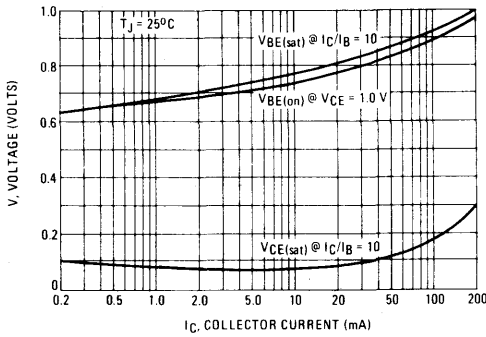
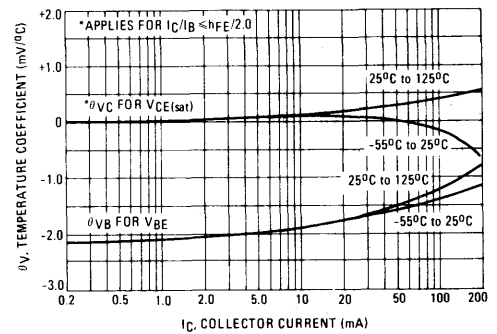
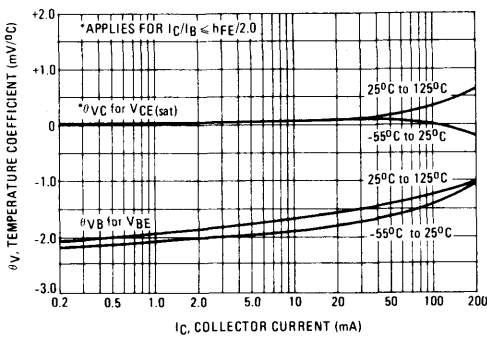


FIGURE 3 - TEMPERATURE COEFFICIENTS



NPN

FIGURE 4 - COLLECTOR SATURATION REGION

PNP

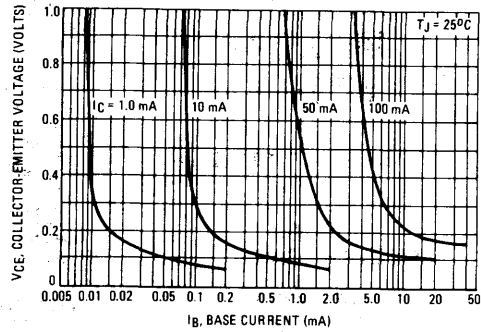
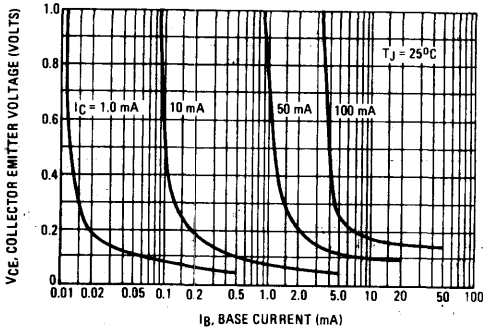
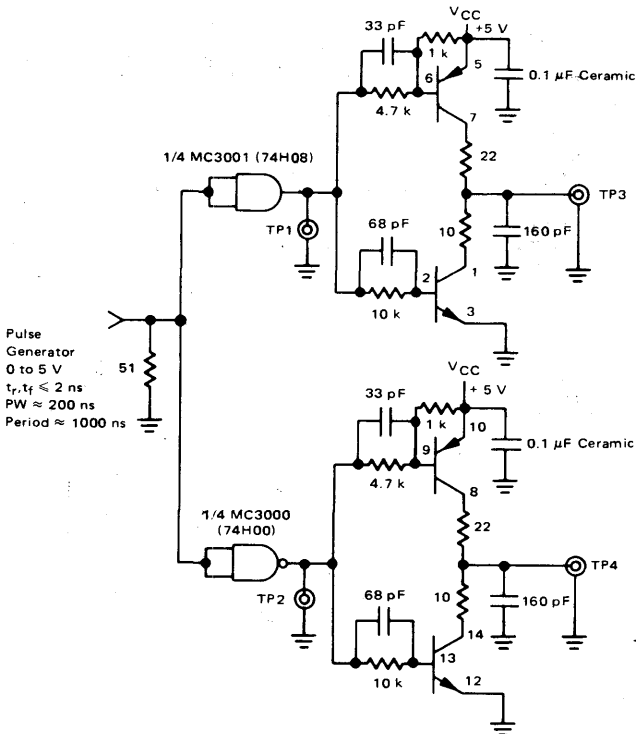
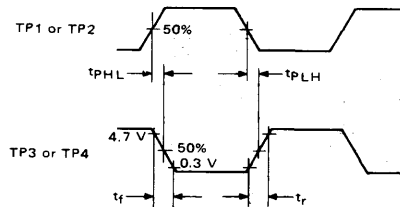


FIGURE 5 - SWITCHING TIMES TEST CIRCUIT AND WAVEFORMS



NOTES:

1. Unless otherwise noted, all resistors carbon composition 1/4 W ±5%, all capacitors dipped mica ±2%.
2. Use short interconnect wiring with good power and ground busses.
3. TP1 thru TP4 are coaxial connectors to accept scope probe tip and provide a good ground.
4. Device under test is MPQ6842.
5. 160 pF load does not include stray or scope probe capacitance.
6. Scope probe resistance > 5 kΩ. Scope probe capacitance < 10 pF.



MPQ7041 MPQ7042 MPQ7043

CASE 646-05, STYLE 1
TO-116

QUAD AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPQ7051 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ7041	MPQ7042	MPQ7043	Unit
Collector-Emitter Voltage	V_{CE0}	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	500			mAdc
		Each Die	Four Die Equal Power		
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	750 5.98	1700 13.6		mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.25 10	3.2 25.6		Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	100	167	$^\circ\text{C/W}$
	Effective, 4 Die	39	73.5	$^\circ\text{C/W}$
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	MPQ7041 MPQ7042 MPQ7043	$V_{(BR)CEO}$	150 200 250	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	MPQ7041 MPQ7042 MPQ7043	$V_{(BR)CBO}$	150 200 250	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 120 \text{ Vdc}, I_E = 0$) ($V_{CB} = 150 \text{ Vdc}, I_E = 0$) ($V_{CB} = 180 \text{ Vdc}, I_E = 0$)	MPQ7041 MPQ7042 MPQ7043	I_{CBO}	— — —	— — —	100 100 100 nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$) ($I_C = 30 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)		h_{FE}	25 40 40	45 60 80	— — —
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)		$V_{CE(sat)}$	—	0.3	0.5
Base-Emitter Saturation Voltage ($I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc}$)		$V_{BE(sat)}$	—	0.7	0.9
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)		f_T	50	80	—
Output Capacitance ($V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)		C_{obo}	—	2.5	5.0
Input Capacitance ($V_{EB} = 3.0 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$)		C_{ibo}	—	40	50

MAXIMUM RATINGS

Rating	Symbol	MPQ7051	MPQ7052	MPQ7053	Unit
Collector-Emitter Voltage	V _{CEO}	150	200	250	V _{dc}
Collector-Base Voltage	V _{CBO}	150	200	250	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current — Continuous	I _C	500			mAdc
		Each Die	Four Die Equal Power		
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	750 5.98	1700 13.6		mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	100	167 °C/W
	Effective, 4 Die	39	73.5 °C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56 %
	Q1-Q2 or Q3-Q4	5.0	10 %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	MPQ7051 MPQ7052 MPQ7053	V _{(BR)CEO}	150 200 250	— — —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	MPQ7051 MPQ7052 MPQ7053	V _{(BR)CBO}	150 200 250	— — —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)		V _{(BR)EBO}	5.0	—	V _{dc}
Collector Cutoff Current (V _{CB} = 120 Vdc, I _E = 0) (V _{CB} = 150 Vdc, I _E = 0) (V _{CB} = 180 Vdc, I _E = 0)	MPQ7051 MPQ7052 MPQ7053	I _{CBO}	— — —	250 250 250	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)		I _{EBO}	—	100	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 30 mAdc, V _{CE} = 10 Vdc)	h _{FE}	25 35 25	— — —	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{CE(sat)}	—	0.7	V _{dc}
Base-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{BE(sat)}	—	0.9	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	50	—	MHz
Output Capacitance (V _{CB} = 20 Vdc, I _C = 0, f = 1.0 MHz)	C _{obo}	—	6.0	pF
Input Capacitance (V _{EB} = 3.0 Vdc, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	50 75	pF

**MPQ7051
MPQ7052
MPQ7053**

**CASE 646-05, TYPE 2
TO-116**

**QUAD
COMPLEMENTARY PAIR
TRANSISTOR**

NPN/PNP SILICON

DC CHARACTERISTICS

NPN

PNP

FIGURE 1 - DC CURRENT GAIN

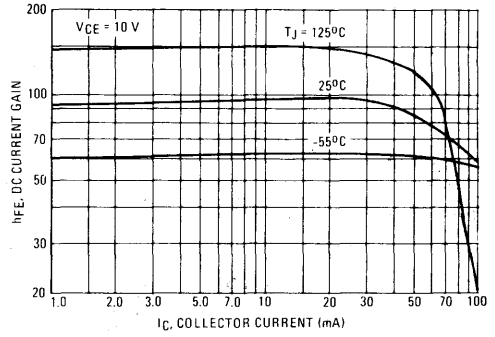
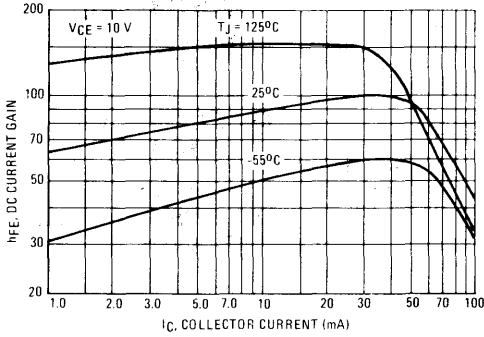


FIGURE 2 - "ON" VOLTAGES

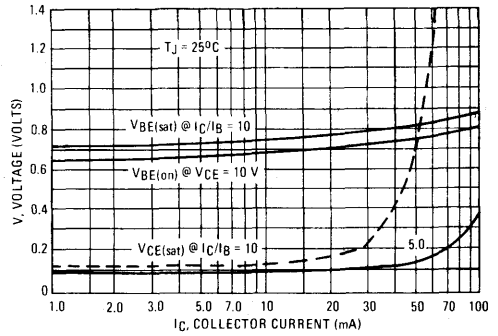
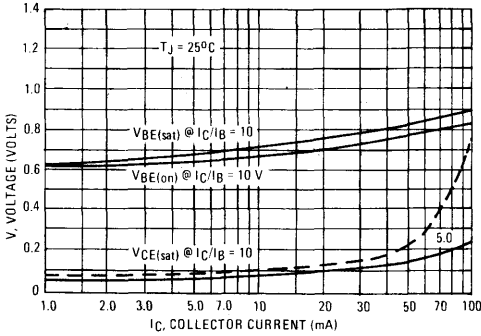
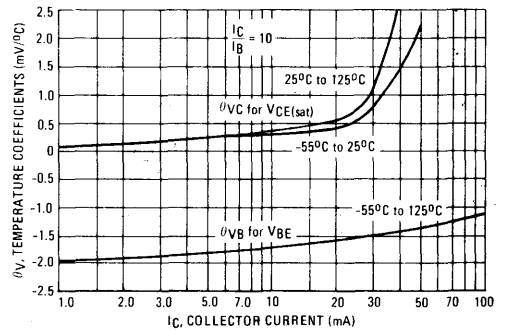
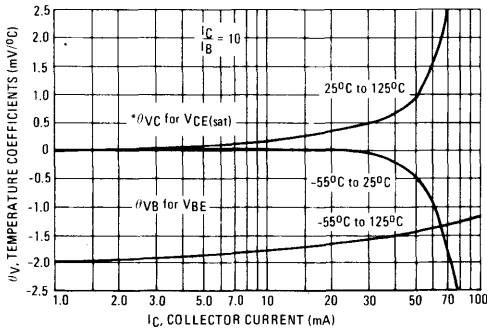


FIGURE 3 - TEMPERATURE COEFFICIENTS



MAXIMUM RATINGS

Rating	Symbol	MPQ7091	MPQ7092	MPQ7093	Unit
Collector-Emitter Voltage	V _{CEO}	150	200	250	V _{dc}
Collector-Base Voltage	V _{CBO}	150	200	250	V _{dc}
Emitter-Base Voltage	V _{EBO}	5.0			V _{dc}
Collector Current — Continuous	I _C	500			mAdc
		Each Die	Four Die Equal Power		
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	750 5.98	1700 13.6		mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	- 55 to + 150			°C

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance Each Die Effective, 4 Die	100 39	167 73.5	°C/W °C/W
Coupling Factors Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	46 5.0	56 10	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	MPQ7091 MPQ7092 MPQ7093	V _{(BR)CEO}	150 200 250	— — —	— — —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	MPQ7091 MPQ7092 MPQ7093	V _{(BR)CBO}	150 200 250	— — —	— — —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)		V _{(BR)EBO}	5.0	—	—	V _{dc}
Collector Cutoff Current (V _{CB} = 120 Vdc, I _E = 0) (V _{CB} = 150 Vdc, I _E = 0) (V _{CB} = 180 Vdc, I _E = 0)	MPQ7091 MPQ7092 MPQ7093	I _{CBO}	— — —	— — —	250 250 250	nAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)		I _{EBO}	—	—	100	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mAdc, V _{CE} = 10 Vdc) (I _C = 10 mAdc, V _{CE} = 10 Vdc) (I _C = 30 mAdc, V _{CE} = 10 Vdc)	h _{FE}	25 35 25	40 55 50	— — —	—
Collector-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{CE(sat)}	—	0.3	0.5	V _{dc}
Base-Emitter Saturation Voltage (I _C = 20 mAdc, I _B = 2.0 mAdc)	V _{BE(sat)}	—	0.7	0.9	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 10 mAdc, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	50	70	—	MHz
Output Capacitance (V _{CB} = 20 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	3.0	5.0	pF
Input Capacitance (V _{EB} = 3.0 Vdc, I _C = 0, f = 1.0 MHz)	C _{ibo}	—	60	75	pF

**MPQ7091
MPQ7092
MPQ7093**

**CASE 646-05, STYLE 1
TO-116**

**QUAD
AMPLIFIER TRANSISTOR**

PNP SILICON

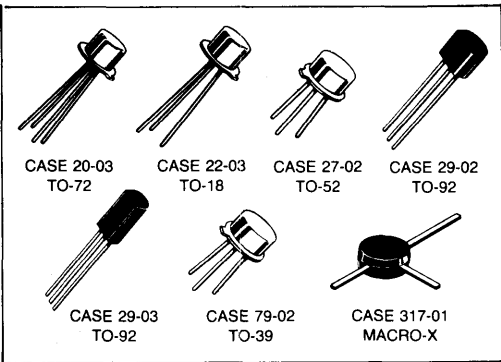
Refer to MPQ7051 for graphs.

5

MQ982

For Specifications, See MD982 Data.





The data sheets on the following pages are designed to emphasize those FET's that by virtue of widespread industry use, ease of manufacture, and consequently low relative cost, merit first consideration for new equipment design. Package options from low-cost plastic to metal packages are available.

CAUTION:

Static electricity is a surface phenomenon which most commonly occurs when two dissimilar materials come into contact and then separate. Electro Static Discharge (ESD) damage of semiconductor components by operating personnel is quickly becoming a very prominent and significant problem. From simple bipolar designs to sensitive MOSFET structures, ESD has its unforgiving effect of degradation or destruction.

Motorola believes it is important to extend an emphasizing note of cautiousness when handling and testing ANY FET product. Precautions include, but are not limited to, the implementation of static safe workstations and proper handling techniques (see below). Additionally, it is very important to keep FET devices in their antistatic shipping containers and away from any static-generating materials.

HANDLING CONSIDERATIONS:

MOS Field-Effect Transistors, due to their extremely high input resistance, are subject to potential damage by the accumulation of excess static charge. To avoid possible damage to the devices while handling, testing, or in actual operation, the following procedure should be followed:

1. The leads of the devices should remain wrapped in the shorting spring except when being tested or in actual operation to avoid the build-up of static charge.
2. Avoid unnecessary handling; when handled, the devices should be picked up by the *can* instead of the leads.
3. The devices should not be inserted or removed from circuits with the power on as transient voltages may cause permanent damage to the devices.

Field-Effect Transistors

2N2608 2N2609

CASE 22-03, STYLE 12
TO-18 (TO-206AA)

JFET
GENERAL PURPOSE

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-60 to +200°C	°C

Refer to 2N5460 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{A}$)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current ($V_{GS} = 5.0 \text{ V}$)	I_{GSS}	—	10	nA
Gate Source Cutoff Voltage ($V_{DS} = -5.0 \text{ V}$, $I_D = -1.0 \mu\text{A}$)	$V_{GS(off)}$	1.0	4.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = -5.0 \text{ V}$, $V_{GS} = 0 \text{ V}$)	I_{DSS}^*			mA
	2N2608	-0.9	-4.5	
	2N2609	-2.0	-10.0	
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = -5.0 \text{ V}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} ^*$			μmhos
	2N2608	1000	—	
	2N2609	2500	—	
Input Capacitance ($V_{DS} = -5.0 \text{ V}$, $V_{GS} = 1.0 \text{ V}$, $f = 140 \text{ kHz}$)	C_{iss}			pF
	2N2608	—	17	
	2N2609	—	30	
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = -5.0 \text{ V}$, $f = 1.0 \text{ kHz}$, $R = 1.0 \text{ meg}$)	NF	—	3.0	dB

*Pulse Width $\leq 100 \text{ msec.}$, Duty Cycle $\leq 10\%$.

2N3330

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET
AMPLIFIER

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.3 2.0	Watts mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

Refer to 2N5460 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = 10 \text{Vdc}$, $V_{DS} = 0$) ($V_{GS} = 10 \text{Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	— —	10 10	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = -10 \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}	2.0	6.0	mAdc
Gate-Source Voltage ($V_{DG} = -15 \text{Vdc}$, $I_D = 10 \mu\text{Adc}$)	V_{GS}	—	6.0	Vdc
Drain-Source Resistance ($I_D = 100 \mu\text{Adc}$, $V_{GS} = 0$)	r_{DS}	—	800	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance(1) ($V_{DS} = -10 \text{Vdc}$, $I_D = 2.0 \text{mAdc}$, $f = 1.0 \text{kHz}$) ($V_{DS} = -10 \text{Vdc}$, $I_D = 2.0 \text{mAdc}$, $f = 10 \text{MHz}$)	$ y_{fs} $	1500 1350	3000 —	μmhos
Output Admittance ($V_{DS} = -10 \text{Vdc}$, $I_D = 2.0 \text{mAdc}$, $f = 1.0 \text{kHz}$)	$ y_{os} $	—	40	μmhos
Reverse Transfer Conductance ($V_{DS} = -10 \text{Vdc}$, $I_D = 2.0 \text{mAdc}$, $f = 1.0 \text{kHz}$)	$ y_{rs} $	—	0.1	μmhos
Input Conductance ($V_{DS} = -10 \text{Vdc}$, $I_D = 2.0 \text{mAdc}$, $f = 1.0 \text{kHz}$)	$ y_{is} $	—	0.2	μmhos
Input Capacitance ($V_{DS} = -10 \text{Vdc}$, $V_{GS} = 1.0 \text{Vdc}$, $f = 1.0 \text{MHz}$)	C_{iss}	—	20	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = -5.0 \text{Vdc}$, $I_D = 1.0 \text{mAdc}$, $R_G = 1.0 \text{Megohm}$, $f = 1.0 \text{kHz}$)	NF	—	3.0	dB

(1) Pulse Test: Pulse Width $\leq 630 \text{ms}$, Duty Cycle $\leq 10\%$.

**2N3436
2N3437
2N3438**

**CASE 22-03, STYLE 4
TO-18 (TO-206AA)**

**JFET
LOW-FREQUENCY**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{A}$)	$V_{(BR)GSS}$	50	—	Vdc
Gate Reverse Current ($V_{GS} = -30 \text{ V}$)	I_{GSS}	—	0.5	nA
Gate Source Cutoff Voltage ($V_{DS} = 20 \text{ V}, I_D = 1.0 \mu\text{A}$)	$V_{GS(off)}$	—	10.0 5.0 2.5	Vdc
Gate Source Voltage ($V_{DS} = 20 \text{ V}, I_D = 1.0 \mu\text{A}$)	V_{GS}	—	9.8 4.8 2.3	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current ($V_{DS} = 20 \text{ V}$)	I_{DSS}^*	3.0 0.8 0.2	15 4.0 1.0	mA
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 20 \text{ V}, f = 1.0 \text{ kHz}$)	$ y_{fs} $	2500 1500 800	10000 6000 4500	μmhos
Output Admittance ($V_{DS} = 30 \text{ V}, f = 1.0 \text{ kHz}$)	$ y_{os} $	— — —	35 20 5	μmhos
Input Capacitance ($V_{DS} = 10 \text{ V}$) ($V_{DS} = 6.0 \text{ V}$) ($V_{DS} = 4.0 \text{ V}, f = 1.0 \text{ MHz}$)	C_{iss}	—	18	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 10 \text{ V}, R_G = 1.0 \text{ m}\Omega, f = 1.0 \text{ kHz}$)	NF	—	2.0	dB
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*Pulse Width $\leq 630 \text{ msec}$, Duty Cycle $\leq 10\%$.

2N3458 2N3459 2N3460

**CASE 22-03, STYLE 4
TO-18 (TO-206AA)**

**JFET
LOW-FREQUENCY/
LOW NOISE**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V _{DG}	50	Vdc
Gate-Source Voltage	V _{GS}	50	Vdc
Gate Current	I _G	10	mA
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	300 1.7	mW mW/°C
Storage Temperature Range	T _{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I _G = 1.0 μA)	V _{(BR)GSS}	-50	—	Vdc
Gate Reverse Current (V _{GS} = -30 V)	I _{GSS}	—	-.25	nA
Gate Source Cutoff Voltage (V _{DS} = 20, I _D = 1.0 μA)	V _{GS(off)}	—	-7.8 -3.4 -1.8	Vdc
				2N3458 2N3459 2N3460

ON CHARACTERISTICS

Zero-Gate-Voltage Drain (V _{DS} = 20 Volts)	I _{DSS} *	3.0 0.8 0.2	15.0 4.0 1.0	mA
				2N3458 2N3459 2N3460

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance (V _{DS} = 20 Volts, f = 1.0 kHz)	y _{fs} *	2500 1500 800	10000 6000 4500	μmhos
				2N3458 2N3459 2N3460
Output Admittance (V _{DS} = 30 Volts, f = 1.0 kHz)	y _{os}	— — —	35 20 5	μmhos
				2N3458 2N3459 2N3460
Input Capacitance (V _{DS} = 10 V)	C _{iss}	—	18	pF
Output Capacitance (V _{DS} = 30 V)	C _{oss}	—	5.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure (V _{DS} = 10 V, f = 20 Hz, R _G = 1.0 MΩ)	NF	— — —	6.0 4.0 4.0	dB
				2N3458 2N3459 2N3460

*Pulse Width ≤ 100 msec, Duty Cycle ≤ 10%.

2N3796 2N3797

CASE 22-03, STYLE 2
TO-18 (TO-206AA)

**MOSFET
LOW-POWER AUDIO**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
2N3796 2N3797		20	
Gate-Source Voltage	V_{GS}	± 10	Vdc
Drain Current	I_D	20	mAdc
Total Device Dissipation (α $T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	+175	$^\circ\text{C}$
Storage Channel Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage ($V_{GS} = -4.0\text{ V}$, $I_D = 5.0\ \mu\text{A}$) ($V_{GS} = -7.0\text{ V}$, $I_D = 5.0\ \mu\text{A}$)	2N3796 2N3797	$V_{(BR)DSX}$	25 20	30 25	— —	Vdc
Gate Reverse Current(1) ($V_{GS} = -10\text{ V}$, $V_{DS} = 0$) ($V_{GS} = -10\text{ V}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)		I_{GSS}	— —	— —	1.0 200	pAdc
Gate Source Cutoff Voltage ($I_D = 0.5\ \mu\text{A}$, $V_{DS} = 10\text{ V}$) ($I_D = 2.0\ \mu\text{A}$, $V_{DS} = 10\text{ V}$)	2N3796 2N3797	$V_{GS(off)}$	— —	-3.0 -5.0	-4.0 -7.0	Vdc
Drain-Gate Reverse Current(1) ($V_{DG} = 10\text{ V}$, $I_S = 0$)		I_{DGO}	—	—	1.0	pAdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$)	2N3796 2N3797	I_{DSS}	0.5 2.0	1.5 2.9	3.0 6.0	mAdc
On-State Drain Current ($V_{DS} = 10\text{ V}$, $V_{GS} = +3.5\text{ V}$)	2N3796 2N3797	$I_{D(on)}$	7.0 9.0	8.3 14	14 18	mAdc

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ kHz}$)	2N3796 2N3797	$ y_{fs} $	900 1500	1200 2300	1800 3000	μmhos
($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	2N3796 2N3797		900 1500	— —	— —	
Output Admittance ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ kHz}$)	2N3796 2N3797	$ y_{os} $	— —	12 27	25 60	μmhos
Input Capacitance ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	2N3796 2N3797	C_{iss}	— —	5.0 6.0	7.0 8.0	pF
Reverse Transfer Capacitance ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)		C_{rss}	—	0.5	0.8	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ kHz}$, $R_S = 3\text{ megohms}$)	NF	—	3.8	—	—	dB
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(1) This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under best attainable conditions.

TYPICAL DRAIN CHARACTERISTICS

FIGURE 1 — 2N3796

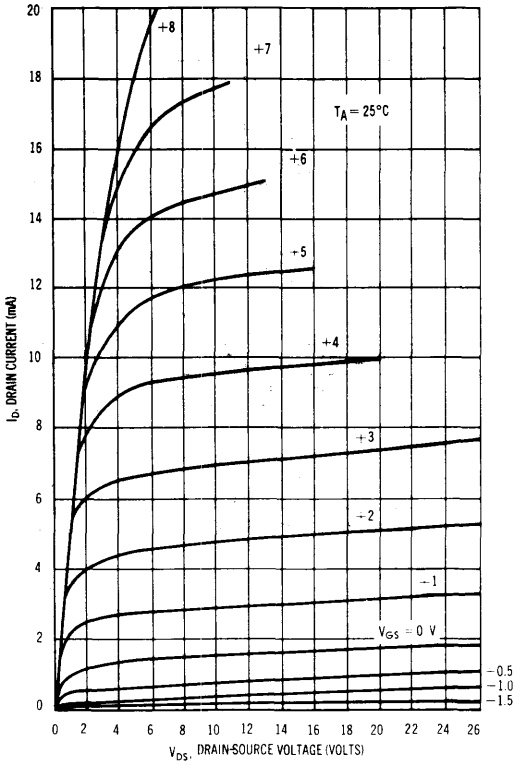
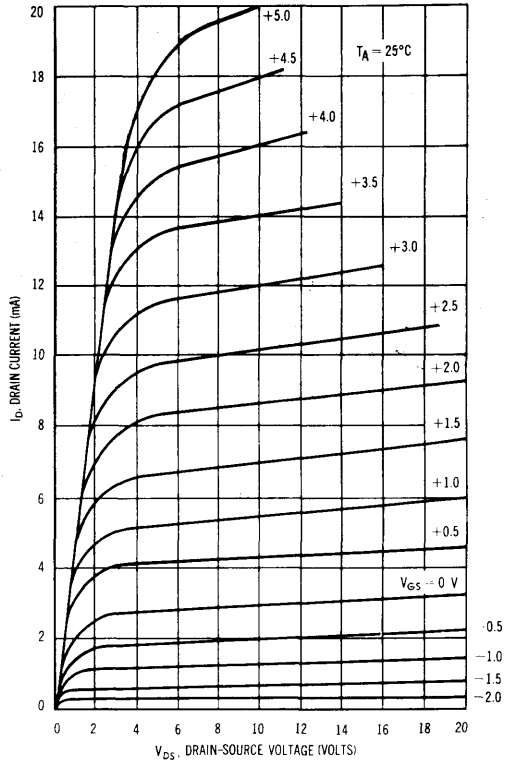


FIGURE 2 — 2N3797



COMMON SOURCE TRANSFER CHARACTERISTICS

FIGURE 3 — 2N3796

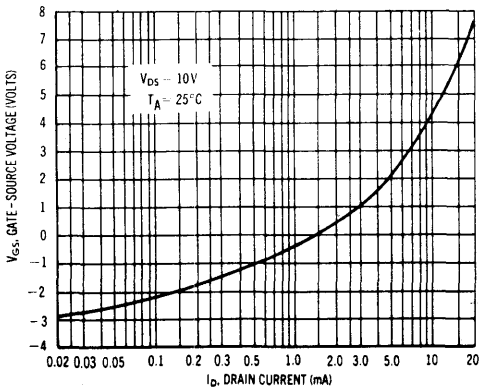
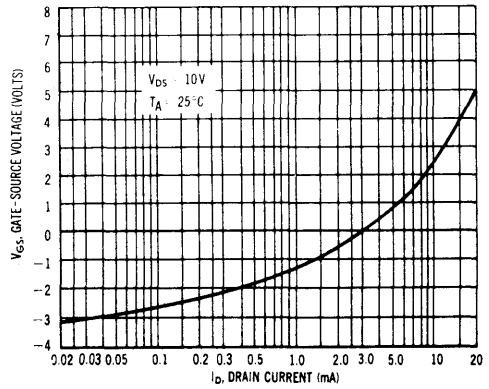


FIGURE 4 — 2N3797



2N3796, 2N3797

FIGURE 5 — FORWARD TRANSFER ADMITTANCE

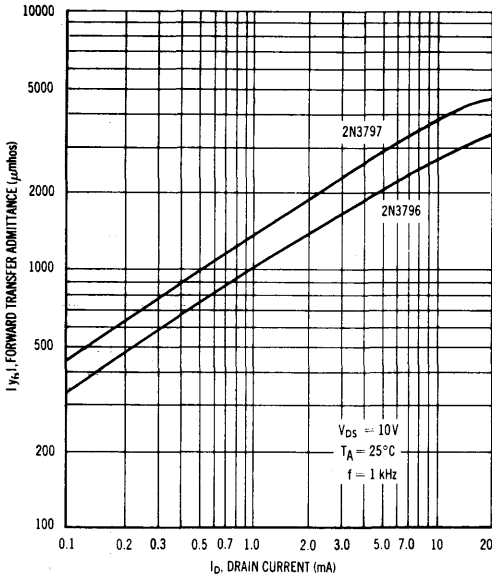


FIGURE 6 — OUTPUT ADMITTANCE

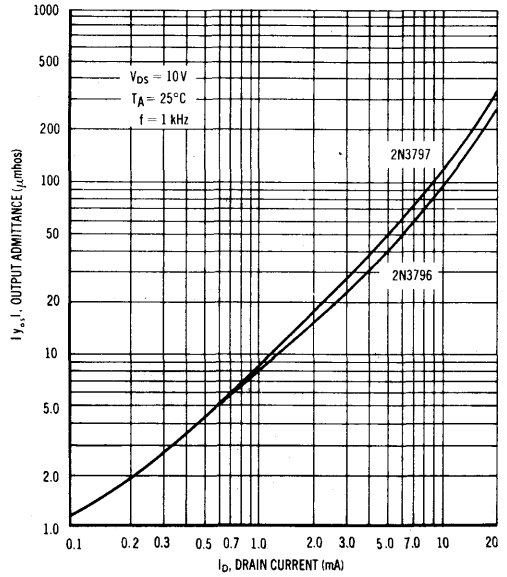
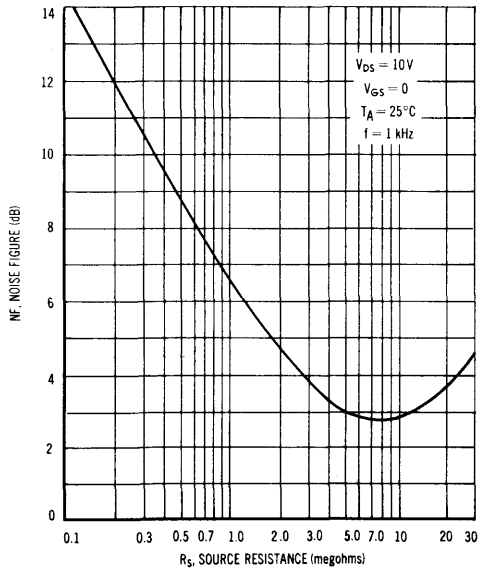


FIGURE 7 — NOISE FIGURE



2N3819

CASE 29-02, STYLE 22
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL - DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.88	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	$^\circ\text{C}$

Refer to 2N4416 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1 \mu\text{Adc}, V_{DS} = 0$)	$V_{(BR)GSS}$	25	—		Vdc
Gate-Source Voltage ($V_{DS} = 15 \text{ Vdc}, I_D = 200 \mu\text{Adc}$)	V_{GS}	0.5	—	7.5	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}, V_{DS} = 0$)	I_{GSS}		—	2	nAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}, I_D = 2 \text{ nAdc}$)	$V_{GS(off)}$		—	8	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}, V_{DS} = 0, T_A = 100^\circ\text{C}$)	I_{GSS}		—	2	μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0$)	I_{DSS}	2	—	20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	$ Y_{fs} $	2		6.5	mmhos
Forward Transadmittance ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0, f = 100 \text{ MHz}$)	Y_{fs}	1.6		—	mmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}, I_D = 10 \text{ mAdc}, f = 1.0 \text{ MHz}$)	C_{iss}	—		8	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}, I_D = 10 \text{ mAdc}, f = 1.0 \text{ MHz}$)	C_{rss}	—		4	pF
Output Admittance ($V_{DS} = 15 \text{ Vdc}, I_D = 10 \text{ mAdc}, f = 1.0 \text{ kHz}$)	Y_{os}			50	μmhos

**2N3821
2N3822
2N3824**

**CASE 20-03, STYLE 1
TO-72 (TO-206AF)**

**JFET
LOW FREQUENCY, LOW NOISE**

**N-CHANNEL — DEPLETION
JAN 2N3821 AND JAN 2N3822 AVAILABLE**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	-50	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

Refer to 2N4220 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-50	—	Vdc
Gate Reverse Current ($V_{GS} = -30 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -30 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	— —	-0.1 -100	nAdc
Gate Source Cutoff Voltage ($I_D = 0.5 \text{ nAdc}$, $V_{DS} = 15 \text{ Vdc}$)	$V_{GS(off)}$	— —	-4.0 -6.0	Vdc
Gate Source Voltage ($I_D = 50 \mu\text{Adc}$, $V_{DS} = 15 \text{ Vdc}$) ($I_D = 200 \mu\text{Adc}$, $V_{DS} = 15 \text{ Vdc}$)	V_{GS}	-0.5 -1.0	-2.0 -4.0	Vdc
Drain Cutoff Current ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -8.0 \text{ Vdc}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -8.0 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	— —	0.1 100	nAdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	0.5 2.0	2.5 10	mAdc
Static Drain-Source On Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r'_{DS(on)}$	—	250	Ohms

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)(1)	$ y_{fs} $	1500 3000	4500 6500	μmhos
($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)		1500 3000	— —	
Output Admittance(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	— —	10 20	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	— —	3.0 3.0	pF
($V_{GS} = -8.0 \text{ Vdc}$, $V_{DS} = 0$, $f = 1.0 \text{ MHz}$)		—	3.0	

2N3821, 2N3822, 2N3824

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $R_S = 1.0\text{ megohm}$, $f = 10\text{ Hz}$, Noise Bandwidth = 5.0 Hz)	NF	—	5.0	dB
Equivalent Input Noise Voltage ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 10\text{ Hz}$, Noise Bandwidth = 5.0 Hz)	e_n	—	200	$\text{nv}/\text{Hz}^{1/2}$

(1) Pulse Test: Pulse Width $\leq 100\text{ ms}$, Duty Cycle $\leq 10\%$.

2N3823

JAN, JANTX AVAILABLE
CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
VHF AMPLIFIER
N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation (at $T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	300 2.0	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	65 to -200	°C

Refer to 2N4416 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-30	—	Vdc
Gate Reverse Current ($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	—	-0.5 -500	nAdc
Gate Source Cutoff Voltage ($I_D = 0.5 \text{ nAdc}$, $V_{DS} = 15 \text{ Vdc}$)	$V_{GS(off)}$	—	8.0	Vdc
Gate Source Voltage ($I_D = 0.4 \text{ mAdc}$, $V_{DS} = 15 \text{ Vdc}$)	V_{GS}	1.0	-7.5	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	4.0	20	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)	Y_{fs}	3500 3200	6500 —	μmhos
Input Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)	$\text{Re}(Y_{is})$	—	800	μmhos
Output Conductance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)	Y_{os} $\text{Re}(Y_{os})$	— —	35 200	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	2.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $R_S = 1000 \text{ ohms}$, $f = 100 \text{ MHz}$)	NF	—	2.5	dB
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(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle = 10%.

2N3909,A

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET
AMPLIFIER

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-20	Vdc
Drain-Gate Voltage	V_{DG}	-20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Forward Gate-Source Voltage	V_{GSF}	20	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

Refer to 2N5460 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.) (1)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = 10 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = 10 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	—	10 1.0	nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = -10 \text{ Vdc}$, $I_D = 10 \mu\text{Adc}$)	$V_{GS(off)}$	—	8.0 8.0	Vdc
Gate Source Voltage ($V_{DS} = -10 \text{ Vdc}$, $I_D = 30 \mu\text{Adc}$)	V_{GS}	0.3	7.9	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(2) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	0.3 1.0	15 15	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance(2) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	1000 2200	5000 5000	μmhos
($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $f = 10 \text{ MHz}$)		900 2000	— —	
Output Admittance ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	—	100	μmhos
Input Capacitance ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	32 9.0	pF
Reverse Transfer Capacitance ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	16 3.0	pF

(1) The fourth lead (case) is connected to the source for all measurements.

(2) Pulse Test: Pulse Width $\leq 630 \text{ ms}$, Duty Cycle $\leq 10\%$.

2N3966

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
HIGH-FREQUENCY AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C (Free Air)	P_D	300 1.71	mW mW/°C
Lead Temperature (1/16" from Case for 10 Seconds)	T_L	300	°C
Storage Temperature Range	T_{stg}	-55 to 200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-30	—	Vdc
Gate Reverse Current ($V_{GS} = 20 \text{ V}$, $V_{DS} = 0$)	I_{GSS}	—	0.1	nA
Drain Cutoff Current ($V_{DS} = 10 \text{ V}$, $V_{GS} = -7.0 \text{ V}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	—	2.0	μA
Gate Source Cutoff Voltage ($I_D = 10 \text{ nA}$, $V_{DS} = 10 \text{ V}$)	$V_{GS(off)}$	4.0	6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 20 \text{ V}$, $V_{GS} = 0$)	I_{DSS}	2.0	—	mA
Drain-Source "ON" Voltage ($I_D = 1.0 \text{ mA}$, $V_{GS} = 0 \text{ V}$)	$V_{DS(on)}$	—	0.25	Vdc
Drain Reverse Current ($V_{DG} = 20 \text{ V}$, $I_S = 0 \text{ A}$)	I_{DGO}	— —	0.1 0.2	nA μA
Static Drain-Source On Resistance ($V_{GS} = 0 \text{ V}$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{DS(on)}$	—	220	Ω
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance ($V_{DS} = 20 \text{ V}$, $V_{GS} = 0 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0 \text{ V}$, $V_{GS} = 7.0 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	1.5	pF
SWITCHING CHARACTERISTICS				
Delay Time (See Figure 1)	t_d	—	0.02	μsec
Rise Time (See Figure 1)	t_r	—	100	nsec
Turn-Off Time (See Figure 1)	t_{off}	—	100	nsec

2N3970 2N3971 2N3972

**CASE 22-03, STYLE 4
TO-18 (TO-206AA)**

**JFET
SWITCHING**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{GS} = 0$)	$V_{(BR)GSS}$	40	—	Vdc
Gate Reverse Current ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	250	pAdc
Drain Reverse Current ($V_{DG} = 20 \text{ Vdc}$, $I_S = 0$)	I_{DGO}	—	250	pAdc
Reverse Gate-Source Current ($V_{DG} = 20 \text{ Vdc}$, $I_S = 0$, $T_A = 150^\circ\text{C}$)	I_{DGO}	—	500	nAdc
Drain Cutoff Current ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = -12 \text{ Vdc}$)	$I_{D(off)}$	—	250	pAdc
Reverse Drain-Source Current ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = -12 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	—	500	nAdc
Gate Source Voltage ($V_{DS} = 20 \text{ Vdc}$, $I_D = 1.0 \text{ nAdc}$)	V_{GS}	4.0 2.0 0.5	10 5.0 3.0	Vdc
	2N3970			
	2N3971			
	2N3972			

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$)	2N3970 2N3971 2N3972	I_{DSS}	50 25 5.0	150 75 30	mAdc
Drain-Source On-Voltage ($I_D = 20 \text{ mAdc}$, $V_{GS} = 0$)	2N3970	$V_{DS(on)}$	—	1.0	Vdc
($I_D = 10 \text{ mAdc}$, $V_{GS} = 0$)	2N3971		—	1.5	
($I_D = 5.0 \text{ mAdc}$, $V_{GS} = 0$)	2N3972		—	2.0	
Static Drain-Source On Resistance ($I_D = 1.0 \text{ mAdc}$, $V_{GS} = 0$)	2N3970 2N3971 2N3972	$r_{DS(on)}$	— — —	30 60 100	Ohms

SMALL-SIGNAL CHARACTERISTICS

Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	2N3970 2N3971 2N3972	$r_{ds(on)}$	— — —	30 60 100	Ohms
Input Capacitance ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)		C_{iss}	—	25	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = -12 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)		C_{rss}	—	6.0	pF

SWITCHING CHARACTERISTICS

Turn-On Delay Time	Test Condition for 2N3970: ($V_{DD} = 10 \text{ Vdc}$, $V_{GS(on)} = 0$, $I_{D(on)} = 20 \text{ mAdc}$, $V_{GS(off)} = 10 \text{ Vdc}$)	2N3970 2N3971 2N3972	$t_{d(on)}$	— — —	10 15 40	ns
Rise Time	Test Condition for 2N3971: ($V_{DD} = 10 \text{ Vdc}$, $V_{GS(on)} = 0$, $I_{D(on)} = 10 \text{ mAdc}$, $V_{GS(on)} = 5.0 \text{ Vdc}$)	2N3970 2N3971 2N3972	t_r	— — —	10 15 40	ns
Turn-Off Time	Test Condition for 2N3972: ($V_{DD} = 10 \text{ Vdc}$, $V_{GS(on)} = 0$, $I_{D(on)} = 5.0 \text{ mAdc}$, $V_{GS(off)} = 3.0 \text{ Vdc}$)	2N3970 2N3971 2N3972	t_{off}	— — —	30 60 100	ns

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 3.0%.

2N3993,A 2N3994,A

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET
SWITCHING

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Drain Reverse Current ($V_{DG} = -15 \text{ Vdc}$, $I_S = 0$) ($V_{DG} = -15 \text{ Vdc}$, $I_S = 0$, $T_A = 150^\circ\text{C}$)	I_{DGO}	— —	1.2 1.2	nAdc μAdc
Drain Cutoff Current ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 10 \text{ Vdc}$) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 6.0 \text{ Vdc}$) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 10 \text{ Vdc}$, $T_A = 150^\circ$) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 6.0 \text{ Vdc}$, $T_A = 150^\circ$)	$I_{D(off)}$	— — — —	1.2 1.2 1.0 1.0	nAdc μAdc
Gate Source Voltage ($V_{DS} = -10 \text{ Vdc}$, $I_D = -1.0 \mu\text{Adc}$)	V_{GS}	4.0 1.0	9.5 5.5	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	10 2.0	— —	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	— —	150 300	Ohms
Forward Transfer Admittance(1) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	6.0 7.0 4.0 5.0	12 12 10 10	mmhos
Input Capacitance ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	— —	16 12	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{rss}	— —	4.5 3.0	pF
($V_{DS} = 0$, $V_{GS} = 6.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)		— —	5.0 3.5	

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle $\leq 10\%$.

2N4091 2N4092 2N4093

JAN, JTX AVAILABLE
CASE 22-03, STYLE 3
TO-18 (TO-206AA)

**JFET
SWITCHING**
N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	40	—	Vdc
Drain-Gate Breakdown Voltage ($I_D = 1.0 \mu\text{Adc}$, $I_S = 0$)	$V_{(BR)DGO}$	40	—	Vdc
Gate Source Cutoff Voltage ($V_{DS} = 20 \text{ Vdc}$, $I_D = 1.0 \text{ nAdc}$)	$V_{GS(off)}$	2N4091 5.0 2N4092 2.0 2N4093 1.0	10 7.0 5.0	Vdc
Source Reverse Current ($V_{SG} = 20 \text{ Vdc}$, $I_D = 0$)	I_{SGO}	—	0.2	nAdc
Drain Reverse Current ($V_{DG} = 20 \text{ Vdc}$, $I_S = 0$) ($V_{DG} = 20 \text{ Vdc}$, $I_D = 0$, $T_A = 150^\circ\text{C}$)	I_{DGO}	— —	0.2 0.4	nAdc μAdc
Drain-Cutoff Current ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 8.0 \text{ Vdc}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 6.0 \text{ Vdc}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$, $T_A = 150^\circ\text{C}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 8.0 \text{ Vdc}$, $T_A = 150^\circ\text{C}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 6.0 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	2N4091 — 2N4092 — 2N4093 — 2N4091 — 2N4092 — 2N4093 —	0.2 0.2 0.2 0.4 0.4 0.4	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}^*	2N4091 30 2N4092 15 2N4093 8.0	— — —	mAdc
Drain-Source On-Voltage ($I_D = 6.6 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 4.0 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 2.5 \text{ mAdc}$, $V_{GS} = 0$)	$V_{DS(on)}$	2N4091 — 2N4092 — 2N4093 —	0.2 0.2 0.2	Vdc
Static Drain-Source On Resistance ($I_D = 1.0 \text{ mAdc}$, $V_{GS} = 0$)	$r_{DS(on)}$	2N4091 — 2N4092 — 2N4093 —	30 50 80	Ohms

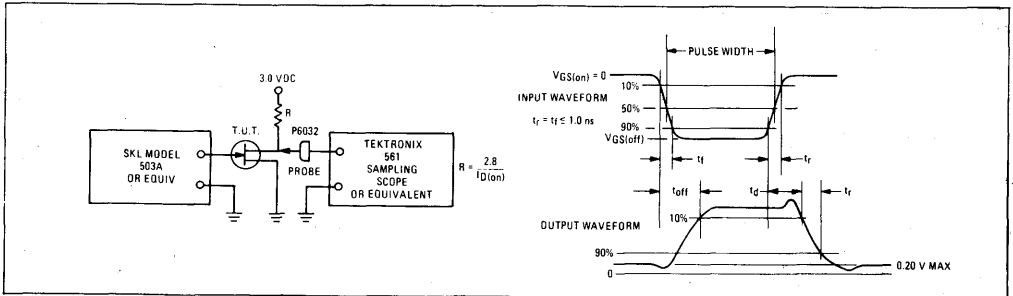
2N4091, 2N4092, 2N4093

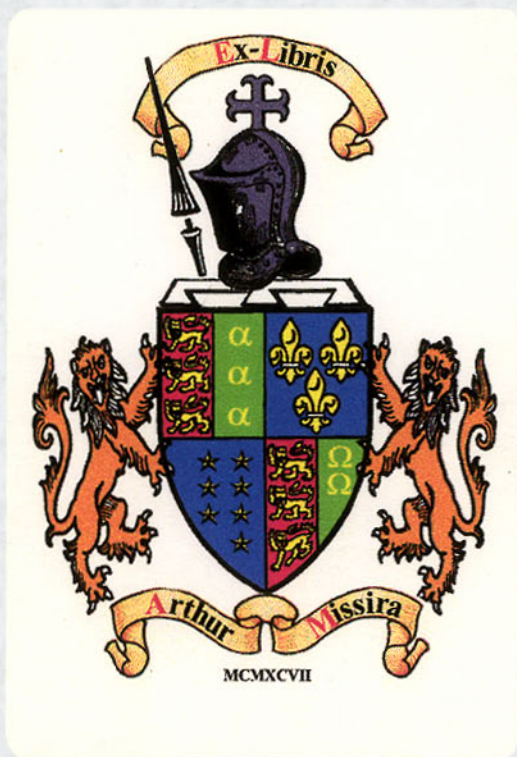
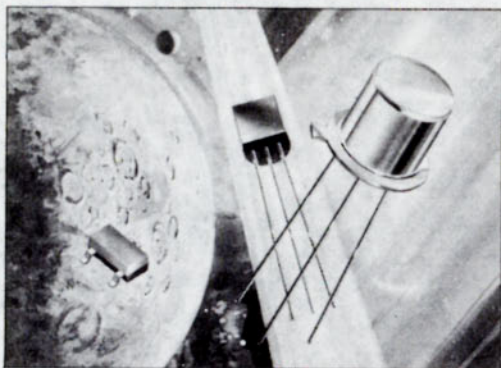
ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($V_{GS} = 0, I_D = 0, f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	—	30 50 80	Ohms
Input Capacitance ($V_{DS} = 20 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	16	pF
Reverse Transfer Capacitance ($V_{DS} = 0, V_{GS} = 20 \text{ Vdc}, f = 1.0 \text{ MHz}$)	C_{rss}	—	5.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (See Figure 1) ($I_{D(on)} = 6.6 \text{ mAdc}$) ($I_{D(on)} = 4.0 \text{ mAdc}$) ($I_{D(on)} = 2.5 \text{ mAdc}$)	t_d	—	15 15 20	ns
Rise Time (See Figure 1) ($I_{D(on)} = 6.6 \text{ mAdc}$) ($I_{D(on)} = 4.0 \text{ mAdc}$) ($I_{D(on)} = 2.5 \text{ mAdc}$)	t_r	—	10 20 40	ns
Turn-Off Time (See Figure 1) ($V_{GS(off)} = 12 \text{ Vdc}$) ($V_{GS(off)} = 8.0 \text{ Vdc}$) ($V_{GS(off)} = 6.0 \text{ Vdc}$)	t_{off}	—	40 60 80	ns

*Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 3.0\%$.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT





Selector Guides 1

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2N4117,A 2N4118,A 2N4119,A

**CASE 20-03, STYLE 1
TO-72 (TO-206AF)**

**JFET
AMPLIFIER**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-40	Vdc
Drain-Gate Voltage	V_{DG}	-40	Vdc
Gate Current	I_G	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Lead Temperature (1/16" from case for 10 s)	T_L	255	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

Refer to MPF4117 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-40	—	Vdc
Gate Reverse Current ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	-10 -1.0	pAdc
($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)		—	-25 -2.5	nAdc
Gate Source Cutoff Voltage ($I_D = 1.0 \text{ nAdc}$, $V_{DS} = 10 \text{ Vdc}$)	$V_{GS(off)}$	-0.6 -1.0 -2.0	-1.8 -3.0 -6.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 10 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	0.03 0.08 0.20	0.09 0.24 0.60	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Input Capacitance ($V_{DS} = 10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	3.0	pF
Reverse Transfer Capacitance ($V_{DS} = 10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	1.5	pF
Forward Transconductance ($V_{DS} = 10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	g_{fs}	70 80 100	210 250 330	μmhos
Output Conductance ($V_{DS} = 10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	g_{os}	— — —	3.0 5.0 10	μmhos

(1) I_{DSS} is measured during a 2.0-ms interval 100 ms after power is applied. (NOT a JEDEC condition.)

**2N4220
thru
2N4222**

**2N4220,A
thru
2N4222,A**

**CASE 20-03, STYLE 3
TO-72 (TO-206AF)**

**JFET
LOW-FREQUENCY, LOW NOISE**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Drain Current	I_D	15	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Channel Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-30	—	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{Vdc}$, $V_{DS} = 0$) ($V_{GS} = -15 \text{Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	—	—	-0.1 -100	nAdc
Gate Source Cutoff Voltage ($I_D = 0.1 \text{nAdc}$, $V_{DS} = 15 \text{Vdc}$)	$V_{GS(off)}$	—	—	-4 -6 -8	Vdc
Gate Source Voltage ($I_D = 50 \mu\text{Adc}$, $V_{DS} = 15 \text{Vdc}$) ($I_D = 200 \mu\text{Adc}$, $V_{DS} = 15 \text{Vdc}$) ($I_D = 500 \mu\text{Adc}$, $V_{DS} = 15 \text{Vdc}$)	V_{GS}	-0.5 -1.0 -2.0	—	-2.5 -5.0 -6.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current* ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}	0.5 2.0 5.0	—	3.0 6.0 15	mAdc
Static Drain-Source On Resistance ($V_{DS} = 0$, $V_{GS} = 0$)	$r_{DS(on)}$	—	500 400 300	—	Ohms

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance Common Source* ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{kHz}$)	$ y_{fs} $	1000 2000 2500	—	4000 5000 6000	μmhos
Output Admittance Common Source ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{kHz}$)	$ y_{os} $	—	—	10 20 40	μmhos
Input Capacitance ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{MHz}$)	C_{iss}	—	4.5	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{MHz}$)	C_{rss}	—	1.2	2.0	pF
Common-Source Output Capacitance ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 0$, $f = 30 \text{MHz}$)	C_{osp}	—	1.5	—	pF

2N4220 thru 2N4222, 2N4220A thru 2N4222A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $R_S = 1.0\text{ megohm}$, $f = 100\text{ Hz}$)	NF	—	—	2.5	dB
		—	—	2.5	
		—	—	2.5	

*Pulse Test: Pulse Width = 630 ms, Duty Cycle = 10%.

FIGURE 1 — NOISE FIGURE versus FREQUENCY

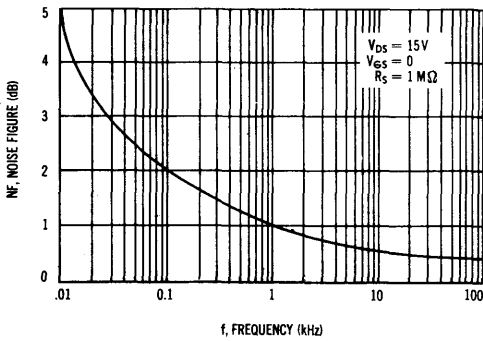


FIGURE 2 — NOISE FIGURE versus SOURCE RESISTANCE

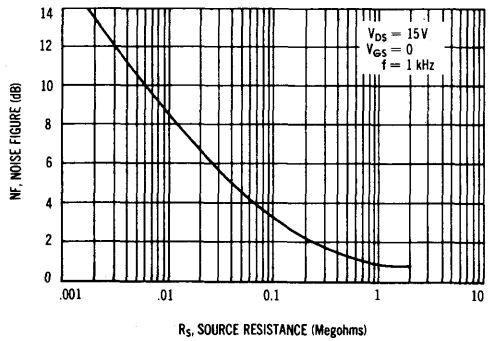


FIGURE 3 — TYPICAL DRAIN CHARACTERISTICS
 $V_{GS(off)} \cong -1.2\text{ VOLTS}$

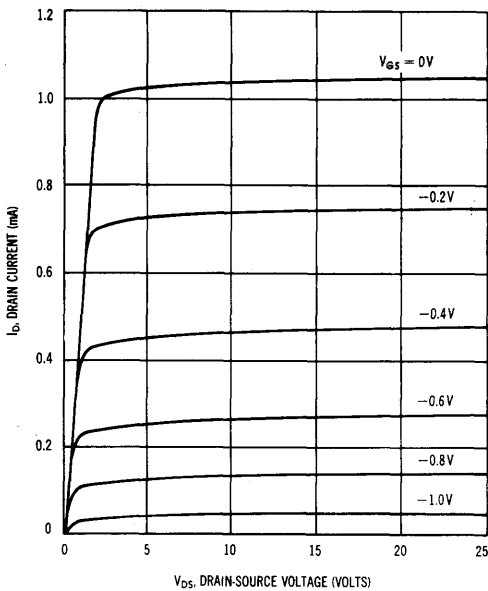
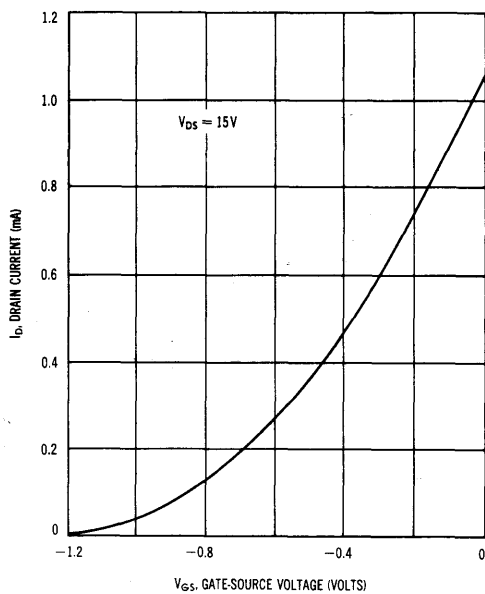


FIGURE 4 — COMMON SOURCE TRANSFER CHARACTERISTICS
 $V_{GS(off)} \cong -1.2\text{ VOLTS}$



2N4220 thru 2N4222, 2N4220A thru 2N4222A

FIGURE 5 — TYPICAL DRAIN CHARACTERISTICS
 $V_{GS(off)} \cong -3.5$ VOLTS

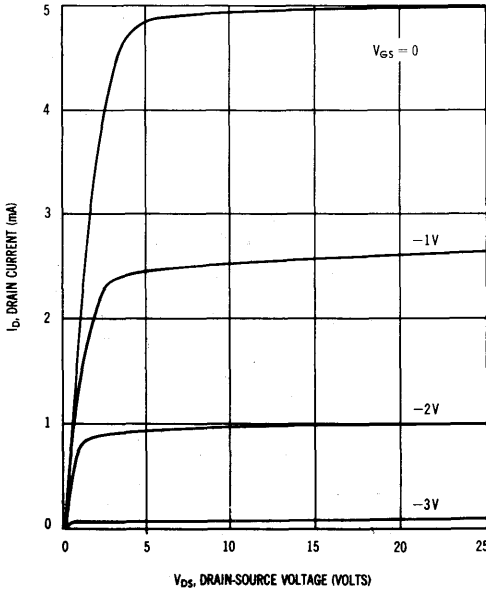


FIGURE 6 — COMMON SOURCE TRANSFER CHARACTERISTICS
 $V_{GS(off)} \cong -3.5$ VOLTS

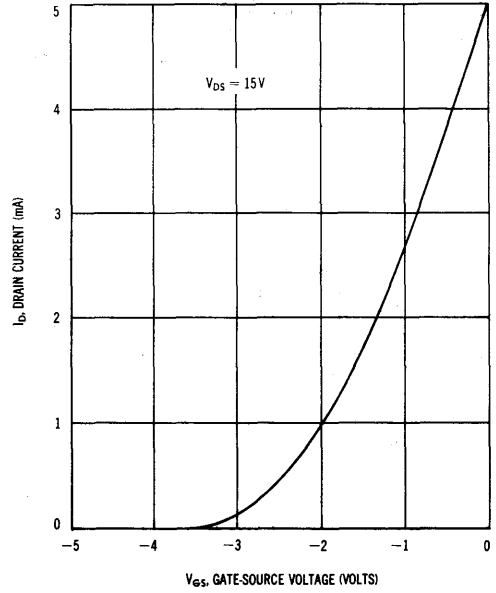


FIGURE 7 — TYPICAL DRAIN CHARACTERISTICS
 $V_{GS(off)} \cong -5.8$ VOLTS

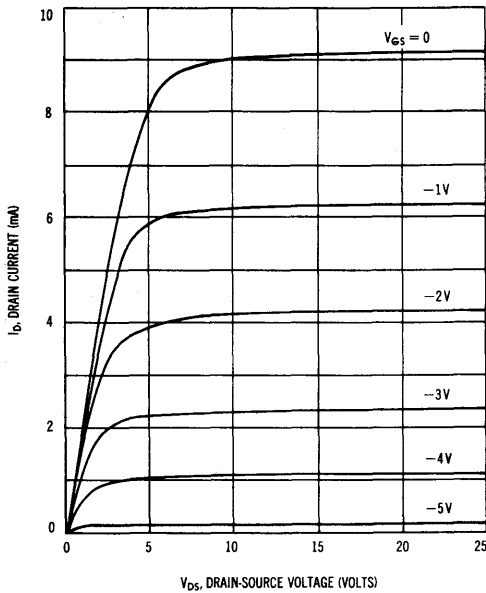
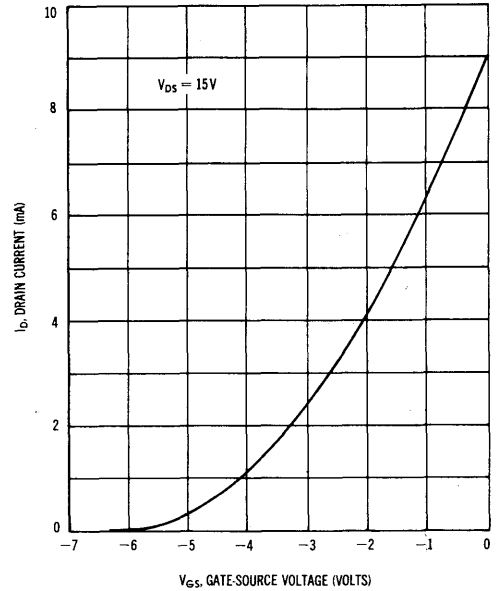


FIGURE 8 — COMMON SOURCE TRANSFER CHARACTERISTICS
 $V_{GS(off)} \cong -5.8$ VOLTS



- NOTES:**
- Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS} (See Figure 10).
 - Figures 8, 9, 10: Data taken in a standard printed circuit with a TO-18 type socket mounting and 1/4" lead length.

6

2N4223 2N4224

**CASE 20-03, STYLE 3
TO-72 (TO-206AF)**

**JFET
VHF AMPLIFIER**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Drain Current	I_D	20	mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Operating and Junction Temperature Range	T_J	-65 to +175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -10 \mu\text{A}_{dc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-30	—	Vdc	
Gate Reverse Current ($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$)		2N4223	—	0.25	nA _{dc}
		2N4224	—	0.50	
($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)		2N4223	—	250	
		2N4224	—	500	
Gate Source Cutoff Voltage ($I_D = 0.25 \text{ mA}_{dc}$, $V_{DS} = 15 \text{ Vdc}$) ($I_D = 0.50 \text{ mA}_{dc}$, $V_{DS} = 15 \text{ Vdc}$)	$V_{GS(off)}$	2N4223	-1.2	-8.0	Vdc
		2N4224	—	-8.0	
Gate Source Voltage ($I_D = 0.3 \text{ mA}_{dc}$, $V_{DS} = 15 \text{ Vdc}$) ($I_D = 0.2 \text{ mA}_{dc}$, $V_{DS} = 15 \text{ Vdc}$)	V_{GS}	2N4223	-1.0	-7.0	Vdc
		2N4224	-1.0	-7.5	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	3.0 2.0	18 20	mA _{dc}	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)*	$ y_{fs} $	2N4223	3000	7000	μmhos
		2N4224	2000	7500	
($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)		2N4223	2700	—	
		2N4224	1700	—	
Input Conductance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)	$\text{Re}(y_{is})$	—	800	μmhos	
Output Conductance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)	$\text{Re}(y_{os})$	—	200	μmhos	
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	6.0	pF	
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	2.0	pF	

2N4223, 2N4224

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $R_S = 1.0\text{ k ohm}$, $f = 200\text{ MHz}$)	NF	—	5.0	dB
Small-Signal Power Gain Common Source ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 200\text{ MHz}$)	G_{ps}	10	—	dB

*Pulse Test: Pulse Width $\leq 630\text{ ms}$, Duty Cycle $\leq 10\%$.

FIGURE 1—NOISE FIGURE AND POWER GAIN TEST CIRCUIT

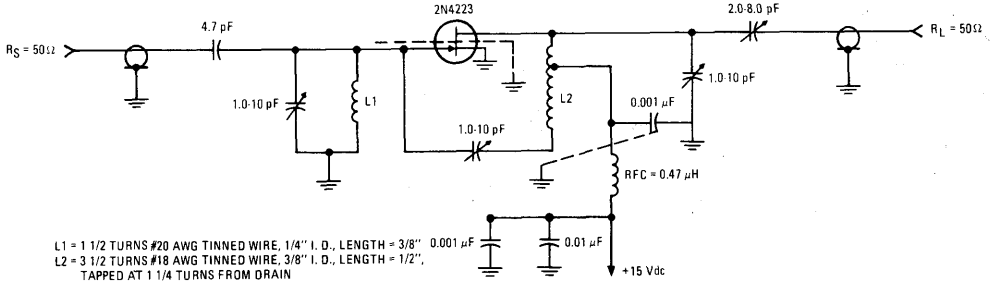


FIGURE 2 — DRAIN CURRENT versus GATE-SOURCE VOLTAGE

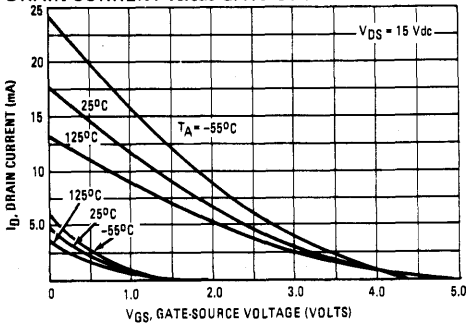


FIGURE 3 — TEMPERATURE COEFFICIENT FOR DRAIN CURRENT

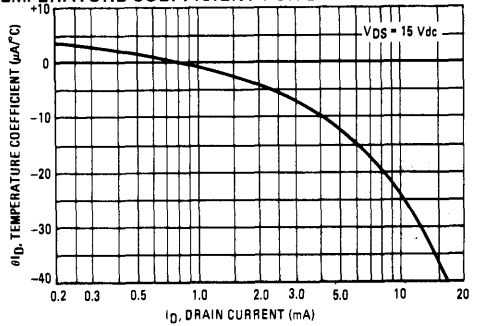


FIGURE 4 — FORWARD TRANSFER ADMITTANCE versus GATE-SOURCE VOLTAGE

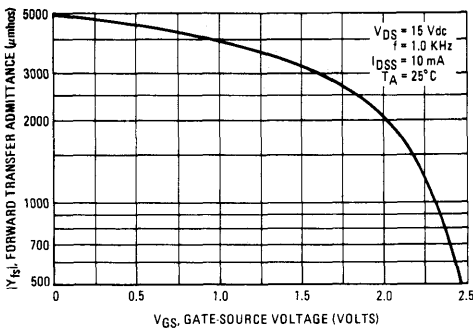


FIGURE 5 — TEMPERATURE COEFFICIENT FOR Y_{fs} versus DRAIN CURRENT

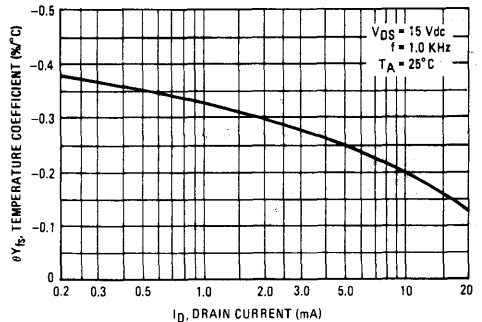


FIGURE 6 – CAPACITANCES

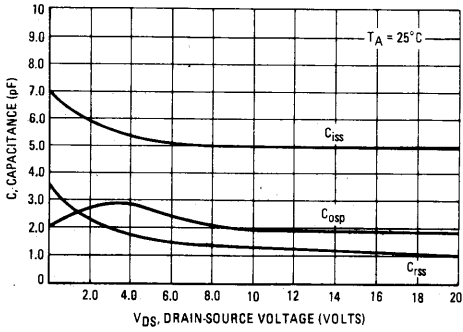


FIGURE 7 – COMMON SOURCE
NOISE FIGURE versus SOURCE RESISTANCE

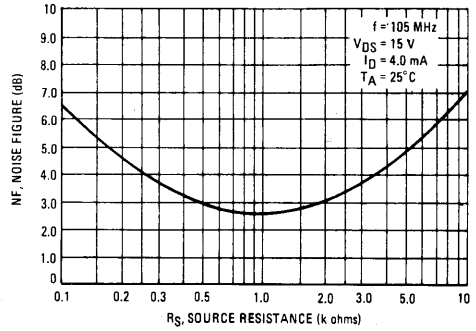


FIGURE 8 – INPUT ADMITTANCE
versus FREQUENCY

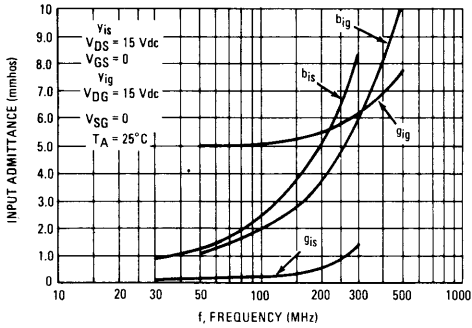


FIGURE 9 – FORWARD TRANSFER ADMITTANCE
versus FREQUENCY

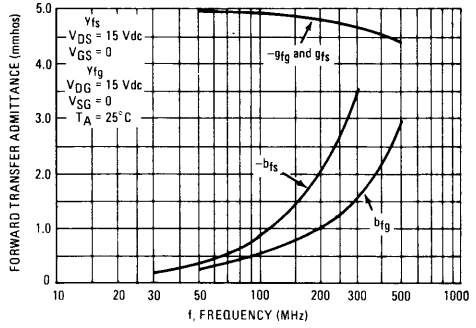


FIGURE 10 – OUTPUT ADMITTANCE
versus FREQUENCY

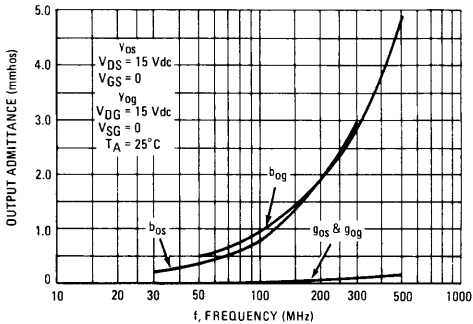


FIGURE 11 – REVERSE TRANSFER ADMITTANCE
versus FREQUENCY

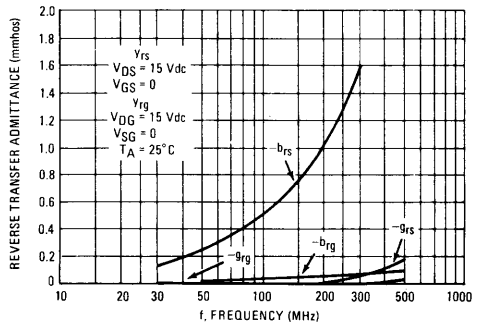


FIGURE 12 – POWER GAIN versus FREQUENCY

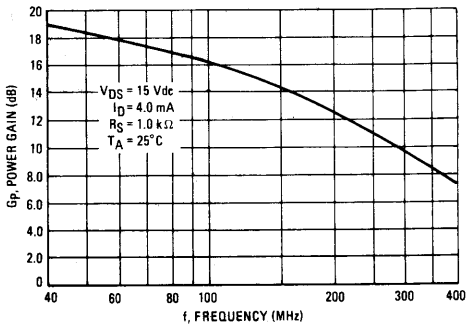
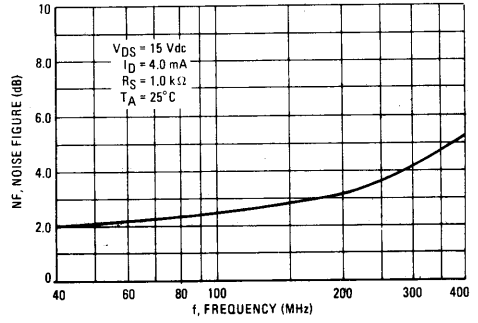


FIGURE 13 – COMMON SOURCE NOISE FIGURE versus FREQUENCY



**2N4338
2N4339
2N4340
2N4341**

**CASE 22-03, STYLE 3
TO-18 (TO-206AA)**

**JFET
LOW-FREQUENCY, LOW NOISE**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Reverse Gate-Source Voltage	V_{GSR}	50	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{A}$)	$V_{(BR)GSS}$	50	—	Vdc
Gate Reverse Current ($V_{GS} = -30 \text{ V}$)	I_{GSS}	—	0.1	nA
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ V}$, $I_D = 0.1 \mu\text{A}$)	$V_{GS(off)}$	-0.3 -0.6 -1.0 -2.0	-1.0 -1.8 -3.0 -6.0	Vdc
		2N4338		
		2N4339		
		2N4340		
		2N4341		

ON CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ V}$)	I_{DSS}^*	0.2 0.5 1.2 3.0	0.6 1.5 3.6 9.0	mA
		2N4338		
		2N4339		
		2N4340		
		2N4341		

SMALL-SIGNAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Forward Transfer Admittance ($V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} ^*$	600 800 1300 2000	1800 2400 3000 4000	μmhos
		2N4338		
		2N4339		
		2N4340		
		2N4341		
Output Admittance ($V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	— — — —	5.0 15 30 60	μmhos
		2N4338		
		2N4339		
		2N4340		
		2N4341		
Input Capacitance ($V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	2.0	pF

FUNCTIONAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Noise Figure ($V_{DS} = 15 \text{ Volts}$, $f = 1.0 \text{ kHz}$, $R_G = 1.0 \text{ M}\Omega$)	NF	—	1.0	dB

*Pulse Test: Pulse Width $\leq 630 \text{ msec}$, Duty Cycle $\leq 10\%$.

6

2N4342

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY, LOW NOISE

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	310 2.82	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	$^\circ\text{C}$

Refer to 2N5460 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}, V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}, V_{DS} = 0$) ($V_{GS} = 15 \text{ Vdc}, V_{DS} = 0, T_A = 65^\circ\text{C}$)	I_{GSS}	—	10 0.5	nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = -10 \text{ Vdc}, I_D = 1.0 \mu\text{Adc}$)	$V_{GS(off)}$	1.0	5.5	Vdc
Gate Source Voltage ($V_{DS} = -10 \text{ Vdc}, I_D = 0.4 \text{ mAdc}$) ($V_{DS} = -10 \text{ Vdc}, I_D = 1.0 \text{ mAdc}$)	V_{GS}	0.7	5.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0$)	I_{DSS}	4.0	12	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($V_{GS} = 0, I_D = 0, f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	—	700	Ohms
Forward Transfer Admittance ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	$ y_{fs} $	2000	6000	μmhos
Output Admittance ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	$ y_{os} $	—	75	μmhos
Common Source Forward Transconductance ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	$Re(y_{fs})$	1500	—	μmhos
Input Capacitance ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	20	pF
Reverse Transfer Capacitance ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{rss}	—	5.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0, R_G = 1.0 \text{ Megohm}, f = 100 \text{ Hz}, BW = 15 \text{ Hz}$)	NF	—	1.5	dB
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0, f = 100 \text{ Hz}, BW = 15 \text{ Hz}$)	E_n	—	0.08	$\mu\text{V}/\sqrt{\text{Hz}}$

2N4351

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOS FET
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage*	V_{GS}	30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	800 4.56	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

*Transient potentials of ± 75 Volt will not cause gate-oxide failure.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = 10 \mu\text{A}$, $V_{GS} = 0$)	$V_{(BR)DSX}$	25	—	Vdc	
Zero-Gate-Voltage Drain Current ($V_{DS} = 10 \text{ V}$, $V_{GS} = 0$) $T_A = 25^\circ\text{C}$ $T_A = 150^\circ\text{C}$	I_{DSS}	—	10 10	nAdc μAdc	
Gate Reverse Current ($V_{GS} = \pm 15 \text{ Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	± 10	pAdc	
ON CHARACTERISTICS					
Gate Threshold Voltage ($V_{DS} = 10 \text{ V}$, $I_D = 10 \mu\text{A}$)	$V_{GS(Th)}$	1.0	5	Vdc	
Drain-Source On-Voltage ($I_D = 2.0 \text{ mA}$, $V_{GS} = 10 \text{ V}$)	$V_{DS(on)}$	—	1.0	V	
On-State Drain Current ($V_{GS} = 10 \text{ V}$, $V_{DS} = 10 \text{ V}$)	$I_{D(on)}$	3.0	—	mAdc	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 10 \text{ V}$, $I_D = 2.0 \text{ mA}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	1000	—	μmho	
Input Capacitance ($V_{DS} = 10 \text{ V}$, $V_{GS} = 0$, $f = 140 \text{ kHz}$)	C_{iss}	—	5.0	pF	
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, $f = 140 \text{ kHz}$)	C_{rss}	—	1.3	pF	
Drain-Substrate Capacitance ($V_{D(SUB)} = 10 \text{ V}$, $f = 140 \text{ kHz}$)	$C_{d(sub)}$	—	5.0	pF	
Drain-Source Resistance ($V_{GS} = 10 \text{ V}$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	—	300	ohms	
SWITCHING CHARACTERISTICS					
Turn-On Delay (Fig. 5)	$I_D = 2.0 \text{ mAdc}$, $V_{DS} = 10 \text{ Vdc}$, $V_{GS} = 10 \text{ Vdc}$ (See Figure 9; Times Circuit Determined)	t_{d1}	—	45	ns
Rise Time (Fig. 6)		t_r	—	65	ns
Turn-Off Delay (Fig. 7)		t_{d2}	—	60	ns
Fall Time (Fig. 8)		t_f	—	100	ns

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

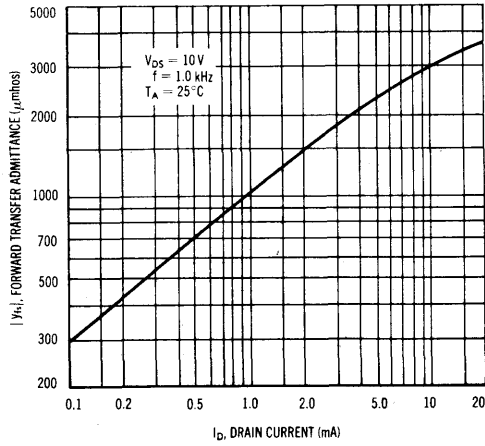


FIGURE 2 — TRANSFER CHARACTERISTICS

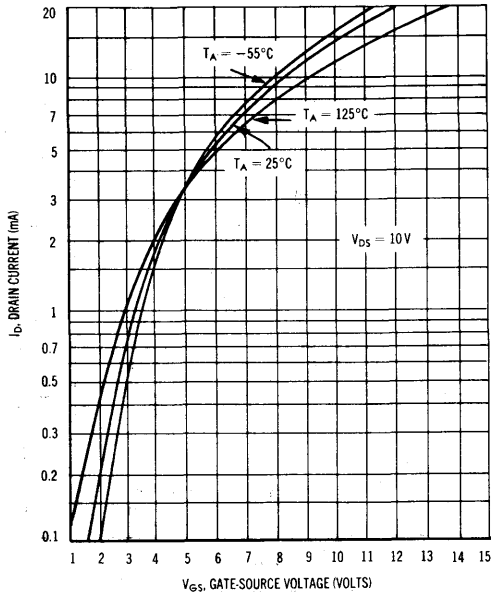


FIGURE 3 — DRAIN-SOURCE "ON" RESISTANCE

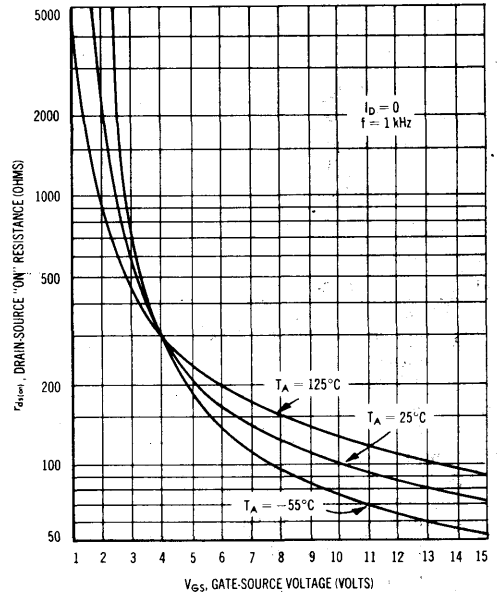
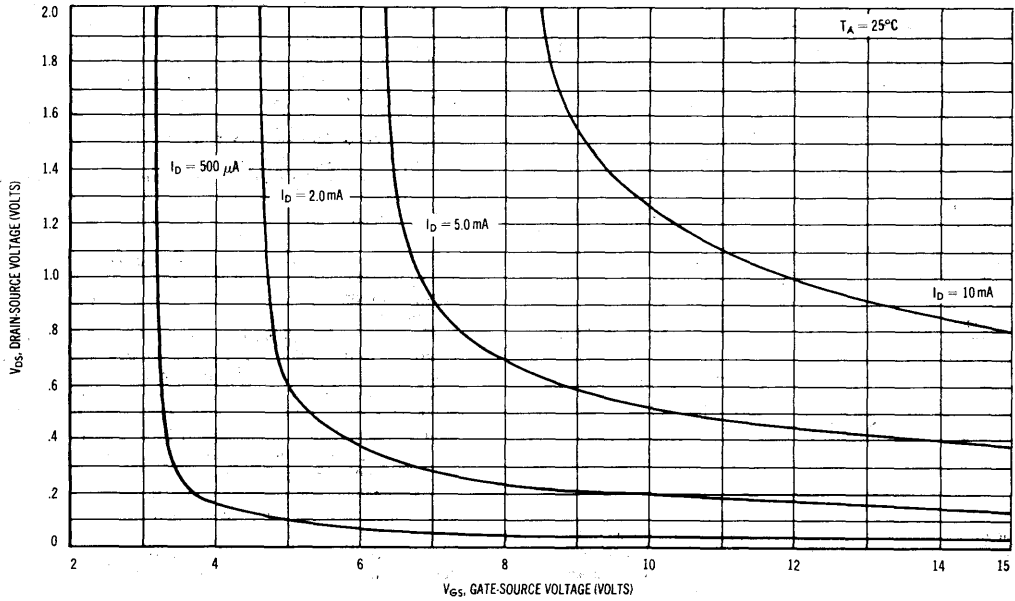


FIGURE 4 — "ON" DRAIN-SOURCE VOLTAGE



SWITCHING CHARACTERISTICS
($T_A = 25^\circ C$)

FIGURE 5 — TURN-ON DELAY TIME

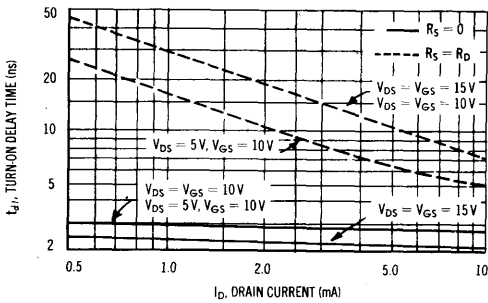


FIGURE 6 — RISE TIME

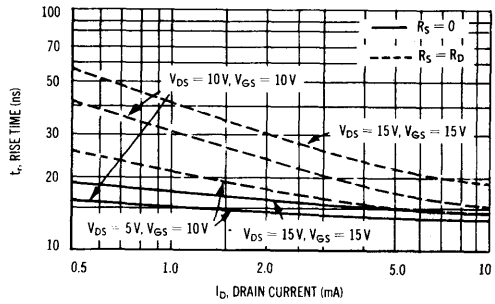


FIGURE 7 — TURN-OFF DELAY TIME

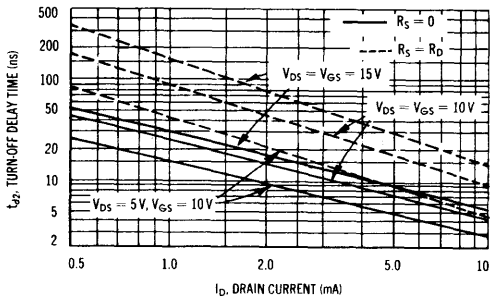


FIGURE 8 — FALL TIME

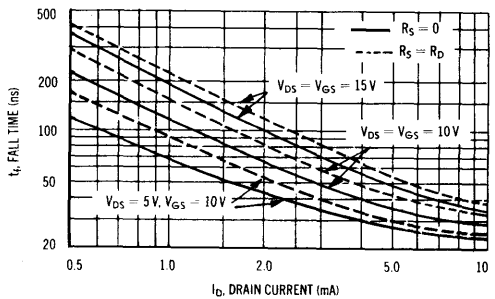
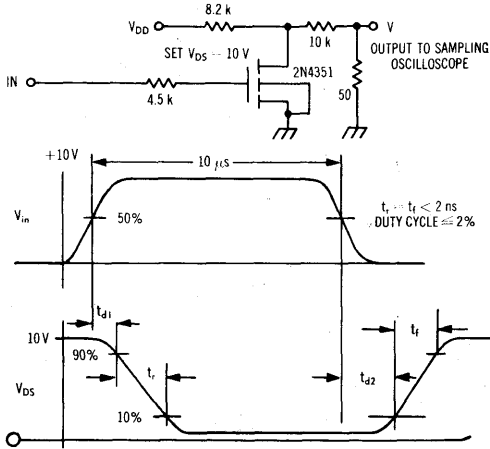


FIGURE 9 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source

capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD} , and thus the feedback capacitance (C_{rss}) is charged to V_{DD} . Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

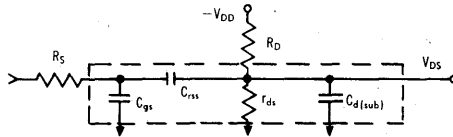
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds} . During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged, V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds} , turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 10 — SWITCHING CIRCUIT MOSFET EQUIVALENT MODEL



2N4352

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOS FET
SWITCHING

P-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	± 30	Vdc
Gate Current	I_G	30	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	800 4.56	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage ($I_D = -10 \mu\text{A}$, $V_{GS} = 0$)	$V_{(BR)DSX}$	-25	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = -10 \text{ V}$, $V_{GS} = 0$) $T_A = 25^\circ\text{C}$ $T_A = 150^\circ\text{C}$	I_{DSS}	—	-10 -10	nAdc μAdc
Gate Reverse Current ($V_{GS} = \pm 30 \text{ V}$, $V_{DS} = 0$)	I_{GSS}	—	± 10	pAdc

ON CHARACTERISTICS

Gate Threshold Voltage ($V_{DS} = -10 \text{ V}$, $I_D = -10 \mu\text{A}$)	$V_{GS(Th)}$	-1.0	-5.0	Vdc
Drain-Source On-Voltage ($I_D = -2.0 \text{ mA}$, $V_{GS} = -10 \text{ V}$)	$V_{DS(on)}$	—	-1.0	V
On-State Drain Current ($V_{GS} = -10 \text{ V}$, $V_{DS} = -10 \text{ V}$)	$I_D(on)$	-3.0	—	mA

SMALL-SIGNAL CHARACTERISTICS

Drain-Source Resistance ($V_{GS} = -10 \text{ V}$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	—	600	ohms
Forward Transfer Admittance ($V_{DS} = -10 \text{ V}$, $I_D = 2.0 \text{ mA}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	1000	—	μmho
Input Capacitance ($V_{DS} = -10 \text{ V}$, $V_{GS} = 0$, $f = 140 \text{ kHz}$)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, $f = 140 \text{ kHz}$)	C_{rss}	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = -10 \text{ V}$, $f = 140 \text{ kHz}$)	$C_{d(sub)}$	—	4.0	pF

SWITCHING CHARACTERISTICS

Turn-On Delay (Figures 5)	$I_D = -2.0 \text{ mAdc}$, $V_{DS} = -10 \text{ Vdc}$, $V_{GS} = -10 \text{ V}$ (See Figure 9, Times Circuit Determined)	t_{d1}	—	45	ns
Rise Time (Figures 6)		t_r	—	65	ns
Turn-Off Delay (Figures 7)		t_{d2}	—	60	ns
Fall Time (Figures 8)		t_f	—	100	ns

FIGURE 1 — FOWARD TRANSFER ADMITTANCE

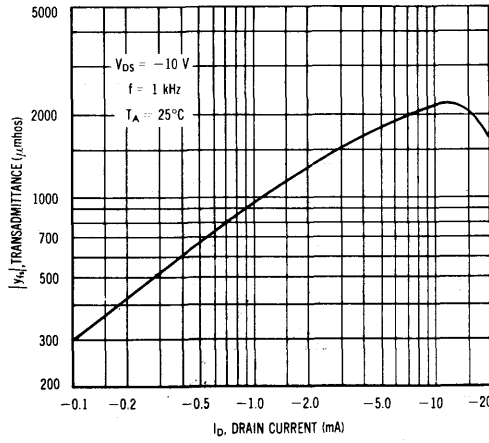


FIGURE 2 — TRANSFER CHARACTERISTICS

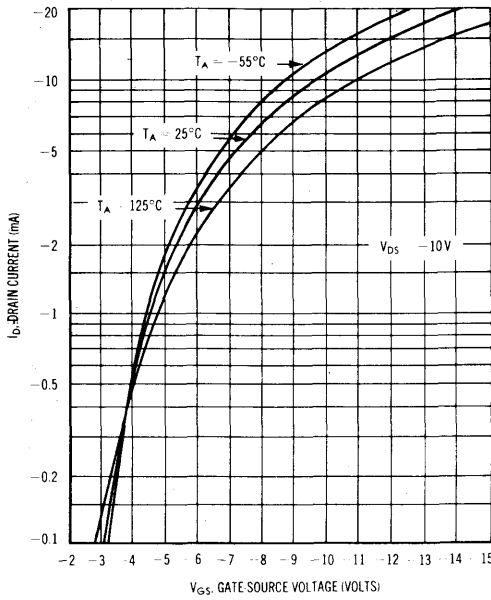


FIGURE 3 — DRAIN-SOURCE "ON" RESISTANCE

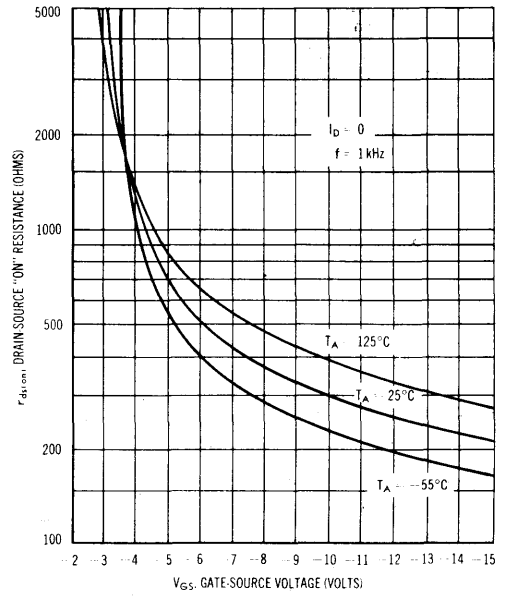
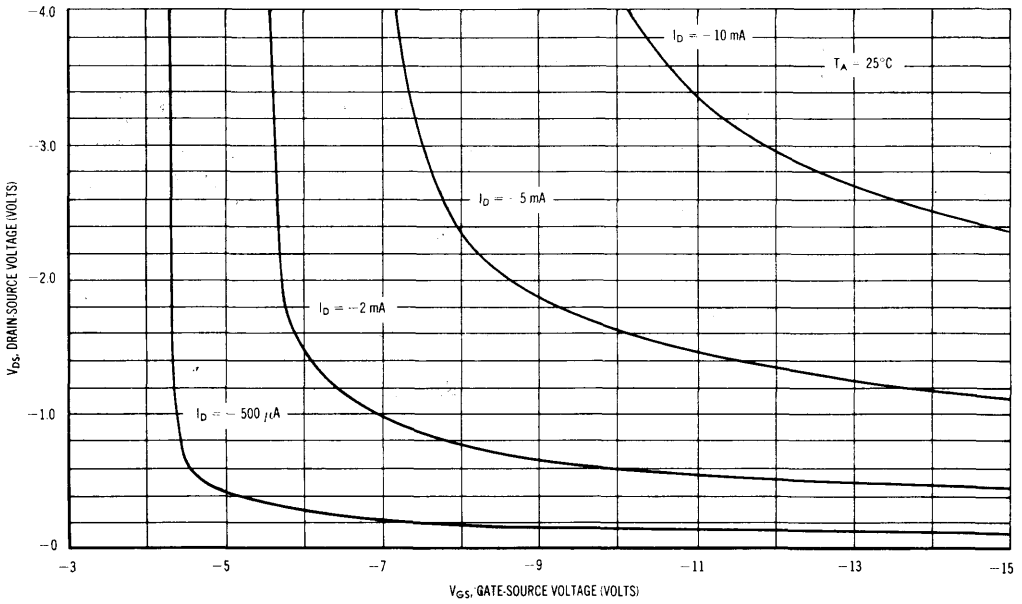


FIGURE 4 — "ON" DRAIN-SOURCE VOLTAGE



6

SWITCHING CHARACTERISTICS
($T_A = 25^\circ\text{C}$)

FIGURE 5 — TURN-ON DELAY TIME

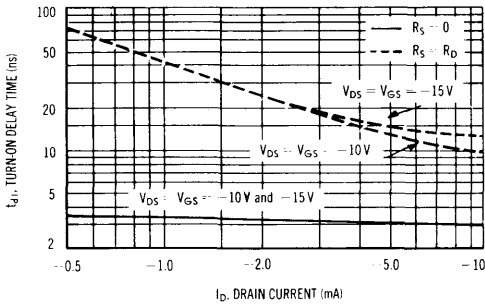


FIGURE 6 — RISE TIME

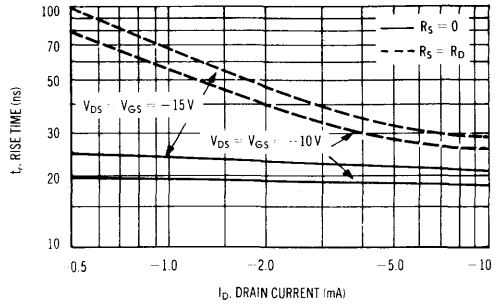


FIGURE 7 — TURN-OFF DELAY TIME

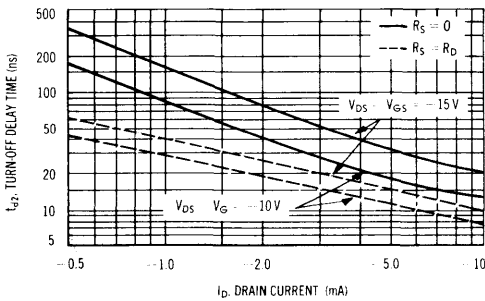


FIGURE 8 — FALL TIME

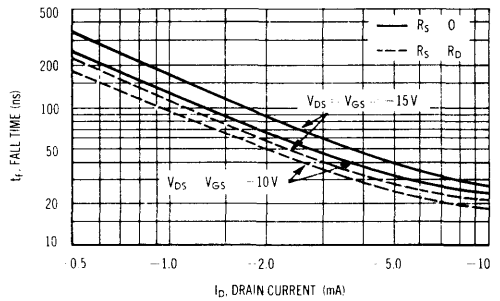
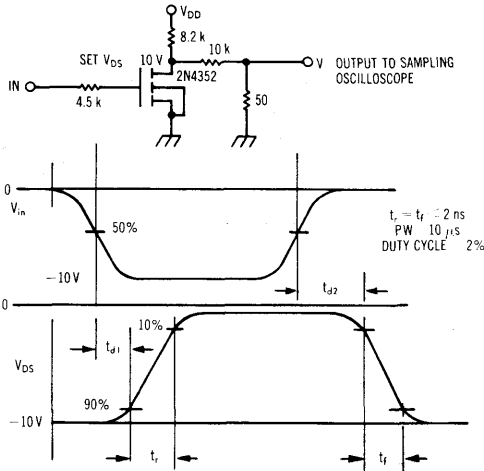


FIGURE 9 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD} , and thus the feedback capacitance (C_{fd}) is charged to V_{DD} . Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

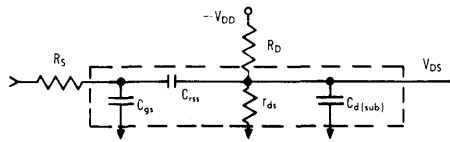
During the turn-on interval, C_{gs} is charged to V_{gs} (the input voltage) through R_s (generator impedance) (Figure 11). C_{fd} must be discharged to $V_{gs} - V_{D(s)}$ through R_s and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(s)}$) through R_D in parallel with r_{ds} . During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{gs}). As C_{gs} becomes charged V_{gs} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds} , turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_s = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_s = R_D$ simulate the switching behavior of cascade J stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_s = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 10 — SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



2N4360

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET
LOW-FREQUENCY/LOW-NOISE

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	20	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	310 2.82	mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-55 to +125	$^\circ\text{C}$

Refer to 2N5460 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{A}$)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = 15$)	I_{GSS}	—	10	nA
Gate Source Cutoff Voltage ($V_{DS} = -10 \text{ V}$, $I_D = 1.0 \mu\text{A}$)	$V_{GS(off)}$	0.7	10.0	Vdc
Gate Source Voltage ($I_D = 0.3 \text{ mA}$, $V_{DS} = -10 \text{ V}$)	V_{GS}	0.4	9.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = -10 \text{ V}$, $V_{GS} = 0 \text{ V}$)	I_{DSS}	3.0	30	mA
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($I_D = 0$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	r_{ds}	—	700	Ohms
Forward Transfer Admittance ($V_{DS} = -10 \text{ V}$, $V_{GS} = 0 \text{ V}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	2000	8000	μmhos
Output Admittance ($V_{DS} = -10 \text{ V}$, $V_{GS} = 0 \text{ V}$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	—	100	μmhos
Common Source Forward Transconductance ($V_{DS} = -10 \text{ V}$, $V_{GS} = 0 \text{ V}$, $f = 1.0 \text{ MHz}$)	$\text{Re}(y_{fs})$	1500	—	μmhos
Input Capacitance ($V_{DS} = -10 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	20	pF
Reverse Transfer Capacitance ($V_{DS} = -10 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	5.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = -10 \text{ V}$, $I_D = 1.0 \text{ mA}$, $R_G = 1.0 \text{ m}\Omega$, $f = 100 \text{ Hz}$)	NF	—	5.0	dB

**2N4391
2N4392
2N4393**

**CASE 22-03, STYLE 2
TO-18 (TO-206AA)**

**JFET
SWITCHING**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	40	Vdc
Drain-Gate Voltage	V _{DG}	40	Vdc
Gate-Source Voltage	V _{GS}	40	Vdc
Forward Gate Current	I _{GF}	50	mAdc
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T _J	-65 to +175	°C
Storage Temperature Range	T _{stg}	-65 to +175	°C

Refer to MPF4391 for graphs.

***ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)**

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I _G = 1.0 μAdc, V _{DS} = 0)	V(BR)GSS	40	—	Vdc
Gate Reverse Current (V _{GS} = 20 Vdc, V _{DS} = 0) (V _{GS} = 20 Vdc, V _{DS} = 0, T _A = 150°C)	I _{GSS}	— —	0.1 0.2	nAdc μAdc
Gate Source Voltage (V _{DS} = 20 Vdc, I _D = 1.0 nAdc)	V _{GS}	4.0 2.0 0.5	10 5.0 3.0	Vdc
Gate-Source Forward Voltage (I _G = 1.0 mAdc, V _{DS} = 0)	V _{GS(f)}	—	1.0	Vdc
Drain-Cutoff Current (V _{DS} = 20 Vdc, V _{GS} = 12 Vdc) (V _{DS} = 20 Vdc, V _{GS} = 7.0 Vdc) (V _{DS} = 20 Vdc, V _{GS} = 5.0 Vdc) (V _{DS} = 20 Vdc, V _{GS} = 12 Vdc, T _A = 150°C) (V _{DS} = 20 Vdc, V _{GS} = 7.0 Vdc, T _A = 150°C) (V _{DS} = 20 Vdc, V _{GS} = 5.0 Vdc, T _A = 150°C)	I _{D(off)}	— — — — — —	0.1 0.1 0.1 0.2 0.2 0.2	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (1) (V _{DS} = 20 Vdc, V _{GS} = 0)	I _{DSS}	50 25 5.0	150 75 30	mAdc
Drain-Source On-Voltage (I _D = 12 mAdc, V _{GS} = 0) (I _D = 6.0 mAdc, V _{GS} = 0) (I _D = 3.0 mAdc, V _{GS} = 0)	V _{DS(on)}	— — —	0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance (I _D = 1.0 mAdc, V _{GS} = 0)	r _{DS(on)}	— — —	30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance (V _{GS} = 0, I _D = 0, f = 1.0 kHz)	r _{ds(on)}	— — —	30 60 100	Ohms

2N4391, 2N4392, 2N4393

***ELECTRICAL CHARACTERISTICS** (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance ($V_{DS} = 20\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{iss}	—	14	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 12\text{ Vdc}$, $f = 1.0\text{ MHz}$)	C_{rss}	—	3.5	pF
($V_{DS} = 0$, $V_{GS} = 7.0\text{ Vdc}$, $f = 1.0\text{ MHz}$)		—	3.5	
($V_{DS} = 0$, $V_{GS} = 5.0\text{ Vdc}$, $f = 1.0\text{ MHz}$)		—	3.5	

SWITCHING CHARACTERISTICS

Rise Time ($I_{D(on)} = 12\text{ mAdc}$)	2N4391	t_r	—	5.0	ns
($I_{D(on)} = 6.0\text{ mAdc}$)	2N4392		—	5.0	
($I_{D(on)} = 3.0\text{ mAdc}$)	2N4393		—	5.0	
Fall Time ($V_{GS(off)} = 12\text{ Vdc}$)	2N4391	t_f	—	15	ns
($V_{GS(off)} = 7.0\text{ Vdc}$)	2N4392		—	20	
($V_{GS(off)} = 5.0\text{ Vdc}$)	2N4393		—	30	
Turn-On Time ($I_{D(on)} = 12\text{ mAdc}$)	2N4391	t_{on}	—	15	ns
($I_{D(on)} = 6.0\text{ mAdc}$)	2N4392		—	15	
($I_{D(on)} = 3.0\text{ mAdc}$)	2N4393		—	15	
Turn-Off Time ($V_{GS(off)} = 12\text{ Vdc}$)	2N4391	t_{off}	—	20	ns
($V_{GS(off)} = 7.0\text{ Vdc}$)	2N4392		—	35	
($V_{GS(off)} = 5.0\text{ Vdc}$)	2N4393		—	50	

(1) Pulse Test: Pulse Width $\leq 100\ \mu\text{s}$, Duty Cycle $\leq 1.0\%$.

*In addition to JEDEC Registered Data.

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2N4416,A

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	30	Vdc
Drain-Gate Voltage	V _{DG}	35 30	Vdc
Gate-Source Voltage	V _{GS}	30	Vdc
Gate Current	I _G	10	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage (I _G = 1.0 μAdc, V _{DS} = 0)	V _{(BR)GSS}	30 35	—	Vdc
Gate Reverse Current (V _{GS} = 20 Vdc, V _{DS} = 0) (V _{GS} = 20 Vdc, V _{DS} = 0, T _A = +150°C)	I _{GSS}	—	100 200	pAdc
Gate Source Cutoff Voltage (I _D = 1.0 nAdc, V _{DS} = 15 Vdc)	V _{GS(off)}	—	6.0	Vdc
Gate Source Voltage (I _D = 0.5 mAdc, V _{DS} = 15 Vdc)	V _{GS}	1.0	5.5	Vdc
Gate-Source Forward Voltage (I _G = 1.0 mAdc, V _{DS} = 0)	V _{GS(f)}	—	1.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) (V _{DS} = 15 Vdc, V _{GS} = 0)	I _{DSS}	5.0	15	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance(1) (V _{DS} = 15 Vdc, V _{GS} = 0, f = 1.0 kHz)	y _{fs}	4500	7500	μmhos
Real Part of Forward Transfer Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 400 MHz)	y _{fs(real)}	4000	—	μmhos
Real Part of Input Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 100 MHz) (V _{DS} = 15 Vdc, V _{GS} = 0, f = 400 MHz)	y _{is(real)}	— —	100 1000	μmhos
Output Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 1.0 kHz)	y _{os}	—	50	μmhos
Real Part of Output Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 100 MHz) (V _{DS} = 15 Vdc, V _{GS} = 0, f = 400 MHz)	y _{os(real)}	— —	75 100	μmhos
Imaginary Part of Input Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 100 MHz) (V _{DS} = 15 Vdc, V _{GS} = 0, f = 400 MHz)	y _{is(imag)}	— —	2500 10,000	μmhos
Imaginary Part of Output Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 100 MHz) (V _{DS} = 15 Vdc, V _{GS} = 0, f = 400 MHz)	y _{os(imag)}	— —	1000 4000	μmhos

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{rss}	—	0.8	pF
Common Source Output Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{oss}	—	2.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure (Figures 3 and 4) ($V_{DS} = 15\text{ Vdc}$, $I_D = 5.0\text{ mAdc}$, $R_g \approx 1000\text{ Ohms}$, $f = 100\text{ MHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 5.0\text{ mAdc}$, $R_g \approx 1000\text{ Ohms}$, $f = 400\text{ MHz}$)	NF	—	2.0 4.0	dB
Small-Signal Power Gain Common Source (Figure 1) ($V_{DS} = 15\text{ Vdc}$, $I_D = 5.0\text{ mAdc}$, $f = 100\text{ MHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 5.0\text{ mAdc}$, $f = 400\text{ MHz}$)	G_{ps}	18 10	— —	dB

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 1.0\%$.

POWER GAIN

FIGURE 1 – EFFECTS OF DRAIN CURRENT

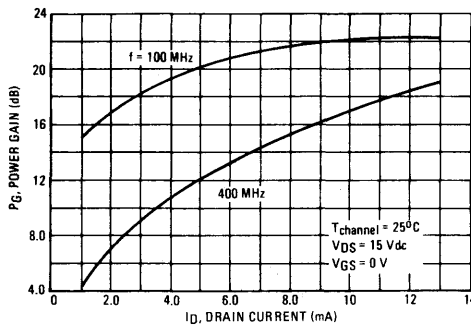
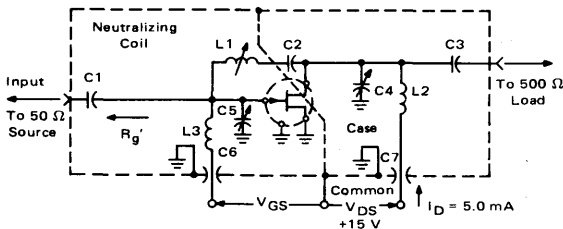


FIGURE 2 – 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Adjust V_{GS} for $I_D = 5.0\text{ mA}$
 $V_{GS} < 0\text{ Volts}$

NOTE: The noise source is a hot-cold body (A1L type 70 or equivalent) with a test receiver (A1L type 136 or equivalent).

Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH^*	0.2 μH^{**}
L2	0.15 μH^*	0.03 μH^{**}
L3	0.14 μH^*	0.022 μH^{**}

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).

L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).

L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).



NOISE FIGURE
($T_{channel} = 25^{\circ}C$)

FIGURE 3 – EFFECTS OF DRAIN-SOURCE VOLTAGE

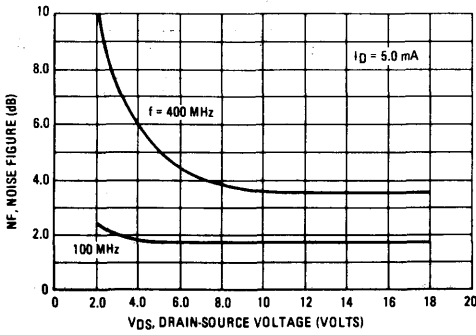
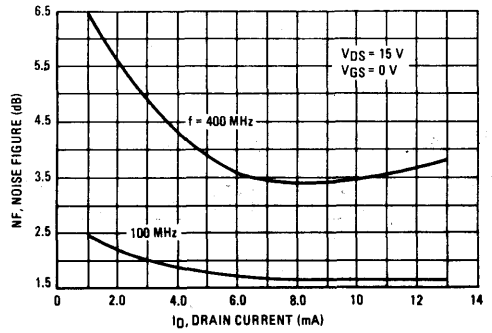
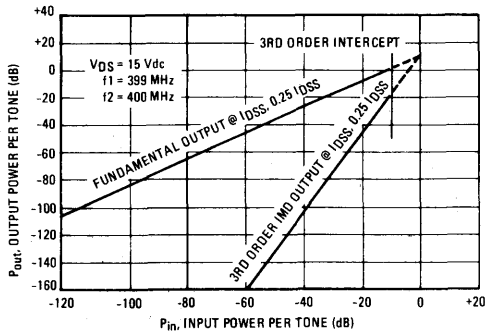


FIGURE 4 – EFFECTS OF DRAIN CURRENT



INTERMODULATION CHARACTERISTICS

FIGURE 5 – THIRD ORDER INTERMODULATION DISTORTION



COMMON SOURCE CHARACTERISTICS
ADMITTANCE PARAMETERS
($V_{DS} = 15\text{ Vdc}$, $T_{channel} = 25^{\circ}C$)

FIGURE 6 – INPUT ADMITTANCE (y_{is})

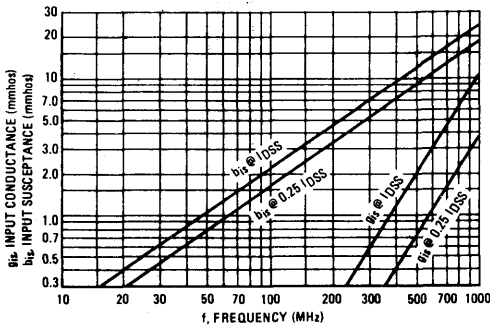


FIGURE 7 – REVERSE TRANSFER ADMITTANCE (y_{rs})

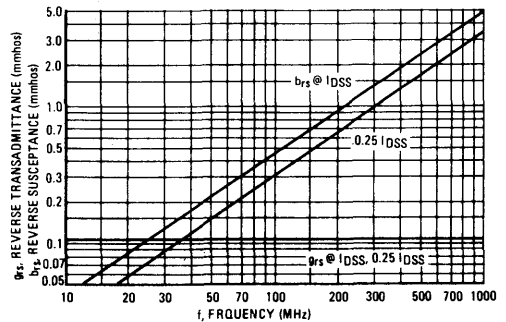


FIGURE 8 - FORWARD TRANSMITTANCE (γ_{f3})

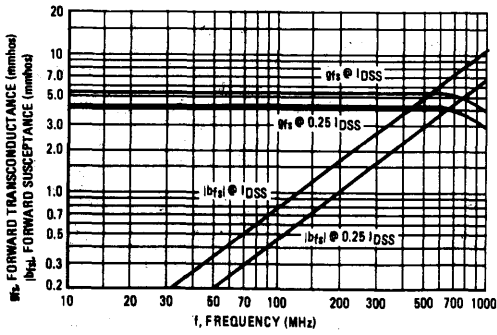
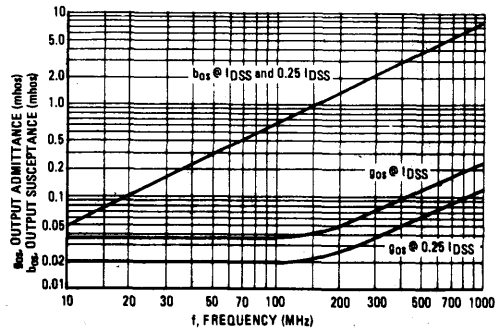


FIGURE 9 - OUTPUT ADMITTANCE (γ_{o3})



COMMON SOURCE CHARACTERISTICS
S-PARAMETERS

($V_{DS} = 15$ Vdc, $T_{channel} = 25^\circ\text{C}$,
Data Points in MHz)

FIGURE 10 - S_{11s}

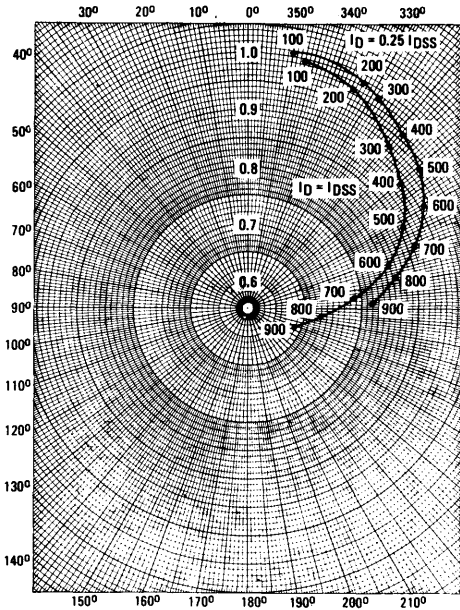


FIGURE 11 - S_{12s}

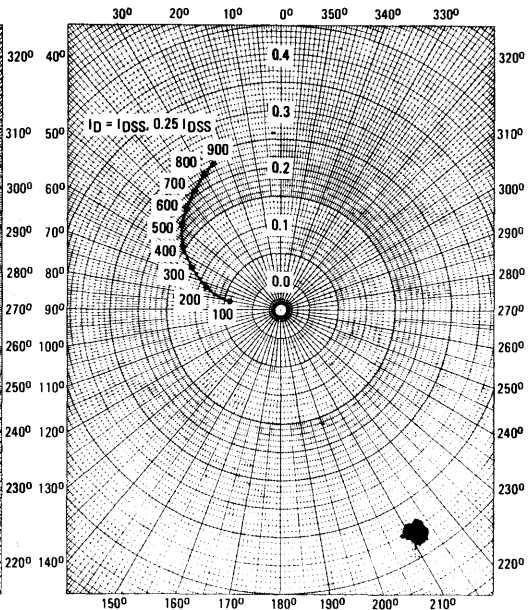


FIGURE 12 - S_{21s}

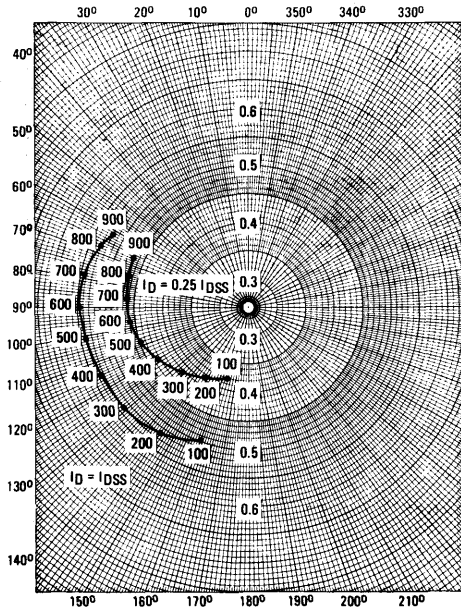
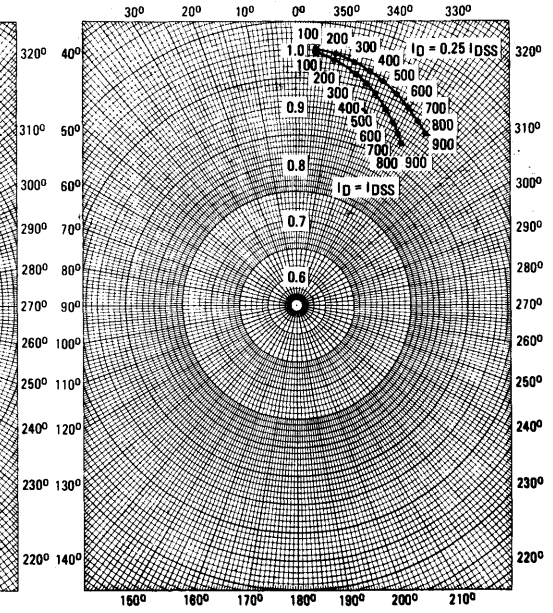


FIGURE 13 - S_{22s}



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COMMON GATE CHARACTERISTICS
 ADMITTANCE PARAMETERS
 (V_{DG} = 15 Vdc, T_{channel} = 25°C)

FIGURE 14 - INPUT ADMITTANCE (y_{ig})

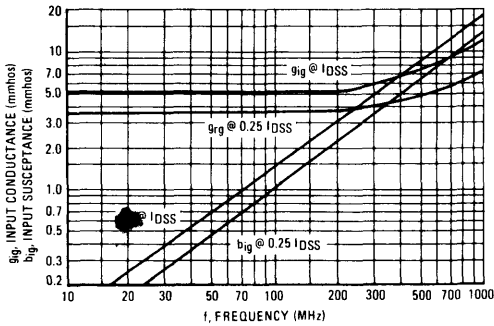


FIGURE 15 - REVERSE TRANSFER ADMITTANCE (y_{rg})

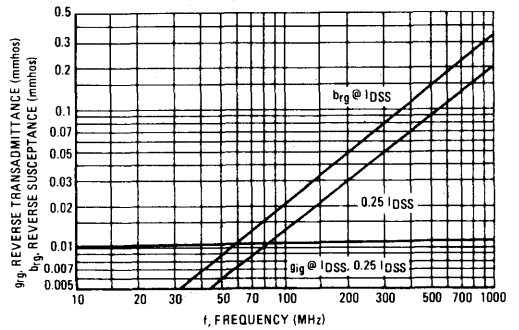


FIGURE 16 - FORWARD TRANSFER ADMITTANCE (y_{fg})

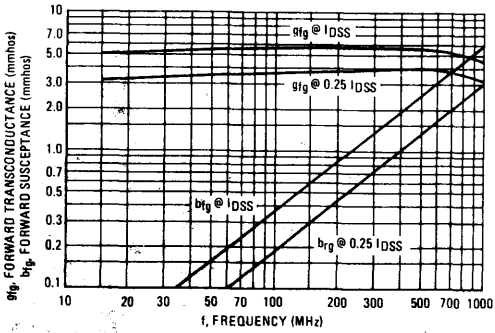
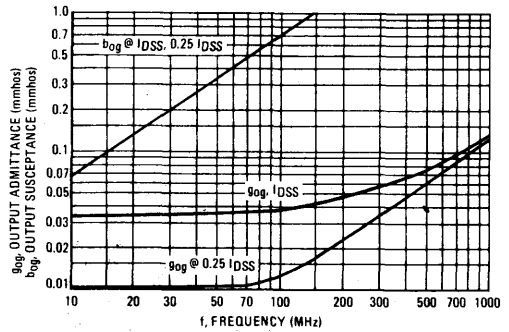


FIGURE 17 - OUTPUT ADMITTANCE (y_{og})



COMMON GATE CHARACTERISTICS
S-PARAMETERS

(VDG = 15 Vdc, $T_{channel} = 25^{\circ}C$,
Data Points in MHz)

FIGURE 18 - S_{11g}

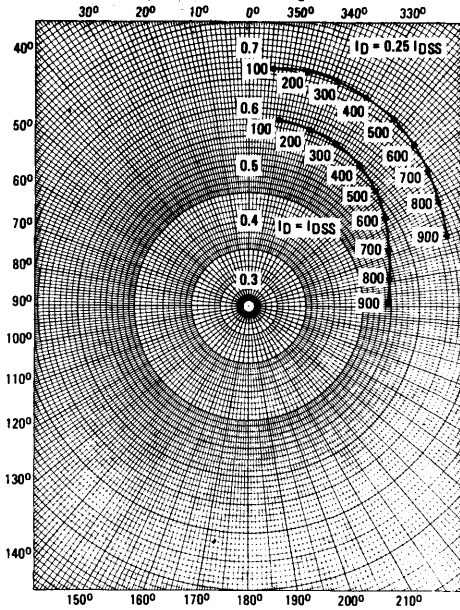


FIGURE 19 - S_{12g}

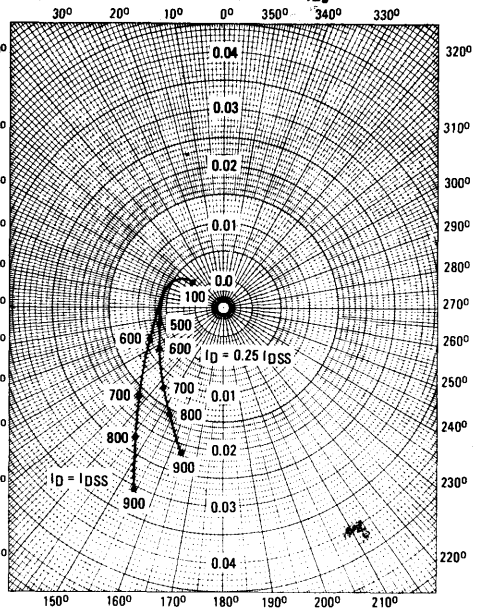


FIGURE 20 - S_{21g}

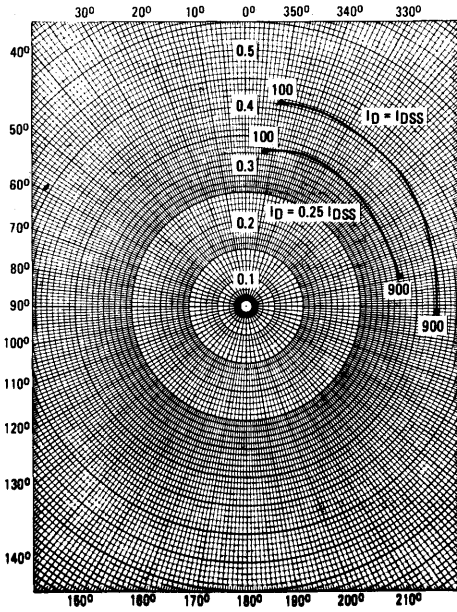
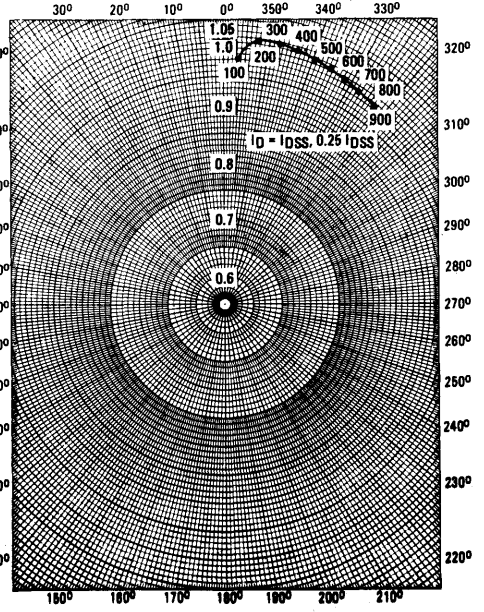


FIGURE 21 - S_{22g}



2N4856,A thru 2N4861,A

JAN, JTX AVAILABLE
CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	2N4856,A 2N4857,A 2N4858,A	2N4859,A 2N4860,A 2N4861,A	Unit
Drain-Source Voltage	V _{DS}	+40	+30	Vdc
Drain-Gate Voltage	V _{DG}	+40	+30	Vdc
Reverse Gate-Source Voltage	V _{GSR}	-40	-30	Vdc
Forward Gate Current	I _{GF}	50		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	360 2.4		mW mW/°C
Storage Temperature Range	T _{stg}	-65 to +175		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage (I _G = 1.0 μAdc, V _{DS} = 0)	2N4856,A, 2N4857,A, 2N4858,A 2N4859,A, 2N4860,A, 2N4861,A	V(BR)GSS	-40 -30	— —	Vdc
Gate Reverse Current (V _{GS} = -20 Vdc, V _{DS} = 0) (V _{GS} = -15 Vdc, V _{DS} = 0) (V _{GS} = -20 Vdc, V _{DS} = 0, T _A = 150°C) (V _{GS} = -15 Vdc, V _{DS} = 0, T _A = 150°C)	2N4856,A, 2N4857,A, 2N4858,A 2N4859,A, 2N4860,A, 2N4861,A 2N4856,A, 2N4857,A, 2N4858,A 2N4859,A, 2N4860,A, 2N4861,A	I _{GSS}	— — — —	0.25 0.25 0.5 0.5	nAdc μAdc
Gate Source Cutoff Voltage (V _{DS} = 15 Vdc, I _D = 0.5 nAdc)	2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	V _{GS(off)}	-4.0 -2.0 -0.8	-10 -6.0 -4.0	Vdc
Drain Cutoff Current (V _{DS} = 15 Vdc, V _{GS} = -10 Vdc) (V _{DS} = 15 Vdc, V _{GS} = -10 Vdc, T _A = 150°C)		I _{D(off)}	— —	0.25 0.5	nAdc μAdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) (V _{DS} = 15 Vdc, V _{GS} = 0)	2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	I _{DSS}	50 20 8.0	— 100 80	mAdc
Drain-Source On-Voltage (I _D = 20 mAdc, V _{GS} = 0) (I _D = 10 mAdc, V _{GS} = 0) (I _D = 5.0 mAdc, V _{GS} = 0)	2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	V _{DS(on)}	— — —	0.75 0.5 0.5	Vdc

SMALL-SIGNAL CHARACTERISTICS

Drain-Source "ON" Resistance (V _{GS} = 0, I _D = 0, f = 1.0 kHz)	2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	r _{ds(on)}	— — —	25 40 60	Ohms
Input Capacitance (V _{DS} = 0, V _{GS} = -10 Vdc, f = 1.0 MHz)	2N4856 thru 2N4861 2N4856A thru 2N4861A	C _{iss}	— —	18 10	pF
Reverse Transfer Capacitance (V _{DS} = 0, V _{GS} = -10 Vdc, f = 1.0 MHz)	2N4856 thru 2N4861 2N4856A, 2N4859A 2N4857A, 2N4858A, 2N4860A, 2N4861A	C _{rss}	— — —	8.0 4.0 3.5	pF

2N4856,A thru 2N4861,A

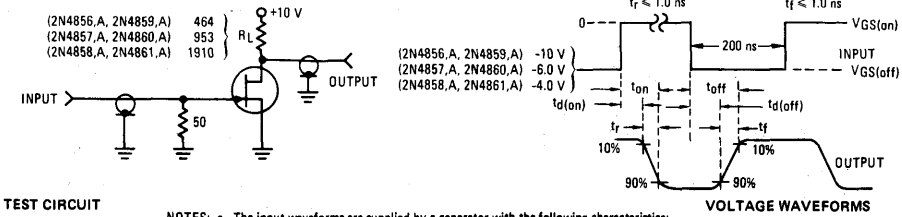
ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS (See Figure 1) (2)					
Turn-On Delay Time	Conditions for 2N4856,A, 2N4859,A:	$t_{d(on)}$	—	6.0	ns
	($V_{DD} = 10\text{ Vdc}$, $I_{D(on)} = 20\text{ mAdc}$, $V_{GS(on)} = 0$, $V_{GS(off)} = -10\text{ Vdc}$)			5.0	
Rise Time	Conditions for 2N4857,A, 2N4860,A:	t_r	—	3.0	ns
	($V_{DD} = 10\text{ Vdc}$, $I_{D(on)} = 10\text{ mAdc}$, $V_{GS(on)} = 0$, $V_{GS(off)} = -6.0\text{ Vdc}$)			4.0	
Turn-Off Time	Conditions for 2N4858,A, 2N4861,A:	t_{off}	—	25	ns
	($V_{DD} = 10\text{ Vdc}$, $I_{D(on)} = 5.0\text{ mAdc}$, $V_{GS(on)} = 0$, $V_{GS(off)} = -4.0\text{ Vdc}$)			20	
				50	
				40	
				100	
				80	

- (1) Pulse Test: Pulse Width = 100 ms, Duty Cycle $\leq 10\%$.
- (2) The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

6

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



- NOTES:**
- a. The input waveforms are supplied by a generator with the following characteristics:
 $Z_{out} = 50\text{ ohms}$, Duty Cycle $\approx 2.0\%$.
 - b. Waveforms are monitored on an oscilloscope with the following characteristics:
 $t_r < 0.75\text{ ns}$, $R_{in} > 1.0\text{ megohm}$, $C_{in} < 2.5\text{ pF}$.

**2N5245
2N5246
2N5247**

**CASE 29-02, STYLE 23
TO-92 (TO-226AA)**

**JFET
HIGH-FREQUENCY
AMPLIFIER**

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C (Free Air)	P_D	360 2.88	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	500 4.0	mW mW/°C
Lead Temperature (1/16" from Case for 10 Seconds)	T_L	260	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-30	—	Vdc
Gate Reverse Current ($V_{GS} = -20 \text{ V}$, $V_{DS} = 0$)	I_{GSS}	—	-1.0	nA
Gate 1 Leakage Current ($V_{G1S} = -20 \text{ V}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{G1SS}	—	-0.5	μA
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ V}$, $I_D = 10 \text{ mA}$)	$V_{GS(off)}$	-1.0 -0.5 -1.5	-6.0 -4.0 -8.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$, Pulsed: See Note 1)	I_{DSS}	5.0 1.5 8.0	15 7.0 24	mA
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	2N5245 2N5246 2N5247	4500 3000 4500	7500 6000 8000	μmhos
Input Admittance ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$)	$\text{Re}(y_{is})$	(100 MHz) (400 MHz)	— —	100 1000	μmhos
Output Admittance ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	2N5245 2N5246 2N5247	— — —	50 50 70	μmhos
Output Conductance ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$)	$\text{Re}(y_{os})$	2N5245 (100 MHz) 2N5246 2N5247 2N5245 (400 MHz) 2N5246 2N5247	— — — — — —	75 75 100 100 100 150	μmhos

2N5245, 2N5246, 2N5247

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Forward Transconductance ($V_{DS} = 15\text{ V}$, $V_{GS} = 0$, $f = 400\text{ MHz}$)	$Re(y_{fs})$	4000 2500 4000	—	μmhos
Input Capacitance ($V_{DS} = 15\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{iss}	—	4.5	pF
Reverse Transfer Capacitance ($V_{DS} = 15\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{rss}	—	1.0	pF
Input Susceptance ($V_{DS} = 15\text{ V}$, $V_{GS} = 0$)	$I_M(Y_{is})$	—	3.0 12.0	mmho

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 15\text{ V}$, $I_D = 5.0\text{ mA}$, $R'_G = 1.0\text{ k}\Omega$)	NF	—	2.0 4.0	dB
Common Source Power Gain ($V_{DS} = 15\text{ V}$, $I_D = 5.0\text{ mA}$, $R'_G = 1.0\text{ k}\Omega$)	G_{ps}	18 10	—	dB
Output Susceptance ($V_{DS} = 15\text{ V}$, $V_{GS} = 0$)	$I_M(Y_{os})$	—	1000 4000	μmho

Note 1: $t_p = 100\text{ ms}$, Duty Cycle = 10%.

2N5265 thru 2N5270

**CASE 20-05, STYLE 5
TO-72 (TO-206AF)**

**JFET
GENERAL PURPOSE**

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Drain-Gate Voltage	V_{DG}	60	Vdc
Reverse Gate-Source Voltage	V_{GSR}	60	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	60	—	Vdc
Gate Reverse Current ($V_{GS} = 30 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = 30 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	— —	2.0 2.0	nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 1.0 \mu\text{Adc}$)	$V_{GS(off)}$	— — —	3.0 6.0 8.0	Vdc
Gate Source Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 0.05 \text{ mAdc}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 0.08 \text{ mAdc}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 0.15 \text{ mAdc}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 0.25 \text{ mAdc}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 0.4 \text{ mAdc}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 0.7 \text{ mAdc}$)	V_{GS}	0.3 0.4 1.0 1.0 2.0 2.0	1.5 2.0 4.0 4.0 6.0 6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	0.5 0.8 1.5 2.5 4.0 7.0	1.0 1.6 3.0 5.0 8.0 14	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	900 1000 1500 2000 2200 2500	2700 3000 3500 4000 4500 5000	μmhos
Output Admittance Common Source ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	—	75	μmhos

2N5265 thru 2N5270

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Common Source Forward Transconductance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 100\text{ MHz}$)	$Re(y_{fs})$			μmhos
2N5265		800	—	
2N5266		900	—	
2N5267		1400	—	
2N5268		1700	—	
2N5269		1900	—	
2N5270		2100	—	
Input Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{rss}	—	2.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $R_G = 1.0\text{ M ohm}$, $f = 100\text{ Hz}$, $BW = 1.0\text{ Hz}$)	NF	—	2.5	dB
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 100\text{ Hz}$, $BW = 1.0\text{ Hz}$)	e_n	—	115	$\text{nV}/\sqrt{\text{Hz}}$

FIGURE 1-6 TRANSFER CHARACTERISTIC CURVES FOR MIN/MAX I_{DSS} LIMITS

FIGURE 1

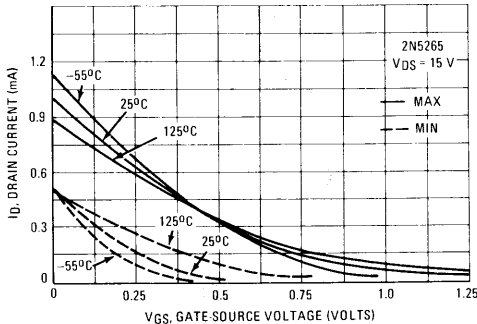


FIGURE 2

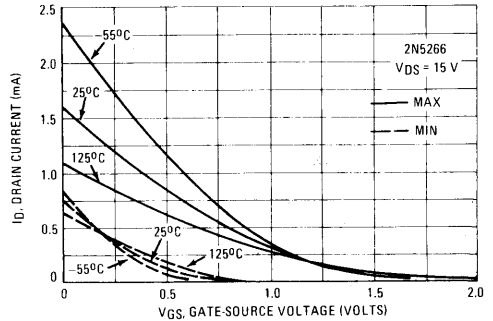


FIGURE 3

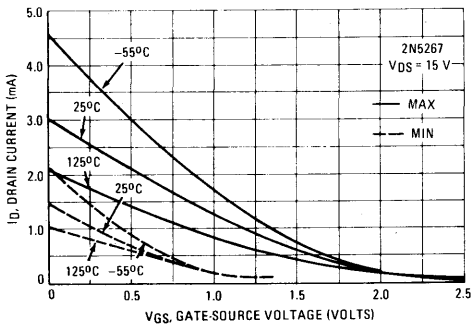


FIGURE 4

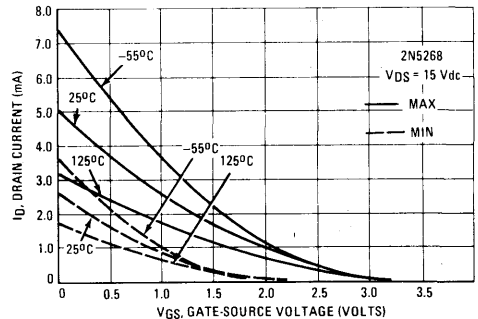


FIGURE 5

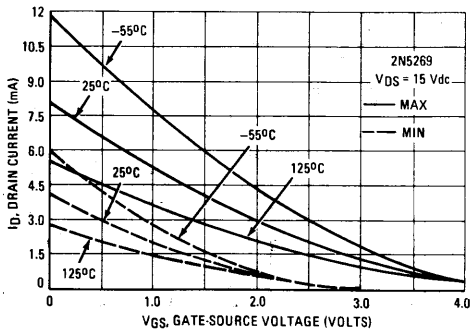
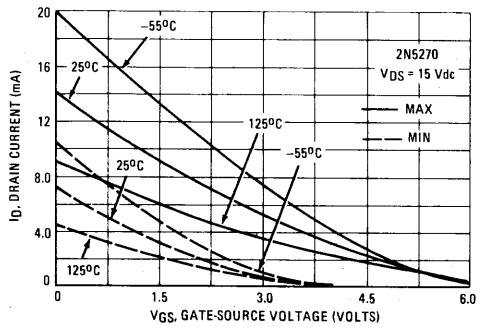


FIGURE 6



FIGURES 7-12 – TYPICAL AND MINIMUM FORWARD TRANSFER ADMITTANCE

FIGURE 7

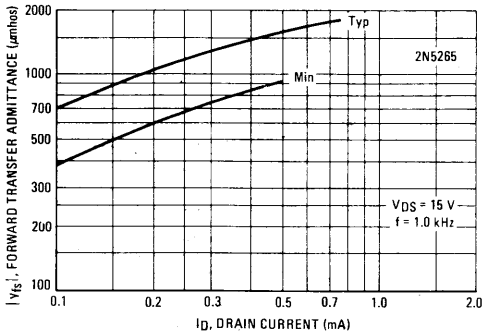


FIGURE 8

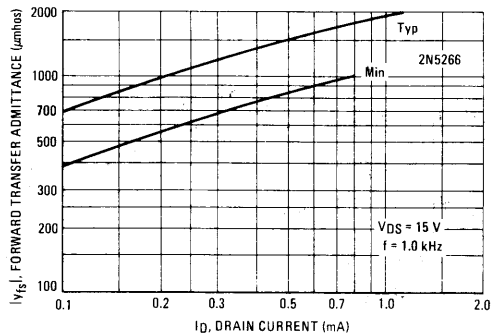


FIGURE 9

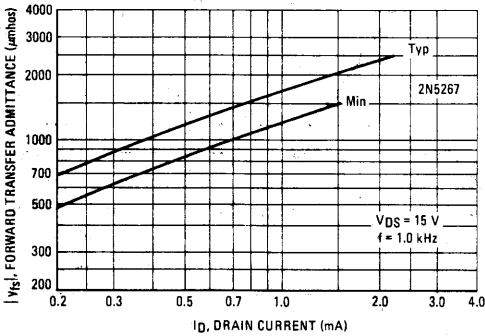


FIGURE 10

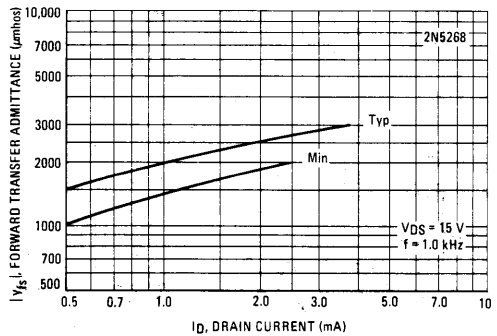


FIGURE 11

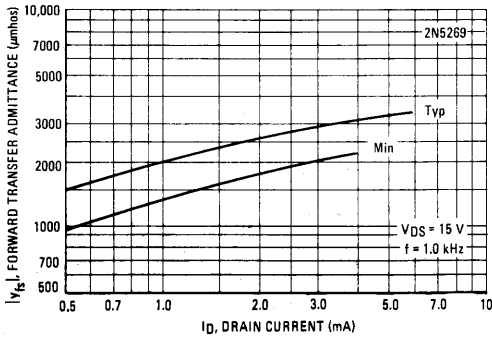
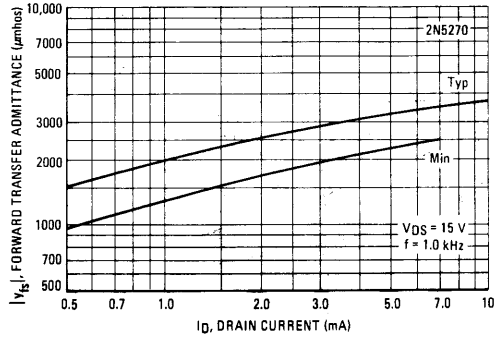


FIGURE 12



TYPICAL CURVES

FIGURE 13 – OUTPUT RESISTANCE versus DRAIN CURRENT

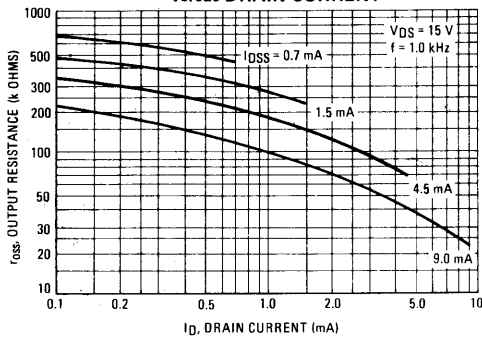


FIGURE 14 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

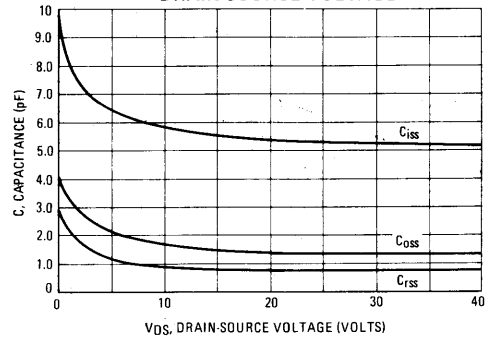


FIGURE 15 – NOISE FIGURE versus FREQUENCY

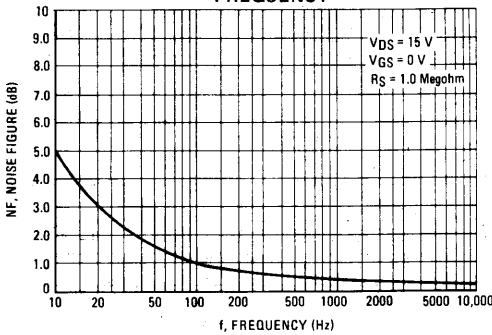


FIGURE 16 – NOISE FIGURE versus SOURCE RESISTANCE

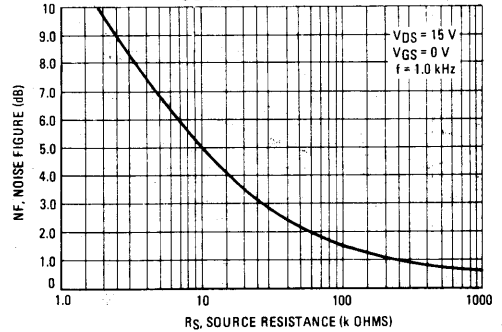


FIGURE 17 – DRAIN CURRENT TEMPERATURE COEFFICIENT versus DRAIN CURRENT

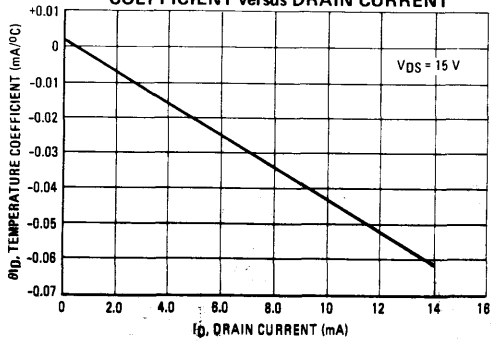
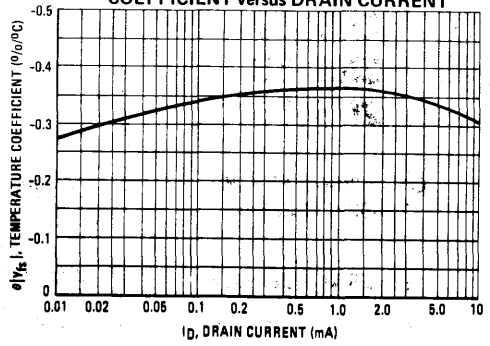


FIGURE 18 – FORWARD TRANSADMITTANCE COEFFICIENT versus DRAIN CURRENT



2N5457
2N5458
2N5459

CASE 29-05, STYLE 5
TO-92 (TO-226AA)

JFET
GENERAL PURPOSE
N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	-25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	310 2.82	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	125	$^\circ\text{C}$
Storage Channel Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-25	—	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	—	—	-1.0 -200	nAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 10 \text{ nAdc}$)	$V_{GS(off)}$	-0.5 -1.0 -2.0	—	-6.0 -7.0 -8.0	Vdc
Gate Source Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 100 \mu\text{Adc}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 200 \mu\text{Adc}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 400 \mu\text{Adc}$)	V_{GS}	—	-2.5 -3.5 -4.5	—	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current* ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	1.0 2.0 4.0	3.0 6.0 9.0	5.0 9.0 16	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance Common Source* ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	1000 1500 2000	—	5000 5500 6000	μmhos
Output Admittance Common Source* ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	—	10	50	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	1.5	3.0	pF

*Pulse Test: Pulse Width $\leq 630 \text{ ms}$; Duty Cycle $\leq 10\%$.

2N5460 thru 2N5465

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET
AMPLIFIER

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	2N5460	2N5463	Unit
		2N5461	2N5464	
Drain-Gate Voltage	V _{DG}	40	60	V _{dc}
Reverse Gate-Source Voltage	V _{GSR}	40	60	V _{dc}
Forward Gate Current	I _{G(f)}	10		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	310		mW
		2.82		mW/°C
Junction Temperature Range	T _J	-65 to +135		°C
Storage Channel Temperature Range	T _{stg}	-65 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage (I _G = 10 μAdc, V _{DS} = 0)	2N5460, 2N5461, 2N5462 2N5463, 2N5464, 2N5465	V _{(BR)GSS}	40 60	— —	— —	V _{dc}
Gate Reverse Current (V _{GS} = 20 V _{dc} , V _{DS} = 0) (V _{GS} = 30 V _{dc} , V _{DS} = 0) (V _{GS} = 20 V _{dc} , V _{DS} = 0, T _A = 100°C) (V _{GS} = 30 V _{dc} , V _{DS} = 0, T _A = 100°C)	2N5460, 2N5461, 2N5462 2N5463, 2N5464, 2N5465 2N5460, 2N5461, 2N5462 2N5463, 2N5464, 2N5465	I _{GSS}	— — — —	— — — —	5.0 5.0 1.0 1.0	nAdc μAdc
Gate Source Cutoff Voltage (V _{DS} = 15 V _{dc} , I _D = 1.0 μAdc)	2N5460, 2N5463 2N5461, 2N5464 2N5462, 2N5465	V _{GS(off)}	0.75 1.0 1.8	— — —	6.0 7.5 9.0	V _{dc}
Gate Source Voltage (V _{DS} = 15 V _{dc} , I _D = 0.1 mAdc) (V _{DS} = 15 V _{dc} , I _D = 0.2 mAdc) (V _{DS} = 15 V _{dc} , I _D = 0.4 mAdc)	2N5460, 2N5463 2N5461, 2N5464 2N5462, 2N5465	V _{GS}	0.5 0.8 1.5	— — —	4.0 4.5 6.0	V _{dc}

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 kHz)	2N5460, 2N5463 2N5461, 2N5464 2N5462, 2N5465	I _{DSS}	1.0 2.0 4.0	— — —	5.0 9.0 16	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 kHz)	2N5460, 2N5463 2N5461, 2N5464 2N5462, 2N5465	y _{fs}	1000 1500 2000	— — —	4000 5000 6000	μmhos
Output Admittance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 kHz)		y _{os}	—	—	75	μmhos
Input Capacitance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 MHz)		C _{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 MHz)		C _{rss}	—	1.0	2.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure (V _{DS} = 15 V _{dc} , V _{GS} = 0, R _G = 1.0 Megohm, f = 100 Hz, BW = 1.0 Hz)		NF	—	1.0	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e _n	—	60	115	nV/√Hz

DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 1 — $V_{GS(off)} = 2.0$ VOLTS

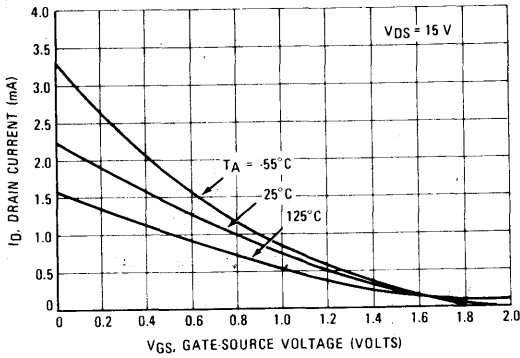


FIGURE 2 — $V_{GS(off)} = 4.0$ VOLTS

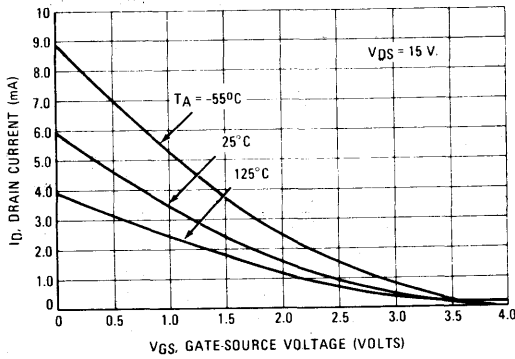
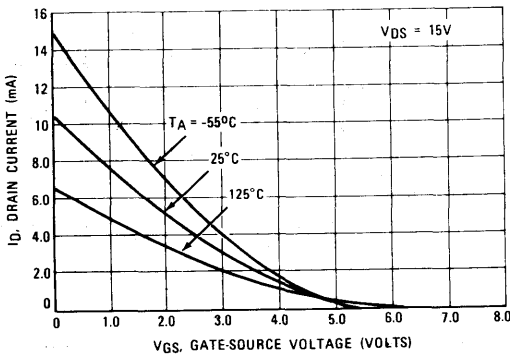


FIGURE 3 — $V_{GS(off)} = 5.0$ VOLTS



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 4 — $V_{GS(off)} = 2.0$ VOLTS

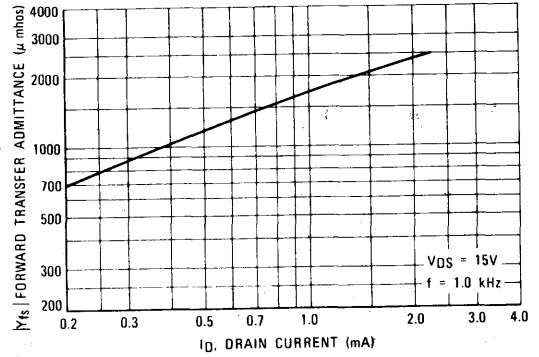


FIGURE 5 — $V_{GS(off)} = 4.0$ VOLTS

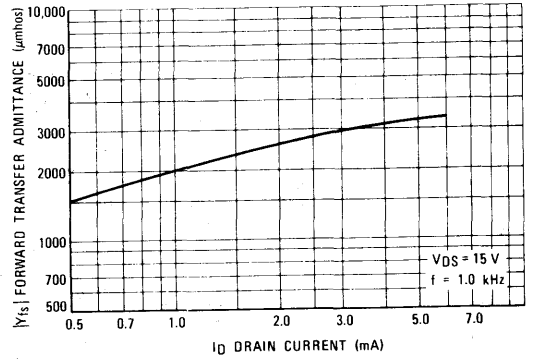
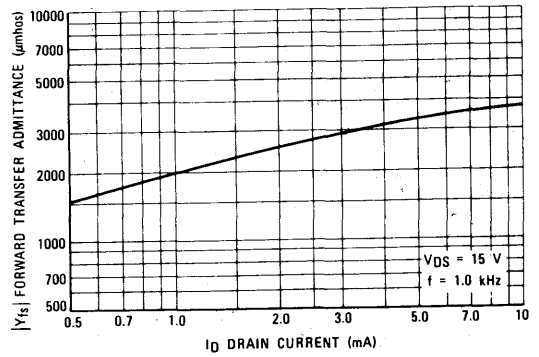


FIGURE 6 — $V_{GS(off)} = 5.0$ VOLTS



6

FIGURE 7 – OUTPUT RESISTANCE
VERSUS DRAIN CURRENT

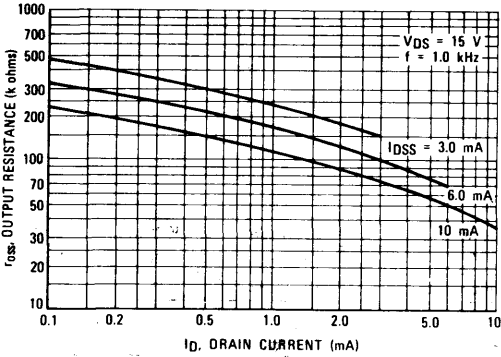


FIGURE 8 – CAPACITANCE VERSUS
DRAIN-SOURCE VOLTAGE

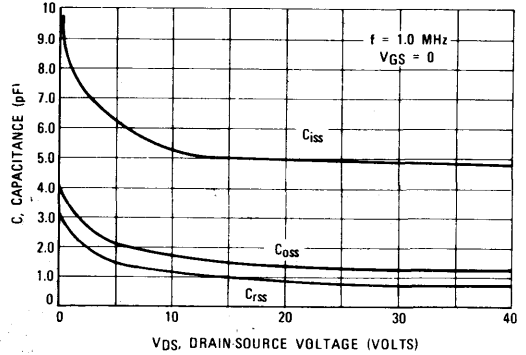


FIGURE 9 – NOISE FIGURE
VERSUS FREQUENCY

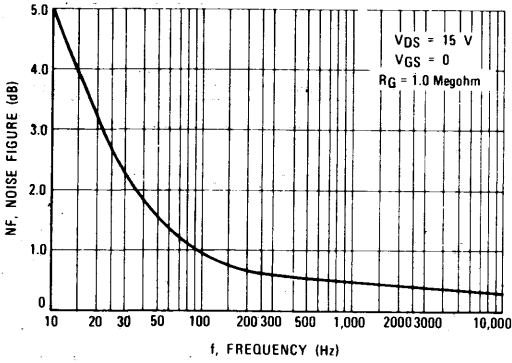


FIGURE 10 – NOISE FIGURE VERSUS
SOURCE RESISTANCE

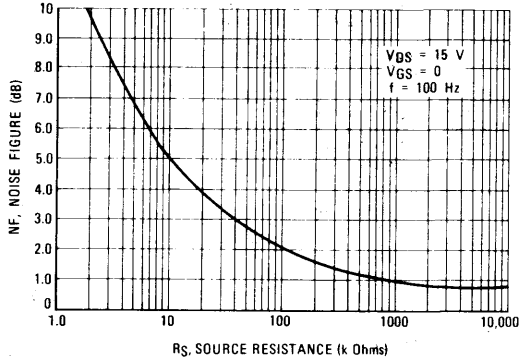
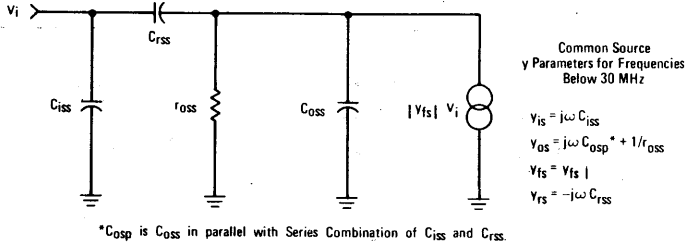


FIGURE 11 – EQUIVALENT LOW FREQUENCY CIRCUIT



NOTE:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ns, Duty Cycle = 10%).

2N5484 thru 2N5486

CASE 29-05, STYLE 5
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER
N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V _{DG}	25	V _{dc}
Reverse Gate-Source Voltage	V _{GSR}	25	V _{dc}
Drain Current	I _D	30	mAdc
Forward Gate Current	I _{G(f)}	10	mAdc
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +150	°C

Refer to 2N4416 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I _G = -1.0 μAdc, V _{DS} = 0)	V _{(BR)GSS}	-25	—	—	V _{dc}
Gate Reverse Current (V _{GS} = -20 V _{dc} , V _{DS} = 0) (V _{GS} = -20 V _{dc} , V _{DS} = 0, T _A = 100°C)	I _{GSS}	— —	— —	-1.0 -0.2	nAdc μAdc
Gate Source Cutoff Voltage (V _{DS} = 15 V _{dc} , I _D = 10 nAdc)	V _{GS(off)}	-0.3 -0.5 -2.0	— — —	-3.0 -4.0 -6.0	V _{dc}
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V _{DS} = 15 V _{dc} , V _{GS} = 0)	I _{DSS}	1.0 4.0 8.0	— — —	5.0 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 kHz)	y _{fs}	3000 3500 4000	— — —	6000 7000 8000	μmhos
Input Admittance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 100 MHz) (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 400 MHz)	Re(y _{is})	— —	— —	100 1000	μmhos
Output Admittance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 1.0 kHz)	y _{os}	— — —	— — —	50 60 75	μmhos
Output Conductance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 100 MHz) (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 400 MHz)	Re(y _{os})	— —	— —	75 100	μmhos
Forward Transconductance (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 100 MHz) (V _{DS} = 15 V _{dc} , V _{GS} = 0, f = 400 MHz)	Re(y _{fs})	2500 3000 3500	— — —	— — —	μmhos

2N5484 thru 2N5486

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{rss}	—	—	1.0	pF
Output Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{oss}	—	—	2.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $R_G = 1.0\text{ Megohm}$, $f = 1.0\text{ kHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 1.0\text{ mAdc}$, $R_G = 1.0\text{ k ohm}$, $f = 100\text{ MHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 1.0\text{ mAdc}$, $R_G = 1.0\text{ k ohm}$, $f = 200\text{ MHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 4.0\text{ mAdc}$, $R_G = 1.0\text{ k ohm}$, $f = 100\text{ MHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 4.0\text{ mAdc}$, $R_G = 1.0\text{ k ohm}$, $f = 400\text{ MHz}$)	NF 2N5484 2N5484 2N5485, 2N5486 2N5485, 2N5486	— — — — —	— — 4.0 — —	2.5 3.0 — 2.0 4.0	dB
Common Source Power Gain ($V_{DS} = 15\text{ Vdc}$, $I_D = 1.0\text{ mAdc}$, $f = 100\text{ MHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 1.0\text{ mAdc}$, $f = 200\text{ MHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 4.0\text{ mAdc}$, $f = 100\text{ MHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 4.0\text{ mAdc}$, $f = 400\text{ MHz}$)	Gps 2N5484 2N5485, 2N5486 2N5485, 2N5486	16 — 18 10	— 14 — —	25 — 30 20	dB

2N5555

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	310 2.82	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +150	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	1.0	nAdc
Drain Cutoff Current ($V_{DS} = 12 \text{Vdc}$, $V_{GS} = -10 \text{V}$) ($V_{DS} = 12 \text{Vdc}$, $V_{GS} = -10 \text{V}$, $T_A = 100^\circ\text{C}$)	$I_{D(off)}$	— —	10 2.0	nAdc μAdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current* ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}	15	—	mAdc
Gate-Source Forward Voltage ($I_{G(f)} = 1.0 \text{mAdc}$, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc
Drain-Source On-Voltage ($I_D = 7.0 \text{mAdc}$, $V_{GS} = 0$)	$V_{DS(on)}$	—	1.5	Vdc
Static Drain-Source On Resistance ($I_D = 0.1 \text{mAdc}$, $V_{GS} = 0$)	$r_{DS(on)}$	—	150	Ohms

SMALL-SIGNAL CHARACTERISTICS

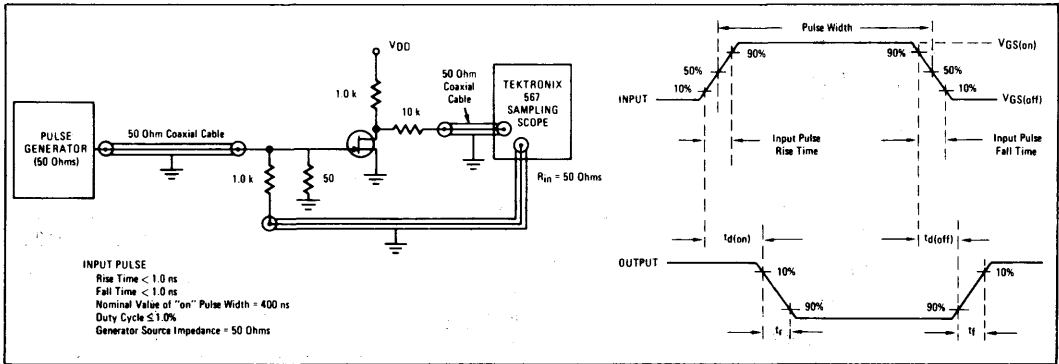
Small-Signal Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{kHz}$)	$r_{ds(on)}$	—	150	Ohms
Input Capacitance ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{MHz}$)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 10 \text{Vdc}$, $f = 1.0 \text{MHz}$)	C_{rss}	—	1.2	pF

SWITCHING CHARACTERISTICS

Turn-On Delay Time	$(V_{DD} = 10 \text{Vdc}$, $I_{D(on)} = 7.0 \text{mAdc}$, $V_{GS(on)} = 0$, $V_{GS(off)} = -10 \text{Vdc}$) (See Figure 1)	$t_{d(on)}$	—	5.0	ns
Rise Time		t_r	—	5.0	ns
Turn-Off Delay Time	$(V_{DD} = 10 \text{Vdc}$, $I_{D(on)} = 7.0 \text{mAdc}$, $V_{GS(on)} = 0$, $V_{GS(off)} = -10 \text{Vdc}$) (See Figure 1)	$t_{d(off)}$	—	15	ns
Fall Time		t_f	—	10	ns

*Pulse Test: Pulse Width < 300 μs , Duty Cycle < 3.0%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



2N5638
2N5639
2N5640

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	30	Vdc
Drain-Gate Voltage	V _{DG}	30	Vdc
Reverse Gate-Source Voltage	V _{GSR}	30	Vdc
Forward Gate Current	I _{GF}	10	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	310 2.82	mW mW/°C
Junction Temperature Range	T _J	-65 to +150	°C
Storage Temperature Range	T _{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I _G = 10 μAdc, V _{DS} = 0)	V _{(BR)GSS}	30	—	Vdc
Gate Reverse Current (V _{GS} = -15 Vdc, V _{DS} = 0) (V _{GS} = -15 Vdc, V _{DS} = 0, T _A = 100°C)	I _{GSS}	— —	1.0 1.0	nAdc μAdc
Drain Cutoff Current (V _{DS} = 15 Vdc, V _{GS} = -12 Vdc) (V _{DS} = 15 Vdc, V _{GS} = -8.0 Vdc) (V _{DS} = 15 Vdc, V _{GS} = -6.0 Vdc) (V _{DS} = 15 Vdc, V _{GS} = -12 Vdc, T _A = 100°C) (V _{DS} = 15 Vdc, V _{GS} = -8.0 Vdc, T _A = 100°C) (V _{DS} = 15 Vdc, V _{GS} = -6.0 Vdc, T _A = 100°C)	I _{D(off)}	— — — — — —	1.0 1.0 1.0 1.0 1.0 1.0	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) (V _{DS} = 20 Vdc, V _{GS} = 0)	I _{DSS}	50 25 5.0	— — —	mAdc
Drain-Source On-Voltage (I _D = 12 mAdc, V _{GS} = 0) (I _D = 6.0 mAdc, V _{GS} = 0) (I _D = 3.0 mAdc, V _{GS} = 0)	V _{DS(on)}	— — —	0.5 0.5 0.5	Vdc
Static Drain-Source On Resistance (I _D = 1.0 mAdc, V _{GS} = 0)	r _{DS(on)}	— — —	30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Static Drain-Source "ON" Resistance (V _{GS} = 0, I _D = 0, f = 1.0 kHz)	r _{ds(on)}	— — —	30 60 100	Ohms
Input Capacitance (V _{DS} = 0, V _{GS} = -12 Vdc, f = 1.0 MHz)	C _{iss}	—	10	pF
Reverse Transfer Capacitance (V _{DS} = 0, V _{GS} = -12 Vdc, f = 1.0 MHz)	C _{rss}	—	4.0	pF

2N5638, 2N5639, 2N5640

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	$V_{DD} = 10 \text{ Vdc}$, $V_{GS(\text{on})} = 0$, $V_{GS(\text{off})} = -10 \text{ Vdc}$, $R_{G'} = 50 \text{ ohms}$	$I_{D(\text{on})} = 12 \text{ mAdc}$ 2N5638	—	4.0	ns
		6.0 mAdc 2N5639	—	6.0	
		3.0 mAdc 2N5640	—	8.0	
Rise Time		$I_{D(\text{on})} = 12 \text{ mAdc}$ 2N5638	t_r	—	5.0
	6.0 mAdc 2N5639		—	8.0	
	3.0 mAdc 2N5640		—	10	
Turn-Off Delay Time		$I_{D(\text{on})} = 12 \text{ mAdc}$ 2N5638	$t_{d(\text{off})}$	—	ns
		6.0 mAdc 2N5639		—	
		3.0 mAdc 2N5640		—	
Fall Time		$I_{D(\text{on})} = 12 \text{ mAdc}$ 2N5638	t_f	—	ns
		6.0 mAdc 2N5639		—	
		3.0 mAdc 2N5640		—	

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 3.0\%$.

2N5653 2N5654

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	310 2.82	mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	— —	1.0 1.0	nAdc μAdc
Drain Cutoff Current ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -12 \text{ Vdc}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -8.0 \text{ Vdc}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -12 \text{ Vdc}$, $T_A = 100^\circ\text{C}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -8.0 \text{ Vdc}$, $T_A = 100^\circ\text{C}$)	$I_{D(off)}$	— — — —	1.0 1.0 1.0 1.0	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	40 15	— —	mAdc
Drain-Source On-Voltage ($I_D = 10 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 5.0 \text{ mAdc}$, $V_{GS} = 0$)	$V_{DS(on)}$	— —	0.75 0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Static Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 1.0 \text{ mAdc}$) ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	— — — —	50 100 50 100	Ohms
Input Capacitance ($V_{DS} = 0$, $V_{GS} = -12 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	10	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = -12 \text{ Vdc}$, $f = 1.0 \text{ MHz}$) ($V_{DS} = 0$, $V_{GS} = -8.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{rss}	— —	3.5 3.5	pF

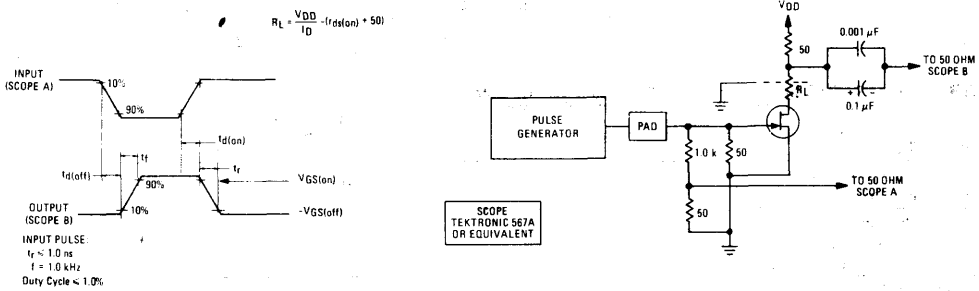
2N5653, 2N5654

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Turn-On Delay Time	$t_{d(on)}$	—	4.0	ns
Rise Time	t_r	—	5.0	ns
Turn-Off Delay Time	$t_{d(off)}$	—	5.0	ns
Fall Time	t_f	—	10	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 3.0\%$.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



2N5668
2N5669
2N5670

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	310 2.82	mW mW/ $^\circ\text{C}$
Storage Channel Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	—	—	2.0 2.0	nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 10 \text{ nAdc}$)	$V_{GS(off)}$	0.2 1.0 2.0	— — —	4.0 6.0 8.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	1.0 4.0 8.0	— — —	5.0 10 20	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	1500 2000 3000	— — —	6500 6500 7500	μmhos
Input Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$\text{Re}(y_{is})$	—	125	800	μmhos
Output Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	— — —	— — —	20 50 75	μmhos
Output Conductance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$\text{Re}(y_{os})$	— — —	10 25 35	50 100 150	μmhos
Forward Transconductance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$\text{Re}(y_{fs})$	1000 1600 2500	— — —	— — —	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	4.7	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	1.0	3.0	pF

2N5668, 2N5669, 2N5670

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

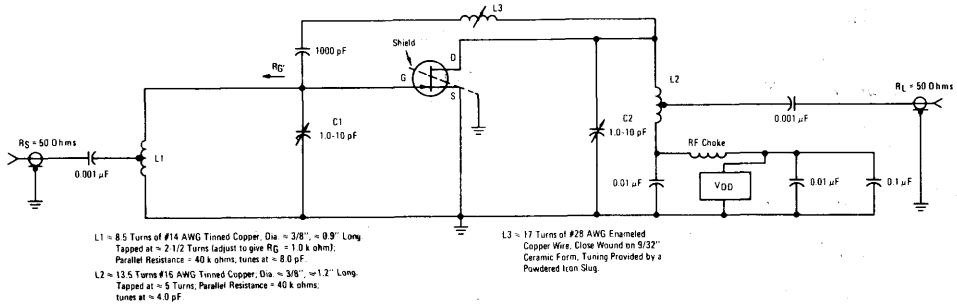
Characteristic	Symbol	Min	Typ	Max	Unit
Output Capacitance ($V_{DS} = 15\text{ Vdc}, V_{GS} = 0, f = 1.0\text{ MHz}$)	C_{oss}	—	1.4	4.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure (Figure 1) ($V_{DS} = 15\text{ Vdc}, V_{GS} = 0, f = 100\text{ MHz}$ at $R_G' = 1.0\text{ k ohm}$)	NF	—	—	2.5	dB
Common Source Power Gain (Figure 1) ($V_{DS} = 15\text{ Vdc}, V_{GS} = 0, f = 100\text{ MHz}$)	G_{ps}	16	—	—	dB

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle $\leq 10\%$.

FIGURE 1 – 100 MHz, POWER GAIN AND NOISE FIGURE TEST CIRCUIT



2N6659
2N6660
2N6661
MPF6659
MPF6660
MPF6661
 2N6659,60,61
CASE 79-02, STYLE 6
TO-39 (TO-205AD)
 MPF6659,60,61
CASE 29-03, STYLE 22
TO-226AE

TMOS
SWITCHING TRANSISTOR

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	2N6659 MPF6659	2N6660 MPF6660	2N6661 MPF6661	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}	± 30			Vdc
Drain Current — Continuous (1) Pulsed (2)	I_D I_{DM}	2.0 3.0			Adc
		2N6659 2N6660 2N6661	MPF6659 MPF6660 MPF6661		
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	6.25 50	2.5 20		Watts mW/°C
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	— —	1.0 8.0		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.

(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = \text{Maximum Rating}, V_{GS} = 0$)	I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current ($V_{GS} = 15\text{ V}, V_{DS} = 0$)	I_{GSS}	—	—	100	nAdc
Drain-Source Breakdown Voltage ($V_{GS} = 0, I_D = 10\ \mu\text{A}$)	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
ON CHARACTERISTICS(1)					
Gate Threshold Voltage ($V_{DS} = V_{GS}, I_D = 1.0\ \text{mA}$)	$V_{GS(Th)}$	0.8	1.4	2.0	Vdc
Drain-Source On-Voltage ($V_{GS} = 10\ \text{V}, I_D = 1.0\ \text{A}$)	$V_{DS(on)}$	— — —	— — —	1.8 3.0 4.0	Vdc
($V_{GS} = 5.0\ \text{V}, I_D = 0.3\ \text{A}$)		— — —	0.8 0.9 0.9	1.5 1.5 1.6	
Static Drain-Source On Resistance ($V_{GS} = 10\ \text{Vdc}, I_D = 1.0\ \text{Adc}$)	$r_{DS(on)}$	— — —	— — —	1.8 3.0 4.0	Ohms
On-State Drain Current ($V_{DS} = 25\ \text{V}, V_{GS} = 10\ \text{V}$)	$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance ($V_{DS} = 25\ \text{V}, V_{GS} = 0, f = 1.0\ \text{MHz}$)	C_{iss}	—	30	50	pF
Reverse Transfer Capacitance ($V_{DS} = 25\ \text{V}, V_{GS} = 0, f = 1.0\ \text{MHz}$)	C_{rss}	—	3.6	10	pF
Output Capacitance ($V_{DS} = 25\ \text{V}, V_{GS} = 0, f = 1.0\ \text{MHz}$)	C_{oss}	—	20	40	pF
Forward Transconductance ($V_{DS} = 25\ \text{V}, I_D = 0.5\ \text{A}$)	g_{fs}	170	—	—	mmhos

2N6659, 2N6660, 2N6661, MPF6659, MPF6660, MPF6661

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS(1)					
Rise Time	t_r	—	—	5.0	ns
Fall Time	t_f	—	—	5.0	ns
Turn-On Time	t_{on}	—	—	5.0	ns
Turn-Off Time	t_{off}	—	—	5.0	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

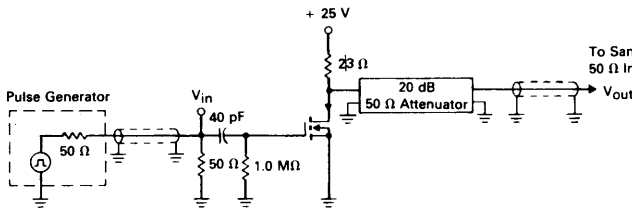


FIGURE 2 — SWITCHING WAVEFORMS

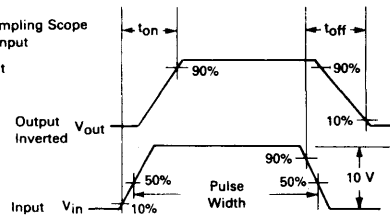


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

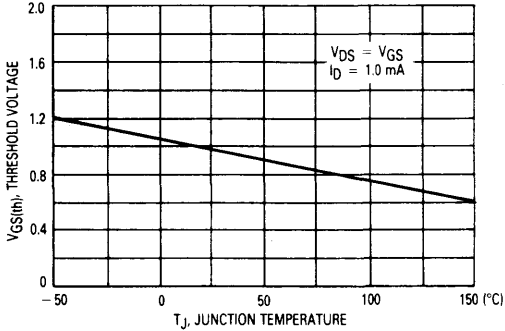


FIGURE 4 — ON-REGION CHARACTERISTICS

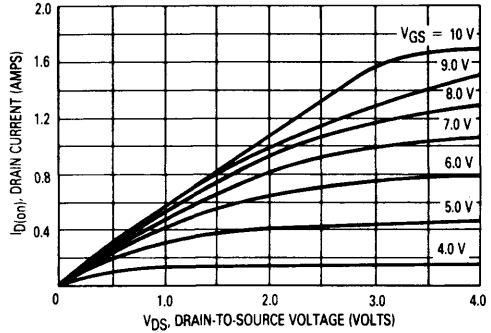


FIGURE 5 — OUTPUT CHARACTERISTICS

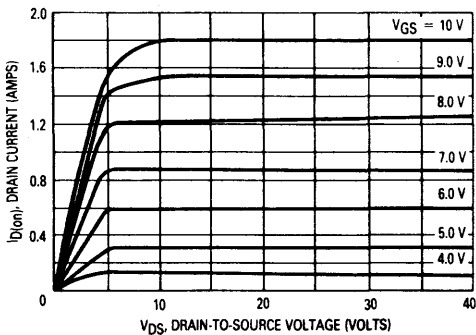
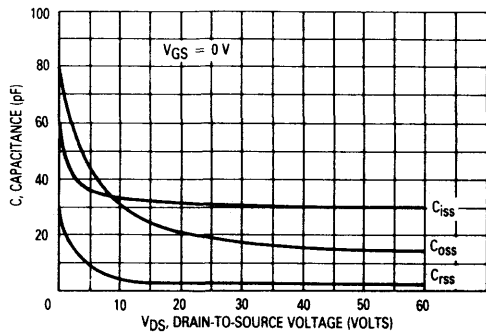
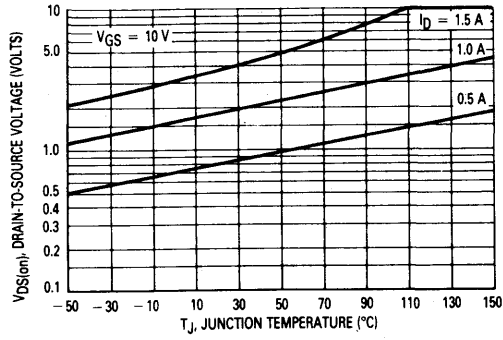


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



2N6659, 2N6660, 2N6661, MPF6659, MPF6660, MPF6661

FIGURE 7 — ON-VOLTAGE versus TEMPERATURE



3N128

CASE 20-03, STYLE 7
TO-72 (TO-206AF)

MOSFET AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+20	Vdc
Drain-Gate Voltage	V_{DG}	+20	Vdc
Gate-Source Voltage	V_{GS}	±10	Vdc
Drain Current	I_D	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	330 2.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage(1) ($I_G = -10 \mu\text{Adc}, V_{DS} = 0$)	$V_{(BR)GSS}$	-50	—	Vdc
Gate Reverse Current ($V_{GS} = -8.0 \text{ Vdc}, V_{DS} = 0$) ($V_{GS} = -8.0 \text{ Vdc}, V_{DS} = 0, T_A = 125^\circ\text{C}$)	I_{GSS}	—	0.05 5.0	nAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}, I_D = 50 \mu\text{Adc}$)	$V_{GS(off)}$	-0.5	-8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(2) ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0$)	I_{DSS}	5.0	25	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}, I_D = 5.0 \text{ mAdc}, f = 1.0 \text{ kHz}$)	$ Y_{fs} $	5000	12,000	μmhos
Input Admittance ($V_{DS} = 15 \text{ Vdc}, I_D = 5.0 \text{ mAdc}, f = 200 \text{ MHz}$)	$\text{Re}(Y_{is})$	—	800	μmhos
Output Conductance ($V_{DS} = 15 \text{ Vdc}, I_D = 5.0 \text{ mAdc}, f = 200 \text{ MHz}$)	$\text{Re}(Y_{os})$	—	500	μmhos
Forward Transconductance ($V_{DS} = 15 \text{ Vdc}, I_D = 5.0 \text{ mAdc}, f = 200 \text{ MHz}$)	$\text{Re}(Y_{fs})$	5000	—	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}, I_D = 5.0 \text{ mAdc}, f = 1.0 \text{ MHz}$)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}, I_D = 5.0 \text{ mAdc}, f = 1.0 \text{ MHz}$)	C_{rss}	0.05	0.35	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 15 \text{ Vdc}, I_D = 5.0 \text{ mAdc}, f = 200 \text{ MHz}$)	NF	—	5.0	dB
Power Gain ($V_{DS} = 15 \text{ Vdc}, I_D = 5.0 \text{ mAdc}, f = 200 \text{ MHz}$)	P_G	13.5	23	dB

(1) Caution Destructive Test, can damage gate oxide beyond operation.

(2) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2.0%.

TYPICAL CHARACTERISTICS
($T_A = 25^\circ\text{C}$)

FIGURE 1 – DRAIN CHARACTERISTICS

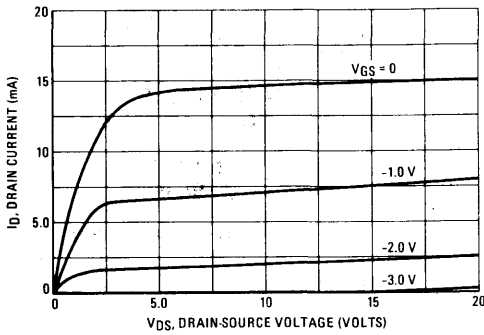
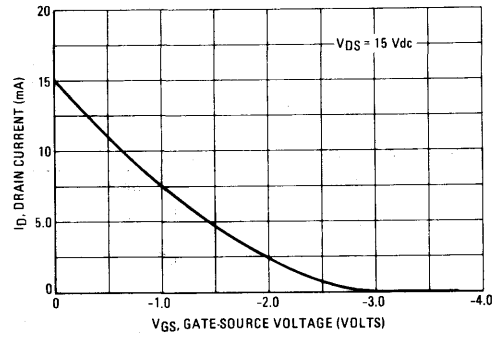


FIGURE 2 – TRANSFER CHARACTERISTICS



TYPICAL 1 kHz DRAIN CHARACTERISTICS
($T_A = 25^\circ\text{C}$, $V_{DS} = 15\text{ Vdc}$, $f = 1.0\text{ kHz}$)

FIGURE 3 – FORWARD TRANSADMITTANCE versus GATE BIAS VOLTAGE

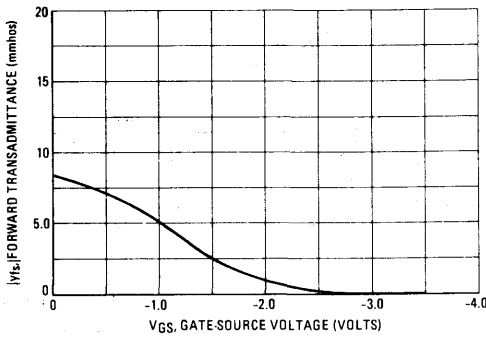
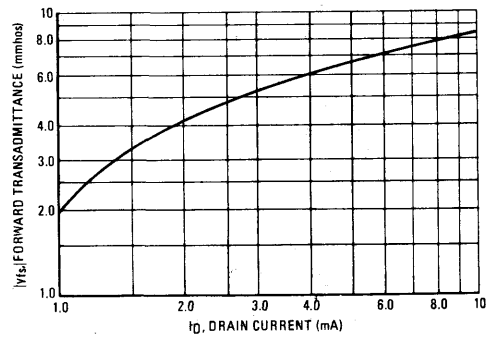


FIGURE 4 – FORWARD TRANSADMITTANCE versus DRAIN CURRENT



TYPICAL 200 MHz COMMON-SOURCE ADMITTANCE CHARACTERISTICS
($T_A = 25^\circ\text{C}$, $V_{DS} = 15\text{ Vdc}$, $f = 200\text{ MHz}$)

FIGURE 5 – INPUT ADMITTANCE (y_{is}) COMPONENTS

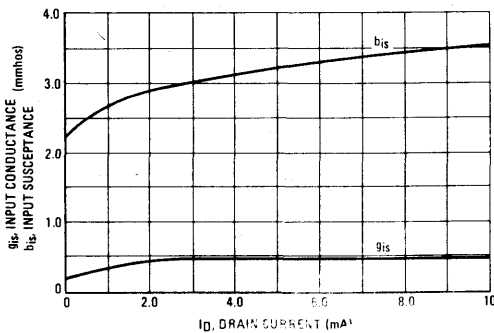


FIGURE 6 – FORWARD TRANSADMITTANCE (y_{fs}) COMPONENTS

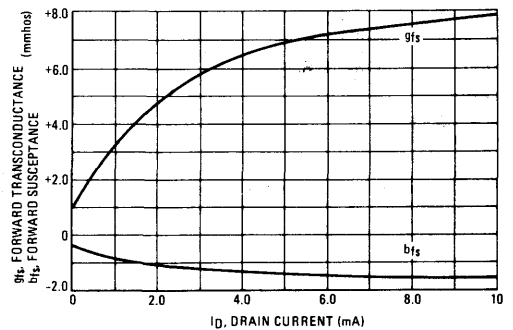


FIGURE 7 - REVERSE TRANSMITTANCE (y_{rs}) COMPONENTS

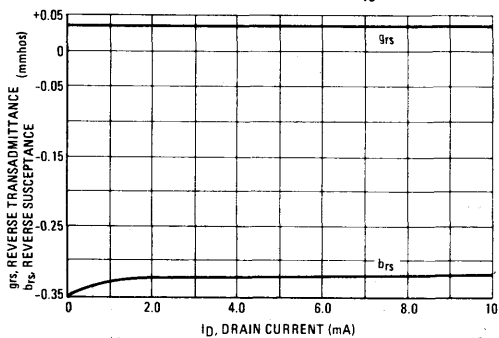


FIGURE 8 - OUTPUT ADMITTANCE (y_{os}) COMPONENTS

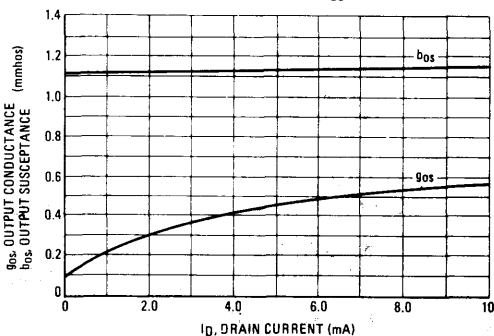


FIGURE 9 - POWER GAIN AND NOISE FIGURE versus DRAIN CURRENT

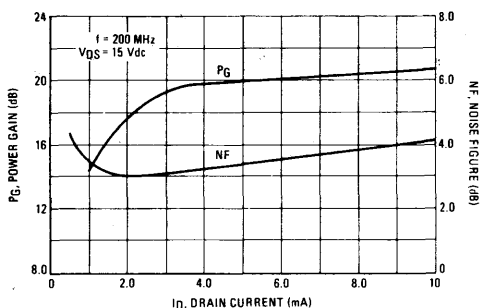


FIGURE 10 - POWER GAIN AND NOISE FIGURE versus DRAIN VOLTAGE

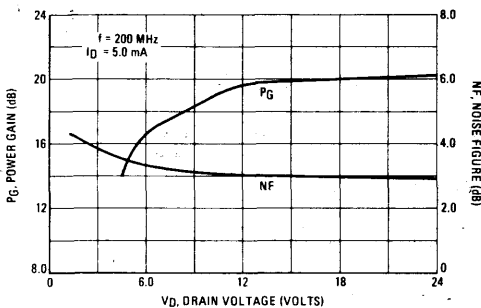


FIGURE 11 - THIRD ORDER INTERMODULATION DISTORTION

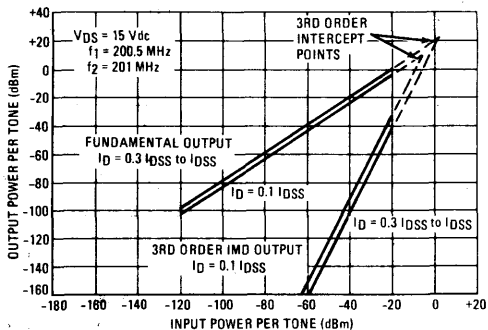
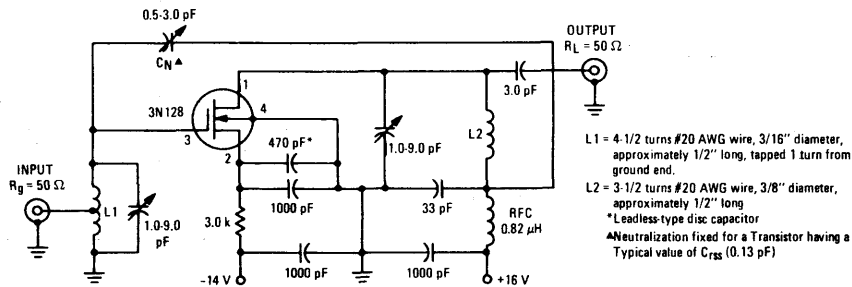


Figure 11 shows the typical third order intermodulation distortion (IMD) performance of the 3N128 at 200 MHz. Both fundamental output and third order IMD output characteristics are plotted. The curves have been extrapolated to show the third order intermodulation output intercept point. Performance for drain currents from I_{DSS} to $0.1 I_{DSS}$, is given. The power gain and noise figure test amplifier shown in Figure 12 was used to generate the IMD data.

FIGURE 12 - POWER GAIN, NOISE FIGURE AND INTERMODULATION DISTORTION TEST CIRCUIT



3N155 3N156

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOSFET SWITCHING

P-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	± 35	Vdc
Drain-Gate Voltage	V_{DG}	± 50	Vdc
Gate-Source Voltage	V_{GS}	± 50	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +175	$^\circ\text{C}$
Storage Channel Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

Refer to 3N157 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage ($I_D = -10 \mu\text{Adc}$, $V_G = V_S = 0$)	$V_{(BR)DSX}$	-35	—	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $T_A = 125^\circ\text{C}$)	I_{DSS}	—	—	-1.0 -1000	nAdc
Gate Reverse Current ($V_{GS} = +50 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = +25 \text{ Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	—	+1000 +10	pAdc
Resistance Drain Source ($I_D = 0$, $V_{GS} = 0$)	$r_{DS(off)}$	$1 \times 10^{+10}$	—	—	Ohms
Resistance Gate Source Input ($V_{GS} = -25 \text{ Vdc}$)	R_{GS}	—	$1 \times 10^{+16}$	—	Ohms
Gate Forward Leakage Current ($V_{GS} = -50 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -25 \text{ Vdc}$, $V_{DS} = 0$)	$I_G(f)$	—	—	-1000 -10	pAdc

ON CHARACTERISTICS

Gate Threshold Voltage ($V_{DS} = -10 \text{ Vdc}$, $I_D = -10 \mu\text{Adc}$)	$V_{GS(Th)}$	-1.5	—	-3.2	Vdc
Drain-Source On-Voltage ($I_D = -2.0 \text{ mAdc}$, $V_{GS} = -10 \text{ Vdc}$)	$V_{DS(on)}$	—	—	-1.0	Vdc
Static Drain-Source On Resistance ($I_D = 0 \text{ mAdc}$, $V_{GS} = -10 \text{ Vdc}$)	$r_{DS(on)}$	—	—	600	Ohms
On-State Drain Current ($V_{DS} = -15 \text{ Vdc}$, $V_{GS} = -10 \text{ Vdc}$)	$I_{D(on)}$	-5.0	—	—	mAdc

SMALL-SIGNAL CHARACTERISTICS

Drain-Source Resistance ($V_{GS} = -10 \text{ Vdc}$, $I_D = 0$, $f = 1.0 \text{ kHz}$) ($V_{GS} = -15 \text{ Vdc}$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	—	—	400 350	Ohms
Forward Transfer Admittance ($V_{DS} = -15 \text{ Vdc}$, $I_D = -2.0 \text{ mAdc}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	1000	—	4000	μmhos
Input Capacitance ($V_{DS} = -15 \text{ Vdc}$, $V_{GS} = -10 \text{ Vdc}$, $f = 140 \text{ kHz}$)	C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, $f = 140 \text{ kHz}$)	C_{rss}	—	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = -10 \text{ Vdc}$, $f = 140 \text{ kHz}$)	$C_{d(sub)}$	4.0	—	—	pF

SWITCHING CHARACTERISTICS

Turn-On Delay	$(V_{DD} = -10 \text{ Vdc}$, $I_{D(on)} = -2.0 \text{ mAdc}$, $V_{GS(on)} = -10 \text{ Vdc}$, $V_{GS(off)} = 0$)	t_d	—	—	45	μs
Rise Time		t_r	—	—	65	ns
Turn-Off Delay		t_s	—	—	60	ns
Fall Time		t_f	—	—	100	ns

3N157 3N158

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

**MOSFET
AMPLIFIER AND SWITCHING**

P-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage*	V _{DS}	±35	Vdc
Drain-Gate Voltage*	V _{DG}	±50	Vdc
Gate-Source Voltage*	V _{GS}	±50	Vdc
Drain Current*	I _D	30	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C*	P _D	300 1.7	mW mW/°C
Junction Temperature Range*	T _J	-65 to +175	°C
Storage Channel Temperature Range*	T _{stg}	-65 to +175	°C

*JEDEC Registered Limits

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I _D = -10 μAdc, V _G = V _S = 0)	V(BR)DSX	-35	—	—	Vdc
Zero-Gate-Voltage Drain Current (V _{DS} = -15 Vdc, V _{GS} = 0) (V _{DS} = -35 Vdc, V _{GS} = 0)	I _{DSS}	—	—	-1.0 -10	nAdc μAdc
Gate Reverse Current* (V _{GS} = +25 Vdc, V _{DS} = 0) (V _{GS} = +50 Vdc, V _{DS} = 0)	I _{GSS}	—	—	+10 +10	pAdc nAdc
Input Resistance (V _{GS} = -25 Vdc)	R _{GS}	—	1 x 10 ⁺¹²	—	Ohms
Gate Source Voltage* (V _{DS} = -15 Vdc, I _D = -0.5 mAdc)	V _{GS}	-1.5 -3.0	—	-5.5 -7.0	Vdc
Gate Forward Current* (V _{GS} = -25 Vdc, V _{DS} = 0) (V _{GS} = -50 Vdc, V _{DS} = 0) (V _{GS} = -25 Vdc, V _{DS} = 0, T _A = +55°C) (V _{GS} = -50 Vdc, V _{DS} = 0, T _A = +55°C)	I _{G(f)}	—	—	-10 -1.0 -10 -1.0	pAdc nAdc nAdc μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage* (V _{DS} = -15 Vdc, I _D = -10 μAdc)	V _{GS(Th)}	-1.5 -3.0	—	-3.2 -5.0	Vdc
On-State Drain Current* (V _{DS} = -15 Vdc, V _{GS} = -10 Vdc)	I _{D(on)}	-5.0	—	—	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance* (V _{DS} = -15 Vdc, I _D = -2.0 mAdc, f = 1.0 kHz)	y _{fs}	1000	—	4000	μmhos
Output Admittance* (V _{DS} = -15 Vdc, I _D = -2.0 mAdc, f = 1.0 kHz)	y _{os}	—	—	60	μmhos
Input Capacitance* (V _{DS} = -15 Vdc, V _{GS} = 0, f = 140 kHz)	C _{iss}	—	—	5.0	pF
Reverse Transfer Capacitance* (V _{DS} = -15 Vdc, V _{GS} = 0, f = 140 kHz)	C _{rss}	—	—	1.3	pF
Drain-Substrate Capacitance (V _{D(SUB)} = -10 Vdc, f = 140 kHz)	C _{d(sub)}	—	—	4.0	pF
Noise Voltage (R _S = 0, BW = 1.0 Hz, V _{DS} = -15 Vdc, I _D = -2.0 mAdc, f = 100 Hz) (R _S = 0, BW = 1.0 Hz, V _{DS} = -15 Vdc, I _D = -2.0 mAdc, f = 1.0 kHz)	e _n	—	300 120	— 500	NV/√Hz

*JEDEC Registered Limits

FIGURE 1 – FORWARD TRANSCONDUCTANCE

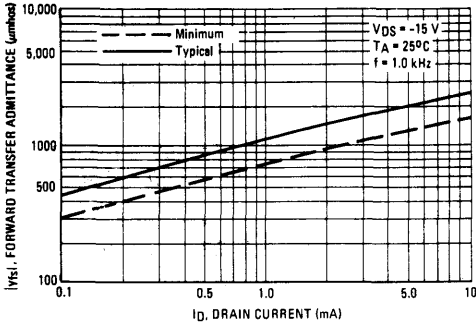


FIGURE 2 – OUTPUT TRANSCONDUCTANCE

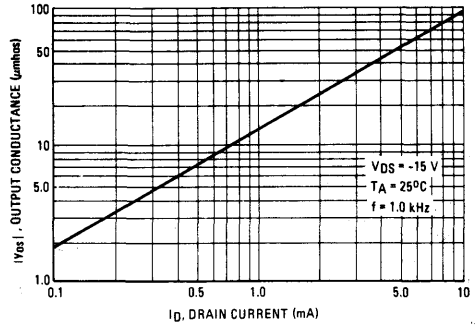


FIGURE 3 – FORWARD TRANSCONDUCTANCE versus TEMPERATURE

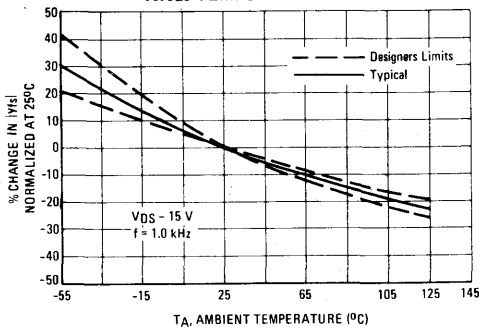


FIGURE 4 – BIAS CURVE

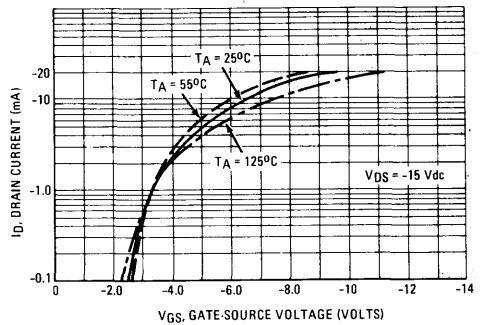


FIGURE 5 – "ON" DRAIN-SOURCE VOLTAGE

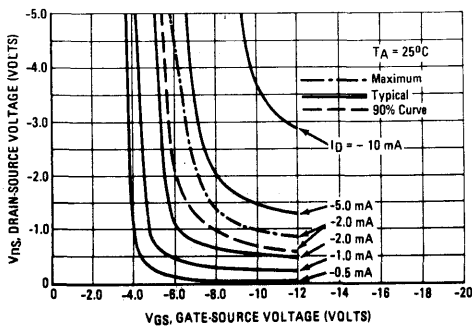
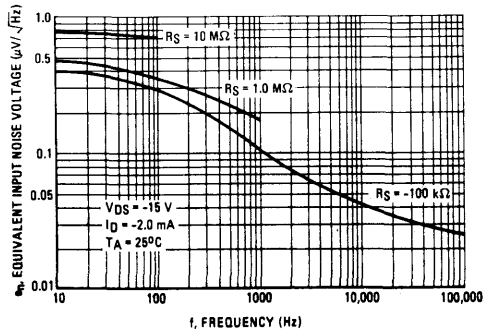


FIGURE 6 – EQUIVALENT INPUT NOISE VOLTAGE



6

SWITCHING CHARACTERISTICS

($T_A = 25^\circ\text{C}$)

FIGURE 7 – TURN-ON DELAY TIME

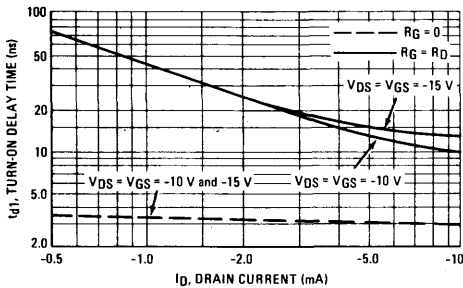


FIGURE 8 – RISE TIME

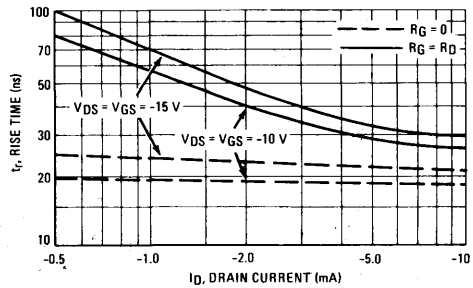


FIGURE 9 – TURN-OFF DELAY TIME

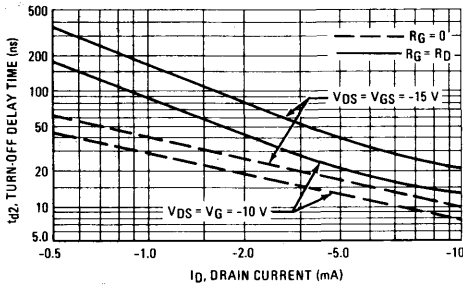


FIGURE 10 – FALL TIME

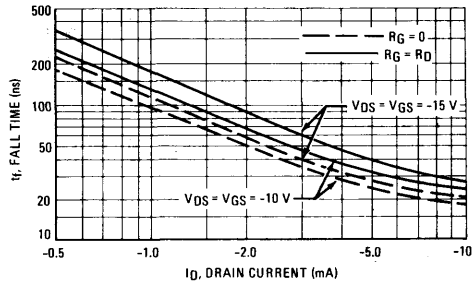


FIGURE 11 – SWITCHING CIRCUIT and WAVEFORMS

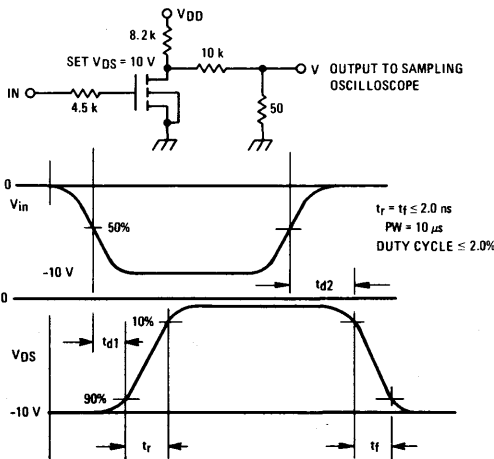
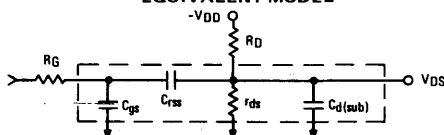


FIGURE 12 – SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



The switching characteristics shown above were measured in a test circuit similar to Figure 11. At the beginning of the switching interval, the gate voltage is at ground and the gate source capacitance ($C_{GS} \cdot C_{RSS} \cdot C_{RSS}$) has no charge. The drain voltage is at V_{DD} and thus the feedback capacitance (C_{RSS}) is charged to V_{DD} . Similarly, the drain substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

During the turn-on interval C_{GS} is charged to V_{GS} (the input voltage) through R_G (generator impedance) (Figure 12). C_{RSS} must be discharged to $V_{GS} \cdot V_{D(on)}$ through R_G and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds} . During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate source voltage (V_{GS}). As C_{GS} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 5) and since C_{RSS} and $C_{d(sub)}$ are charged through r_{ds} , turn-on time is quite non-linear.

If the charging time of C_{GS} is short compared to that of C_{RSS} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{RSS} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_G = 0$ and C_{GS} is charged through the pulse generator impedance only.

The switching curves shown with $R_G = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_G = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

**3N169
3N170
3N171**

**CASE 20-03, STYLE 2
TO-72 (TO-206AF)**

**MOSFET
SWITCHING**

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	25	Vdc
Drain-Gate Voltage	V _{DG}	± 35	Vdc
Gate-Source Voltage	V _{GS}	± 35	Vdc
Drain Current	I _D	30	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	300 1.7	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	800 4.56	mW mW/°C
Junction Temperature Range	T _J	175	°C
Storage Temperature Range	T _{stg}	- 65 to + 175	°C

Refer to 2N4351 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage (I _D = 10 μAdc, V _{GS} = 0)	V _{(BR)DSX}	25	—	Vdc
Zero-Gate-Voltage Drain Current (V _{DS} = 10 Vdc, V _{GS} = 0) (V _{DS} = 10 Vdc, V _{GS} = 0, T _A = 125°C)	I _{DSS}	—	10 1.0	nAdc μAdc
Gate Reverse Current (V _{GS} = - 35 Vdc, V _{DS} = 0) (V _{GS} = - 35 Vdc, V _{DS} = 0, T _A = 125°C)	I _{GSS}	—	10 100	pAdc

ON CHARACTERISTICS

Gate Threshold Voltage (V _{DS} = 10 Vdc, I _D = 10 μAdc)	V _{GS(Th)}	0.5 1.0 1.5	1.5 2.0 3.0	Vdc
Drain-Source On-Voltage (I _D = 10 mAdc, V _{GS} = 10 Vdc)	V _{DS(on)}	—	2.0	Vdc
On-State Drain Current (V _{GS} = 10 Vdc, V _{DS} = 10 Vdc)	I _{D(on)}	10	—	mAdc

SMALL-SIGNAL CHARACTERISTICS

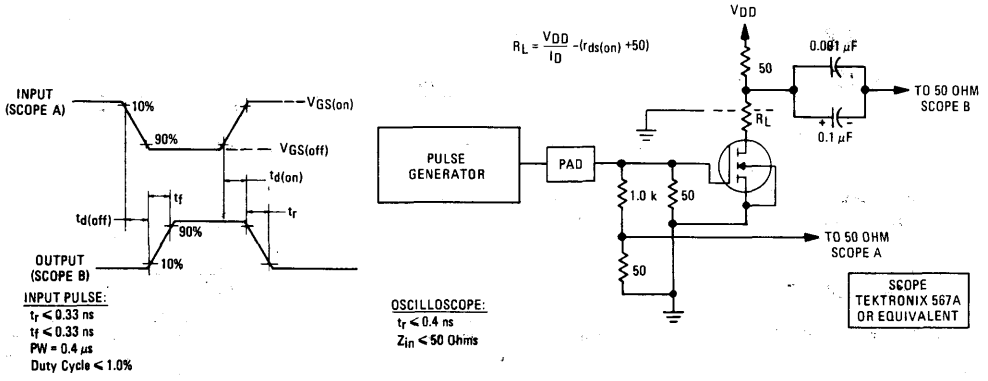
Drain-Source Resistance (V _{GS} = 10 Vdc, I _D = 0, f = 1.0 kHz)	r _{ds(on)}	—	200	Ohms
Forward Transfer Admittance (V _{DS} = 10 Vdc, I _D = 2.0 mAdc, f = 1.0 kHz)	y _{fs}	1000	—	μmhos
Input Capacitance (V _{DS} = 10 Vdc, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	—	5.0	pF
Reverse Transfer Capacitance (V _{DS} = 0, V _{GS} = 0, f = 1.0 MHz)	C _{rss}	—	1.3	pF
Drain-Substrate Capacitance (V _{D(SUB)} = 10 Vdc, f = 1.0 MHz)	C _{d(sub)}	—	5.0	pF

SWITCHING CHARACTERISTICS

Turn-On Delay Time	(V _{DD} = 10 Vdc, I _{D(on)} = 10 mAdc, V _{GS(on)} = 10 Vdc, V _{GS(off)} = 0, R _G = 50 Ohms) See Figure 1	t _{d(on)}	—	3.0	ns
Rise Time		t _r	—	10	ns
Turn-Off Delay Time		t _{d(off)}	—	3.0	ns
Fall Time		t _f	—	15	ns

3N169, 3N170, 3N171

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



3N201 3N202 3N203

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30	Vdc
Drain Current	I_D	50	mAdc
Gate Current	I_{G1} I_{G2}	± 10 ± 10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.4	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 8.0	Watt mW/ $^\circ\text{C}$
Lead Temperature	T_L	300	$^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +175	$^\circ\text{C}$
Storage Channel Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

Refer to MPF201 for additional graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage ($I_D = 10 \mu\text{Adc}$, $V_S = 0$, $V_{G1S} = V_{G2S} = -5.0 \text{ Vdc}$)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage(1) ($I_{G1} = \pm 10 \text{ mAdc}$, $V_{G2S} = V_{DS} = 0$)	$V_{(BR)G1SO}$	± 6.0	± 12	± 30	Vdc
Gate 2-Source Breakdown Voltage(1) ($I_{G2} = \pm 10 \text{ mAdc}$, $V_{G1S} = V_{DS} = 0$)	$V_{(BR)G2SO}$	± 6.0	± 12	± 30	Vdc
Gate 1 Leakage Current ($V_{G1S} = \pm 5.0 \text{ Vdc}$, $V_{G2S} = V_{DS} = 0$) ($V_{G1S} = -5.0 \text{ Vdc}$, $V_{G2S} = V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{G1SS}	—	$\pm .040$	± 10	nAdc μAdc
Gate 2 Leakage Current ($V_{G2S} = \pm 5.0 \text{ Vdc}$, $V_{G1S} = V_{DS} = 0$) ($V_{G2S} = -5.0 \text{ Vdc}$, $V_{G1S} = V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{G2SS}	—	$\pm .050$	± 10	nAdc μAdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 20 \mu\text{Adc}$)	$V_{G1S(off)}$	-0.5	-1.5	-5.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{G1S} = 0$, $I_D = 20 \mu\text{Adc}$)	$V_{G2S(off)}$	-0.2	-1.4	-5.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(2) ($V_{DS} = 15 \text{ Vdc}$, $V_{G1S} = 0$, $V_{G2S} = 4.0 \text{ Vdc}$)	I_{DSS}	6.0 3.0	13 11	30 15	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance(3) ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $V_{G1S} = 0$, $f = 1.0 \text{ kHz}$)	$ Y_{fs} $	8.0 7.0	12.8 12.5	20 15	mmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = I_{DSS}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	3.3	—	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 10 \text{ mAdc}$, $f = 1.0 \text{ MHz}$)	C_{rss}	0.005	0.014	0.03	pF
Output Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = I_{DSS}$, $f = 1.0 \text{ MHz}$)	C_{oss}	—	1.7	—	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DD} = 18 \text{ Vdc}$, $V_{GG} = 7.0 \text{ Vdc}$, $f = 200 \text{ MHz}$) (Figure 1)	NF	—	1.8	4.5	dB
($V_{DD} = 18 \text{ Vdc}$, $V_{GG} = 6.0 \text{ Vdc}$, $f = 45 \text{ MHz}$) (Figure 3)		—	5.3	6.0	

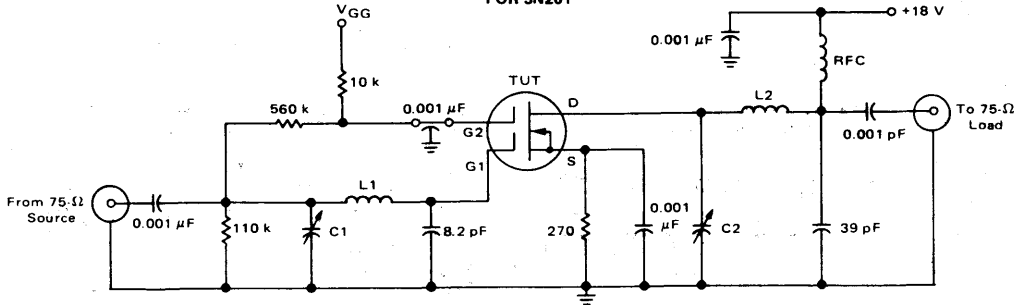
3N201, 3N202, 3N203

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Common Source Power Gain ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 7.0\text{ Vdc}$, $f = 200\text{ MHz}$) (Figure 1) ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$) (Figure 3) ($V_{DD} = 18\text{ Vdc}$, $f_{LO} = 245\text{ MHz}$, $f_{RF} = 200\text{ MHz}$) (Figure 2)	G_{ps} 3N201 3N203 $G_c(5)$	15 20 15	20 25 19	25 30 25	dB
Bandwidth ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 7.0\text{ Vdc}$, $f = 200\text{ MHz}$) (Figure 1) ($V_{DD} = 18\text{ Vdc}$, $f_{LO} = 245\text{ MHz}$, $f_{RF} = 200\text{ MHz}$) (Figure 2) ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$) (Figure 3)	BW 3N201 3N202 3N203	5.0 4.5 3.0	— — —	9.0 7.5 6.0	MHz
Gain Control Gate-Supply Voltage(4) ($V_{DD} = 18\text{ Vdc}$, $\Delta G_{ps} = -30\text{ dB}$, $f = 200\text{ MHz}$) (Figure 1) ($V_{DD} = 18\text{ Vdc}$, $\Delta G_{ps} = -30\text{ dB}$, $f = 45\text{ MHz}$) (Figure 3)	$V_{GG}(GC)$ 3N201 3N203	0 0	-1.0 -0.6	-3.0 -3.0	Vdc

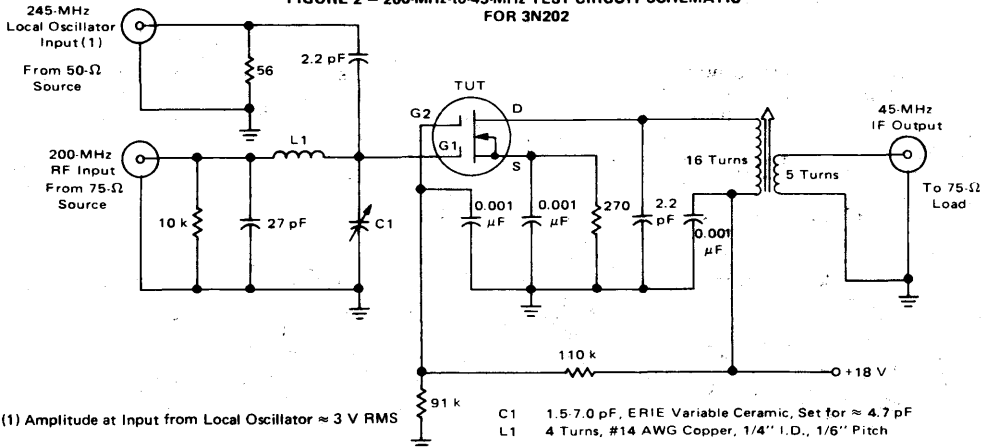
- (1) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage limiting network is functioning properly.
- (2) Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2.0\%$.
- (3) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.
- (4) ΔG_{ps} is defined as the change in G_{ps} from the value at $V_{GG} = 7.0$ volts (3N201) and $V_{GG} = 6.0$ volts (3N203).
- (5) Power Gain Conversion

FIGURE 1 - 200-MHz TEST CIRCUIT SCHEMATIC FOR 3N201



- C1 4.0-30 pF, ERIE Variable Ceramic, Set for $\approx 22\text{ pF}$
- C2 4.0-30 pF, ERIE Variable Ceramic, Set for $\approx 10\text{ pF}$
- L1 4 Turns, #14 AWG Cooper, 1/4" I.D., 1/6" Pitch
- L2 3 Turns, #14 AWG Cooper, 1/4" I.D., 1/8" Pitch
- RFC DELEVAN No. 153712, 1.0 μH

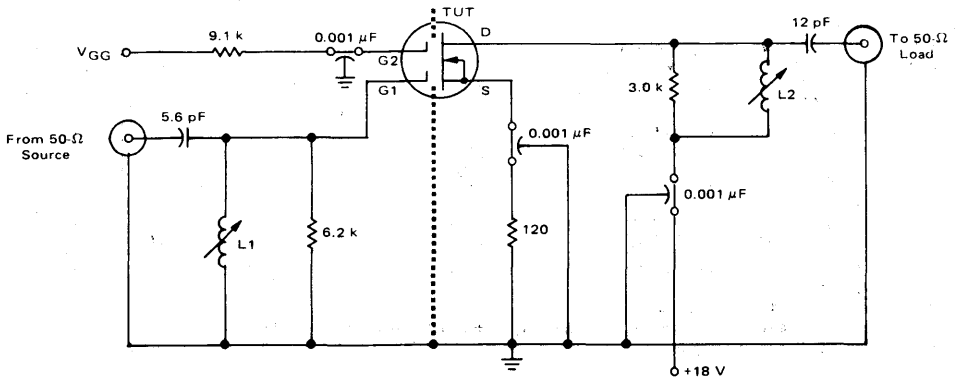
FIGURE 2 - 200-MHz-to-45-MHz TEST CIRCUIT SCHEMATIC FOR 3N202



- (1) Amplitude at Input from Local Oscillator $\approx 3\text{ V RMS}$
- C1 1.5-7.0 pF, ERIE Variable Ceramic, Set for $\approx 4.7\text{ pF}$
- L1 4 Turns, #14 AWG Copper, 1/4" I.D., 1/6" Pitch

6

FIGURE 3 - 45-MHz TEST CIRCUIT SCHEMATIC
3N203



- L1 14 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core
- L2 10 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core

TYPICAL CHARACTERISTICS

FIGURE 4 - DRAIN CURRENT versus DRAIN TO SOURCE VOLTAGE

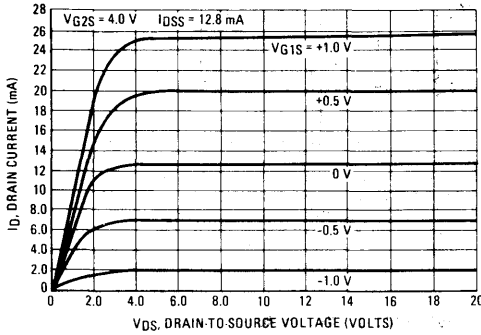


FIGURE 5 - DRAIN CURRENT versus GATE-ONE to SOURCE VOLTAGE

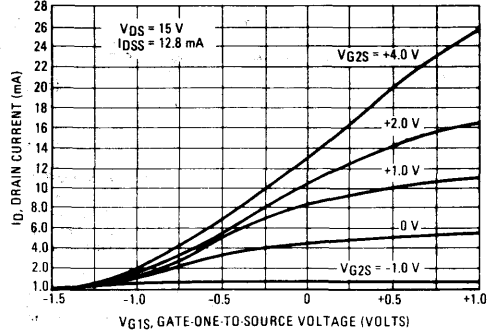


FIGURE 6 - SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

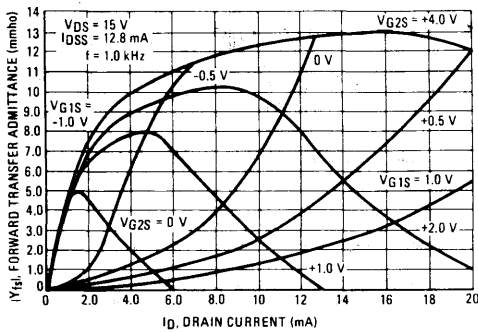


FIGURE 7 - SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-ONE to SOURCE VOLTAGE

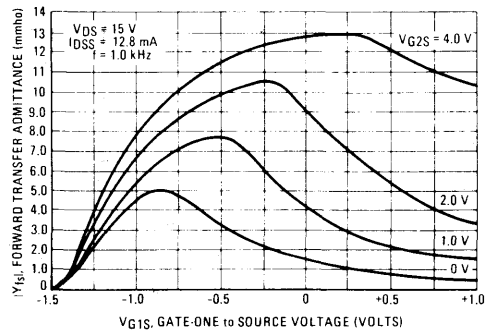


FIGURE 8 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-TWO to SOURCE VOLTAGE

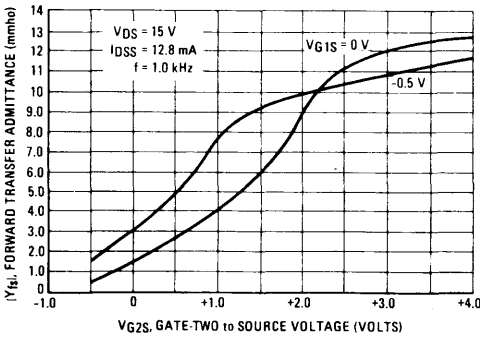
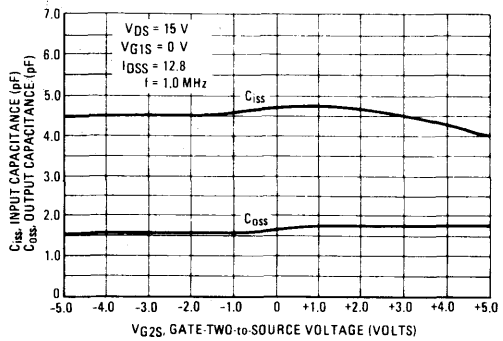


FIGURE 9 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE INPUT AND OUTPUT CAPACITANCE versus GATE-TWO to SOURCE VOLTAGE



TYPICAL CHARACTERISTICS

FIGURE 10 – COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus DRAIN CURRENT

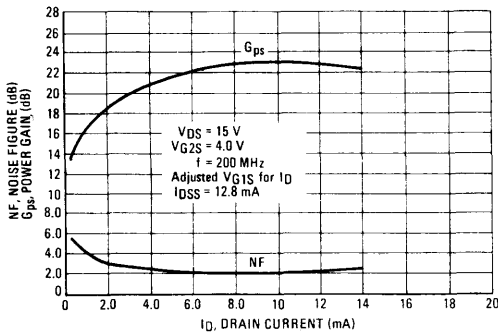


FIGURE 11 – COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus GAIN CONTROL GATE-SUPPLY VOLTAGE – 3N201

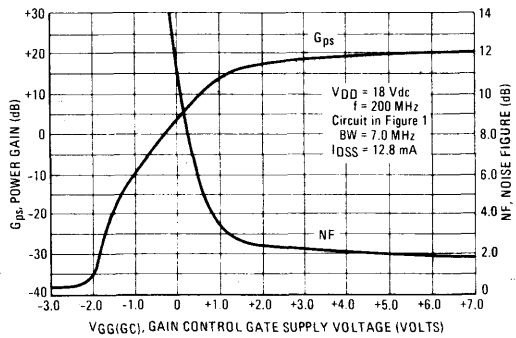


FIGURE 12 – COMMON-SOURCE POWER GAIN versus DRAIN SUPPLY CURRENT – 3N201

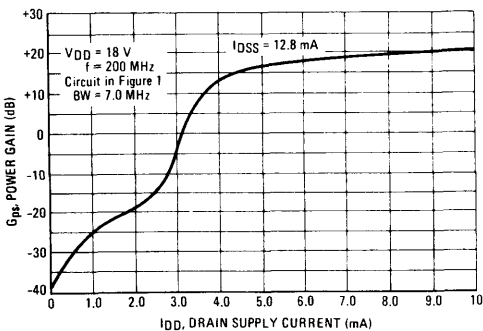
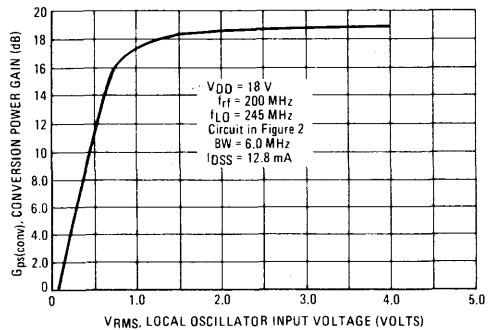
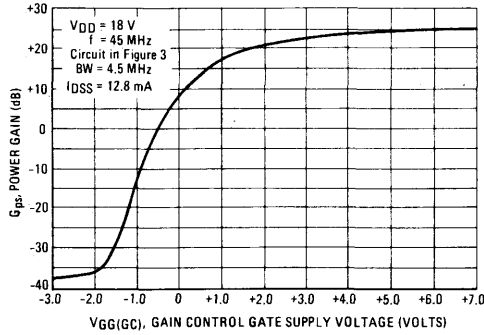


FIGURE 13 – SMALL-SIGNAL COMMON-SOURCE CONVERSION POWER GAIN versus LOCAL OSCILLATOR INPUT VOLTAGE – 3N202

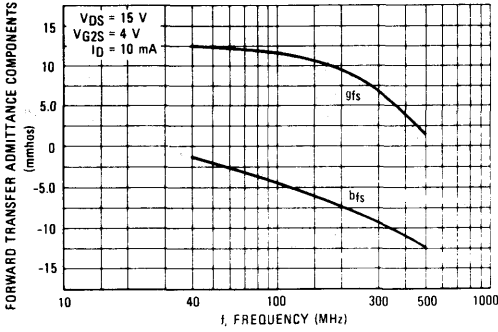


**FIGURE 14 – SMALL-SIGNAL COMMON SOURCE
INSERTION POWER GAIN versus GAIN CONTROL
GATE-SUPPLY VOLTAGE – 3N203**

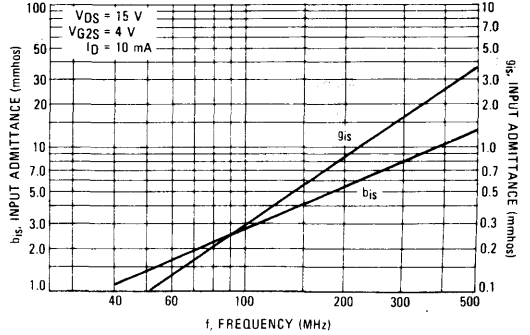


TYPICAL CHARACTERISTICS

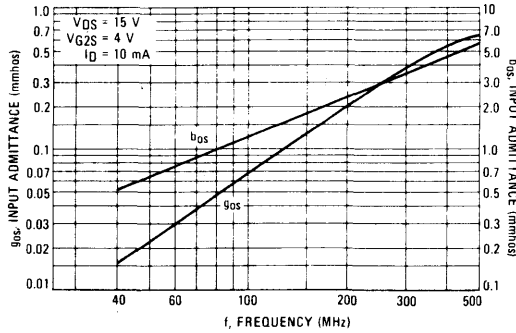
**FIGURE 15 – SMALL-SIGNAL GATE ONE FORWARD
TRANSFER ADMITTANCE versus FREQUENCY**



**FIGURE 16 – SMALL-SIGNAL GATE ONE INPUT
ADMITTANCE versus FREQUENCY**



**FIGURE 17 – SMALL-SIGNAL GATE ONE OUTPUT
ADMITTANCE versus FREQUENCY**



3N204 3N205

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL GATE
MOS-FET

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Drain Current	I_D	50	mA
Reverse Gate Current	I_G	-10	mA
Forward Gate Current	I_{GF}	10	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.4	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 0.8	mW mW/ $^\circ\text{C}$
Lead Temperature	T_L	300	$^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 $^\circ\text{C}$ to +175 $^\circ\text{C}$	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = 10 \mu\text{A}, V_{G1} = V_{G2} = -5.0 \text{ V}$)	$V_{(BR)DSX}$	25	—	Vdc
Gate 1-Source Breakdown Voltage ($I_{G1} = \pm 10 \text{ mA}$) Note 1	$V_{(BR)G1SO}$	± 6	± 30	Vdc
Gate 2-Source Breakdown Voltage ($I_{G2} = \pm 10 \text{ mA}$) Note 1	$V_{(BR)G2SO}$	± 6	± 30	Vdc
Gate 1 Leakage Current ($V_{G1S} = \pm 5.0 \text{ V}, V_{G2S} = V_{DS} = 0$)	I_{G1SS}	—	± 10	nA
Gate 2 Leakage Current ($V_{G2S} = \pm 5.0 \text{ V}, V_{G1S} = V_{DS} = 0$)	I_{G2SS}	—	± 10	nA
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15 \text{ V}, V_{G2S} = 4.0 \text{ V}, I_D = 20 \mu\text{A}$)	$V_{G1S(off)}$	-0.5	-4.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15 \text{ V}, V_{G1S} = 0 \text{ V}, I_D = 20 \mu\text{A}$)	$V_{G2S(off)}$	-0.2	-4.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current* ($V_{DS} = 15 \text{ V}, V_{G2S} = 4.0 \text{ V}, V_{G1S} = 0 \text{ V}$)	I_{DSS}^*	6	30	mA
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ V}, V_{G2S} = 4.0 \text{ V}, V_{G1S} = 0 \text{ V}, f = 1.0 \text{ kHz}$) Note 2	$ Y_{fs} $	10	22	mmhos
Input Capacitance ($V_{DS} = 15 \text{ V}, V_{G2S} = 4.0 \text{ V}, I_D = I_{DSS}, f = 1.0 \text{ MHz}$)	C_{iss}	Typ. 3.0		pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ V}, V_{G2S} = 4.0 \text{ V}, I_D = 10 \text{ mA}, f = 1.0 \text{ MHz}$)	C_{rss}	0.005	0.03	pF
Output Capacitance ($V_{DS} = 15 \text{ V}, V_{G2S} = 4.0 \text{ V}, I_D = I_{DSS}, f = 1.0 \text{ MHz}$)	C_{oss}	Typ. 1.4		pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DD} = 18 \text{ V}, V_{GG} = 7.0 \text{ V}, f = 200 \text{ MHz}$) ($V_{DS} = 15 \text{ V}, V_{G2S} = 4.0 \text{ V}, I_D = 10 \text{ mA}, f = 450 \text{ MHz}$)	NF	— —	3.5 5.0	dB
Common Source Power Gain ($V_{DD} = 18 \text{ V}, V_{GG} = 7.0 \text{ V}, f = 200 \text{ MHz}$) ($V_{DS} = 15 \text{ V}, V_{G2S} = 4.0 \text{ V}, I_D = 10 \text{ mA}, f = 450 \text{ MHz}$)	G_{ps}	20 14	28 —	dB

3N204, 3N205

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Bandwidth ($V_{DD} = 18\text{ V}$, $V_{GG} = 7.0\text{ V}$, $f = 200\text{ MHz}$) ($V_{DD} = 18\text{ V}$, $f_{LO} = 245\text{ MHz}$, $f_{RF} = 200\text{ MHz}$) (Note 4)	3N3204	BW	7.0	12	MHz
	3N205		4.0	7.0	
Gain Control Gate-Supply Voltage (Note 3) ($V_{DD} = 18\text{ V}$, $\Delta G_{PS} = 300\text{ dB}$, $f = 200\text{ MHz}$)	3N204	$V_{GG}(GC)$	0	-2.0	Vdc
Conversion Gain (Note 4) ($V_{DD} = 18\text{ V}$, $f_{LO} = 245\text{ MHz}$, $f_{RF} = 200\text{ MHz}$)	3N205	$G(\text{conv.})$	17	28	dB

*PW = 30 μsec , Duty Cycle $\leq 2.0\%$.

(1) All gate breakdown voltages are measured while the device is conducting rated gate current. This insures that the gate voltage limiting network is functioning properly.

(2) This parameter must be measured with bias voltages applied for less than five (5) seconds to avoid overheating.

(3) ΔG_{ps} is defined as the change in G_{ps} from the value at $V_{GG} = 7.0\text{ V}$.

(4) Amplitude at input from local oscillator is 3 volts RMS.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	25		Vdc
Drain-Gate Voltage	V_{DG1}	30		Vdc
	V_{DG2}	30		
Drain Current	I_D	30		mAdc
Gate Current	I_{G1R}	-10		mAdc
	I_{G1F}	10		
	I_{G2R}	-10		
	I_{G2F}	10		
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	3N209	MPF209	mW mW/°C
		300	—	
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300		mW mW/°C
		2.4		
Lead Temperature, 1/16" From Seated Surface for 10 seconds	T_L	260	200	°C
Storage Channel Temperature Range	T_{stg}	-65 to +175	-65 to +150	°C
Operating Channel Temperature	$T_{channel}$	175	150	°C

3N209 MPF209

3N209
CASE 20-03, STYLE 9
TO-72 (TO-206AF)

MPF209
CASE 317-01, STYLE 1

DUAL-GATE
MOSFET
UHF COMMUNICATIONS

N-CHANNEL — DEPLETION

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

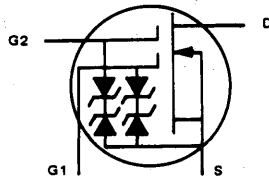
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = 10 \mu\text{Adc}$, $V_{G1S} = -4.0 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1 — Source Forward Breakdown Voltage ($I_{G1} = 10 \text{ mAdc}$, $V_{G2S} = V_{DS} = 0$)	$V_{(BR)G1SSF}$	7.0	—	22	Vdc
Gate 1 — Source Reverse Breakdown Voltage ($I_{G1} = -10 \text{ mAdc}$, $V_{G2S} = V_{DS} = 0$)	$V_{(BR)G1SSR}$	-7.0	—	-22	Vdc
Gate 2 — Source Forward Breakdown Voltage ($I_{G2} = 10 \text{ mAdc}$, $V_{G1S} = V_{DS} = 0$)	$V_{(BR)G2SSF}$	7.0	—	22	Vdc
Gate 2 — Source Reverse Breakdown Voltage ($I_{G2} = -10 \text{ mAdc}$, $V_{G1S} = V_{DS} = 0$)	$V_{(BR)G2SSR}$	-7.0	—	-22	Vdc
Gate 1 — Terminal Forward Current ($V_{G1S} = 6.0 \text{ Vdc}$, $V_{G2S} = V_{DS} = 0$)	I_{G1SSF}	—	—	20	nAdc
Gate 1 — Terminal Reverse Current ($V_{G1S} = -6.0 \text{ Vdc}$, $V_{G2S} = V_{DS} = 0$) ($V_{G1S} = -6.0 \text{ Vdc}$, $V_{G2S} = V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{G1SSR}	—	—	-20	nAdc
		—	—	-10	μAdc
Gate 2 — Terminal Forward Current ($V_{G2S} = 6.0 \text{ Vdc}$, $V_{G1S} = V_{DS} = 0$)	I_{G2SSF}	—	—	20	nAdc
Gate 2 — Terminal Reverse Current ($V_{G2S} = -6.0 \text{ Vdc}$, $V_{G1S} = V_{DS} = 0$) ($V_{G2S} = -6.0 \text{ Vdc}$, $V_{G1S} = V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{G2SSR}	—	—	-20	nAdc
		—	—	-10	μAdc
ON CHARACTERISTICS					
Gate 1 — Zero Voltage Drain Current ($V_{DS} = 15 \text{ Vdc}$, $V_{G1S} = 0$, $V_{G2S} = 4.0 \text{ Vdc}$)	I_{DSS}	5.0	—	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 10 \text{ mAdc}$, $f = 1.0 \text{ kHz}$)	Y_{fs}	10	13	20	mmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D \geq 5.0 \text{ mAdc}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	3.3	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D \geq 5.0 \text{ mAdc}$, $f = 1.0 \text{ MHz}$)	C_{rss}	0.005	0.023	0.03	pF
Output Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D \geq 5.0 \text{ mAdc}$, $f = 1.0 \text{ MHz}$)	C_{oss}	0.5	2.0	4.0	pF

3N209, MPF209

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15\text{ Vdc}$, $V_{G2S} = 4.0\text{ Vdc}$, $I_D = 10\text{ mAdc}$, $f = 500\text{ MHz}$)	NF	—	4.0	6.0	dB
Common Source Power Gain (Figure 12) ($V_{DS} = 15\text{ Vdc}$, $V_{G2S} = 4.0\text{ Vdc}$, $I_D = 10\text{ mAdc}$, $f = 500\text{ MHz}$)	G_{ps}	10	13	20	dB
*Bandwidth ($V_{DS} = 15\text{ Vdc}$, $V_{G2S} = 4.0\text{ Vdc}$, $I_D = 10\text{ mAdc}$, $f = 500\text{ MHz}$)	BW	7.0	—	17	MHz

FIGURE 1 – MOS FET CIRCUIT SCHEMATIC



TYPICAL SCATTERING PARAMETERS

FIGURE 2 – S_{11} , INPUT REFLECTION COEFFICIENT
versus FREQUENCY

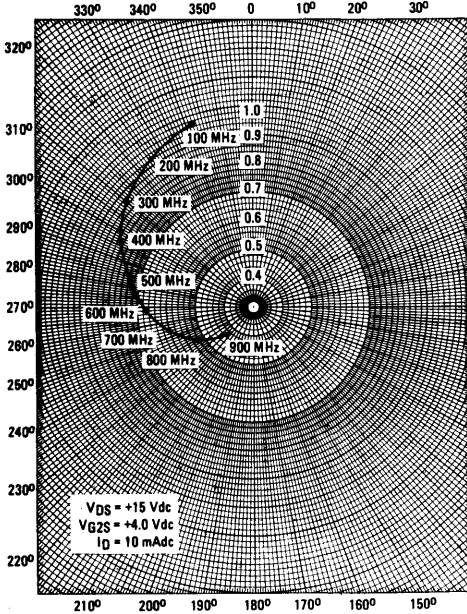


FIGURE 3 – S_{12} , REVERSE TRANSMISSION COEFFICIENT
versus FREQUENCY

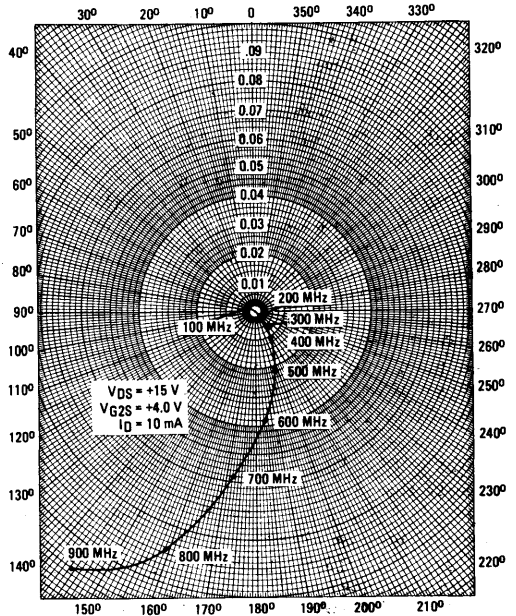


FIGURE 4 - S_{21} , FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

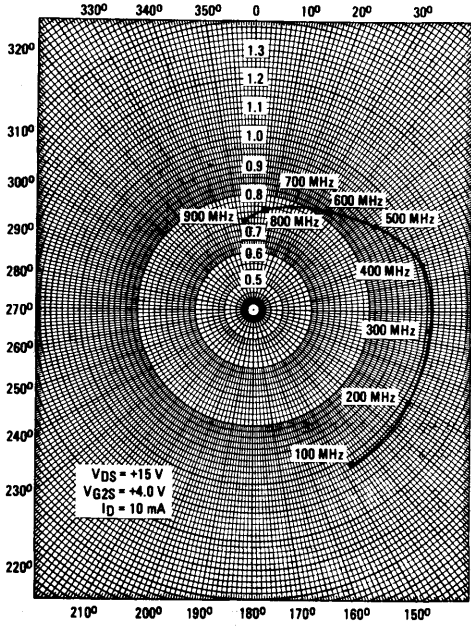
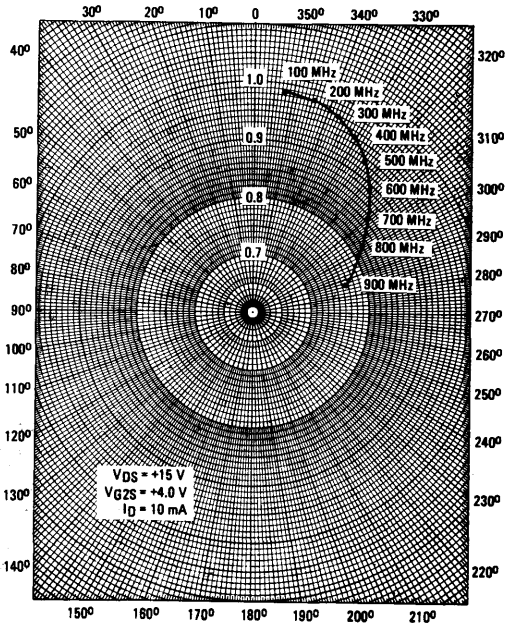


FIGURE 5 - S_{22} , OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



TYPICAL COMMON-SOURCE ADMITTANCE PARAMETERS

($V_{DS} = 15$ Vdc, $V_{GS2} = 4.0$ Vdc, $I_D = 10$ mAdc)

FIGURE 6 - Y_{11} , INPUT ADMITTANCE versus FREQUENCY

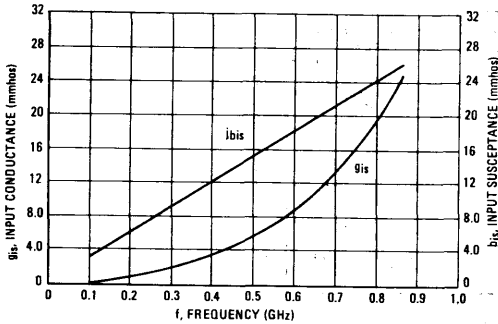


FIGURE 7 - Y_{12} , REVERSE TRANSFER ADMITTANCE versus FREQUENCY

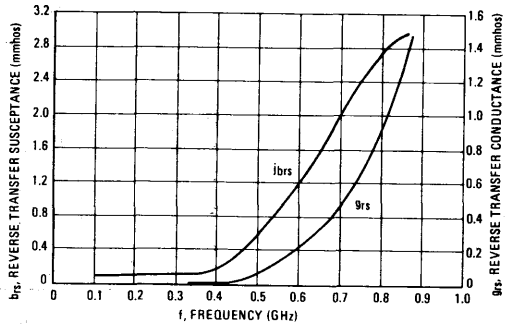


FIGURE 8 - Y_{21} , FORWARD TRANSFER ADMITTANCE versus FREQUENCY

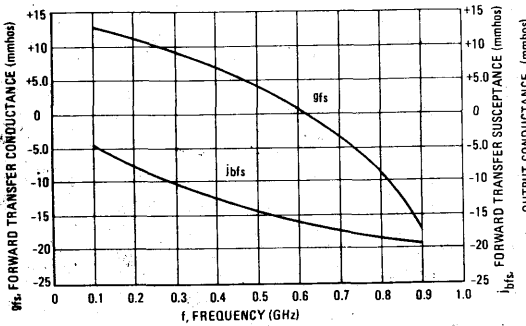


FIGURE 9 - Y_{22} , OUTPUT ADMITTANCE versus FREQUENCY

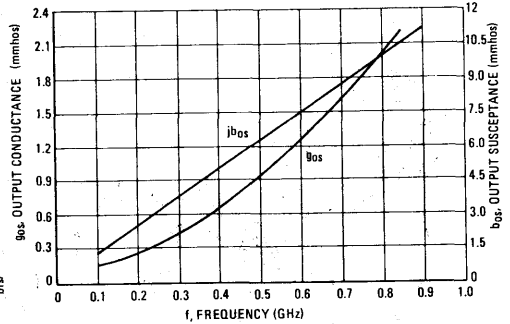
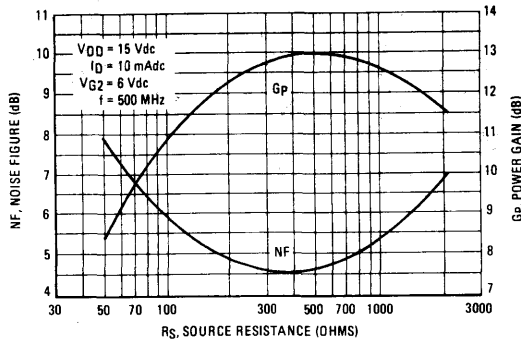


FIGURE 10 - POWER GAIN AND NOISE FIGURE versus SOURCE RESISTANCE (See Schematic Figure 12)



The Test Circuit shown in Figure 12 was used to generate Power Gain and Noise Figure as a function of Source Resistance curves.

FIGURE 11 - THIRD ORDER INTERMODULATION DISTORTION (See Schematic Figure 12)

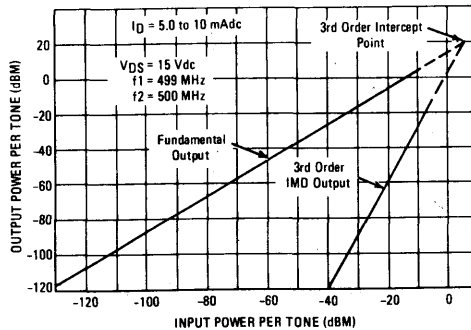
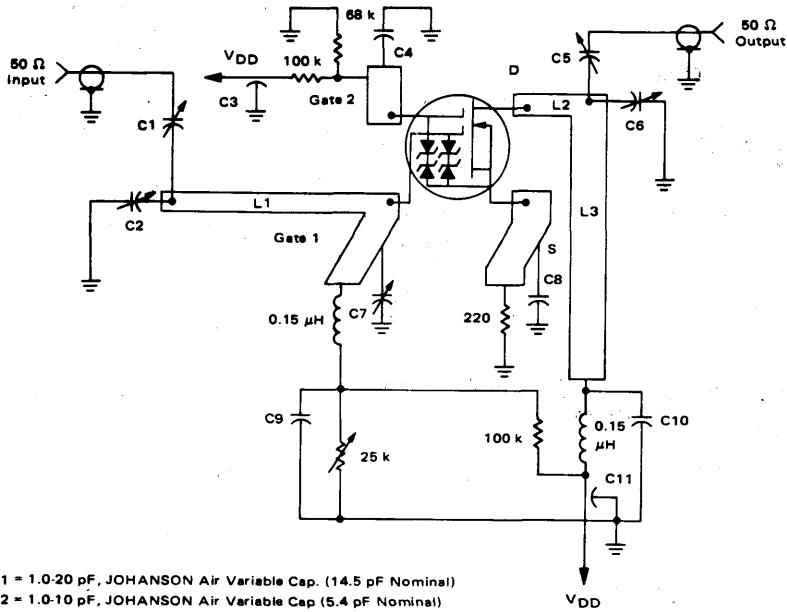


Figure 11 shows the typical third order intermodulation distortion (IMD) performance of the 3N209 and 3N210 at 500 MHz.

Both fundamental output and third order IMD output characteristics are plotted. The curves have been extrapolated to show the third order intermodulation output intercept point.

The performance is typical for I_Q between 5.0 mAdc and 10 mAdc. The test circuit shown in Figure 12 was used to generate the IMD Data.

FIGURE 12 – TEST CIRCUIT FOR POWER GAIN, NOISE FIGURE AND THIRD ORDER INTERMODULATION DISTORTION



- C1 = 1.0-20 pF, JOHANSON Air Variable Cap. (14.5 pF Nominal)
 - C2 = 1.0-10 pF, JOHANSON Air Variable Cap. (5.4 pF Nominal)
 - C3, C11 = 470 pF, Low Inductance Feedthru Cap.
 - C4, C8, C9, C10 = 250 pF, Low Inductance, UNDERWOOD Cap. (J-101)
 - C5 = 0.4-6.0 pF, JOHANSON Air Variable Cap. (0.92 pF Nominal)
 - C6 = 1.0-10 pF, JOHANSON Air Variable Cap. (5.9 pF Nominal)
 - C7 = 1.0-10 pF, JOHANSON Air Variable Cap. (3.0 pF Nominal)
 - L1 = 2.52 x 0.1 inches
 - L2 = 0.4 x 0.1 inches
 - L3 = 1.23 x 0.2 inches
- } On 2 sided glass Teflon, 1 oz. copper clad, 1/16"
 $\epsilon_R = 2.55$

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**3N211
3N212
3N213**

**CASE 20-03, STYLE 9
TO-72 (TO-206AF)**

**DUAL-GATE
MOSFET
VHF AMPLIFIER**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	3N211 3N212	3N213	Unit
Drain-Source Voltage	V_{DS}	27	35	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	35 35	40 40	Vdc
Drain Current	I_D	50		mAdc
Gate Current	I_{G1} I_{G2}	± 10 ± 10		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360	2.4	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2	8.0	Watt mW/ $^\circ\text{C}$
Lead Temperature, 1/16" From Seated Surface for 10 seconds	T_L	300		$^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +175		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175		$^\circ\text{C}$

Refer to MPF211 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = 10 \mu\text{Adc}$, $V_{G1S} = V_{G2S} = -4.0 \text{ Vdc}$)	3N211,212 3N213 $V_{(BR)DSX}$	25 30	—	Vdc
Instantaneous Drain-Source Breakdown Voltage(1) ($I_D = 10 \mu\text{Adc}$, $V_{G1S} = V_{G2S} = -4.0 \text{ Vdc}$)	3N211,212 3N213 $V_{(BR)DSX}$	27 35	—	Vdc
Gate 1-Source Breakdown Voltage(2) ($I_{G1} = \pm 10 \text{ mAdc}$, $V_{G2S} = V_{DS} = 0$)	$V_{(BR)G1SO}$	± 6.0	—	Vdc
Gate 2-Source Breakdown Voltage(2) ($I_{G2} = \pm 10 \text{ mAdc}$, $V_{G1S} = V_{DS} = 0$)	$V_{(BR)G2SO}$	± 6.0	—	Vdc
Gate 1 Leakage Current ($V_{G1S} = \pm 5.0 \text{ Vdc}$, $V_{G2S} = V_{DS} = 0$) ($V_{G1S} = -5.0 \text{ Vdc}$, $V_{G2S} = V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{G1SS}	—	± 10 -10	nAdc μAdc
Gate 2 Leakage Current ($V_{G2S} = \pm 5.0 \text{ Vdc}$, $V_{G1S} = V_{DS} = 0$) ($V_{G2S} = -5.0 \text{ Vdc}$, $V_{G1S} = V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{G2SS}	—	± 10 -10	nAdc μAdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 20 \mu\text{Adc}$)	3N211,213 3N212 $V_{G1S(off)}$	-0.5 -0.5	-5.5 -4.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{G1S} = 0$, $I_D = 20 \mu\text{Adc}$)	3N211 3N212,213 $V_{G2S(off)}$	-0.2 -0.2	-2.5 -4.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(3) ($V_{DS} = 15 \text{ Vdc}$, $V_{G1S} = 0$, $V_{G2S} = 4.0 \text{ Vdc}$)	I_{DSS}	6.0	40	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance(4) ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $V_{G1S} = 0$, $f = 1.0 \text{ kHz}$)	3N211,212 3N213 $ Y_{fs} $	17 15	40 35	mmhos
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 10 \text{ mAdc}$, $f = 1.0 \text{ MHz}$)	C_{rss}	0.005	0.05	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DD} = 18 \text{ Vdc}$, $V_{GG} = 7.0 \text{ Vdc}$, $f = 200 \text{ MHz}$) ($V_{DD} = 24 \text{ Vdc}$, $V_{GG} = 6.0 \text{ Vdc}$, $f = 45 \text{ MHz}$)	3N211 3N211,13 NF	—	3.5 4.0	dB

3N211, 3N212, 3N213

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
Common Source Power Gain ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 7.0\text{ Vdc}$, $f = 200\text{ MHz}$) ($V_{DD} = 24\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$) ($V_{DD} = 24\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$) ($V_{DD} = 18\text{ Vdc}$, $f_{LO} = 245\text{ MHz}$, $f_{RF} = 200\text{ MHz}$)	3N211 3N211 3N213 3N212	G_{ps}	24 29 27 21	35 37 35 28	dB
Bandwidth ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 7.0\text{ Vdc}$, $f = 200\text{ MHz}$) ($V_{DD} = 18\text{ Vdc}$, $f_{LO} = 245\text{ MHz}$, $f_{RF} = 200\text{ MHz}$) ($V_{DD} = 24\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$)	3N211 3N212 3N211,213	BW	5.0 4.0 3.5	12 7.0 6.0	MHz
Gain Control Gate-Supply Voltage(5) ($V_{DD} = 18\text{ Vdc}$, $\Delta G_{ps} = -30\text{ dB}$, $f = 200\text{ MHz}$) ($V_{DD} = 24\text{ Vdc}$, $\Delta G_{ps} = -30\text{ dB}$, $f = 45\text{ MHz}$)	3N211 2N211,213	$V_{GG}(GC)$	— —	-2.0 ± 1.0	Vdc

(1) Measured after five seconds of applied voltage.

(2) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage limiting network is functioning properly.

(3) Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2.0\%$.

(4) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating. The signal is applied to gate 1 with gate 2 at ac ground.

(5) ΔG_{ps} is defined as the change in G_{ps} from the value at $V_{GG} = 7.0\text{ Volts}$ (3N211) and $V_{GG} = 6.0\text{ Volts}$ (3N213).

(6) Power Gain Conversion. Amplitude at input from local oscillator is adjusted for maximum G_C .

BC264,A,B,C,D

CASE 29-02, STYLE 23
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL - DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	100	mA dc
Forward Gate Current	$I_{G(f)}$	10	mA dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	PD	360 2.88	mW mW/ $^\circ\text{C}$
Storage Channel Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

Refer to 2N4416 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{A dc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	—	—	Vdc
Gate-Source ($V_{DS} = 15 \text{ Vdc}$)	V_{GS}	0.4 0.2 0.4 0.5 0.6	— — — — —	1.2 1.4 1.5 1.6	Vdc
Gate-Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 10 \text{ nA}$)	$V_{GS(off)}$	0.5	—	8	Vdc
Gate Reverse Current ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	—	10	nA dc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current $V_{DS} = 15 \text{ V}$	I_{DSS}	2.0 2.0 3.5 5.0 7.0		12.0 4.5 6.5 8.0 12.0	mA dc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1 \text{ KHz}$)	(Y_{fs})	2.5 2.5 3.0 3.5 4.0			mmhos
Output Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1 \text{ KHz}$)	(Y_{OS})		40		μmhos
Reverse Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)	$ Y_{rs} $		1.0		mmhos
Input Capacitance ($V_{DS} = 20 \text{ Vdc}$, $-V_{GS} = 1 \text{ Vdc}$)	C_{iss}		3		pF
Reverse Transfer Capacitance ($V_{DS} = 20 \text{ Vdc}$, $-V_{GS} = 1 \text{ Vdc}$, $f = 1 \text{ MHz}$)	C_{rss}		0.7		pF
Output Capacitance ($V_{DS} = 20 \text{ Vds}$, $-V_{GS} = 1 \text{ Vdc}$, $f = 1 \text{ MHz}$)	C_{oss}		0.9		pF
Noise Figure ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $R_G = 1 \text{ k}\Omega$, $f = 100 \text{ MHz}$)	N _F		1.5		db
Cut-off Frequency (2) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	f_{gfs}		700		MHz

- (1) On orders against the BC264 any or all subgroups might be shipped.
(2) The frequency at which f_{gfs} is 0.7 of its value at 1 kHz.

BF244,A,B,C

CASE 29-02, STYLE 22
TO-92 (TO-226AA)

BF245,A,B,C

CASE 29-02, STYLE 23
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER
N-CHANNEL - DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	±30	Vdc
Drain-Gate Voltage	V _{DG}	30	Vdc
Gate-Source Voltage	V _{GS}	30	Vdc
Drain Current	I _D	100	mAdc
Forward Gate Current	I _{G(f)}	10	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	360 2.88	mW mW/°C
Storage Channel Temperature Range	T _{stg}	-65 to +150	°C

Refer to 2N4416 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I _G = 1.0 μAdc, V _{DS} = 0)	V _{(BR)GSS}	30	—	—	V
Gate-Source (V _{DS} = 15 Vdc, I _D = 200 μA)	V _{GS}	0.4 0.4 1.6 3.2	— — — —	7.5 2.2 3.8 7.5	V
Gate-Source Cutoff Voltage (V _{DS} = 15 Vdc, I _D = 10 nA)	V _{GS(off)}	0.5	—	8	V
Gate Reverse Current (V _{GS} = 20 Vdc, V _{DS} = 0)	I _{GSS}	—	—	5	nA
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V _{DS} = 15 Vdc, V _{GS} = 0)	I _{DSS}	2 2 6 12		25 6.5 15 25	mA

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 1 KHz)	Y _{fs}	3.0		6.5	mmhos
Output Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 1 KHz)	Y _{os}		40		μmhos
Forward Transfer Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 200 MHz)	Y _{fs}		5.6		mmhos
Reverse Transfer Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 200 MHz)	Y _{rs}		1.0		mmhos
Input Capacitance (V _{DS} = 20 Vdc, -V _{GS} = 1 Vdc)	C _{iss}		3		pF
Reverse Transfer Capacitance (V _{DS} = 20 Vdc, -V _{GS} = 1 Vdc, f = 1 MHz)	C _{rss}		0.7		pF
Output Capacitance (V _{DS} = 20 Vdc, -V _{GS} = 1 Vdc, f = 1 MHz)	C _{oss}		0.9		pF
Noise Figure (V _{DS} = 15 Vdc, V _{GS} = 0, R _G = 1 KΩ, f = 100 MHz)	N _F		1.5		db
Cut-off Frequency(3) (V _{DS} = 15 Vdc, V _{GS} = 0)	F(Y _{fs})		700		MHz

(1) On orders against the BF245, any or all subgroups might be shipped.

(2) On orders against the BF244, any or all subgroups might be shipped.

(3) The frequency at which g_{fs} is 0.7 of its value at 1 KHz.

BF246,A,B,C

CASE 29-02, STYLE 22
TO-92 (TO-226AA)

BF247,A,B,C

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL - DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	± 25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.88	mW mW/ $^\circ\text{C}$
Storage Channel Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

Refer to MPF4391 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 1 \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	—	V
Gate-Source ($V_{DS} = 15 \text{ V}$, $I_D = 200 \mu\text{A}$)	V_{GS}	0.5 1.5 3 5.5	— — — —	14 4 7 12	V
BF246, BF247 BF246A, BF247A BF246B, BF247B BF246C, BF247C					
Gate-Source Cutoff Voltage ($V_{DS} = 15 \text{ V}$, $I_D = 10 \text{ nA}$)	$V_{GS(off)}$	0.6	—	14.5	V
Gate Cutoff Current ($V_{GS} = 15 \text{ V}$, $V_{DS} = 0$)	I_{GSS}	—	—	5	nA

ON CHARACTERISTICS

Zero-Gate Voltage Drain Current ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$)	I_{DSS}	30 30 60 110		250 80 140 250	mA
BF246, BF247 BF246A, BF247A BF246B, BF247B BF246C, BF247C					

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 1 \text{ kHz}$)	$ Y_{fs} $	8	23		mmhos
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 1 \text{ kHz}$)	C_{rss}		3.3		pF
Input Capacitance ($V_{DS} = 15 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 1 \text{ MHz}$)	C_{in}		6		pF
Output Capacitance ($V_{DS} = 15 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 1 \text{ MHz}$)	C_{out}		5		pF
Cutoff Frequency ($V_{DS} = 15 \text{ V}$, $V_{GS} = 0$)	$F_1(Y_{fs})$		450		MHz

BF256,A,B,C

CASE 29-02, STYLE 23
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL - DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	± 30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.88	mW mW/ $^\circ\text{C}$
Storage Channel Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

Refer to 2N4416 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	—	—	Vdc
Gate-Source Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 200 \mu\text{A}$)	$V_{GS(off)}$	0.5	—	7.5	Vdc
Gate Reverse Current ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	—	5	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current - ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}				mAdc
	BF256(1)	3	—	18	
	BF256A	3	—	7	
	BF256B	6	—	13	
	BF256C	11	—	18	

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1 \text{ kHz}$)	$ Y_{fs} $	4.5	5	—	mmhos
Reverse Transfer Capacitance ($V_{DS} = 20 \text{ Vdc}$, $-V_{GS} = 1 \text{ Vdc}$, $f = 1 \text{ MHz}$)	C_{rss}	—	0.7	—	pF
Output Capacitance ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$, $f = 1 \text{ MHz}$)	C_{oss}	—	1.0	—	pF
Noise Figure ($V_{DS} = 10 \text{ Vdc}$, $R_S = 47\Omega$, $f = 800 \text{ MHz}$)	N_F	—	7.5	—	db
Cut-off Frequency(2) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	f_{gfs}	—	1000	—	MHz
Power Gain ($V_{DS} = 15 \text{ Vdc}$, $R_S = 47\Omega$, $f = 800 \text{ MHz}$)	G_p	—	11	—	dB

(1) On orders against the BF256, any or all subgroups might be shipped.

(2) The frequency at which f_{gfs} is 0.7 of its value at 1 kHz.

BFW10

BFW11

CASE 20-03, STYLE 1
TO-72 (TO-206A)

JFET
VHF/UHF AMPLIFIER

N-CANNEL — DEPLETION

MAXIMUM RATINGS

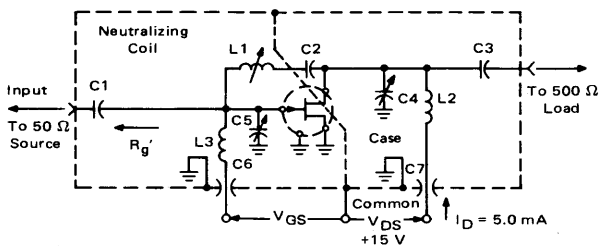
Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	30	Vdc
Drain-Gate Voltage	V _{DG}	30	Vdc
Reverse Gate-Source Voltage	V _{GSR}	-30	Vdc
Forward Gate Current	I _{GF}	10	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +150	°C

Refer to 2N4416 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I _G = 10 μAdc, V _{DS} = 0)	V _{(BR)GSS}	30	—	—	Vdc
Gate-Source Cutoff Voltage (V _{DS} = 15 Vdc, I _D = 0.5 nAdc)	V _{GS(off)}	—	—	8 6	Vdc
Gate Reverse Current (V _{GS} = 20 Vdc, V _{DS} = 0)	I _{GSS}	—	—	0.1	nAdc
Gate-Source Voltage (V _{DS} = 15 Vdc, I _D = 400 μAdc)	V _{GS}	2	—	7.5	Vdc
Gate-Source Voltage (V _{DS} = 15 Vdc, I _D = 50 μAdc)	V _{GS}	1.25	—	4	Vdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V _{DS} = 15 Vdc, V _{GS} = 0)	I _{DSS}	8 4	— —	20 10	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 1 kHz)	Y _{fs}	3.5 3.0	— —	6.5 6.5	mmhos
Output Admittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 1.0 kHz)	Y _{os}	— —	— —	85 50	μmhos
Input Capacitance (V _{DS} = 15 Vdc, V _{GS} = 0 Vdc, f = 1.0 MHz)	C _{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V _{DS} = 15 Vdc, V _{GS} = 0 Vdc, f = 1.0 MHz)	C _{rss}	—	—	0.8	pF
Forward Transadmittance (V _{DS} = 15 Vdc, V _{GS} = 0, f = 200 MHz)	Y _{fs}	3.2	—	—	mmhos
Equivalent Noise Voltage (V _{DS} = 15 Vdc, V _{GS} = 0, f = 25 Hz)	e _n	—	—	75	nV/√Hz
Noise Figure (V _{DS} = 15 Vdc, V _{GS} = 0 V, see Figures 1, 2, 3)	NF	—	—	2.5	dB

FIGURE 1 — 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Adjust V_{GS} for
 $I_D = 50 \text{ mA}$
 $V_{GS} < 0 \text{ Volts}$

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH^*	0.2 μH^{**}
L2	0.15 μH^*	0.03 μH^{**}
L3	0.14 μH^*	0.022 μH^{**}

- *L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.
- L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).
- L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

- **L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.
- L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).
- L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

NOISE FIGURE

($T_{\text{channel}} = 25^\circ\text{C}$)

FIGURE 2 — EFFECTS OF DRAIN-SOURCE VOLTAGE

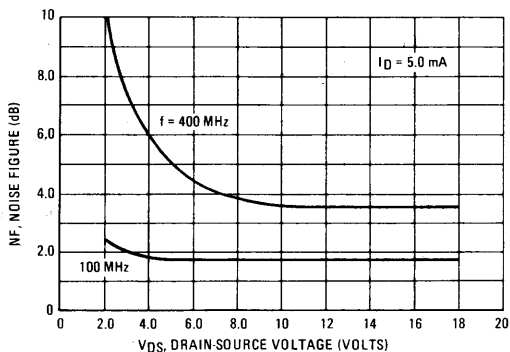
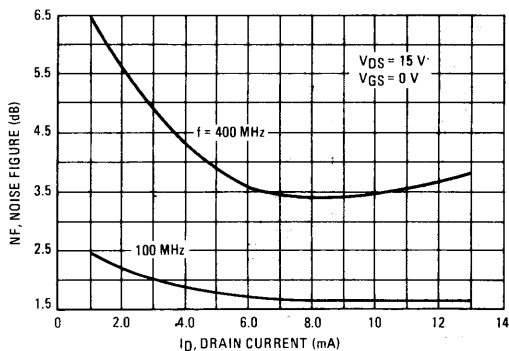


FIGURE 3 — EFFECTS OF DRAIN CURRENT



BS107,A

CASE 29-02, STYLE 30
TO-92 (TO-226AA)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	200	Vdc
Gate-Source Voltage	V_{GS}	± 20	Vdc
Drain Current Continuous(1) Pulsed(2)	I_D I_{DM}	250 500	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to 150	$^\circ\text{C}$

(1) The Power Dissipation of the package may result in a lower continuous drain current.

(2) Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

Refer to MFE9200 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 130 \text{ V}, V_{GS} = 0$)	I_{DSS}	—	—	30	nAdc
Drain-Source Breakdown Voltage ($V_{GS} = 0, I_D = 10 \mu\text{A}$)	$V_{(BR)DSX}$	200	—	—	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}, V_{DS} = 0$)	I_{GSS}	—	0.01	10	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage ($I_D = 1.0 \text{ mA}, V_{DS} = V_{GS}$)	$V_{GS(Th)}$	1.0	—	3.0	Vdc
Static Drain-Source On Resistance BS107 ($V_{GS} = 2.6 \text{ V}, I_D = 20 \text{ mA}$) ($V_{GS} = 10 \text{ V}, I_D = 200 \text{ mA}$) BS107A ($V_{GS} = 10 \text{ Vdc}$) ($I_D = 100 \text{ mA}$) ($I_D = 250 \text{ mA}$)	$r_{DS(on)}$	—	—	28 14 6.0 6.4	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	72	90	pF
Reverse Transfer Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{rss}	—	2.8	3.5	pF
Output Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{oss}	—	15	20	pF
Forward Transconductance ($V_{DS} = 25 \text{ V}, I_D = 250 \text{ mA}$)	g_{fs}	200	400	—	mmhos
SWITCHING CHARACTERISTICS					
Turn-On Time	t_{on}	—	6.0	15	ns
Turn-Off Time	t_{off}	—	12	15	ns

*Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

BS170

CASE 29-02, STYLE 30
TO-92 (TO-226AA)

TMOS FET
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	60	Vdc
Gate-Source Voltage	V _{GS}	±20	Vdc
Drain Current(1)	I _D	0.5	A dc
Total Device Dissipation @ T _C = 25°C	P _D	0.83	Watt
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate Reverse Current (V _{GS} = 15 V, V _{DS} = 0)	I _{GSS}	—	0.01	10	nA dc
Drain-Source Breakdown Voltage (V _{GS} = 0, I _D = 100 μA)	V _{(BR)DSS}	60	90	—	Vdc
ON CHARACTERISTICS(2)					
Gate Threshold Voltage (V _{DS} = V _{GS} , I _D = 1.0 mA)	V _{GS(Th)}	0.8	2.0	3.0	Vdc
Static Drain-Source On Resistance (V _{GS} = 10 V, I _D = 200 mA)	r _{DS(on)}	—	1.8	5.0	Ohms
Drain Cutoff Current (V _{DS} = 25 V, V _{GS} = 0 V)	I _{D(off)}	—	—	0.5	μA
Forward Transconductance (V _{DS} = 10 V, I _D = 250 mA)	g _{fs}	—	200	—	mmhos
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V _{DS} = 10 V, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	—	60	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I _D = 0.2 A) See Figure 1	t _{on}	—	4.0	10	ns
Turn-Off Time (I _D = 0.2 A) See Figure 1	t _{off}	—	4.0	10	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

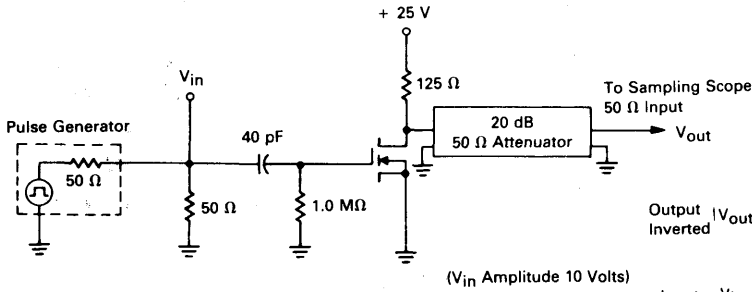


FIGURE 2 — SWITCHING WAVEFORMS

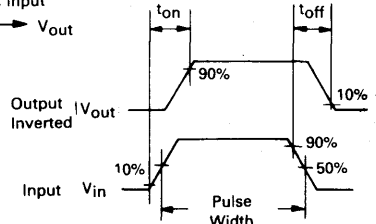


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

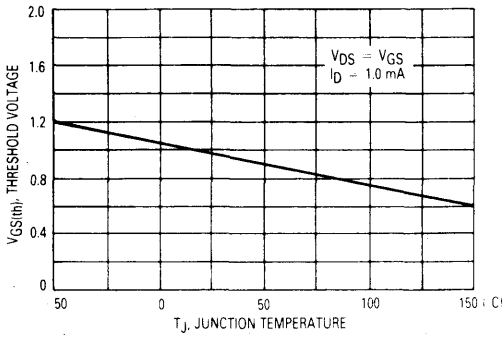


FIGURE 4 — ON-REGION CHARACTERISTICS

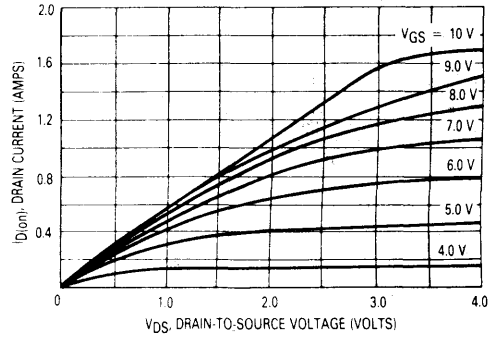


FIGURE 5 — OUTPUT CHARACTERISTICS

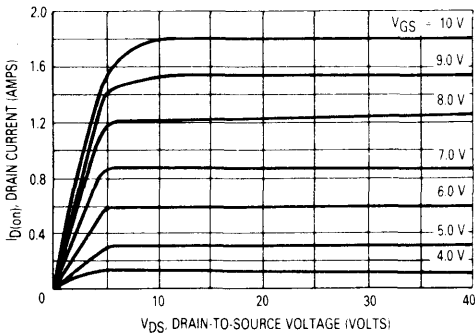
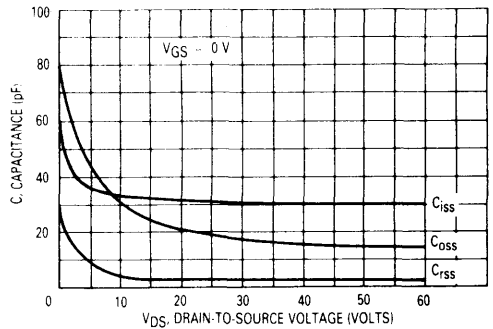


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



6

J107, J108 J109, J110

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
GENERAL-PURPOSE
TRANSISTOR

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V _{DG}	-25	Vdc
Gate-Source Voltage	V _{GS}	-25	Vdc
Gate Current	I _G	10	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	310 2.82	mW mW/°C
Junction Temperature Range	T _J	135	°C
Storage Channel Temperature Range	T _{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage (V _{DS} = 0, I _G = -10 μAdc)	V _{(BR)GSS}	-25	—	—	Vdc
Gate Reverse Current (V _{GS} = -15 Vdc, V _{DS} = 0) (V _{GS} = -15 Vdc, V _{DS} = 0, T _A = 100°C)	I _{GSS}	—	—	-3.0 -200	nAdc
Gate Source Cutoff Voltage (V _{DS} = 15 Vdc, I _D = 10 nAdc)	V _{GS(off)}	J107 -0.5 J108 -3.0 J109 -2.0 J110 -0.5	— — — —	-4.5 -10 -6.0 -4.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) (V _{DS} = 15, V _{GS} = 0)	I _{DSS}	J107 100 J108 80 J109 40 J110 10	— — — —	— — — —	mAdc
Drain-Source On-Resistance (V _{DS} < 0.1 V, V _{GS} = 0 V)	r _{DS(on)}	J107 — J108 — J109 — J110 —	— — — —	8.0 8.0 12 18	ohms

SMALL-SIGNAL CHARACTERISTICS

Drain Gate + Source Gate On-Capacitance (V _{DS} = 0 Vdc, V _{GS} = 0, f = 1.0 MHz)	C _{dg(on)} + C _{sg(on)}	—	—	85	pF
Drain Gate Off-Capacitance (V _{DS} = 0 Vdc, V _{GS} = -10 V, f = 1.0 MHz)	C _{dg(off)}	—	—	15	pF
Source Gate Off-Capacitance (V _{DS} = 0 Vdc, V _{GS} = -10 V, f = 1.0 MHz)	C _{sg(off)}	—	—	15	pF

(1) Pulse Duration 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — COMMON SOURCE INPUT CAPACITANCE versus GATE-SOURCE VOLTAGE

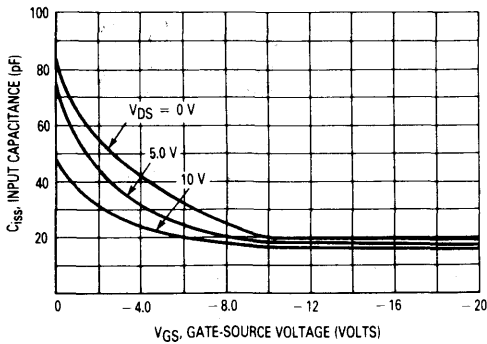


FIGURE 2 — COMMON SOURCE REVERSE FEEDBACK CAPACITANCE versus GATE-SOURCE VOLTAGE

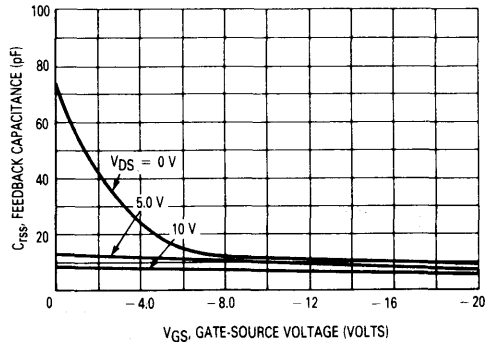


FIGURE 3 — ON-RESISTANCE versus GATE-SOURCE CUTOFF VOLTAGE

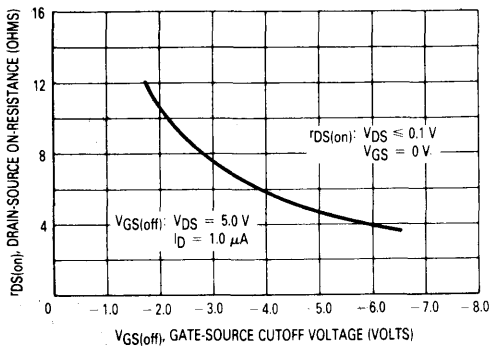


FIGURE 4 — OUTPUT CHARACTERISTIC
 $V_{GS(off)} = -2.0$ V

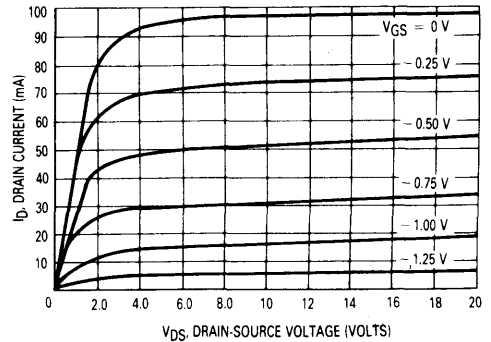


FIGURE 5 — OUTPUT CHARACTERISTIC
 $V_{GS(off)} = -3.0$ V

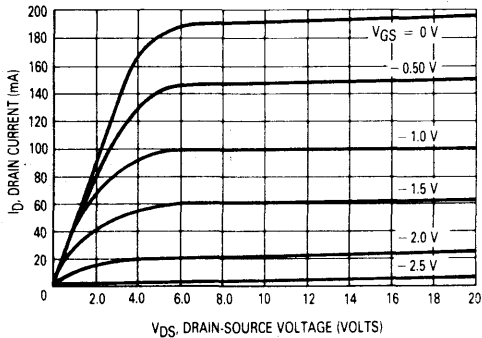
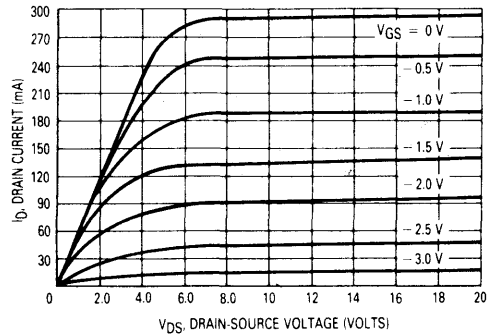


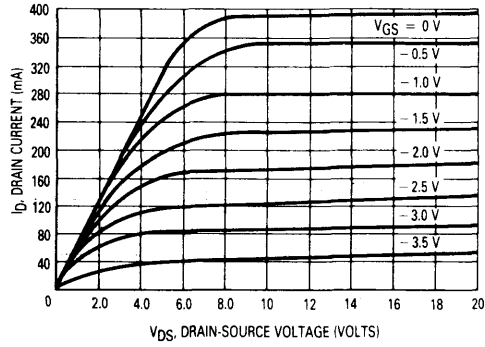
FIGURE 6 — OUTPUT CHARACTERISTIC
 $V_{GS(off)} = -4.0$ V



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FIGURE 7 — OUTPUT CHARACTERISTIC

$V_{GS(off)} = -5.0\text{ V}$



J111
J112
J113

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
CHOPPER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V _{DG}	-35	Vdc
Gate-Source Voltage	V _{GS}	-35	Vdc
Gate Current	I _G	50	mA
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 5.68	mW mW/°C
Lead Temperature	T _L	300	°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I _G = -1.0 μA)	V _{(BR)GSS}	35	—	Vdc
Gate Reverse Current (V _{GS} = -15 V)	I _{GSS}	—	-1.0	nA
Gate Source Cutoff Voltage (V _{DS} = 5.0 V, I _D = 1.0 μA)	V _{GS(off)}	J111 -3.0 J112 -1.0 J113 -0.5	-10 -5.0 -3.0	V
Drain-Cutoff Current (V _{DS} = 5.0 V, V _{GS} = -10 V)	I _{D(off)}	—	1.0	nA
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V _{DS} = 15 V)	I _{DSS}	J111 20 J112 5.0 J113 2.0	— — —	mA
Static Drain-Source On Resistance (V _{DS} = 0.1 V)	r _{DS(on)}	J111 — J112 — J113 —	33 50 100	Ohms
Drain Gate and Source Gate On-Capacitance (V _{DS} = V _{GS} = 0, f = 1.0 MHz)	C _{dg(on)} + C _{sg(on)}	—	28	pF
Drain Gate Off-Capacitance (V _{GS} = -10 V, f = 1.0 MHz)	C _{dg(off)}	—	5.0	pF
Source Gate Off-Capacitance (V _{GS} = -10 V, f = 1.0 MHz)	C _{sg(off)}	—	5.0	pF

*Pulse Width = 300 μsec, Duty Cycle = 3.0%.

**J174
J175
J176
J177**

**CASE 29-02, STYLE 7
TO-92 (TO-226AA)**

**JFET
CHOPPER TRANSISTOR**

P-CHANNEL — DEPLETION

Refer to MPF970 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	30	Vdc
Drain-Gate Voltage	V _{DG}	30	Vdc
Gate-Source Voltage	V _{GS}	30	Vdc
Gate Current	I _G	50	mA
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 2.8	mW mW/°C
Storage Temperature Range	T _{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I _G = 1.0 μA)	V _{(BR)GSS}	30	—	Vdc
Gate Reverse Current (V _{GS} = 20 Volts)	I _{GSS}	—	1.0	nA
Gate Source Cutoff Voltage (V _{DS} = -15 V, I _D = -10 nA)	V _{GS(off)}	J174 5.0 J175 3.0 J176 1.0 J177 0.8	10 6.0 4.0 2.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V _{DS} = -15 V)	I _{DSS} *	J174 -2.0 J175 -7.0 J176 -2.0 J177 -1.5	-100 -60 -25 -20	mA
Static Drain-Source On Resistance (V _{DS} ≤ -0.1 Volt)	r _{DS(on)}	J174 — J175 — J176 — J177 —	85 125 250 300	Ω

*Pulse Width = 300 μs, Duty Cycle ≤ 3.0%.

6

**J201
J202
J203**

**CASE 29-02, STYLE 5
TO-92 (TO-226AA)**

**JFET
LOW FREQUENCY/LOW NOISE**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

Refer to 2N4220 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{A}$)	$V_{(BR)GSS}$	-40	—	Vdc
Gate Reverse Current ($V_{GS} = -20 \text{ V}$)	I_{GSS}	—	-100	pA
Gate Source Cutoff Voltage ($V_{DS} = 20 \text{ V}$, $I_D = 10 \text{ nA}$)	$V_{GS(off)}$	-0.3 -0.8 -2.0	-1.5 -4.0 -10.0	Vdc
	J201			
	J202			
	J203			
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 20 \text{ V}$)	I_{DSS}^*	0.2 0.9 4.0	1.0 4.5 20.0	mA
	J201			
	J202			
	J203			
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 20 \text{ V}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} ^*$	500 1000 1500	— — —	μmhos
	J201			
	J202			
	J203			

*Pulse Width $\leq 2.0 \text{ msec}$.

J270 J271

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
CHOPPER TRANSISTOR

P-CHANNEL — DEPLETION

Refer to MPF970 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 3.27	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{A}$)	$V_{(BR)GSS}$	30	—	Vdc	
Gate Reverse Current ($V_{GS} = 20$ Volts)	I_{GSS}	—	200	pA	
Gate Source Cutoff Voltage ($V_{DS} = -15$ V, $I_D = -1.0$ nA)	$V_{GS(off)}$	J270 J271	0.5 1.5	2.0 4.5	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current ($V_{DS} = -15$ V)	J270 J271	I_{DSS}^*	-2.0 -6.0	-15 -50	mA
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = -15$ V, $f = 1.0$ kHz)	J270 J271	$ y_{fs} $	6000 8000	15000 18000	μmhos
Output Admittance ($V_{DS} = -15$ V, $f = 1.0$ kHz)	J270 J271	$ y_{os} $	— —	200 500	μmhos
Input Capacitance ($V_{DS} = -15$ V, $f = 1.0$ MHz)		C_{iss}	—	32	pF
Reverse Transfer Capacitance ($V_{DS} = -15$ V, $f = 1.0$ MHz)		C_{rss}	—	8.0	pF

*Pulse Width ≤ 2.0 ms.

J300

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET HIGH FREQUENCY AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	-25	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 3.5	mW mW/ $^\circ\text{C}$
Lead Temperature (1/16" from Case for 10 Seconds)	T_L	300	$^\circ\text{C}$
Junction Temperature Range	T_J	-55 to +150	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-55 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-25	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ V}$, $V_{DS} = 0$)	I_{GSS}	—	500	pA
Gate Source Cutoff Voltage ($V_{DS} = 10 \text{ V}$, $I_D = 1.0 \text{ mA}$)	$V_{GS(off)}$	-1.0	-6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 10 \text{ V}$, $V_{GS} = 0$)	I_{DSS}	6.0	30	mA
Gate-Source Forward Voltage ($V_{DS} = 0$, $I_G = 1.0 \text{ mA}$)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 10 \text{ V}$, $I_D = 5.0 \text{ mA}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	4500	9000	μmhos
Output Admittance ($V_{DS} = 10 \text{ V}$, $I_D = 5.0 \text{ mA}$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	—	200	μmhos
Input Capacitance ($V_{DS} = 10 \text{ V}$, $I_D = 5.0 \text{ mA}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	5.5	pF
Reverse Transfer Capacitance ($V_{DS} = 10 \text{ V}$, $I_D = 5.0 \text{ mA}$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	1.7	pF

J304 J305

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V _{DG}	-30	Vdc
Gate-Source Voltage	V _{GS}	-30	Vdc
Gate Current	I _G	10	mA
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	350 3.5	mW mW/°C
Lead Temperature (1/16" from Case for 10 Seconds)	T _L	300	°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I _G = 1.0 μA, V _{DS} = 0)	V _{(BR)GSS}	30	—	Vdc
Gate Reverse Current (V _{GS} = -20 V, V _{DS} = 0)	I _{GSS}	—	100	pA
Gate Source Cutoff Voltage (V _{DS} = 15 V, I _D = 1.0 nA)	V _{GS(off)}	-2.0 -0.5	-6.0 -3.0	Vdc
				J304 J305
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V _{DS} = 15 V, V _{GS} = 0)	I _{DSS}	5.0 1.0	15 8.0	mA
				J304 J305
SMALL-SIGNAL CHARACTERISTICS				
Output Admittance (V _{DS} = 15 V, V _{GS} = 0, f = 1.0 kHz)	y _{os}	—	50	μmhos
Forward Transconductance (V _{DS} = 15 V, V _{GS} = 0, f = 1.0 kHz)	Re(y _{fs})	4500 3000	7500 —	μmhos
				J304 J305

J308 J309 J310

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER
N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 3.5	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	-55 to +125	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-55 to +150	$^\circ\text{C}$

Refer to U308 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-25	—	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ V}$, $V_{DS} = 0$, $T_A = 25^\circ\text{C}$) ($V_{GS} = -15 \text{ V}$, $V_{DS} = 0$, $T_A = +125^\circ\text{C}$)	I_{GSS}	— —	— —	-1.0 -1.0	nA μA
Gate Source Cutoff Voltage ($V_{DS} = 10 \text{ V}$, $I_D = 1.0 \text{ nA}$)	$V_{GS(off)}$	-1.0 -1.0 -2.0	— — —	-6.5 -4.0 -6.5	Vdc
	J308 J309 J310				

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 10 \text{ V}$, $V_{GS} = 0$)	I_{DSS}	12 12 24	— — —	60 30 60	mA
	J308 J309 J310				
Gate-Source Forward Voltage ($V_{DS} = 0$, $I_G = 1.0 \text{ mA}$)	$V_{GS(f)}$	—	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Common-Source Input Conductance ($V_{DS} = 10 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 100 \text{ MHz}$)	$Re(y_{is})$	— — —	0.7 0.7 0.5	— — —	mmhos
	J308 J309 J310				
Common-Source Output Conductance ($V_{DS} = 10 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 100 \text{ MHz}$)	$Re(y_{os})$	—	0.25	—	mmhos
Common-Gate Power Gain ($V_{DS} = 10 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 100 \text{ MHz}$)	G_{pg}	—	16	—	dB
Common-Source Forward Transconductance ($V_{DS} = 10 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 100 \text{ MHz}$)	$Re(y_{fs})$	—	12	—	mmhos
Common-Gate Input Conductance ($V_{DS} = 10 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 100 \text{ MHz}$)	$Re(y_{ig})$	—	12	—	mmhos
Common-Gate Forward Transconductance ($V_{DS} = 10 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 1.0 \text{ kHz}$)	g_{fs}	8000 10000 8000	— — —	20000 20000 18000	μmhos
	J308 J309 J310				
Common-Gate Output Conductance ($V_{DS} = 10 \text{ V}$, $I_D = 10 \text{ mA}$, $f = 1.0 \text{ kHz}$)	g_{os}	— — —	— — —	200 150 200	μmhos
	J308 J309 J310				

J308, J309, J310

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common-Gate Forward Transconductance ($V_{DS} = 10\text{ V}$, $I_D = 10\text{ mA}$, $f = 1.0\text{ kHz}$)	J308	g_{fg}	—	13000	—	μmhos
	J309			13000		
	J310			12000		
Common-Gate Output Conductance ($V_{DS} = 10\text{ V}$, $I_D = 10\text{ mA}$, $f = 1.0\text{ kHz}$)	J308	g_{og}	—	150	—	μmhos
	J309			100		
	J310			150		
Gate-Drain Capacitance ($V_{DS} = 0$, $V_{GS} = -10\text{ V}$, $f = 1.0\text{ MHz}$)		C_{gd}	—	1.8	2.5	pF
Gate-Source Capacitance ($V_{DS} = 0$, $V_{GS} = -10\text{ V}$, $f = 1.0\text{ MHz}$)		C_{gs}	—	4.3	5.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 10\text{ V}$, $I_D = 10\text{ mA}$, $f = 450\text{ MHz}$)	NF	—	1.5	—	dB
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = 10\text{ V}$, $I_D = 10\text{ mA}$, $f = 100\text{ Hz}$)	\bar{e}_n	—	10	—	$\text{nV}/\sqrt{\text{Hz}}$

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 3.0\%$.

JF1033B
JF1033S
JF1033Y

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY AMPLIFIER

N-CHANNEL DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	20	mA
Forward Gate Current	I_{GF}	10	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	310 2.82	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -10 \mu\text{A}$)	$V_{(BR)GSS}$	-25	—	Vdc
Drain-Source Breakdown Voltage ($I_D = 10 \mu\text{A}$)	$V_{(BR)DGO}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = -10 \text{ V}, V_{DS} = 0$)	I_{GSS}	—	-100	nA
Gate Source Cutoff Voltage ($V_{DS} = 10 \text{ V}, I_D = 10 \mu\text{A}$)	$V_{GS(off)}$	-1.0	-8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 10 \text{ V}, V_{GS} = 0$)	I_{DSS}			mA
	JF1033Y	2.5	6.0	
	JF1033B	5.0	12.0	
	JF1033S	10.0	20.0	
SMALL-SIGNAL CHARACTERISTICS				
Forward Transconductance ($V_{DS} = 10 \text{ V}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	$Re(y_{fs})$	4.5	13.0	mmhos
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 10 \text{ V}, V_{GS} = 0, f = 100 \text{ MHz}$)	NF	—	2.5	dB

MFE120 MFE121 MFE122

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = 100 \mu\text{Adc}, V_S = 0, V_{G1S} = -4.0 \text{ V}, V_{G2S} = +4.0 \text{ V}$)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage ($I_{G1} = \pm 10 \mu\text{Adc}, V_{G2S} = 0$)	$V_{(BR)G1SO}$	± 7.0	—	± 20	Vdc
Gate 2-Source Breakdown Voltage ($I_{G2} = \pm 10 \mu\text{Adc}, V_{G1S} = 0$)	$V_{(BR)G2SO}$	± 7.0	—	± 20	Vdc
Gate 1 Leakage Current ($V_{G1S} = +6.0 \text{ Vdc}, V_{G2S} = 0, V_{DS} = 0$)	I_{G1SS}	—	—	20	nAdc
Gate 2 Leakage Current ($V_{G2S} = +6.0 \text{ Vdc}, V_{G1S} = 0, V_{DS} = 0$)	I_{G2SS}	—	—	20	nAdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = 200 \mu\text{Adc}$)	$V_{G1S(off)}$	—	—	-4.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}, V_{G1S} = 0, I_D = 200 \mu\text{Adc}$)	$V_{G2S(off)}$	—	—	-4.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ Vdc}, V_{G1S} = 0, V_{G2S} = 4.0 \text{ Vdc}$)	MFE120 MFE121 MFE122	I_{DSS}	2.0 5.0 2.0	7.0 10 9.0	18 30 20	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance (Gate 1 to Drain) ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = 10 \text{ mAdc}, f = 1.0 \text{ kHz}$)	MFE120,22 MFE121	$ Y_{fs} $	8000 10,000	— —	18,000 20,000	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = I_{DSS}, f = 1.0 \text{ MHz}$)	MFE120,22 MFE121	C_{iss}	— —	4.5 4.5	7.0 6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = 6.0 \text{ mAdc}, f = 1.0 \text{ MHz}$)		C_{rss}	—	0.023	—	pF
Output Capacitance ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = I_{DSS}, f = 1.0 \text{ MHz}$)	MFE120,22 MFE121	C_{oss}	— —	2.5 2.5	4.0 3.5	pF

MFE120, MFE121, MFE122

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure $V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 6.0 \text{ mAdc}$, Z_S is optimized for NF (f = 105 MHz — Figure 1) (f = 60 MHz — Figure 3) (f = 200 MHz — Figure 3)	NF	—	2.9	5.0	dB
Common Source Power Gain $V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 6.0 \text{ mAdc}$, Z_S is optimized for NF (f = 105 MHz — Figure 1) (f = 60 MHz — Figure 3) (f = 200 MHz — Figure 3)	G_{ps}	17	19.6	—	dB
Level of Unwanted Signal for 1.0% Cross Modulation $V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 6.0 \text{ mAdc}$	—	—	100	—	mV
Common-Source Conversion Power Gain (Gate 1 Injection, Figure 2) $V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, Local Oscillator Voltage = 925 mVrms (Signal Frequency = 60 MHz, Local Oscillator Frequency = 104 MHz) (Signal Frequency = 200 MHz, Local Oscillator Frequency = 244 MHz)	G_C	15	16.5	—	dB
		12	13.3	—	

6

FIGURE 1 — 105 MHz TEST CIRCUIT

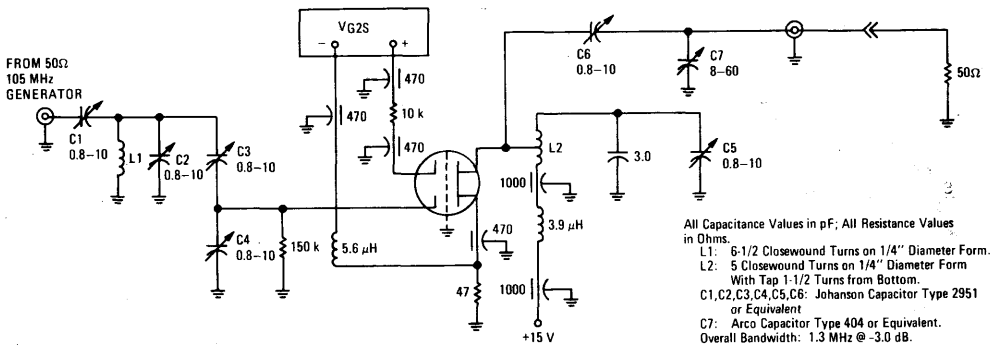


FIGURE 2 — 60 AND 200 MHz TEST CIRCUIT

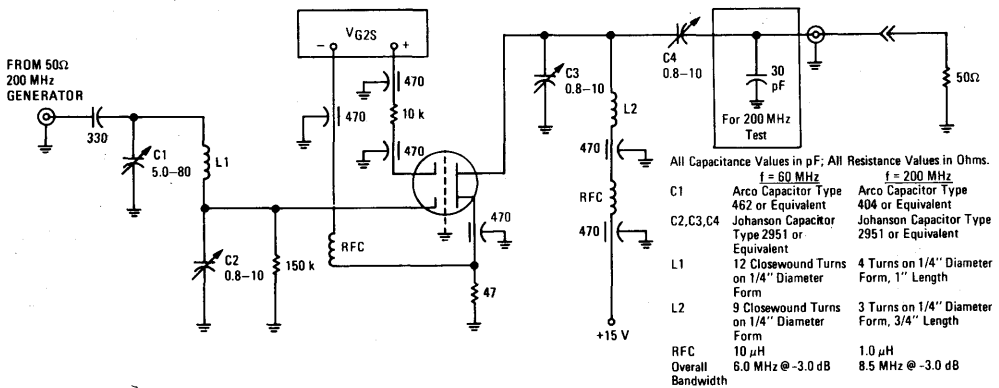
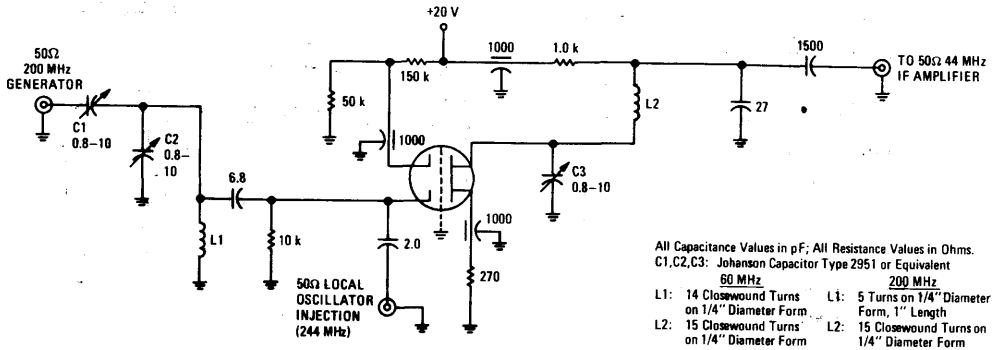


FIGURE 3 - 60 AND 200 MHz CONVERSION POWER GAIN



COMMON-SOURCE ADMITTANCE PARAMETERS
 ($V_{DS} = 15$ Vdc, $V_{GS} = 4.0$ Vdc, $I_D = 6.0$ mAdc)

FIGURE 4 - INPUT ADMITTANCE

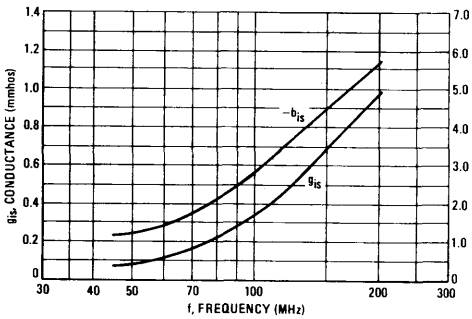


FIGURE 5 - REVERSE TRANSFER ADMITTANCE

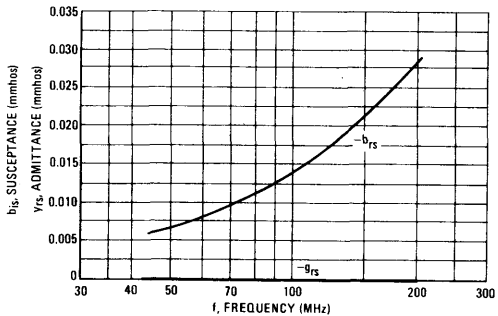


FIGURE 6 - FORWARD TRANSFER ADMITTANCE

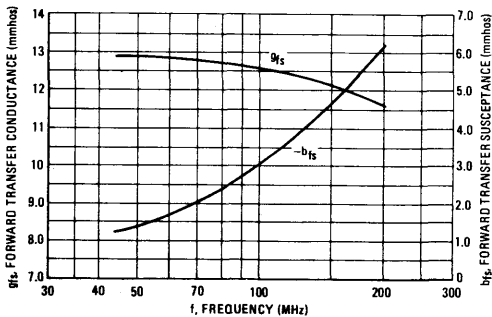
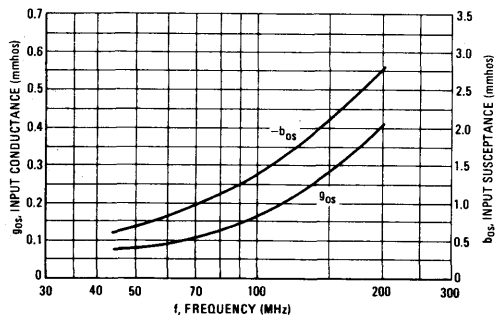


FIGURE 7 - OUTPUT ADMITTANCE



MFE120, MFE121, MFE122

FIGURE 8 - GAIN REDUCTION

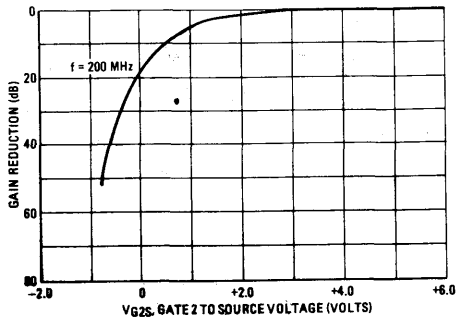
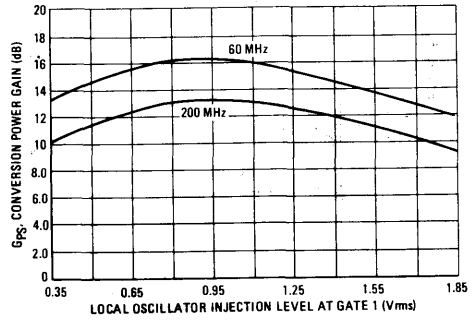


FIGURE 9 - CONVERSION POWER GAIN



MFE140

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE
MOSFET
FM AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	± 7.0	Vdc
Drain Current	I_D	30	mAdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300	mW
Operating and Storage Channel Temperature Range	T_{channel} , T_{stg}	-65 to +175	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = 10 \mu\text{Adc}$, $V_S = 0$, $V_{G1} = -4.0 \text{ Vdc}$, $V_{G2} = +4.0 \text{ Vdc}$)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage ($I_{G1} = \pm 10 \mu\text{Adc}$, $V_{G2S} = 0$)	$V_{(BR)G1SO}$	± 7.0	—	± 20	Vdc
Gate 2-Source Breakdown Voltage ($I_{G2} = \pm 10 \mu\text{Adc}$, $V_{G1S} = 0$)	$V_{(BR)G2SO}$	± 7.0	—	± 20	Vdc
Gate 1 Leakage Current ($V_{G1S} = \pm 6.0 \text{ Vdc}$, $V_{G2S} = 0$, $V_{DS} = 0$)	I_{G1SS}	—	—	20	nAdc
Gate 2 Leakage Current ($V_{G2S} = \pm 6.0 \text{ Vdc}$, $V_{G1S} = 0$, $V_{DS} = 0$)	I_{G2SS}	—	—	20	nAdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 200 \mu\text{Adc}$)	$V_{G1S(\text{off})}$	—	—	-4.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{G1S} = 0$, $I_D = 200 \mu\text{Adc}$)	$V_{G2S(\text{off})}$	—	—	-4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 0$, $V_{G1S} = 4.0 \text{ Vdc}$)	I_{DSS}	3.0	10	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (Gate 1 connected to Drain) ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 10 \text{ mAdc}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	10	—	20	mmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = I_{DSS}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = I_{DSS}$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	0.023	0.05	pF
Output Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = I_{DSS}$, $f = 1.0 \text{ MHz}$)	C_{oss}	—	2.5	4.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figure 8) (See Test Circuit in Figure 11)	NF	—	2.5	3.5	dB
Common Source Power Gain (Figure 7) (See Test Circuit in Figure 11)	G_{ps}	20	23	—	dB
Level of Unwanted Signal for 1.0% Cross Modulation (Figure 10) (See Test Circuit in Figure 11)	—	—	45	—	mV

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Common-Source Conversion Power Gain (Gate 1 or Gate 2 Injection, Figure 12) (See Test Circuit in Figure 13) (Signal Frequency = 100 MHz, Local Oscillator Frequency = 110.7 MHz)	G_C	15	18.5	—	dB
1/2 I.F. Rejection (See Test Circuit in Figure 13)	$1/2 f_{REJ} $	—	50	—	dB

COMMON-SOURCE ADMITTANCE PARAMETERS

($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 4.0\text{ Vdc}$, $I_D = 6.0\text{ mAdc}$)

FIGURE 1 – INPUT ADMITTANCE

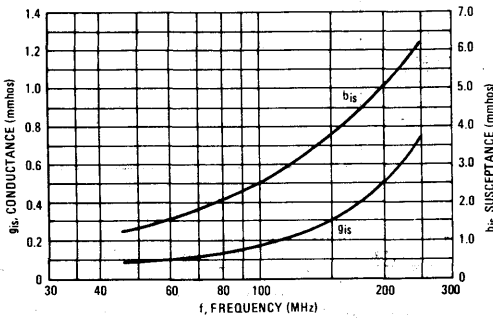


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

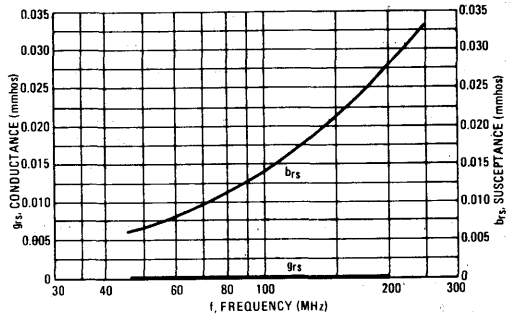


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

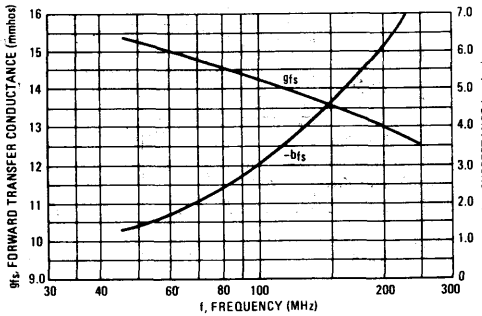
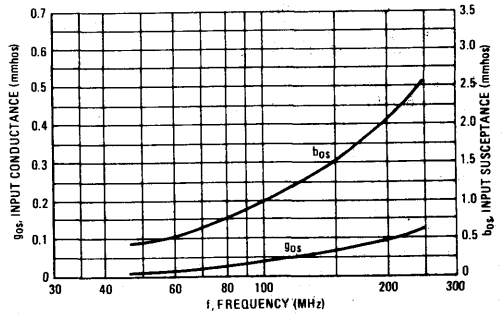


FIGURE 4 – OUTPUT ADMITTANCE



FORWARD TRANSFER ADMITTANCE

($V_{DS} = 15\text{ Vdc}$, $f = 1.0\text{ kHz}$)

FIGURE 5 – GATE 1

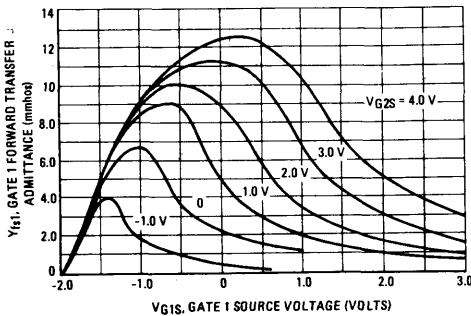


FIGURE 6 – GATE 2

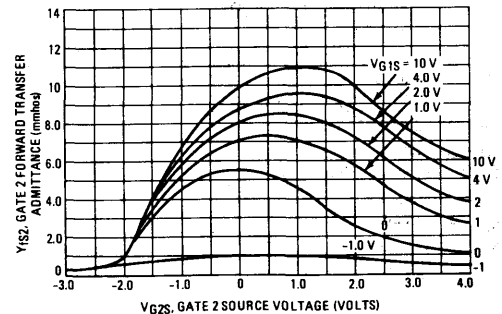


FIGURE 7 - POWER GAIN

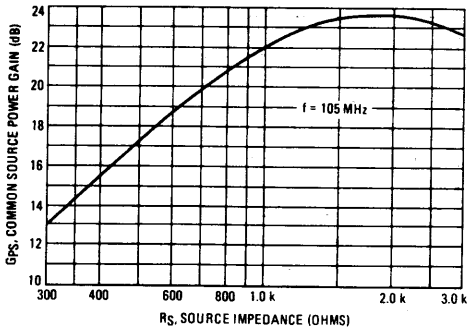


FIGURE 8 - NOISE FIGURE

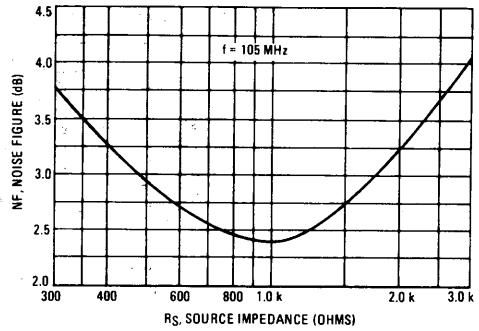


FIGURE 9 - GAIN REDUCTION

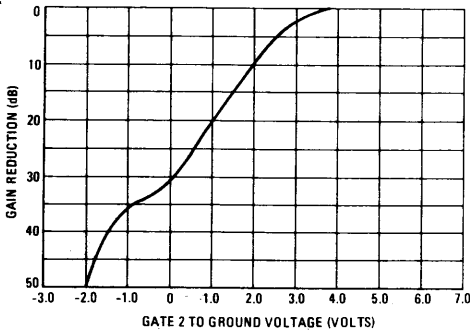
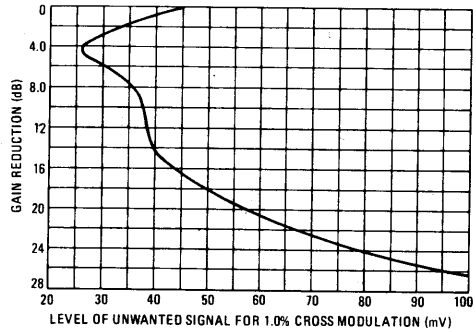
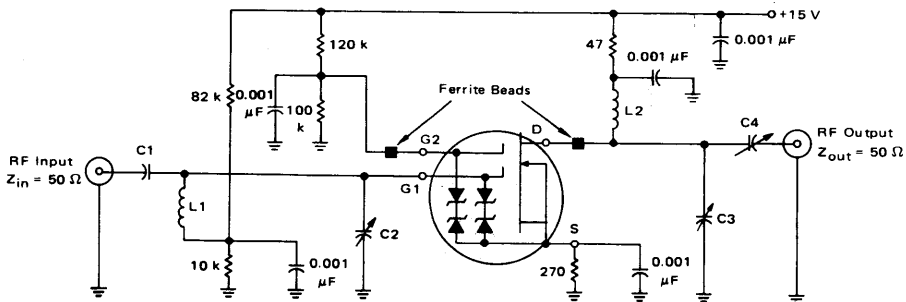


FIGURE 10 - CROSS MODULATION



6

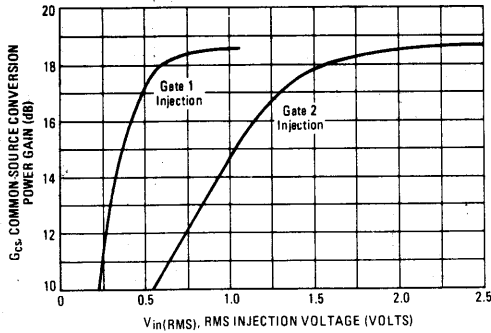
FIGURE 11 - 105 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



The following component values are for a stern stability factor = 2.0.
 L1, L2 126 nH PAUL SMITH CO. SK-138-1
 4-1/2 Turns (yellow)
 C1 Nominal 7.0 pF Adjusted for source impedance of approximately 1000 Ohms, JOHANSON JMC2951

C2 Nominal 4.0 pF ARCO 402
 C3 Nominal 13.73 pF ARCO 403
 C4 Nominal 4.36 pF JOHANSON JMC2951
 All Decoupling Capacitors are Ceramic Discs.

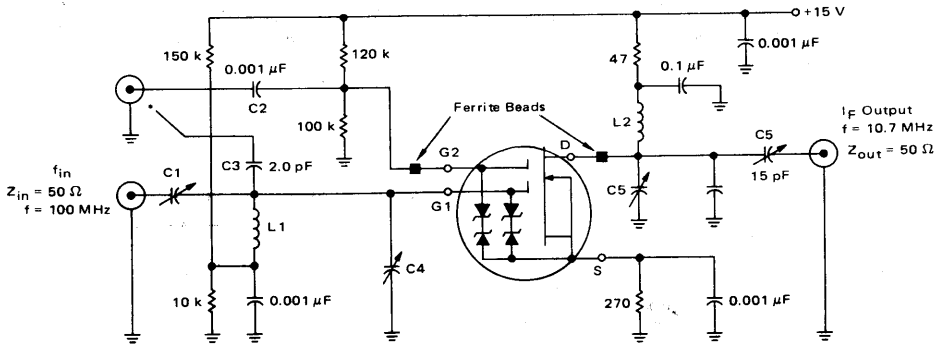
FIGURE 12 – CONVERSION GAIN



6

FIGURE 13 – CONVERSION GAIN TEST CIRCUIT

Local Oscillator Injection
 $V_{in(RMS)} \approx 2.0$ V for G2
 ≈ 0.9 V for G1
 $f = 110.7$ MHz



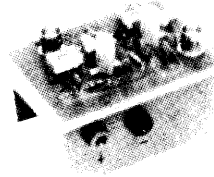
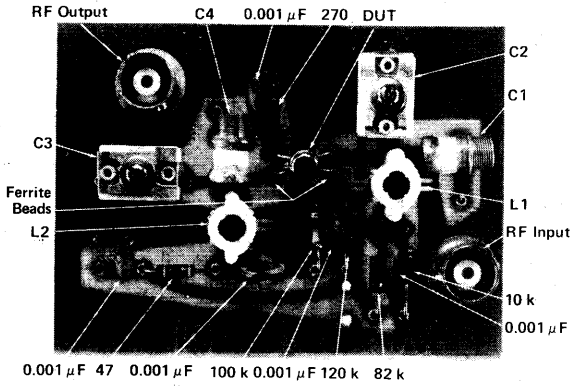
- L1 126 nH PAUL SMITH CO. SK-138-1
4-1/2 Turns (yellow)
- L2 2.73 μ H High Unloaded Q
- C1 JOHANSON JMC2951
- C4, C5, C6 ARCO 402

*For G1 injection, C2 is changed to bypass G2 to ground and C3 is added to connect G1 to the injection input.

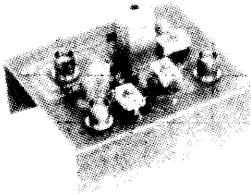
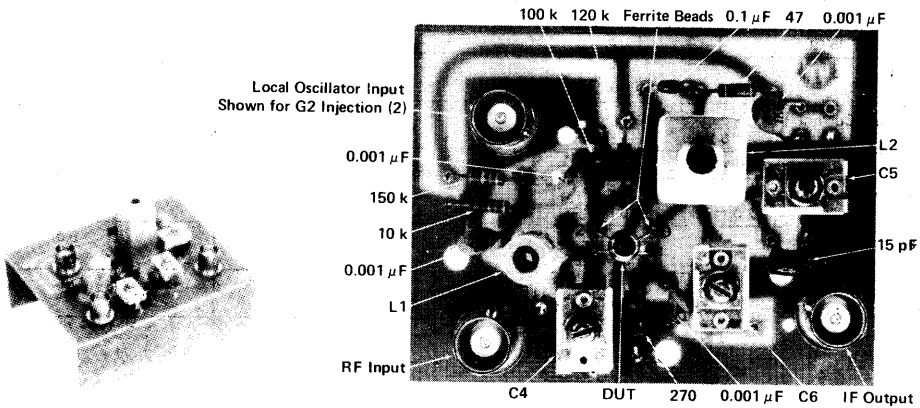
PRINTED CIRCUIT BOARD LAYOUT INFORMATION

FIGURE 14 – TEST FIXTURES

105 MHz POWER GAIN AND NOISE
FIGURE TEST CIRCUIT



100 MHz to 10.7 MHz CONVERSION
GAIN TEST CIRCUIT



Notes:

1. C1 is on the bottom side of the board.
2. For G1 Injection, C2 is changed to bypass G2 to ground and C3 is added to connect G1 to the injection input. See Figure 13.

MFE823

CASE 22-03, STYLE 11
TO-18 (TO-206AA)

MOSFET

P-CHANNEL — ENHANCEMENT

Refer to 2N4352 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	25	Vdc
Drain-Gate Voltage	V _{DG}	± 10	Vdc
Drain Current	I _D	30	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	584	°C/W
Thermal Resistance, Junction to Case	R _{θJC}	250	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

OFF CHARACTERISTICS

Drain-Source Breakdown Voltage (I _D = -10 μAdc, V _{GS} = 0 Vdc)	V _{(BR)DSX}	-25	—	Vdc
Zero-Gate-Voltage Drain Current (V _{DS} = -10 Vdc, V _{GS} = 0)	I _{DSS}	—	-20	nAdc
Gate Reverse Current (V _{GS} = -10 Vdc, V _{DS} = 0)	I _{GSS}	—	1.0	pAdc

ON CHARACTERISTICS

Gate Threshold Voltage (V _{DS} = -10 Vdc, I _D = -10 μAdc)	V _{GS(Th)}	-2.0	-6.0	Vdc
On-State Drain Current (V _{DS} = -10 Vdc, V _{GS} = -10 Vdc)	I _{D(on)}	-3.0	—	mAdc

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance (V _{DS} = -10 Vdc, I _D = -2.0 mAdc, f = 1.0 kHz)	y _{fs}	1000	—	μmhos
Input Capacitance (V _{DS} = -10 Vdc, V _{GS} = -10 Vdc, f = 1.0 MHz)	C _{iss}	—	6.0	pF
Reverse Transfer Capacitance (V _{DS} = -10 Vdc, V _{GS} = -10 Vdc, f = 1.0 MHz)	C _{rss}	—	1.5	pF

MFE825

CASE 22-03, STYLE 2
TO-18 (TO-206AA)

MOSFET

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	25	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.6	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	150	$^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	$^\circ\text{C}$

Refer to 2N3796 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = 1.0 \mu\text{A}, V_{GS} = -8.0 \text{ V}$)	$V_{(BR)DSX}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = -10 \text{ V}, V_{DS} = 0 \text{ V}$)	I_{GSS}	—	-1.0	pA
Gate Source Voltage ($I_D = 1.0 \mu\text{A}, V_{DS} = 2.0 \text{ V}$)	V_{GS}	0	-2.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 10 \text{ V}, V_{GS} = 0$)	I_{DSS}	1.0	25	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 10 \text{ V}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	$ y_{fs} $	500	—	μmhos

MFE910 MPF910

MFE910
CASE 79-02, STYLE 6
TO-39 (TO-205AD)

MPE910
CASE 29-03, STYLE 22
(TO-226AE)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Gate-Source Voltage	V_{GS}	± 15	Vdc
Drain Current — Continuous(1)	I_D	0.5	Adc
Pulsed(2)	I_{DM}	1.0	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C MPF910	P_D	1.0	Watts
		8.0	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C MFE910	P_D	6.25	Watts
		50	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

(1) The Power Dissipation of the package may result in a lower continuous drain current.

(2) Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

Refer to 2N6659 for additional graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 40 \text{ V}, V_{GS} = 0$)	I_{DSS}	—	0.1	10	μAdc
Gate Reverse Current ($V_{GS} = 10 \text{ V}, V_{DS} = 0$)	I_{GSS}	—	0.01	10	nAdc
Drain-Source Breakdown Voltage ($V_{GS} = 0, I_D = 100 \mu\text{A}$)	$V_{(BR)DSS}$	60	90	—	Vdc
ON CHARACTERISTICS					
Gate Threshold Voltage ($V_{DS} = V_{GS}, I_D = 1.0 \text{ mA}$)	$V_{GS(th)}$	0.3	1.5	2.5	Vdc
Drain-Source On-Voltage ($V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$)	$V_{DS(on)}$	—	—	2.5	Vdc
On-State Drain Current ($V_{DS} = 25 \text{ V}, V_{GS} = 10 \text{ V}$)	$I_{D(on)}$	500	—	—	mA
Forward Transconductance ($V_{DS} = 15 \text{ V}, I_D = 500 \text{ mA}$)	g_{fs}	100	—	—	mmhos

FIGURE 1 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

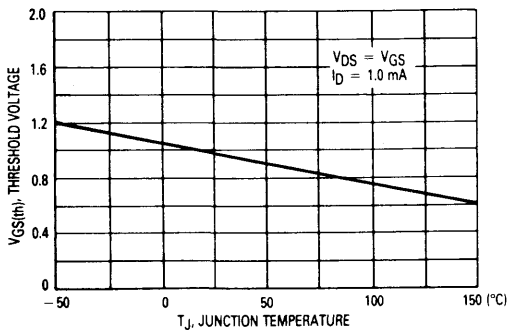
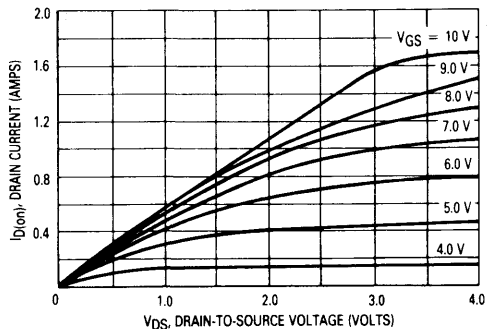


FIGURE 2 — ON-REGION CHARACTERISTICS



MF910, MPF910

FIGURE 3 — OUTPUT CHARACTERISTICS

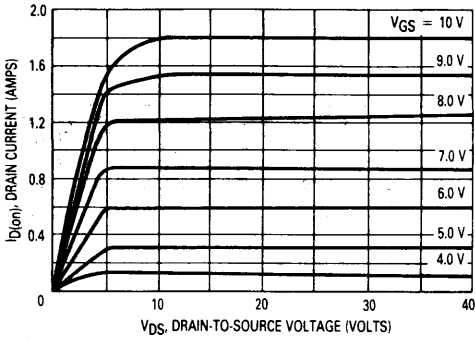
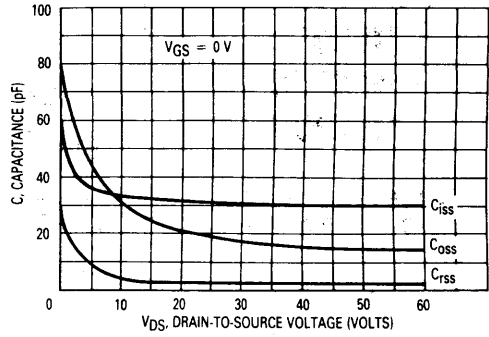


FIGURE 4 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



MFE930 MFE960 MFE990

CASE 79-02, STYLE 6
TO-39 (TO-205AD)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	MFE930	MFE960	MFE990	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}	±30			Vdc
Drain Current Continuous(1) Pulsed(2)	I_D I_{DM}	2.0 3.0			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	6.25 50			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to 150			°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.

(2) Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($V_{GS} = 0, I_D = 10 \mu\text{A}$)	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}, V_{DS} = 0$)	I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*					
Zero-Gate-Voltage Drain Current ($V_{DS} = \text{Maximum Rating}, V_{GS} = 0$)	I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage ($V_{DS} = V_{GS}, I_D = 1.0 \text{ mA}$)	$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage ($V_{GS} = 10 \text{ V}$) ($I_D = 0.5 \text{ A}$)	$V_{DS(on)}$	—	0.4 0.6 0.6	0.7 0.8 1.0	Vdc
($I_D = 1.0 \text{ A}$)		—	0.9 1.2 1.2	1.4 1.7 2.0	
($I_D = 2.0 \text{ A}$)		—	2.2 2.8 2.8	3.0 3.5 4.0	
Static Drain-Source On Resistance ($V_{GS} = 10 \text{ Vdc}, I_D = 1.0 \text{ Adc}$)	$r_{DS(on)}$	—	0.9 1.2 1.2	1.4 1.7 2.0	Ohms
On-State Drain Current ($V_{DS} = 25 \text{ V}, V_{GS} = 10 \text{ V}$)	$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	60	70	pF
Reverse Transfer Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{rss}	—	13	18	pF
Output Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{oss}	—	49	60	pF

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Forward Transconductance ($V_{DS} = 25\text{ V}$, $I_D = 0.5\text{ A}$)	g_{fs}	200	380	—	mmhos
SWITCHING CHARACTERISTICS*					
Turn-On Time (See Figure 1)	t_{on}	—	7.0	15	ns
Turn-Off Time (See Figure 1)	t_{off}	—	7.0	15	ns

*Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

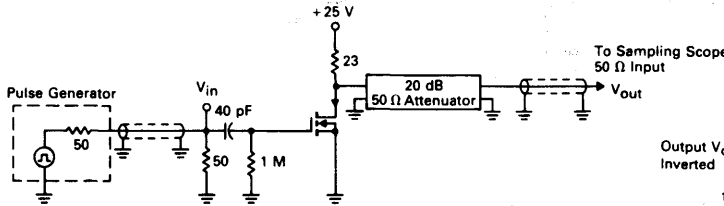


FIGURE 2 — SWITCHING WAVEFORMS

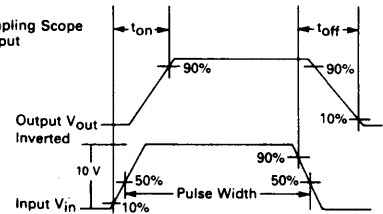


FIGURE 3 — ON VOLTAGE versus TEMPERATURE.

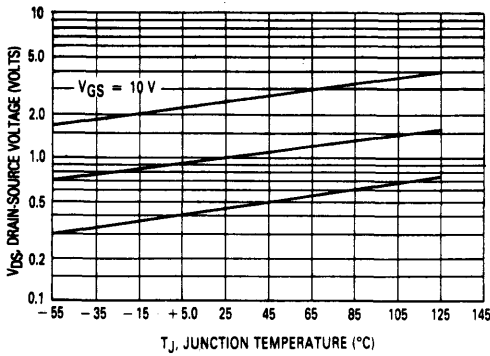


FIGURE 4 — CAPACITANCE VARIATION

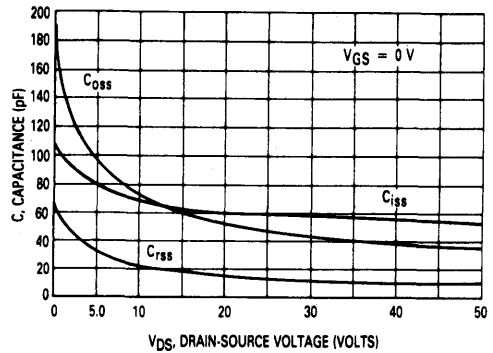


FIGURE 5 — TRANSFER CHARACTERISTIC

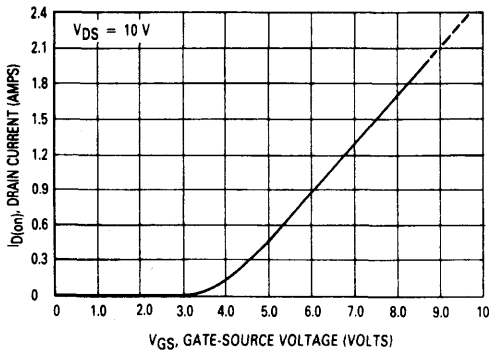


FIGURE 6 — OUTPUT CHARACTERISTIC

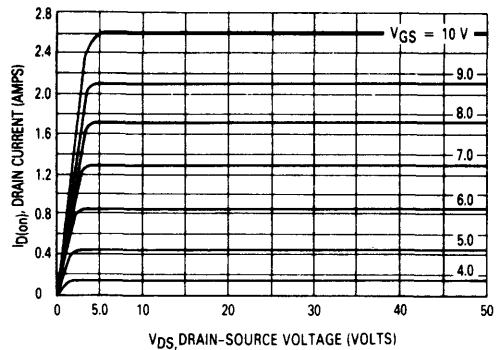
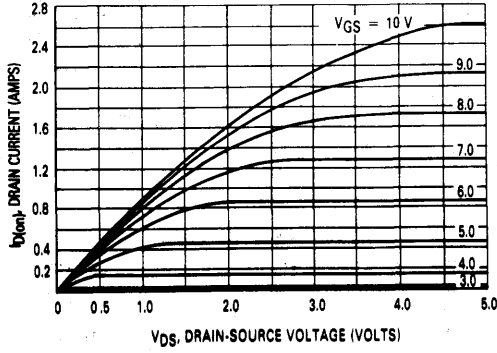


FIGURE 7 — SATURATION CHARACTERISTIC



6

MFE2000 MFE2001

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation (α $T_C = 25^\circ\text{C}$ Derate above 25°C)	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$

Refer to 2N4416 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{Adc}, V_{DS} = 0$)	$V_{(BR)GSS}$	-25	—	—	Vdc
Gate Reverse Current ($V_{GS} = -20 \text{ Vdc}, V_{DS} = 0$) ($V_{GS} = -20 \text{ Vdc}, V_{DS} = 0, T_A = 150^\circ\text{C}$)	I_{GSS}	—	—	-100 -200	pAdc nAdc
Gate Source Cutoff Voltage ($I_D = 0.5 \text{ mAdc}, V_{DS} = 15 \text{ Vdc}$)	$V_{GS(off)}$	-0.5 -2.0	—	-4.0 -6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0$)	I_{DSS}	4.0 8.0	—	10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	$ Y_{fs} $	2500 4000	—	6000 8000	μmhos
Output Admittance ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	$ Y_{os} $	—	—	50 75	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{rss}	—	—	1.0	pF
Output Capacitance ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{oss}	—	—	2.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15 \text{ Vdc}, I_D = 4.0 \text{ mAdc}, f = 100 \text{ MHz}, R_G \approx 1.0 \text{ k ohm}$) ($V_{DS} = 15 \text{ Vdc}, I_D = 4.0 \text{ mAdc}, f = 400 \text{ MHz}, R_G \approx 1.0 \text{ k ohm}$)	NF	—	1.6 3.3	2.0 4.0	dB
Common Source Power Gain ($V_{DS} = 15 \text{ Vdc}, I_D = 4.0 \text{ mAdc}, f = 100 \text{ MHz}$) ($V_{DS} = 15 \text{ Vdc}, I_D = 4.0 \text{ mAdc}, f = 400 \text{ MHz}$)	G_{ps}	18 10	23 14	— —	dB

MFE2004 MFE2005 MFE2006

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
CHOPPER

N-CHANNEL — DEPLETION

Refer to 2N4091 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10	Watts $\text{mW}/^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	— —	0.2 0.4	nAdc μAdc
Drain Cutoff Current ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	— —	0.2 0.4	nAdc μAdc
Gate Source Voltage ($V_{DS} = 20 \text{ Vdc}$, $I_D = 50 \mu\text{Adc}$)	V_{GS}	1.0 2.0 5.0	6.0 8.0 10	Vdc
	MFE2004 MFE2005 MFE2006			

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current* ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}^*	8.0 15 30	— — —	mAdc
	MFE2004 MFE2005 MFE2006			
Gate-Source Forward Voltage ($I_G = 1.0 \text{ mAdc}$, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc
Drain-Source On-Voltage ($I_D = 3.0 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 6.0 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 10 \text{ mAdc}$, $V_{GS} = 0$)	$V_{DS(on)}$	— — —	0.4 0.4 0.4	Vdc
	MFE2004 MFE2005 MFE2006			
Static Drain-Source On Resistance ($I_D = 1.0 \text{ mAdc}$, $V_{GS} = 0$)	$r_{DS(on)}$	— — —	80 50 30	Ohms
	MFE2004 MFE2005 MFE2006			

SMALL-SIGNAL CHARACTERISTICS

Static Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	— — —	80 50 30	Ohms
	MFE2004 MFE2005 MFE2006			
Input Capacitance ($V_{DS} = 0$, $V_{GS} = -12 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	16	pF

MFE2004, MFE2005, MFE2006

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
Reverse Transfer Capacitance	C_{rss}	—	5.0	pF	
($V_{DS} = 0, V_{GS} = 6.0 \text{ Vdc}, f = 1.0 \text{ MHz}$)					MFE2004
($V_{DS} = 0, V_{GS} = 8.0 \text{ Vdc}, f = 1.0 \text{ MHz}$)					MFE2005
($V_{DS} = 0, V_{GS} = 12 \text{ Vdc}, f = 1.0 \text{ MHz}$)					MFE2006

SWITCHING CHARACTERISTICS

Turn-On Delay Time	$t_{d(on)}$	—	20	ns	
($V_{DD} = 3.0 \text{ Vdc}, I_D = 3.0 \text{ mAdc}, V_{GS} = 0$)					MFE2004
($V_{DD} = 3.0 \text{ Vdc}, I_D = 6.0 \text{ mAdc}, V_{GS} = 0$)					MFE2005
($V_{DD} = 3.0 \text{ Vdc}, I_D = 10 \text{ mAdc}, V_{GS} = 0$)					MFE2006
Rise Time	t_r	—	40	ns	
($V_{DD} = 3.0 \text{ Vdc}, I_D = 3.0 \text{ mAdc}, V_{GS} = 0$)					MFE2004
($V_{DD} = 3.0 \text{ Vdc}, I_D = 6.0 \text{ mAdc}, V_{GS} = 0$)					MFE2005
($V_{DD} = 3.0 \text{ Vdc}, I_D = 10 \text{ mAdc}, V_{GS} = 0$)					MFE2006
Turn-Off Time	t_{off}	—	80	ns	
($V_{DD} = 3.0 \text{ Vdc}, I_D = 3.0 \text{ mAdc}, V_{GS(off)} = 6.0 \text{ Vdc}$)					MFE2004
($V_{DD} = 3.0 \text{ Vdc}, I_D = 6.0 \text{ mAdc}, V_{GS(off)} = 8.0 \text{ Vdc}$)					MFE2005
($V_{DD} = 3.0 \text{ Vdc}, I_D = 10 \text{ mAdc}, V_{GS(off)} = 12 \text{ Vdc}$)					MFE2006

*Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 3.0\%$.

MFE2010 MFE2011 MFE2012

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
CHOPPER

N-CHANNEL — DEPLETION

Refer to J107 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10	Watt mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{Vdc}$, $V_{DS} = 0$) ($V_{GS} = 15 \text{Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	— —	3.0 6.0	nAdc μAdc
Drain Cutoff Current ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 12 \text{Vdc}$) ($V_{DS} = 15 \text{Vdc}$, $V_{GS} = 12 \text{Vdc}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	— —	3.0 6.0	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* ($V_{DS} = 20 \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}^*			mAdc
	MFE2010	15	—	
	MFE2011	40	—	
	MFE2012	100	—	
Gate-Source Forward Voltage ($I_G = 1.0 \text{mAdc}$, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc
Gate-Source Voltage ($V_{DS} = 15 \text{Vdc}$, $I_D = 1.0 \mu\text{Adc}$)	V_{GS}			Vdc
	MFE2010	0.5	10	
	MFE2011	1.0	10	
	MFE2012	3.0	10	
Drain-Source On-Voltage ($I_D = 8.0 \text{mAdc}$, $V_{GS} = 0$) ($I_D = 15 \text{mAdc}$, $V_{GS} = 0$) ($I_D = 30 \text{mAdc}$, $V_{GS} = 0$)	$V_{DS(on)}$			Vdc
	MFE2010	—	0.75	
	MFE2011	—	0.75	
	MFE2012	—	0.75	
Static Drain-Source On Resistance ($I_D = 1.0 \text{mAdc}$, $V_{GS} = 0$)	$r_{DS(on)}$			Ohms
	MFE2010	—	25	
	MFE2011	—	15	
	MFE2012	—	10	
SMALL-SIGNAL CHARACTERISTICS				
Static Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{kHz}$)	$r_{ds(on)}$			Ohms
	MFE2010	—	25	
	MFE2011	—	15	
	MFE2012	—	10	
Input Capacitance ($V_{DS} = 0$, $V_{GS} = 10 \text{Vdc}$, $f = 1.0 \text{MHz}$)	C_{iss}	—	50	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 12 \text{Vdc}$, $f = 1.0 \text{MHz}$)	C_{rss}	—	20	pF

MFE2010, MFE2011, MFE2012

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Turn-On Delay Time	$t_{d(on)}$	—	10	ns
Rise Time	t_r	—	6.0	ns
Turn-Off Delay Time ($V_{DD} = 15\text{ Vdc}$, $I_D = 8.0\text{ mAdc}$) ($V_{DD} = 15\text{ Vdc}$, $I_D = 15\text{ mAdc}$) ($V_{DD} = 15\text{ Vdc}$, $I_D = 30\text{ mAdc}$)	$t_{d(off)}$	— — —	35 20 12	ns
Fall Time ($V_{DD} = 15\text{ Vdc}$, $I_D = 8.0\text{ mAdc}$) ($V_{DD} = 15\text{ Vdc}$, $I_D = 15\text{ mAdc}$) ($V_{DD} = 15\text{ Vdc}$, $I_D = 30\text{ mAdc}$)	t_f	— — —	75 45 25	ns

*Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 3.0\%$.

MFE3001

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

FET
LOW-POWER AUDIO

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	± 20	Vdc
Drain Current	I_D	20	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	+200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

Refer to 2N3796 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($V_{GS} = -8.0\text{ V}$, $I_D = 10\ \mu\text{Adc}$)	$V_{(BR)DSX}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = -10\text{ Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	10	pAdc
Gate Source Cutoff Voltage ($I_{DS} = 1.0\ \mu\text{Adc}$, $V_{DS} = 10\text{ Vdc}$)	$V_{GS(off)}$	—	-8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{GS} = 0\text{ Vdc}$, $V_{DS} = 10\text{ Vdc}$)	I_{DSS}	0.5	6.0	mAdc
On-State Drain Current ($V_{GS} = 3.5\text{ Vdc}$, $V_{DS} = 10\text{ Vdc}$)	$I_{D(on)}$	5.0	—	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 10\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ kHz}$)	$ y_{fs} $	700	3500	μhos
Output Admittance ($V_{DS} = 10\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ kHz}$)	$ y_{os} $	—	100	μhos
Input Capacitance ($V_{DS} = 10\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 10\text{ Vdc}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{rss}	—	1.5	pF

MFE3002

CASE 20-03, STYLE 7
TO-72 (TO-206AF)

**MOSFET
CHOPPER**

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	15	Vdc
Drain-Gate Voltage	V _{DG}	20	Vdc
Gate-Source Voltage	V _{GS}	±20	Vdc
Drain Current	I _D	30	mAdc
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	200 1.4	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V _{DS} = +10 Vdc, V _{GS} = 0) (V _{DS} = +10 Vdc, V _{GS} = 0, T _C = 125°C)	I _{DSS}	— —	10 100	nAdc
Gate Reverse Current (V _{GS} = ±10 Vdc, V _{DS} = 0)	I _{GSS}	—	±100	pAdc
Drain-Source Breakdown Voltage (V _{GS} = 0, I _D = 10 μAdc)	V _{(BR)DS}	15	—	Vdc
ON CHARACTERISTICS				
Gate Threshold Voltage (V _{DS} = +10 Vdc, I _D = 10 μAdc)	V _{GS(TH)}	—	3.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance (V _{DS} = +10 Vdc, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	—	5.0	pF
Reverse Transfer Capacitance (V _{DS} = 0, V _{GS} = 0, f = 1.0 MHz)	C _{rss}	—	1.0	pF
Drain-Substrate Capacitance (V _{D(SUB)} = +10 Vdc, f = 1.0 MHz)	C _{d(sub)}	—	4.0	pF
Static Drain-Source On Resistance (V _{GS} = +10 Vdc, I _D = 0, f = 1.0 kHz)	r _{ds(on)}	—	100	Ohms

MFE3003

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

MOSFET
CHOPPER

P-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-15	Vdc
Drain-Gate Voltage	V_{DG}	± 20	Vdc
Gate-Source Voltage	V_{GS}	± 20	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.33	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($V_{GS} = 0, I_D = -10 \mu\text{Adc}$)	$V_{(BR)DSX}$	-15	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0$) ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0, T_C = 125^\circ\text{C}$)	I_{DSS}	— —	-10 -100	nAdc
Gate Reverse Current ($V_{GS} = \pm 10 \text{ Vdc}, V_{DS} = 0$)	I_{GSS}	—	± 100	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage ($V_{DS} = -10 \text{ Vdc}, I_D = -10 \mu\text{Adc}$)	$V_{GS(Th)}$	—	-4.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance ($V_{GS} = -10 \text{ Vdc}, I_D = 0, f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	—	200	Ohms
Input Capacitance ($V_{DS} = -10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{rss}	—	1.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = -10 \text{ Vdc}, f = 1.0 \text{ MHz}$)	$C_{d(sub)}$	—	2.0	pF

MFE3004 MFE3005

CASE 20-03, STYLE 7
TO-72 (TO-206AF)

MOSFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	± 20	Vdc
Drain Current	I_D	10	mA _{dc}
Total Device Dissipation (at $T_C = 25^\circ\text{C}$ Derate above 25°C)	P_D	200 1.33	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage ($V_{GS} = -5.0$ Vdc, $I_D = 10$ μA dc)	$V_{(BR)DSX}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = \pm 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	± 50	pA _{dc}
Gate Source Cutoff Voltage ($I_D = 10$ μA dc, $V_{DS} = 15$ Vdc)	$V_{GS(off)}$	—	-5.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	2.0	10	mA _{dc}
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SMALL-SIGNAL CHARACTERISTICS

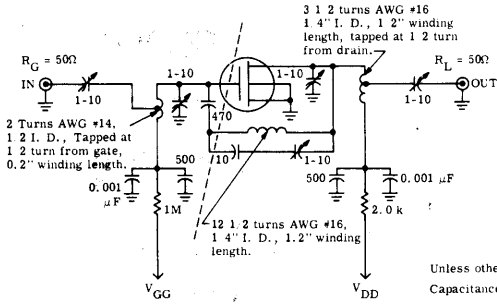
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $I_D = 2.0$ mA _{dc} , $f = 1.0$ kHz)	$ Y_{fs} $	2000	—	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1.0$ MHz)	C_{iss}	—	4.5	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1.0$ MHz)	C_{rss}	—	0.4	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 15$ Vdc, $I_D = 2.0$ mA _{dc} , $R_S \approx 1.8$ k ohms, $f = 200$ MHz) (Figure 1) MFE3004 ($V_{DS} = 15$ Vdc, $I_D = 2.0$ mA _{dc} , $R_S \approx 650$ ohms, $f = 400$ MHz) (Figure 2) MFE3005	NF	—	4.5 4.5	dB
Common Source Power Gain ($V_{DS} = 15$ Vdc, $I_D = 2.0$ mA _{dc} , $R_S \approx 1.8$ k ohms, $f = 200$ MHz) (Figure 1) MFE3004 ($V_{DS} = 15$ Vdc, $I_D = 2.0$ mA _{dc} , $R_S \approx 650$ ohms, $f = 400$ MHz) (Figure 2) MFE3005	G_{ps}	16 10	— —	dB

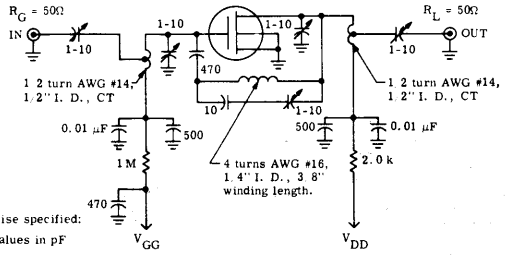
MFE3004, MFE3005

FIGURE 1 - 200 MHz TEST CIRCUIT - NEUTRALIZED



Unless otherwise specified:
Capacitance values in pF

FIGURE 2 - 400 MHz TEST CIRCUIT - NEUTRALIZED



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MFE9200

CASE 22-03, STYLE 12
TO-18 (TO-206AA)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	200	Vdc
Gate-Source Voltage	V _{GS}	± 20	Vdc
Drain Current Continuous (1)	I _D	400	mAdc
Pulsed (2)	I _{DM}	800	
Total Device Dissipation (at T _C = 25°C Derate above 25°C)	P _D	1.8 14.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage (V _{GS} = 0, I _D = 10 μA)	V _{(BR)DSX}	200	—	—	Vdc
Gate Reverse Current (V _{GS} = 15 Vdc, V _{DS} = 0)	I _{GSS}	—	0.01	50	nAdc

ON CHARACTERISTICS*

Zero-Gate-Voltage Drain Current (V _{DS} = 200 V, V _{GS} = 0)	I _{DSS}	—	0.1	10	μAdc
Gate Threshold Voltage (V _{DS} = V _{GS} , I _D = 1.0 mA)	V _{GS(Th)}	1.0	—	4.0	Vdc
Drain-Source On-Voltage (V _{GS} = 10 V) (I _D = 100 mA) (I _D = 250 mA) (I _D = 500 mA)	V _{DS(on)}	— — —	0.45 1.20 3.0	0.6 1.60 —	Vdc
Static Drain-Source On Resistance (V _{GS} = 10 Vdc) (I _D = 100 mA) (I _D = 250 mA) (I _D = 500 mA)	r _{DS(on)}	— — —	4.5 4.8 6.0	6.0 6.4 —	Ohms
On-State Drain Current (V _{DS} = 25 V, V _{GS} = 10 V)	I _{D(on)}	400	700	—	mA

SMALL-SIGNAL CHARACTERISTICS

Input Capacitance (V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	—	72	90	pF
Reverse Transfer Capacitance (V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{rss}	—	2.8	3.5	pF
Output Capacitance (V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{oss}	—	15	20	pF
Forward Transconductance (V _{DS} = 25 V, I _D = 250 mA)	g _{fs}	200	400	—	mmhos

SWITCHING CHARACTERISTICS

Turn-On Time See Figure 1	t _{on}	—	6.0	15	ns
Turn-Off Time See Figure 1	t _{off}	—	6.0	15	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

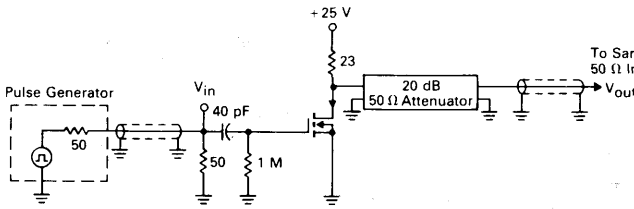


FIGURE 2 — SWITCHING WAVEFORMS

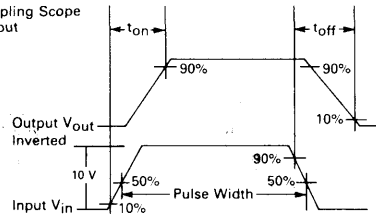


FIGURE 3 — ON VOLTAGE versus TEMPERATURE

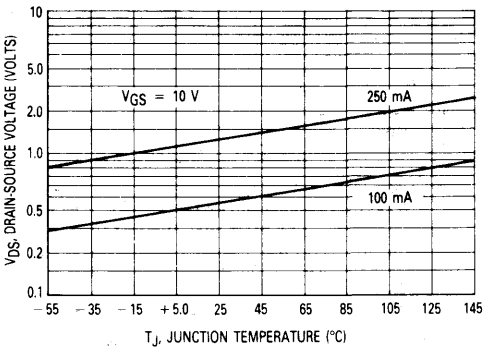


FIGURE 4 — CAPACITANCE VARIATION

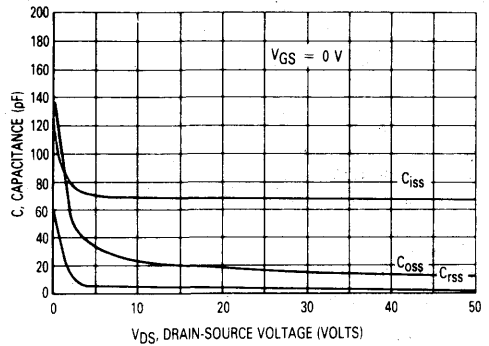


FIGURE 5 — TRANSFER CHARACTERISTIC

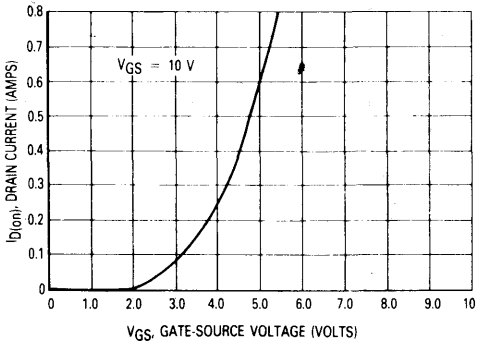
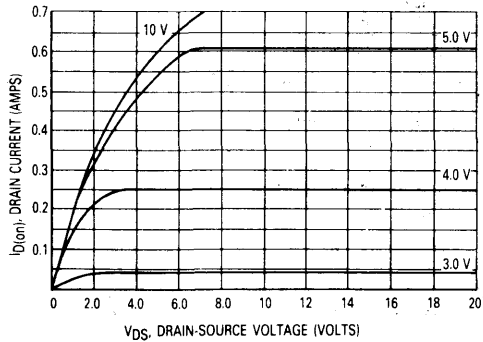
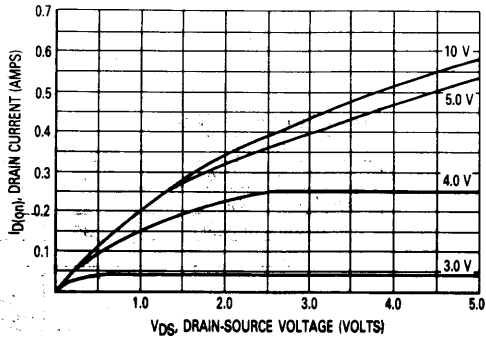


FIGURE 6 — OUTPUT CHARACTERISTIC



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FIGURE 7 — SATURATION CHARACTERISTIC



MFQ107

CASE 646-05, STYLE 1

QUAD
DUAL IN LINE
TMOS

N-CHANNEL - ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Drain-Source Voltage	V _{DS}	200		Vdc
Drain-Gate Voltage	V _{DG}	200		Vdc
Gate-Source Voltage	V _{GS}	±20		Vdc
Drain Current	I _D	400		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T _A = 25°C (1) Derate above 25°C	P _D	0.5 4.0	1.2 9.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150		°C

Refer to MFE9200 for graphs

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V _{GS} = 0, I _D = 10 μA)	V(BR)DSS	200	—	—	Vdc
Zero Gate Voltage Drain Current (V _{DS} = 130 V, V _{GS} = 0)	I _{DSS}	—	0.1	10	μAdc
Gate-Body Leakage Current (V _{GS} = 15 Vdc, V _{DS} = 0)	I _{GSS}	—	0.01	50	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (I _D = 1.0 mA, V _{DS} = V _{GS})	V _{GS(th)}	1.0	—	4.0	Vdc
Static Drain-Source On-Resistance (V _{GS} = 10 Vdc) (I _D = 100 mA) (I _D = 250 mA) (V _{GS} = 2.6 V, I _D = 20 mA)	r _{DS(on)}	—	4.5 — 4.8	15 15 30	Ohms
Drain-Source On-Voltage (V _{GS} = 10 V) (I _D = 100 mA) (I _D = 250 mA) (I _D = 500 mA)	V _{DS(on)}	—	0.45 — 1.20 — 3.0	1.5 3.75 —	Vdc
Forward Transconductance (V _{DS} = 25 V, I _D = 250 mA)	g _{fs}	200	400	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	—	72	90	pF
Output Capacitance (V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{oss}	—	15	20	pF
Reverse Transfer Capacitance (V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{rss}	—	2.8	3.5	pF
SWITCHING CHARACTERISTICS*					
Turn-On Time See Figure 1	t _{on}	—	6.0	15	ns
Turn-Off Time See Figure 1	t _{off}	—	12	15	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

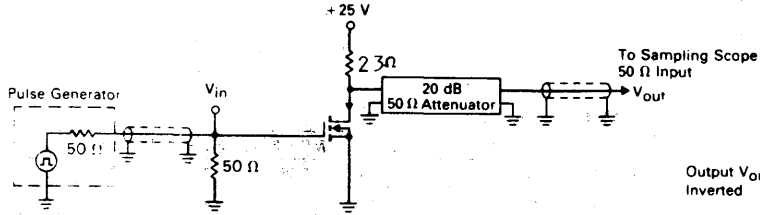
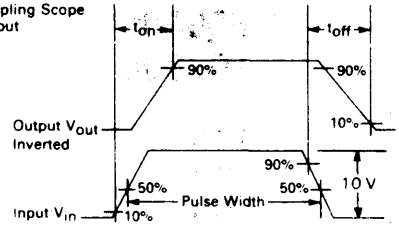


FIGURE 2 — SWITCHING WAVEFORMS



MFQ930C MFQ960C MFQ990C

CASE 632-02, STYLE 1
TO-116

QUAD
DUAL-IN-LINE
T MOS

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	MFQ930C	MFQ960C	MFQ990C	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}	± 30			Vdc
Drain Current Continuous (1) Pulsed (2)	I_D I_{DM}	2.0 3.0			Adc
			Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate Above 25°C	P_D	0.5	17.0	2.0 66.6	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150			$^\circ\text{C}$

Refer to MFE930 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($V_{GS} = 0, I_D = 10 \mu\text{A}$)	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}, V_{DS} = 0$)	I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*					
Zero-Gate-Voltage Drain Current ($V_{DS} = \text{Maximum Rating}, V_{GS} = 0$)	I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage ($I_D = 1.0 \text{ mA}, V_{DS} = V_{GS}$)	$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage ($V_{GS} = 10 \text{ V}$) ($I_D = 0.5 \text{ A}$)	$V_{DS(on)}$	— — —	0.4 0.6 0.6	0.7 0.8 1.0	Vdc
($I_D = 1.0 \text{ A}$)		— — —	0.9 1.2 1.2	1.4 1.7 2.0	
($I_D = 2.0 \text{ A}$)		— — —	2.2 2.8 2.8	3.0 3.5 4.0	
Static Drain-Source On Resistance ($V_{GS} = 10 \text{ Vdc}, I_D = 1.0 \text{ Adc}$)	$r_{DS(on)}$	— — —	0.9 1.2 1.2	1.4 1.7 2.0	Ohms
On-State Drain Current ($V_{DS} = 25 \text{ V}, V_{GS} = 10 \text{ V}$)	$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	60	70	pF
Reverse Transfer Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{rss}	—	13	18	pF
Output Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{oss}	—	49	60	pF
Forward Transconductance ($V_{DS} = 25 \text{ V}, I_D = 0.5 \text{ A}$)	g_{fs}	200	380	—	mmhos
SWITCHING CHARACTERISTICS					
Turn-On Time	t_{on}	—	7.0	15	ns
Turn-Off Time	t_{off}	—	7.0	15	ns

MPF102

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF AMPLIFIER
N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 2	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-25	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	—	-2.0 -2.0	nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 2.0 \text{ nAdc}$)	$V_{GS(off)}$	—	-8.0	Vdc
Gate Source Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 0.2 \text{ mAdc}$)	V_{GS}	-0.5	-7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0 \text{ Vdc}$)	I_{DSS}	2.0	20	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance* ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$ y_{fs} $	2000 1600	7500 —	μmhos
Input Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$\text{Re}(y_{is})$	—	800	μmhos
Output Conductance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$\text{Re}(y_{os})$	—	200	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	3.0	pF

*Pulse Test: Pulse Width $\leq 630 \text{ ms}$; Duty Cycle $\leq 10\%$.

MPF108

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF AMPLIFIER
N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	310 2.82	mW mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +135	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

Refer to 2N4416 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-25	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	—	1.0 -1.0	nAdc μAdc
Gate-Source Cutoff Voltage* ($V_{DS} = 15 \text{ Vdc}$, $I_D = 10 \mu\text{Adc}$)	$V_{GS(off)}$ *	0.5	8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS} *	1.5	24	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$ y_{fs} $	1600	—	μhos
Forward Transadmittance* ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	y_{fs} *	2000	7500	μhos
Input Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$\text{Re}(y_{is})$	—	800	μhos
Output Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	—	75	μhos
Output Conductance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$\text{Re}(y_{os})$	—	200	μhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	6.5	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	2.5	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $R_G = 1.0 \text{ Megohm}$, $f = 1.0 \text{ kHz}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $R_G = 1.0 \text{ k ohm}$, $f = 100 \text{ MHz}$)	NF	—	2.5 3.0	dB

*To characterize these devices to narrower limits, regarding I_{DSS} , $V_{GS(off)}$ and y_{fs} , the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	I_{DS}	$V_{GS(off)}$	y_{fs}
Orange	1.5 mAdc Min, 3.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μhos
Yellow	2.5 mAdc Min, 5.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μhos
Green	4.0 mAdc Min, 8.0 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μhos
Blue	7.0 mAdc Min, 14 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μhos
Violet	12 mAdc Min, 24 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	3000 to 7500 μhos

MPF130,131,132 MFE130,131,132

**MPF130 SERIES
CASE 317-01, STYLE 1**

**MFE130 SERIES
CASE 20-03, STYLE 9
TO-72 (TO-206AF)**

**DUAL-GATE
MOSFET
VHF AMPLIFIER**

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	25		Vdc
Drain Current	I_D	30		mAdc
		MPF130 Series	MFE130 Series	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ (Package Limitation) Derate above 25°C	P_D	300	300	mW mW/°C
		2.4	1.71	
Operating and Storage Channel Temperature Range	$T_{\text{channel}}, T_{\text{stg}}$	-65 to +150	-65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage ($I_D = 10 \mu\text{Adc}, V_S = 0, V_{G1} = -4.0 \text{ V}, V_{G2} = +4.0 \text{ V}$)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage ($I_{G1} = \pm 10 \mu\text{Adc}, V_{G2S} = 0$)	$V_{(BR)G1SO}$	± 7.0	—	± 20	Vdc
Gate 2-Source Breakdown Voltage ($I_{G2} = \pm 10 \mu\text{Adc}, V_{G2S} = 0$)	$V_{(BR)G2SO}$	± 7.0	—	± 20	Vdc
Gate 1 Leakage Current ($V_{G1S} = \pm 6.0 \text{ Vdc}, V_{G2S} = 0, V_{DS} = 0$)	I_{G1SS}	—	—	20	nAdc
Gate 2 Leakage Current ($V_{G2S} = \pm 6.0 \text{ Vdc}, V_{G1S} = 0, V_{DS} = 0$)	I_{G2SS}	—	—	20	nAdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = 200 \mu\text{Adc}$)	$V_{G1S(\text{off})}$	—	—	-4.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}, V_{G1S} = 0, I_D = 200 \mu\text{Adc}$)	$V_{G2S(\text{off})}$	—	—	-4.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ Vdc}, V_{G1S} = 0, V_{G2S} = 4.0 \text{ Vdc}$)	I_{DSS}	3.0	10	30	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance (Gate 1 connected to Drain) ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = 10 \text{ mAdc}, f = 1.0 \text{ kHz}$)	$ y_{fs} $	8000	—	20000	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = I_{DSS}, f = 1.0 \text{ MHz}$)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = 6.0 \text{ mAdc}, f = 1.0 \text{ MHz}$)	C_{rss}	—	0.023	0.05	pF
Output Capacitance ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = I_{DSS}, f = 1.0 \text{ MHz}$)	C_{oss}	—	2.5	4.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure (Figure 7) ($V_{DS} = 15 \text{ Vdc}, V_{G2S} = 4.0 \text{ Vdc}, I_D = 6.0 \text{ mAdc}, Z_S$ is optimized for NF) (f = 105 MHz) (f = 60 MHz) (f = 100 MHz)	NF				dB
		MPF/MFE130	—	2.9	5.0
		MPF/MFE131	—	2.5	5.0
		MPF/MFE131	—	3.0	5.0

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MPF130,131,132, MFE130,131,132

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Common Source Power Gain (Figure 7) ($V_{DS} = 15\text{ Vdc}$, $V_{G2S} = 4.0\text{ Vdc}$, $I_D = 6.0\text{ mAdc}$, Z_S is optimized for NF)	G_{ps}				dB
($f = 105\text{ MHz}$)	MPF/MFE130	17	23	—	
($f = 60\text{ MHz}$)	MPF/MFE131	20	27	—	
($f = 200\text{ MHz}$)	MPF/MFE131	17	20	—	
Level of Unwanted Signal for 1.0% Cross Modulation ($V_{DS} = 15\text{ Vdc}$, $V_{G2S} = 4.0\text{ Vdc}$, $I_D = 6.0\text{ mAdc}$)	—	—	100	—	mV
Common-Source Conversion Power Gain (Gate 1 Injection, Figure 8) ($V_{DS} = 15\text{ Vdc}$, $V_{G2S} = 4.0\text{ Vdc}$, Local Oscillator Voltage = 925 mVrms)	G_C				dB
(Signal Frequency = 60 MHz, Local Oscillator Frequency = 104 MHz)	MPF/MFE132	15	16.5	—	
(Signal Frequency = 200 MHz, Local Oscillator Frequency = 244 MHz)	MPF/MFE132	12	14	—	

COMMON-SOURCE ADMITTANCE PARAMETERS

($V_{DS} = 15\text{ Vdc}$, $V_{G2S} = 4.0\text{ Vdc}$, $I_D = 6.0\text{ mAdc}$)

6

FIGURE 1 – INPUT ADMITTANCE

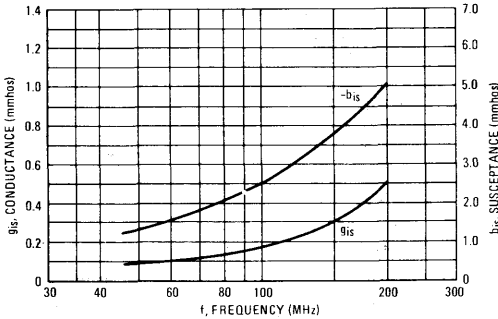


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

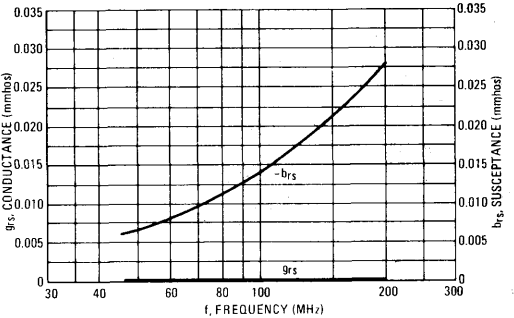


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

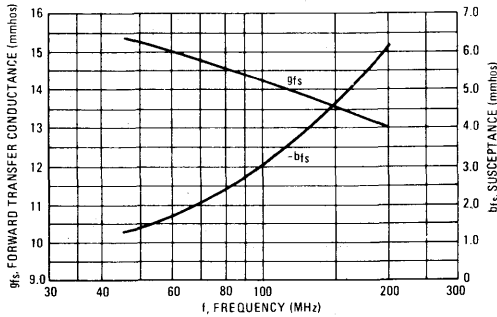


FIGURE 4 – OUTPUT ADMITTANCE

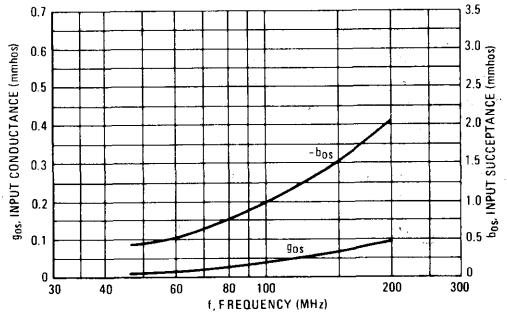


FIGURE 5 - GAIN REDUCTION

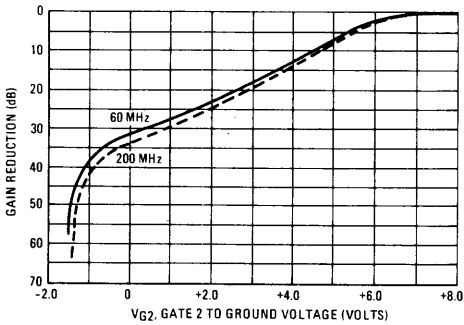


FIGURE 6 - CONVERSION POWER GAIN

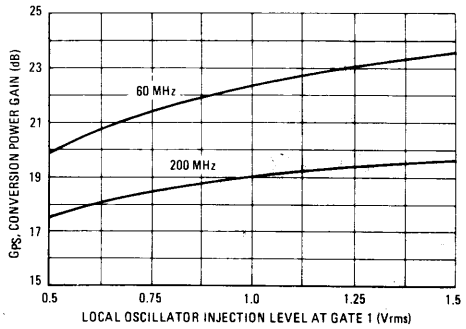


FIGURE 7 - 60, 105 AND 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT

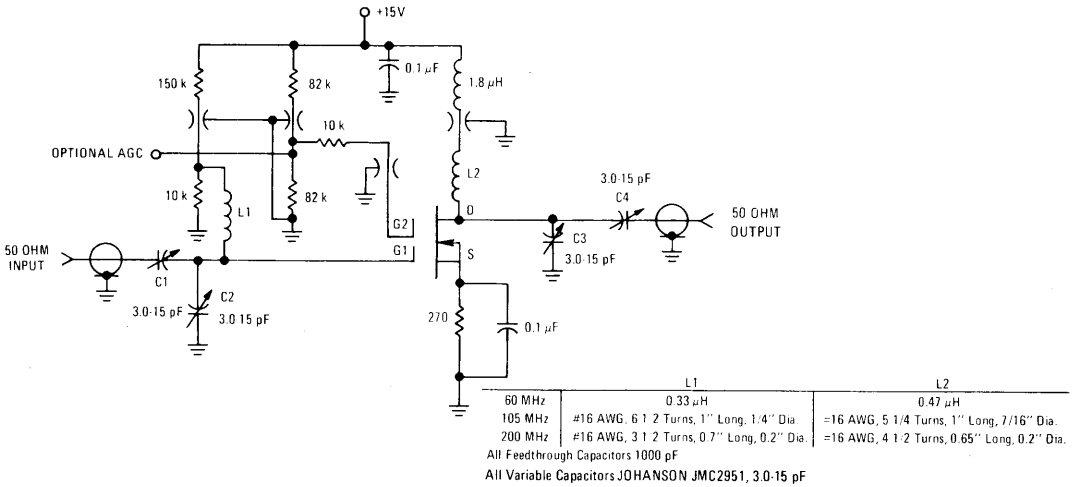
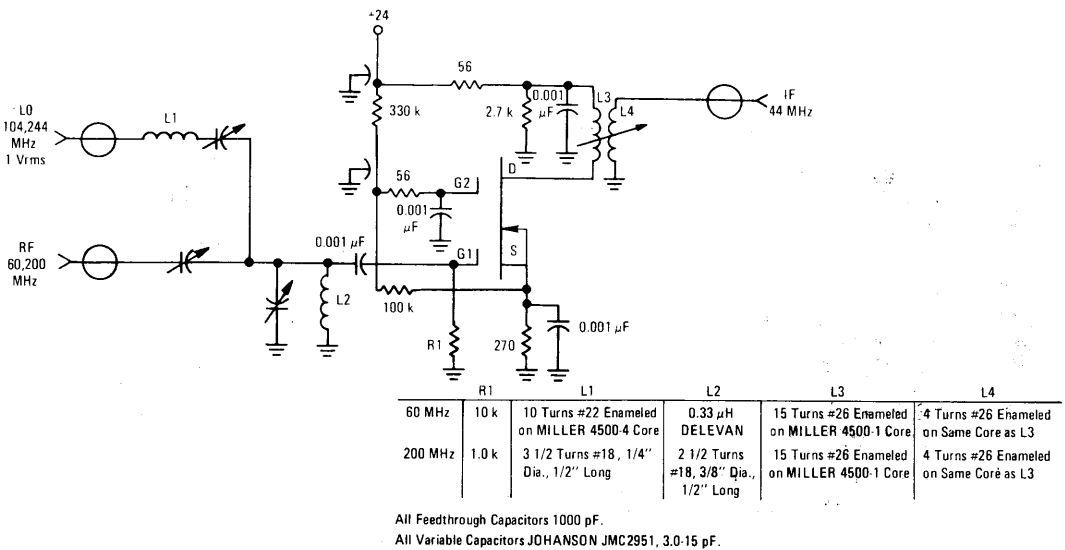


FIGURE 8 - 60 AND 200 MHz CONVERSION GAIN TEST CIRCUIT



MPF201 MPF202 MPF203

CASE 317-01, STYLE 1

DUAL-GATE MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30	Vdc
Drain Current	I_D	50	mAdc
Gate Current	I_{G1} I_{G2}	± 10 ± 10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.4	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 8.0	Watt mW/ $^\circ\text{C}$
Lead Temperature	T_L	260	$^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +150	$^\circ\text{C}$
Storage Channel Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage ($I_D = 10 \mu\text{Adc}$, $V_S = 0$, $V_{G1S} = V_{G2S} = -5.0 \text{ Vdc}$)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage(1) ($I_{G1} = \pm 10 \text{ mAdc}$, $V_{G2S} = V_{DS} = 0$)	$V_{(BR)G1SO}$	± 6.0	± 12	± 30	Vdc
Gate 2-Source Breakdown Voltage(1) ($I_{G2} = \pm 10 \text{ mAdc}$, $V_{G1S} = V_{DS} = 0$)	$V_{(BR)G2SO}$	± 6.0	± 12	± 30	Vdc
Gate 1 Leakage Current ($V_{G1S} = \pm 5.0 \text{ Vdc}$, $V_{G2S} = V_{DS} = 0$) ($V_{G1S} = -5.0 \text{ Vdc}$, $V_{G2S} = V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{G1SS}	—	± 0.040	± 100	nAdc μAdc
Gate 2 Leakage Current ($V_{G2S} = \pm 5.0 \text{ Vdc}$, $V_{G1S} = V_{DS} = 0$) ($V_{G2S} = -5.0 \text{ Vdc}$, $V_{G1S} = V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{G2SS}	—	± 0.050	± 100	nAdc μAdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 20 \mu\text{Adc}$)	$V_{G1S(\text{off})}$	-0.5	-1.5	-5.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{G1S} = 0$, $I_D = 20 \mu\text{Adc}$)	$V_{G2S(\text{off})}$	-0.2	-1.4	-5.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(2) ($V_{DS} = 15 \text{ Vdc}$, $V_{G1S} = V_{G2S} = 4.0 \text{ Vdc}$)	I_{DSS}	6.0 3.0	13 11	30 15	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance(3) ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $V_{G1S} = 0$, $f = 1.0 \text{ kHz}$)	$ Y_{fs} $	8.0 7.0	12.8 12.5	20 15	mmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = I_{DSS}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	3.3	—	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = 10 \text{ mAdc}$, $f = 1.0 \text{ MHz}$)	C_{rss}	0.005	0.014	0.05	pF
Output Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{G2S} = 4.0 \text{ Vdc}$, $I_D = I_{DSS}$, $f = 1.0 \text{ MHz}$)	C_{oss}	—	1.7	—	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DD} = 18 \text{ Vdc}$, $V_{GG} = 7.0 \text{ Vdc}$, $f = 200 \text{ MHz}$) (Figure 1) ($V_{DD} = 18 \text{ Vdc}$, $V_{GG} = 6.0 \text{ Vdc}$, $f = 45 \text{ MHz}$) (Figure 3)	MPF201 MPF203	NF	— —	1.8 5.3	5.0 6.0	dB
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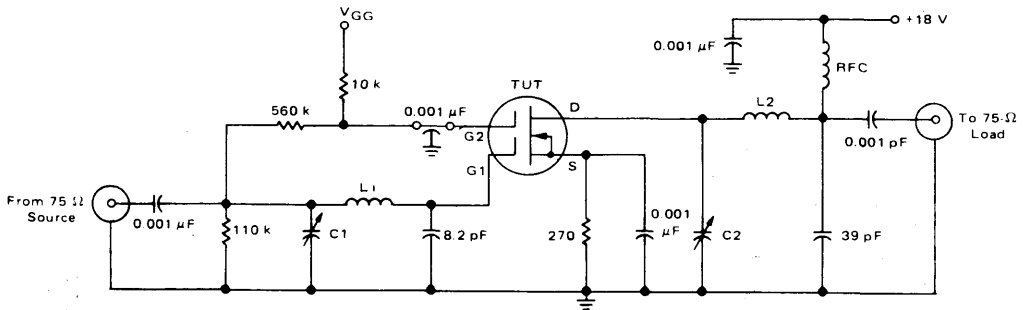
MPF201, MPF202, MPF203

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
Common Source Power Gain ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 7.0\text{ Vdc}$, $f = 200\text{ MHz}$) (Figure 1)	G_{ps}	15	20	25	dB	
($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$) (Figure 3)	MPF203	20	25	30		
($V_{DD} = 18\text{ Vdc}$, $f_{LO} = 245\text{ MHz}$, $f_{RF} = 200\text{ MHz}$) (Figure 2)	MPF202	15	19	25		
Bandwidth ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 7.0\text{ Vdc}$, $f = 200\text{ MHz}$) (Figure 1)	BW	5.0	—	9.0	MHz	
($V_{DD} = 18\text{ Vdc}$, $f_{LO} = 245\text{ MHz}$, $f_{RF} = 200\text{ MHz}$) (Figure 2)		MPF201	4.5	—		7.5
($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$) (Figure 3)		MPF203	3.0	—		6.0
Gain Control Gate-Supply Voltage(4)	$V_{GG}(GC)$	0	-1.0	-3.0	Vdc	
($V_{DD} = 18\text{ Vdc}$, $\Delta G_{ps} = -30\text{ dB}$, $f = 200\text{ MHz}$) (Figure 1)		MPF201	0	-1.0		-3.0
($V_{DD} = 18\text{ Vdc}$, $\Delta G_{ps} = -30\text{ dB}$, $f = 45\text{ MHz}$) (Figure 3)		MPF203	0	-0.6		-3.0

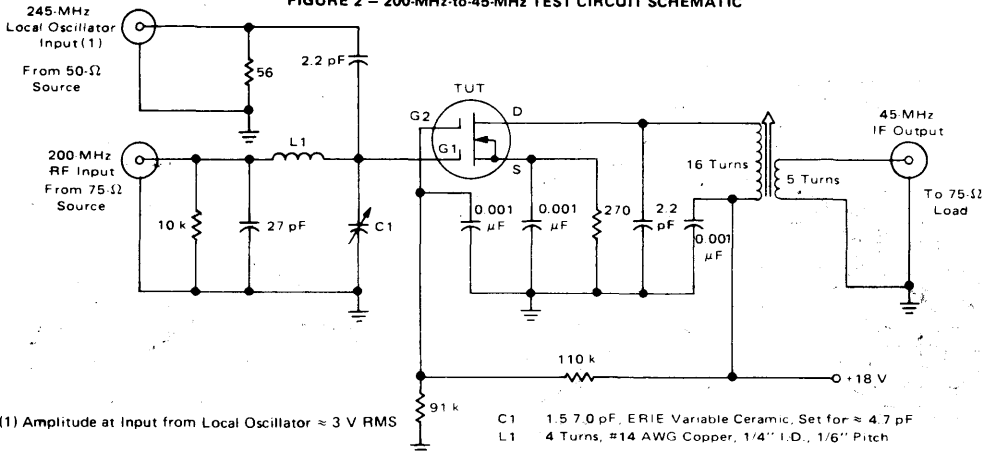
- (1) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage limiting network is functioning properly.
- (2) Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2.0\%$.
- (3) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.
- (4) ΔG_{ps} is defined as the change in G_{ps} from the value at $V_{GG} = 7.0$ volts (MPF201) and $V_{GG} = 6.0$ volts (MPF203).
- (5) Power Gain Conversion

FIGURE 1 - 200-MHz TEST CIRCUIT SCHEMATIC



- C1 4.0 30 pF, ERIE Variable Ceramic, Set for $\approx 22\text{ pF}$
- C2 4.0 30 pF, ERIE Variable Ceramic, Set for $\approx 10\text{ pF}$
- L1 4 Turns, #14 AWG Cooper, 1/4" I.D., 1/8" Pitch
- L2 3 Turns, #14 AWG Cooper, 1/4" I.D., 1/8" Pitch
- RFC DELEVAN No. 153712, 1.0 μH

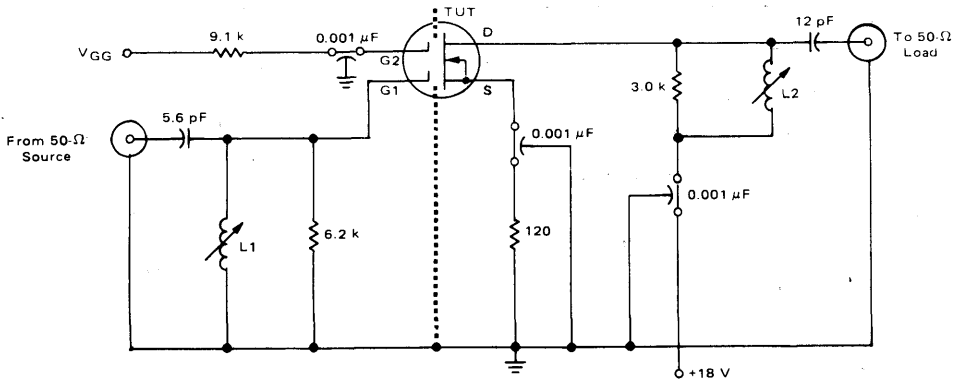
FIGURE 2 - 200-MHz-to-45-MHz TEST CIRCUIT SCHEMATIC



- (1) Amplitude at Input from Local Oscillator $\approx 3\text{ V RMS}$

- C1 1.5 7.0 pF, ERIE Variable Ceramic, Set for $\approx 4.7\text{ pF}$
- L1 4 Turns, #14 AWG Copper, 1/4" I.D., 1/8" Pitch

FIGURE 3 - 45-MHz TEST CIRCUIT SCHEMATIC



- L1 14 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core
- L2 10 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core

TYPICAL CHARACTERISTICS

FIGURE 4 - DRAIN CURRENT versus DRAIN to SOURCE VOLTAGE

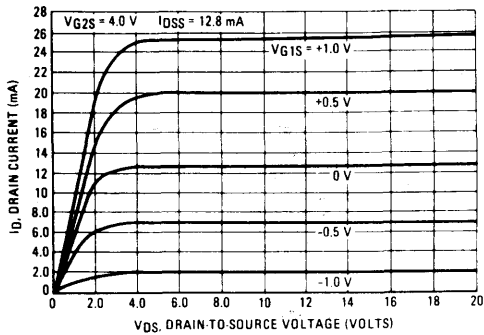


FIGURE 5 - DRAIN CURRENT versus GATE-ONE to SOURCE VOLTAGE

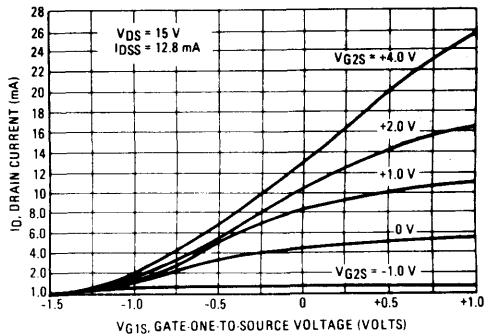


FIGURE 6 - SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

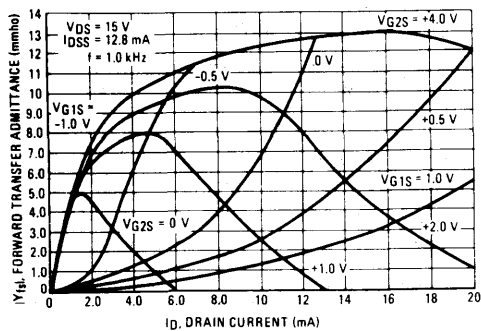
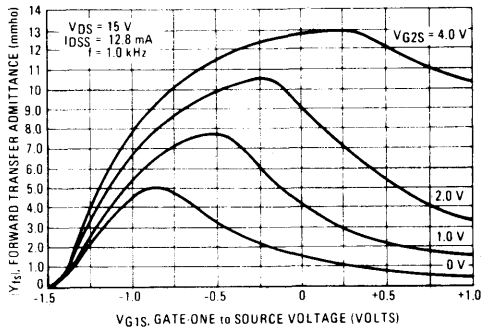


FIGURE 7 - SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-ONE to SOURCE VOLTAGE



MPF201, MPF202, MPF203

FIGURE 8 - SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-TWO to SOURCE VOLTAGE

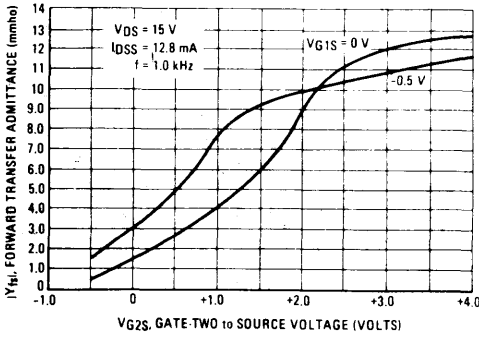


FIGURE 9 - SMALL-SIGNAL COMMON-SOURCE GATE-ONE INPUT AND OUTPUT CAPACITANCE versus GATE-TWO to SOURCE VOLTAGE

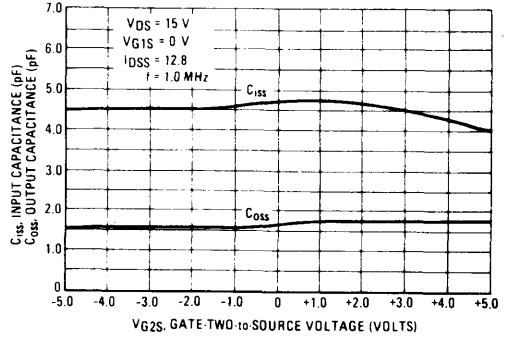


FIGURE 10 - COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus DRAIN CURRENT

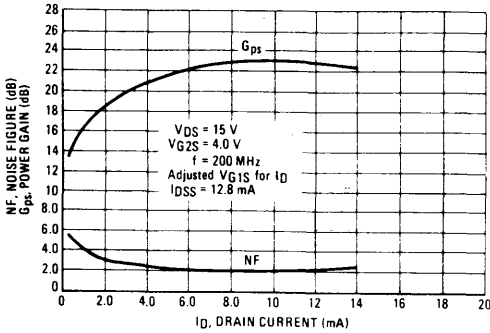


FIGURE 11 - COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus GAIN CONTROL GATE-SUPPLY VOLTAGE - MPF201

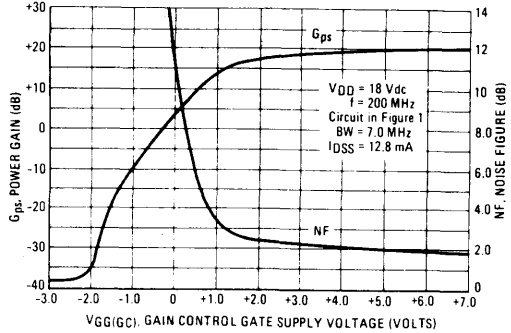


FIGURE 12 - SMALL-SIGNAL COMMON SOURCE INSERTION POWER GAIN versus GAIN CONTROL GATE-SUPPLY VOLTAGE - MPF203

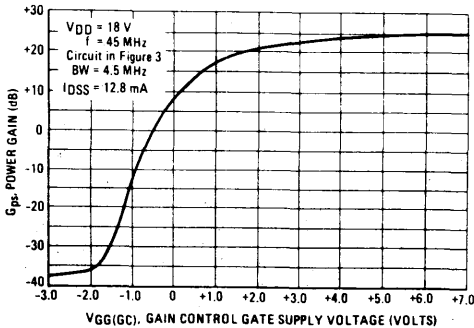
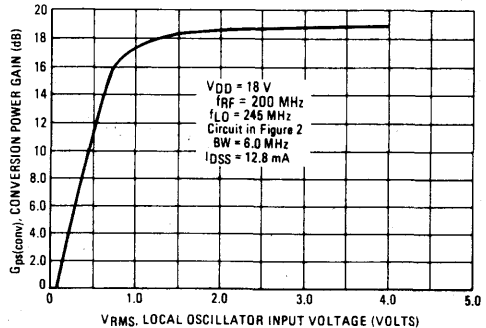


FIGURE 13 - SMALL-SIGNAL COMMON-SOURCE CONVERSION POWER GAIN versus LOCAL OSCILLATOR INPUT VOLTAGE - MPF202



MPF201, MPF202, MPF203

FIGURE 14 — SMALL-SIGNAL GATE ONE FORWARD TRANSFER ADMITTANCE versus FREQUENCY

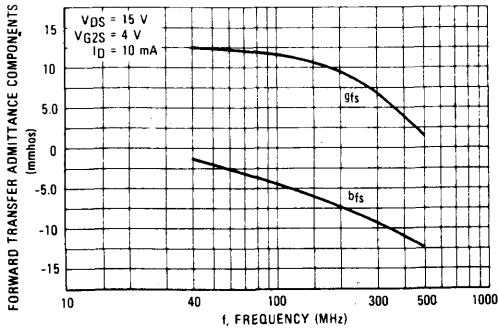


FIGURE 15 — SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

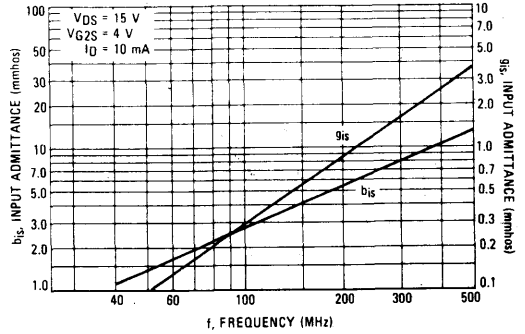


FIGURE 16 — SMALL-SIGNAL GATE ONE OUTPUT ADMITTANCE versus FREQUENCY

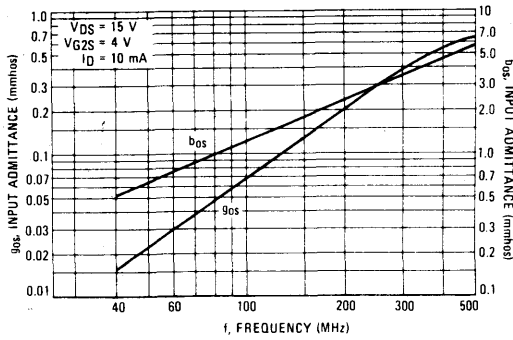
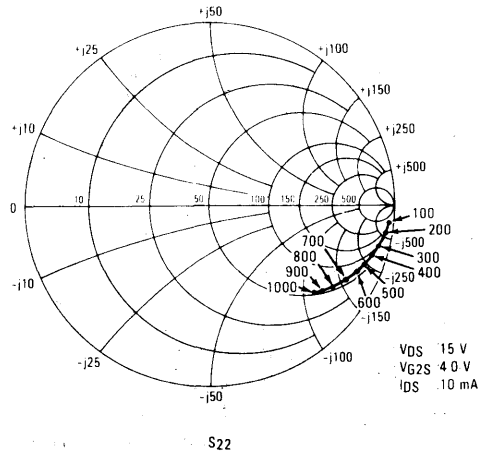
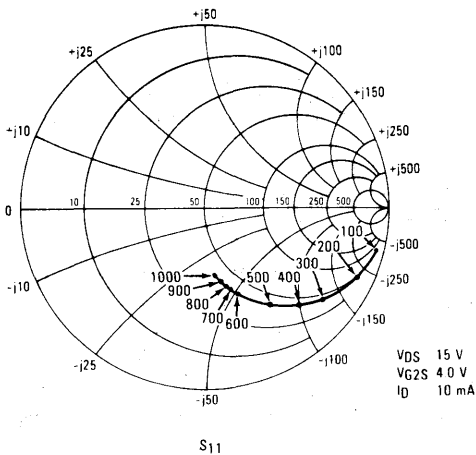


FIGURE 17 — S PARAMETERS PLOTTED ON 50 OHM SMITH CHART



MPF211 MPF212 MPF213

CASE 317-01, STYLE 1

DUAL-GATE MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	MPF211 MPF212	MPF213	Unit
Drain-Source Voltage	V _{DS}	27	35	Vdc
Drain-Gate Voltage	V _{DG1} V _{DG2}	35 35	40 40	Vdc
Drain Current — Continuous	I _D	50		mAdc
Gate Current	I _{G1} I _{G2}	± 10 ± 10		mAdc
Total Device Dissipation (α T _A = 25°C Derate above 25°C	P _D	300 1.71		mW mW/°C
Total Device Dissipation (α T _C = 25°C Derate above 25°C	P _D	1.2 8.0		Watt mW/°C
Lead Temperature, 1/16" From Seated Surface for 10 Seconds	T _L	260		°C
Junction Temperature Range	T _J	-65 to +150		°C
Storage Channel Temperature Range	T _{stg}	-65 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage (V _{G1S} = V _{G2S} = -4.0 Vdc, I _D = 10 μAdc)	MPF211,212 MPF213	V _{(BR)DSX}	25 30	— —	Vdc
Instantaneous Drain-Source Breakdown Voltage(1) (V _{G1S} = V _{G2S} = -4.0 Vdc, I _D = 10 μAdc)	MPF211,212 MPF213	V _{(BR)DSX}	27 35	— —	Vdc
Gate 1-Source Breakdown Voltage(2) (V _{G2S} = V _{DS} = 0, I _{G1} = ± 10 mAdc)		V _{(BR)G1SO}	± 6.0	—	Vdc
Gate 2-Source Breakdown Voltage(2) (V _{G1S} = V _{DS} = 0, I _{G2} = ± 10 mAdc)		V _{(BR)G2SO}	± 6.0	—	Vdc
Gate 1 Leakage Current (V _{G1S} = ± 5.0 Vdc, V _{G2S} = V _{DS} = 0) (V _{G1S} = -5.0 Vdc, V _{G2S} = V _{DS} = 0, T _A = 150°C)		I _{G1SS}	± 0.04(Typ) —	± 100 -100	nAdc μAdc
Gate 2 Leakage Current (V _{G2S} = ± 5.0 Vdc, V _{G1S} = V _{DS} = 0) (V _{G2S} = -5.0 Vdc, V _{G1S} = V _{DS} = 0, T _A = 150°C)		I _{G2SS}	± 0.04(Typ) —	± 100 -100	nAdc μAdc
Gate 1 to Source Cutoff Voltage (V _{DS} = 15 Vdc, V _{G2S} = 4.0 Vdc, I _D = 2.0 μAdc)	MPF211,213 MPF212	V _{G1S(off)}	-0.5 -0.5	-5.5 -4.0	Vdc
Gate 2 to Source Cutoff Voltage (V _{DS} = 15 Vdc, V _{G1S} = 0, I _D = 20 μAdc)	MPF211 MPF212,213	V _{G2S(off)}	-0.2 -0.2	-2.5 -4.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(3) (V _{DS} = 15 Vdc, V _{G1S} = 0, V _{G2S} = 4.0 Vdc)		I _{DSS}	6.0	4.0	mAdc
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance(4) (V _{DS} = 15 Vdc, V _{G2S} = 4.0 Vdc, V _{G1S} = 0, f = 1.0 kHz)	MPF211,212 MPF213	Y _{fs}	17 15	40 35	mmhos
Reverse Transfer Capacitance (V _{DS} = 15 Vdc, V _{G2S} = 4.0 Vdc, I _D = 10 mAdc, f = 1.0 MHz)		C _{rss}	0.005	0.05	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure (V _{DD} = 18 Vdc, V _{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1) (V _{DD} = 24 Vdc, V _{GG} = 6.0 Vdc, f = 45 MHz) (Figure 2)	MPF211 MPF211,213	NF	— —	4.0 4.5	dB
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MPF211, MPF212, MPF213

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Common Source Power Gain ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 7.0\text{ Vdc}$, $f = 200\text{ MHz}$) (Figure 1) MPF211		G_{ps}	24	35	dB
($V_{DD} = 24\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$) (Figure 2) MPF211					
($V_{DD} = 24\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$) (Figure 2) MPF213					
($V_{DD} = 18\text{ Vdc}$, $f_{LO} = 245\text{ MHz}$, $f_{RE} = 200\text{ MHz}$) (Figure 3) MPF212					
Bandwidth ($V_{DD} = 18\text{ Vdc}$, $V_{GG} = 7.0\text{ Vdc}$, $f = 200\text{ MHz}$) (Figure 1) MPF211		BW	5.0	12	MHz
($V_{DD} = 18\text{ Vdc}$, $f_{LO} = 245\text{ MHz}$, $f_{RE} = 200\text{ MHz}$) (Figure 3) MPF212					
($V_{DD} = 24\text{ Vdc}$, $V_{GG} = 6.0\text{ Vdc}$, $f = 45\text{ MHz}$) (Figure 2) MPF211,213					
Gain Control Gate-Supply Voltage(5) ($V_{DD} = 18\text{ Vdc}$, $\Delta G_{ps} = -30\text{ dB}$, $f = 200\text{ MHz}$) (Figure 1) MPF211		$V_{GG}(GC)$	—	-2.0	Vdc
($V_{DD} = 24\text{ Vdc}$, $\Delta G_{ps} = -30\text{ dB}$, $f = 45\text{ MHz}$) (Figure 2) MPF211,213					

(1) Measured after five seconds of applied voltage.

(2) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate voltage limiting network is functioning properly.

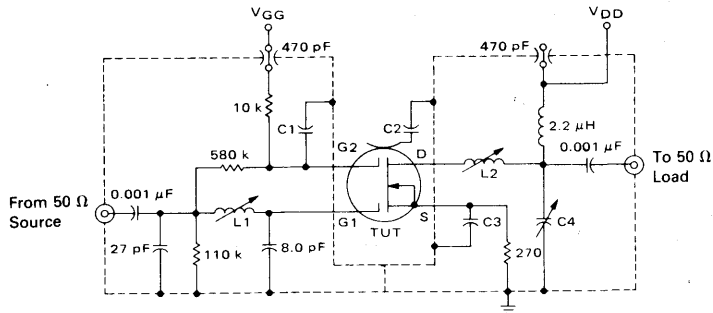
(3) Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2.0\%$.

(4) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating. The signal is applied to Gate 1 with Gate 2 at ac ground.

(5) ΔG_{ps} is defined as the change in G_{ps} from the value at $V_{GG} = 7.0\text{ Volts}$ (MPF211) and $V_{GG} = 6.0\text{ Volts}$ (MPF213).

(6) Power Gain Conversion. Amplitude at input from local oscillator is adjusted for maximum G_c .

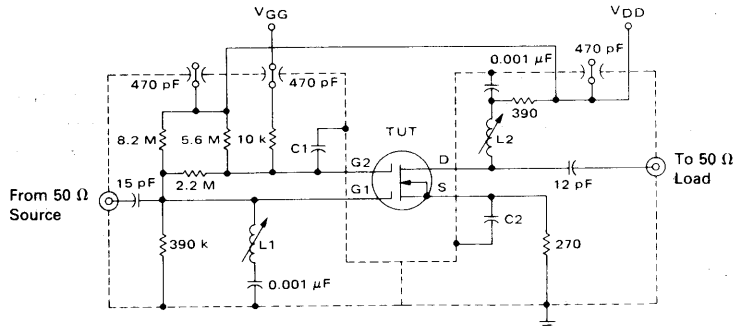
FIGURE 1 — 200 MHz POWER GAIN, GAIN CONTROL VOLTAGE, AND NOISE FIGURE TEST CIRCUIT



C1, C2 & C3: Leadless disc ceramic, 0.001 μF
C4: Arco 462, 5-80 pF, or equivalent

L1: 3 Turns #18, 3/16" diameter aluminum slug
L2: 8 Turns #20, 3/16" diameter aluminum slug

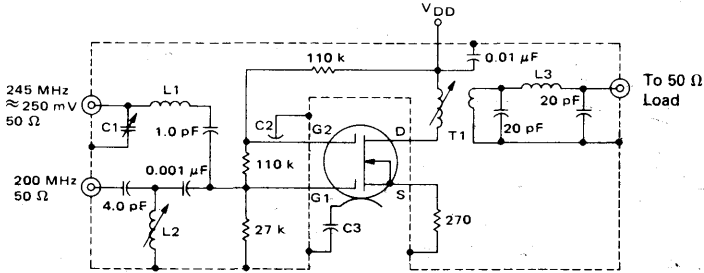
FIGURE 2 — 45-MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1: Leadless disc ceramic, 0.001 μF
C2: Leadless disc ceramic, 0.01 μF

L1: 8 Turns #28, 5/32" diameter form, type "J" slug
L2: 9 Turns #28, 5/32" diameter form, type "J" slug

FIGURE 3 — 200-MHz-to-45-MHz CIRCUIT FOR CONVERSION POWER GAIN



- L1: 7 Turns #34, 1/4" diameter aluminum slug
- L2: 5-1/2 Turns #20, 1/4" diameter aluminum slug
- L3: 7 Turns #24, 1/4" diameter air core
- C1: Arco type 462, 5-80 pF
- C2: 0.001 μF leadless disc
- C3: 0.01 μF leadless disc
- T1: Pri: 25 Turns #30, close wound on 1/4" diameter form, type "J" slug
- Sec: 4 Turns #30, centered over primary

TYPICAL CHARACTERISTICS

FIGURE 4 — DRAIN CURRENT versus DRAIN-TO-SOURCE VOLTAGE

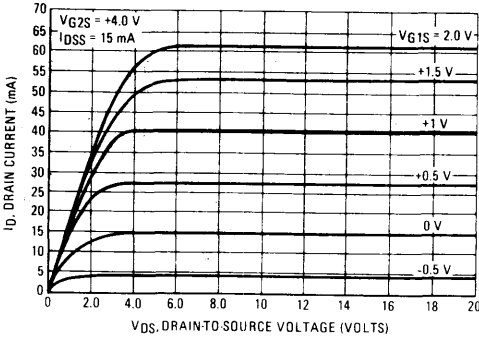
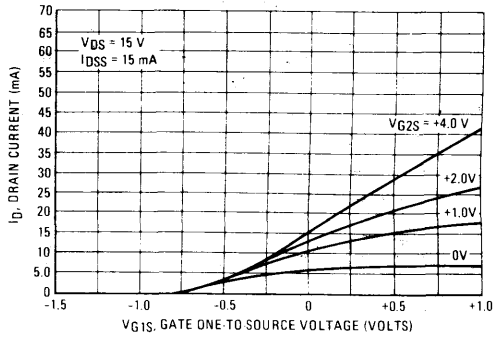


FIGURE 5 — DRAIN CURRENT versus GATE ONE-TO-SOURCE VOLTAGE



SMALL-SIGNAL COMMON-SOURCE PARAMETER — GATE ONE

FIGURE 6 — FORWARD TRANSFER ADMITTANCE versus GATE TWO-TO-SOURCE VOLTAGE

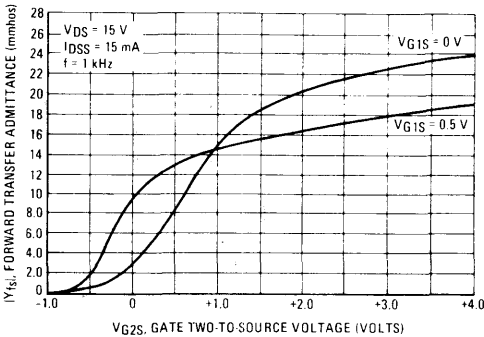


FIGURE 7 — FORWARD TRANSFER ADMITTANCE versus GATE ONE-TO-SOURCE VOLTAGE

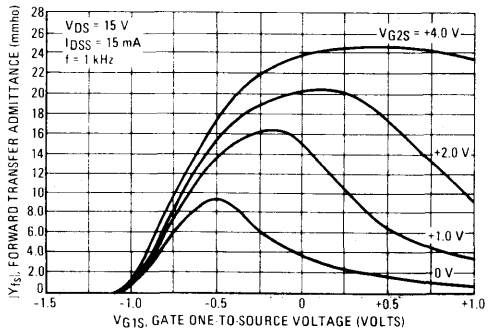


FIGURE 8 — FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

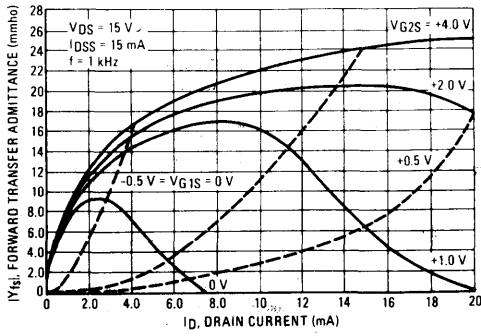


FIGURE 9 — INPUT AND OUTPUT CAPACITANCE versus GATE TWO-TO-SOURCE VOLTAGE

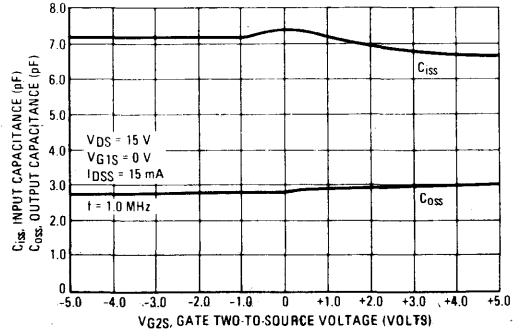


FIGURE 10 — SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

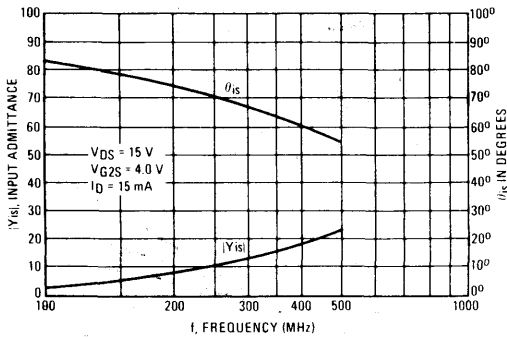


FIGURE 11 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus FREQUENCY

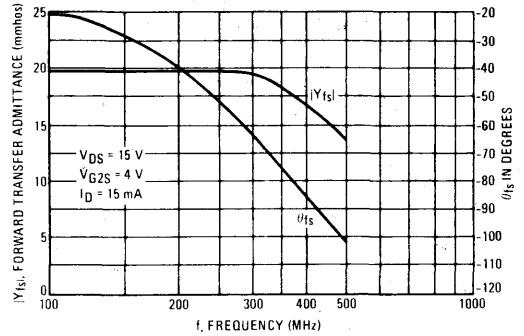


FIGURE 12 — SMALL-SIGNAL GATE ONE REVERSE TRANSFERS ADMITTANCE versus FREQUENCY

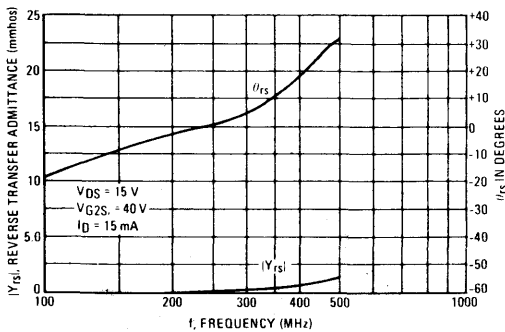
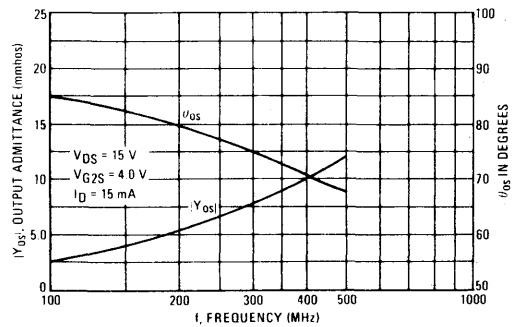


FIGURE 13 — SMALL-SIGNAL GATE ONE OUTPUT ADMITTANCE versus FREQUENCY



6

MPF211, MPF212, MPF213

FIGURE 14 — RELATIVE SMALL-SIGNAL POWER GAIN versus GAIN CONTROL GATE SUPPLY VOLTAGE MPF211

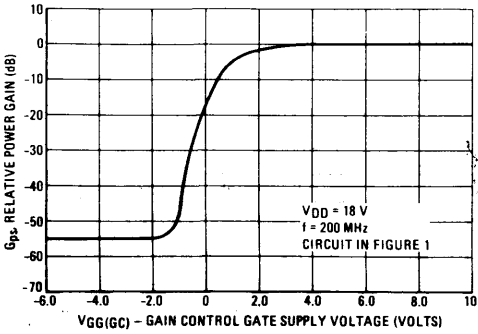


FIGURE 15 — COMMON SOURCE SPOT NOISE FIGURE versus GAIN CONTROL GATE SUPPLY VOLTAGE MPF211

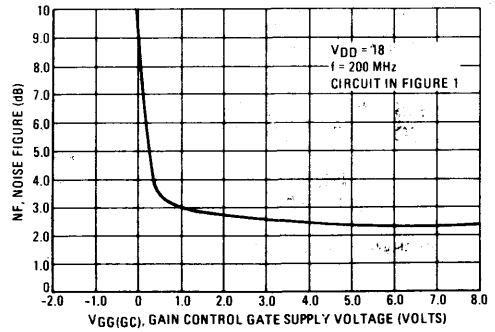


FIGURE 16 — SMALL-SIGNAL COMMON-SOURCE INSERTION POWER GAIN versus GAIN CONTROL GATE SUPPLY VOLTAGE MPF211, 213

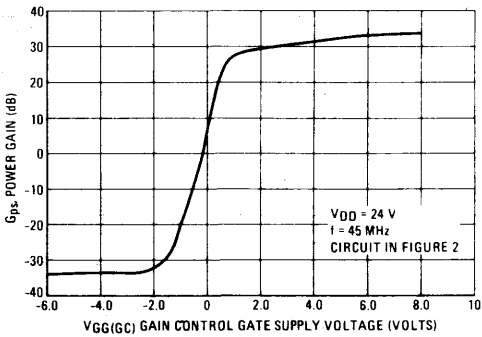


FIGURE 17 — OPTIMUM SPOT NOISE FIGURE versus FREQUENCY

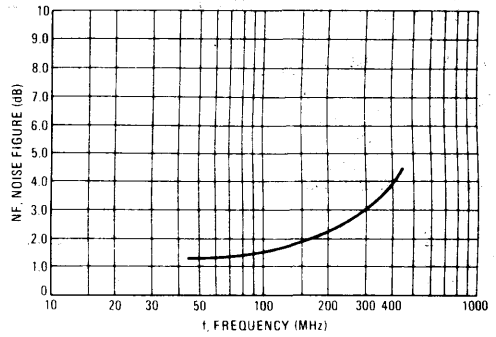
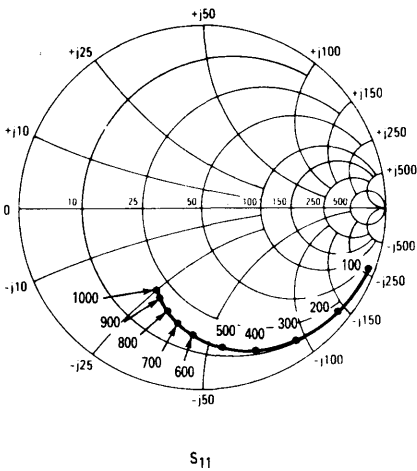
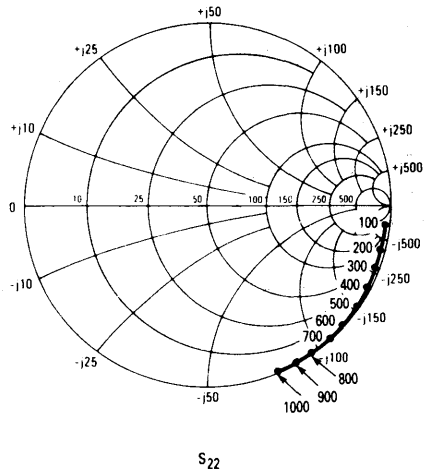


FIGURE 18 — INPUT/OUTPUT IMPEDANCE



$V_{DS} = 15 \text{ V}$
 $V_{G2S} = 4.0 \text{ V}$
 $I_D = 15 \text{ mA}$



MPF256

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	± 30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation (at $T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	350 2.73	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}, V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	—	Vdc	
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}, V_{DS} = 0$)	I_{GSS}	—	—	5.0	nAdc	
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}, I_D = 200 \mu\text{Adc}$)	$V_{GS(off)}$	0.5	—	7.5	Vdc	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0$)	I_{DSS}^*	3.0 6.0 11	— — —	7.0 13 18	mAdc	
	Red					
	Green					
	Violet					
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	$ y_{fs} $	6.0	—	—	mmhos	
Input Capacitance ($V_{DS} = 15 \text{ Vdc}, I_D = 10 \text{ mAdc}, f = 1.0 \text{ MHz}$)	C_{iss}	—	3.0	—	pF	
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}, I_D = 10 \text{ mAdc}, f = 1.0 \text{ MHz}$)	C_{rss}	—	1.2	—	pF	
Output Capacitance ($V_{DS} = 15 \text{ Vdc}, I_D = 10 \text{ mAdc}, f = 1.0 \text{ kHz}$)	C_{oss}	—	2.0	—	pF	
FUNCTIONAL CHARACTERISTICS						
Noise Figure ($V_{DS} = 15 \text{ Vdc}, R_S = 50 \text{ Ohms}$)	NF	100 MHz 400 MHz	— —	— —	2.0 4.0	dB
Common Source Power Gain ($V_{DS} = 15 \text{ Vdc}, R_S = 50 \text{ Ohms}$)	G_{ps}	100 MHz 400 MHz	20 12	— —	— —	dB

*To characterize these devices to narrower limits, the entire production lot is tested and divided into color-coded groups, with each color dot representing an I_{DSS} range.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

MPF521

CASE 317-01, STYLE 1

**MOSFET
DUAL GATE
VHF AMPLIFIER TRANSISTOR**

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	25	Vdc
Drain-Gate Voltage	V _{DG1}	30	Vdc
	V _{DG2}	30	Vdc
Drain Current	I _D	30	mAdc
Gate Current	I _{G1F}	10	mAdc
	I _{G2F}	10	mAdc
Total Device Dissipation (at T _A = 25°C Derate above 25°C)	P _D	300	mW
		1.71	mW/°C
Operating Channel Temperature	T _{channel}	150	°C
Lead Temperature, 1/16" From Seated Surface for 10 Seconds	T _L	200	°C
Storage Channel Temperature Range	T _{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate 1-Source Breakdown Voltage (V _{G2} = V _{DS} = 0, I _{G1} = 10 μAdc)	V(BR)G1SO	10	15	—	Vdc
Gate 2-Source Breakdown Voltage (V _{G1S} = V _{DS} = 0, I _{G2} = 10 μAdc)	V(BR)G2SO	12	16	—	Vdc
Gate 1 Reverse Leakage Current (V _{G1S} = 5.0 Vdc, V _{G2S} = V _{DS} = 0)	I _{G1SS}	—	30	100	nAdc
Gate 2 Reverse Leakage Current (V _{G2S} = 5.0 Vdc, V _{G1S} = V _{DS} = 0)	I _{G2SS}	—	30	100	nAdc
Drain-Source Breakdown Voltage (V _{G2} = 0, I _D = 10 μAdc)	V(BR)DS	25	28	—	Vdc

ON CHARACTERISTICS

Gate-Source Threshold Voltage (V _{G2S} = 10 Vdc, I _D = 10 μAdc, V _{DS} = 15 V) (V _{G1S} = 4.0 Vdc, I _D = 10 μAdc, V _{DS} = 15 V)	V _{G1S(TH)}	0.5	1.2	2.0	Vdc
	V _{G2S(TH)}	0.5	1.0	2.0	
Gate-Source On Voltage (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, I _D = 10 mAdc)	V _{G1S(on)}	2.0	2.6	4.0	Vdc
"On" Drain Current (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, V _{G1S} = 3.0 Vdc)	I _{D(on)}	5.0	15	20	mAdc

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance(1) (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, I _D = 10 mAdc, f = 1.0 kHz) (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, I _D = 10 mAdc, f = 200 MHz)	Y _{fs}	10	12	20	mmhos
	Y _{fs}	—	10.57-j6.86	—	
Input Admittance(1) (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, I _D = 10 mAdc, f = 200 MHz)	Y _{is}	—	0.524 + j4.27	—	mmhos
Reverse Transfer Admittance(1) (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, I _D = 10 mAdc, f = 200 MHz)	Y _{rs}	—	-1.7-j9.8	—	μmhos
Output Admittance(1) (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, I _D = 10 mAdc, f = 200 MHz)	Y _{os}	—	0.126 + j1.79	—	mmhos
Input Capacitance (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, V _{G1} = 2.5 Vdc, f = 1.0 MHz)	C _{iss}	—	3.3	4.0	pF
Reverse Transfer Capacitance (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, V _{G1} = 2.5 Vdc, f = 1.0 MHz)	C _{rss}	—	0.015	0.03	pF
Output Capacitance (V _{DS} = 15 Vdc, V _{G2S} = 10 Vdc, V _{G1} = 2.5 Vdc, f = 1.0 MHz)	C _{oss}	—	1.1	2.5	pF

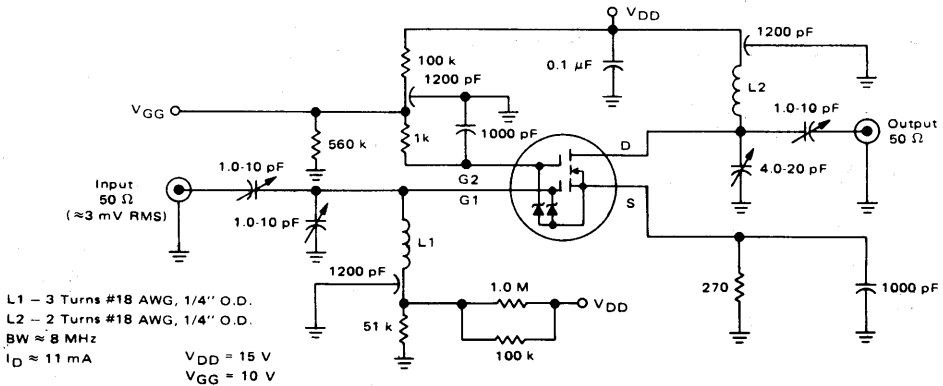
MPF521

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figures 1 and 9) ($V_{DS} = 15\text{ Vdc}$, $V_{GG} = 10\text{ V}$, $f = 200\text{ MHz}$)	NF	—	1.7	3.5	dB
Common Source Power Gain (Figures 1 and 9) ($V_{DS} = 15\text{ Vdc}$, $V_{GG} = 10\text{ V}$, $f = 200\text{ MHz}$, $BW = 7.0\text{ MHz (Min)}$)	G_{ps}	21	25	—	dB

(1) All y-parameters are with respect to Gate 1.

FIGURE 1 – 200 MHz NOISE FIGURE AND POWER GAIN TEST CIRCUIT



TYPICAL CHARACTERISTICS

FIGURE 2 – DRAIN CURRENT versus DRAIN to SOURCE VOLTAGE

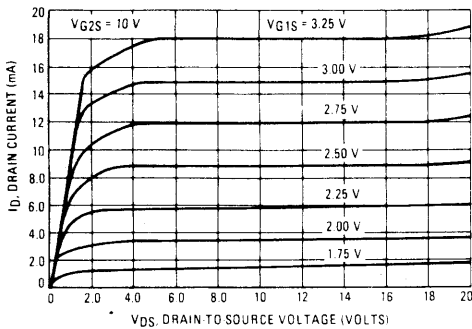


FIGURE 3 – DRAIN CURRENT versus GATE-ONE to SOURCE VOLTAGE

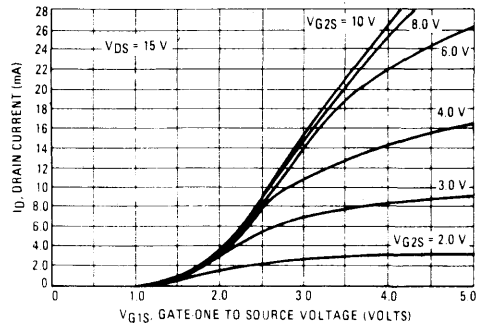


FIGURE 4 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-ONE to SOURCE VOLTAGE

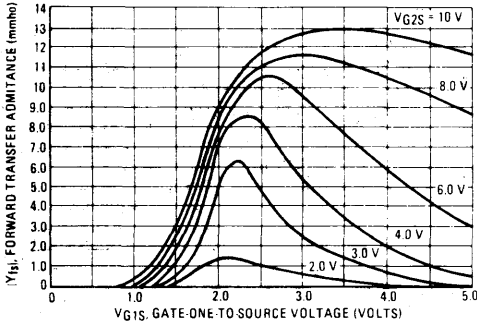


FIGURE 5 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

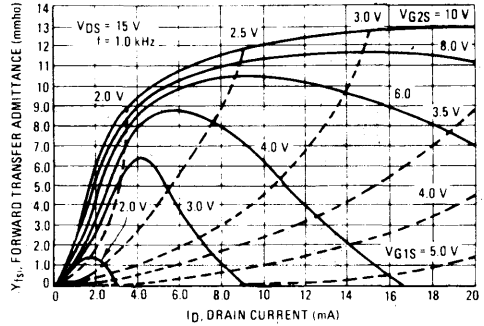


FIGURE 6 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE INPUT AND OUTPUT CAPACITANCE versus GATE-TWO to SOURCE VOLTAGE

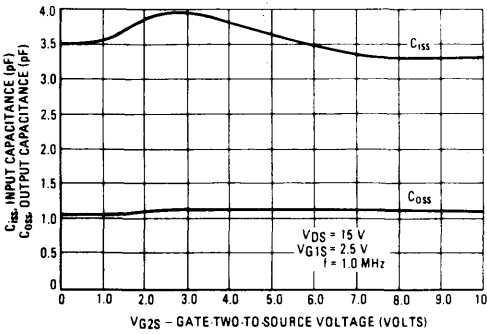


FIGURE 7 – COMMON SOURCE POWER GAIN versus DRAIN SUPPLY CURRENT

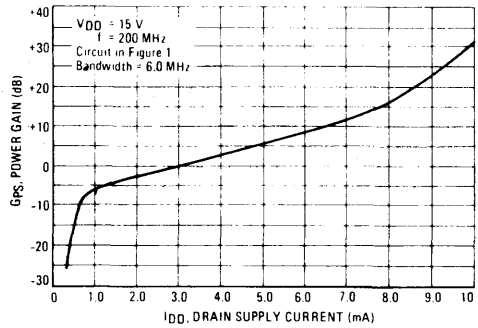


FIGURE 8 – COMMON SOURCE POWER GAIN AND SPOT NOISE FIGURE versus DRAIN CURRENT

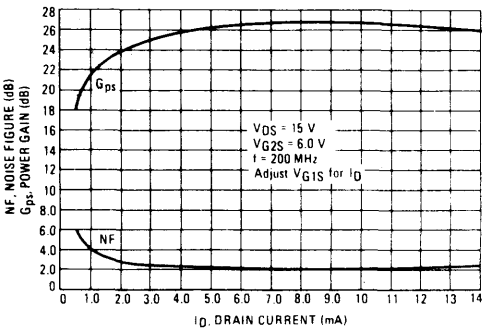


FIGURE 9 – COMMON SOURCE POWER GAIN AND SPOT NOISE FIGURE versus GAIN CONTROL GATE-SUPPLY VOLTAGE

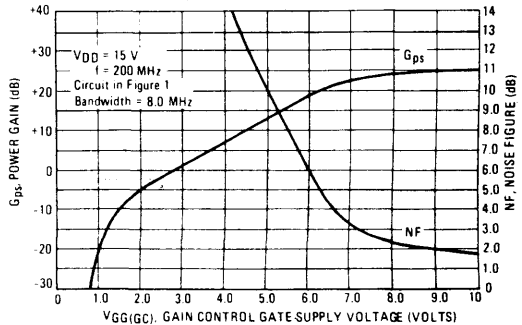


FIGURE 10 - SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

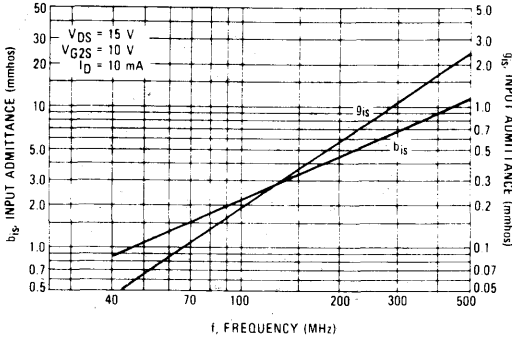


FIGURE 11 - SMALL-SIGNAL COMMON SOURCE GATE ONE FORWARD TRANSFER ADMITTANCE versus FREQUENCY

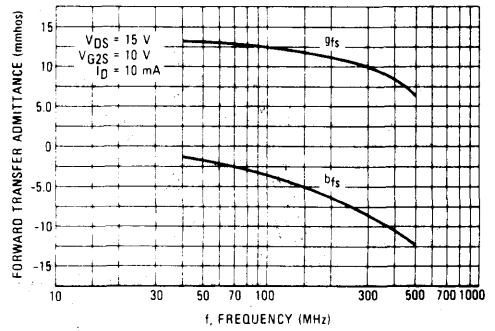


FIGURE 12 - SMALL-SIGNAL COMMON SOURCE OUTPUT ADMITTANCE versus FREQUENCY

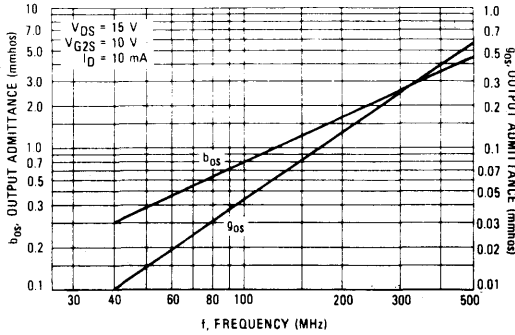
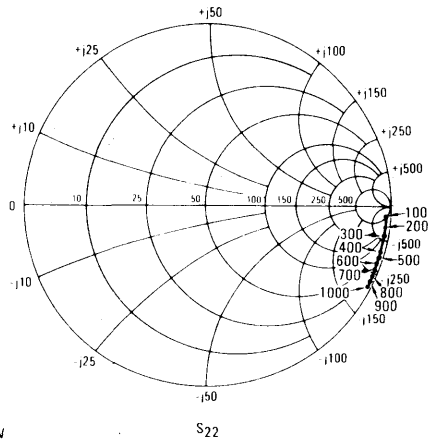
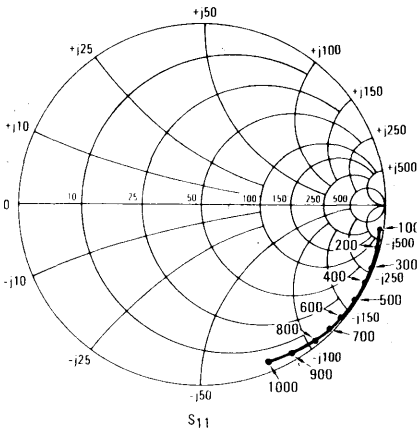


FIGURE 13 - INPUT/OUTPUT IMPEDANCE



$V_{DD} = 18 \text{ V}$
 $V_{GG} = 10 \text{ V}$
 $I_D = 10 \text{ mA}$

MPF820

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
RF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 10 \mu\text{Adc}, V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{Vdc}, V_{DS} = 0$)	I_{GSS}	—	—	5.0	nAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{Vdc}, I_D = 200 \mu\text{Adc}$)	$V_{GS(off)}$	—	—	5.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain ($V_{DS} = 15 \text{Vdc}, V_{GS} = 0$)	I_{DSS}	10	—	—	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15 \text{Vdc}, V_{GS} = 0, f = 1.0 \text{kHz}$)	$ y_{fs} $	—	20	—	mmhos
Input Capacitance ($V_{DS} = 15 \text{Vdc}, I_D = 10 \text{mAdc}, f = 1.0 \text{MHz}$)	C_{iss}	—	15	—	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{Vdc}, I_D = 10 \text{mAdc}, f = 1.0 \text{MHz}$)	C_{rss}	—	3.5	—	pF
Common-Gate Input Conductance ($V_{DS} = 15 \text{Vdc}, I_D = 10 \text{mAdc}, f = 100 \text{MHz}$)	g_{ig}	—	16	—	mmhos
Common-Gate Output Conductance ($V_{DS} = 15 \text{Vdc}, I_D = 10 \text{mAdc}, f = 100 \text{MHz}$)	G_{og}	—	—	16	μmhos
Common-Gate Forward Transadmittance ($V_{DS} = 15 \text{Vdc}, I_D = 10 \text{mAdc}, f = 100 \text{MHz}$)	Y_{fg}	—	18	—	mmhos
Common-Gate Reverse Transadmittance ($V_{DS} = 15 \text{Vdc}, I_D = 10 \text{mAdc}, f = 100 \text{MHz}$)	Y_{rg}	—	—	130	μmhos
Output Capacitance ($V_{DS} = 15 \text{Vdc}, I_D = 10 \text{mAdc}, f = 1.0 \text{kHz}$)	C_{oss}	—	3.5	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15 \text{Vdc}, I_D = 10 \text{mAdc}$, See Figure 5)	NF	—	—	4.0	dB
Small-Signal Power Gain ($V_{DS} = 15 \text{Vdc}, I_D = 10 \text{mAdc}$, See Figure 5)	G_{pg}	—	11	—	dB

FIGURE 1 - NOISE FIGURE

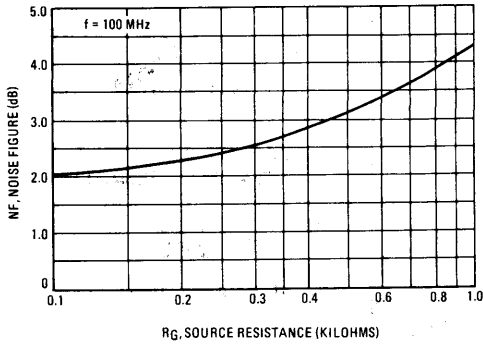
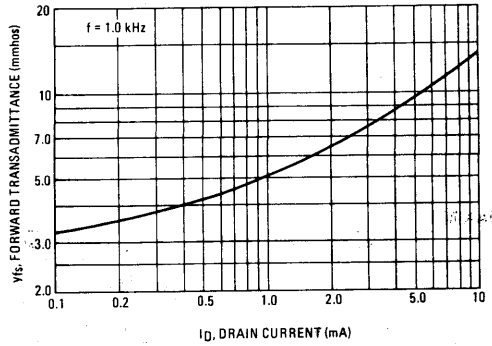


FIGURE 2 - FORWARD TRANSADMITTANCE



6

FIGURE 3 - INPUT CAPACITANCE

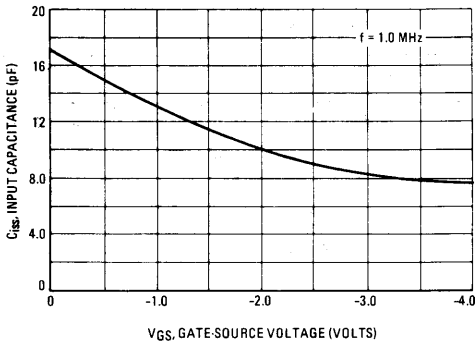


FIGURE 4 - OUTPUT AND REVERSE TRANSFER CAPACITANCE

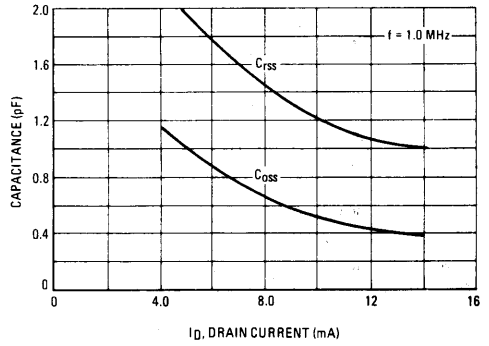
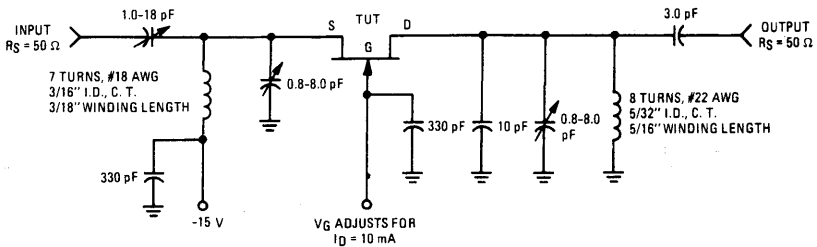


FIGURE 5 - 100 MHz TEST CIRCUIT



MPF930 MPF960 MPF990

CASE 29-03, STYLE 22
TO-226AE

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	MPF930	MPF960	MPF990	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}	±30			Vdc
Drain Current Continuous (1) Pulsed (2)	I_D I_{DM}	2.0 3.0			Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to 150			°C
Thermal Resistance	θ_{JA}	125			°C/W

(1) The Power Dissipation of the package may result in a lower continuous drain current.

(2) Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

Refer to MFE930 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($V_{GS} = 0, I_D = 10 \mu\text{A}$)	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}, V_{DS} = 0$)	I_{GSS}	—	—	50	nAdc

ON CHARACTERISTICS*

Zero-Gate-Voltage Drain Current ($V_{DS} = \text{Maximum Rating}, V_{GS} = 0$)	I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage ($I_D = 1.0 \text{ mA}, V_{DS} = V_{GS}$)	$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage ($V_{GS} = 10 \text{ V}$) ($I_D = 0.5 \text{ A}$)	$V_{DS(on)}$	— — —	0.4 0.6 0.6	0.7 0.8 1.0	Vdc
($I_D = 1.0 \text{ A}$)		— — —	0.9 1.2 1.2	1.4 1.7 2.0	
($I_D = 2.0 \text{ A}$)		— — —	2.2 2.8 2.8	3.0 3.5 4.0	
Static Drain-Source On Resistance ($V_{GS} = 10 \text{ Vdc}, I_D = 1.0 \text{ Adc}$)	$r_{DS(on)}$	— — —	0.9 1.2 1.2	1.4 1.7 2.0	Ohms
On-State Drain Current ($V_{DS} = 25 \text{ V}, V_{GS} = 10 \text{ V}$)	$I_{D(on)}$	1.0	2.0	—	Amps

SMALL-SIGNAL CHARACTERISTICS

Input Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	60	70	pF
Reverse Transfer Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{rss}	—	13	18	pF
Output Capacitance ($V_{DS} = 25 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{oss}	—	49	60	pF
Forward Transconductance ($V_{DS} = 25 \text{ V}, I_D = 0.5 \text{ A}$)	g_{fs}	200	380	—	mmhos

SWITCHING CHARACTERISTICS

Turn-On Time	t_{on}	—	7.0	15	ns
Turn-Off Time	t_{off}	—	7.0	15	ns

* Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

MPF970 MPF971

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation (at $T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	-65 to +150	°C
Operating Temperature Range	$T_{channel}$	-65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	—	—	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = 15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	— —	— —	1.0 1.0	nAdc μAdc
Drain-Cutoff Current ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$, $T_A = 150^\circ\text{C}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 7.0 \text{ Vdc}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 7.0 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	— — — —	— — — —	10 10 10 10	nAdc μAdc nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 10 \text{ nAdc}$)	$V_{GS(off)}$	5.0 1.0	— —	12 7.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	15 2.0	— —	100 50	mAdc
Drain-Source On-Voltage ($I_D = 10 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 1.5 \text{ mAdc}$, $V_{GS} = 0$)	$V_{DS(on)}$	— —	— —	1.5 1.5	Vdc
Static Drain-Source On Resistance ($I_D = 1.0 \text{ mAdc}$, $V_{GS} = 0$)	$r_{DS(on)}$	— —	— —	100 250	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	— —	— —	100 250	Ohms
Input Capacitance ($V_{GS} = 12 \text{ Vdc}$, $V_{DS} = 0$, $f = 1.0 \text{ MHz}$) ($V_{GS} = 7.0 \text{ Vdc}$, $V_{DS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	— —	— —	12 12	pF
Reverse Transfer Capacitance ($V_{GS} = 12 \text{ Vdc}$, $V_{DS} = 0$, $f = 1.0 \text{ MHz}$) ($V_{GS} = 7.0 \text{ Vdc}$, $V_{DS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	— —	— —	5.0 5.0	pF

MPF970, MPF971

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
SWITCHING CHARACTERISTICS (See Figure 6, $R_K = 0$) (1)						
Rise Time ($I_{D(on)} = 10 \text{ mAdc}$, $V_{GS(off)} = 12 \text{ Vdc}$) ($I_{D(on)} = 1.5 \text{ mAdc}$, $V_{GS(off)} = 7.0 \text{ Vdc}$)	MPF970 MPF971	t_r	— —	2.0 3.0	5.0 5.0	ns
Fall Time ($I_{D(on)} = 10 \text{ mAdc}$, $V_{GS(off)} = 12 \text{ Vdc}$) ($I_{D(on)} = 1.5 \text{ mAdc}$, $V_{GS(off)} = 7.0 \text{ Vdc}$)	MPF970 MPF971	t_f	— —	9.0 68	15 80	ns
Turn-On Time ($I_{D(on)} = 10 \text{ mAdc}$, $V_{GS(off)} = 12 \text{ Vdc}$) ($I_{D(on)} = 1.5 \text{ mAdc}$, $V_{GS(off)} = 7.0 \text{ Vdc}$)	MPF970 MPF971	t_{on}	— —	3.5 5.0	8.0 10	ns
Turn-Off Time ($I_{D(on)} = 10 \text{ mAdc}$, $V_{GS(off)} = 12 \text{ Vdc}$) ($I_{D(on)} = 1.5 \text{ mAdc}$, $V_{GS(off)} = 7.0 \text{ Vdc}$)	MPF970 MPF971	t_{off}	— —	13 88	25 120	ns

(1) Pulse Test: Pulse Width $\leq 100 \mu\text{s}$, Duty Cycle $\leq 1.0\%$.

FIGURE 1 – EFFECT OF I_{DSS} ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE

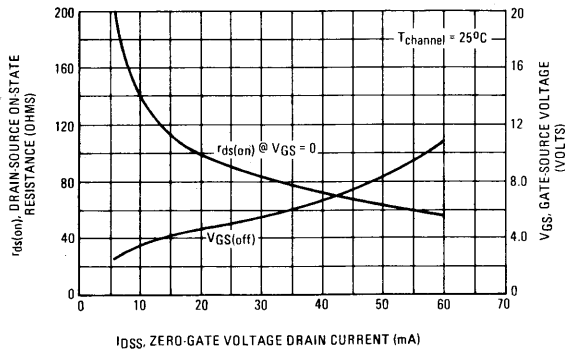


FIGURE 2 – TURN-ON DELAY TIME

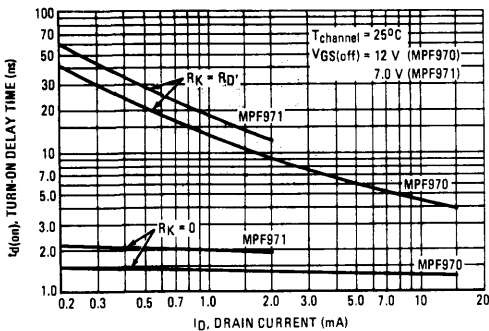
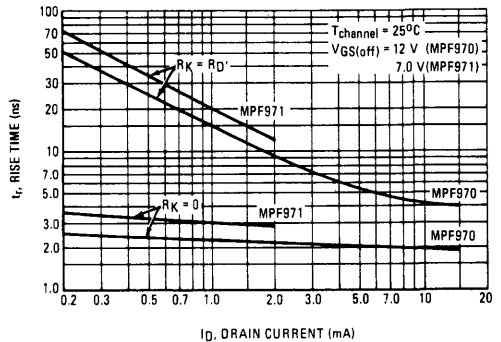


FIGURE 3 – RISE TIME



MPF970, MPF971

FIGURE 4 – TURN-OFF DELAY TIME

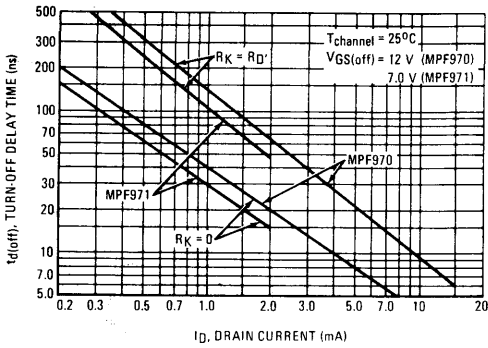


FIGURE 5 – FALL TIME

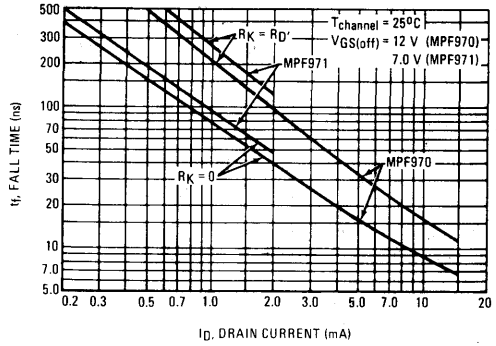
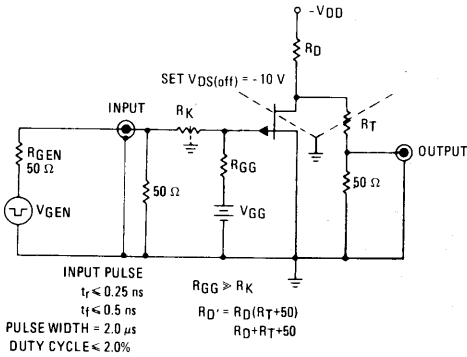


FIGURE 6 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 6. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage (+ V_{GG}). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{GEN} and R_K . C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R_D') and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds} , turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to R_D , which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

FIGURE 7 – TYPICAL FORWARD TRANSFER ADMITTANCE

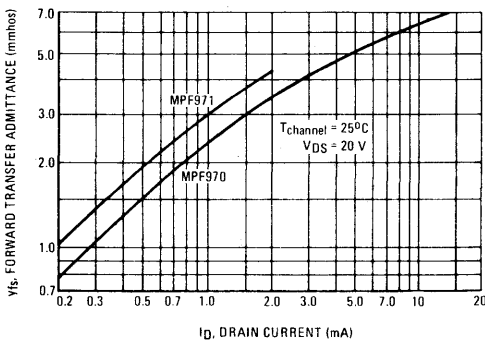
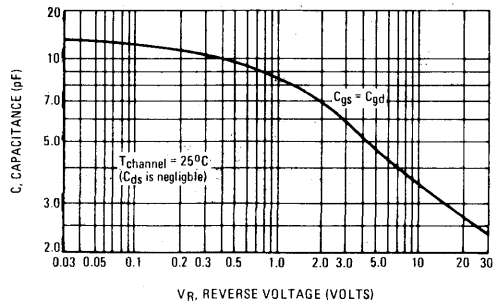


FIGURE 8 – TYPICAL CAPACITANCE



MPF970, MPF971

FIGURE 9 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

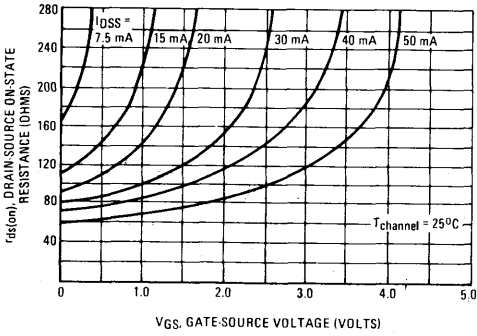


FIGURE 10 – EFFECT OF TEMPERATURE ON DRAIN-SOURCE ON-STATE RESISTANCE

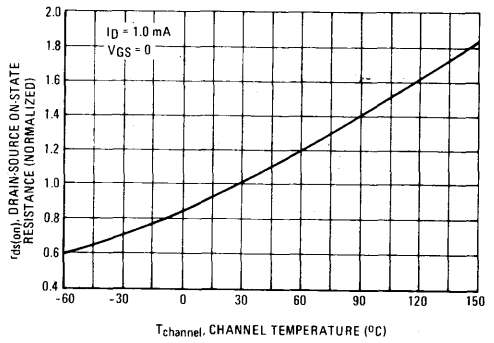
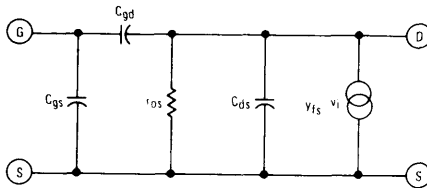


FIGURE 11 – LOW FREQUENCY CIRCUIT MODEL



$$\begin{aligned}
 Y_{fs} &= j\omega C_{iss} \\
 Y_{os} &= 1/r_{oss} + j\omega C_{oss} \\
 Y_{fs} &= Y_{fs} \\
 Y_{rs} &= -j\omega C_{rss} \\
 C_{rss} &= C_{gd} + C_{gs} \\
 C_{rss} &= C_{gd} \\
 C_{oss} &= C_{gd} + C_{ds}, C_{ds} = 0
 \end{aligned}$$

MPF1010

CASE 29-03, STYLE 22
TO-92 (TO-226AE)

TMOS
SWITCHING

N-CHANNEL - ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DSS}	100	Vdc
Gate-Source Voltage	V _{GS}	±30	Vdc
Drain Current - Continuous (1) Pulsed (2)	I _D I _{DM}	500 1000	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1 8	Watts mW/°C
Operating and Storage Temperature Range	T _J , T _{stg}	-55 to +150	°C
Thermal Resistance Junction to Ambient	θ _{JA}	125	°C/W

(1) The Power Dissipation of the package may result in a lower continuous drain current.

(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V _{GS} = 0, I _D = 100 μA)	V(BR)DSS	100	—	—	Vdc
Zero Gate Voltage Drain Current (V _{DS} = 60 V, V _{GS} = 0)	I _{DSS}	—	—	10	μAdc
Gate-Body Leakage Current (V _{GS} = 10 Vdc, V _{DS} = 0)	I _{GSS}	—	0.01	10	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (I _D = 15 mA, V _{DS} = V _{GS})	V _{GS(th)}	0.3	—	2.5	Vdc
Drain-Source On-Voltage (I _D = 120 mA, V _{GS} = 5 V) (I _D = 20 mA, V _{GS} = 3.5 V)	V _{DS(on)}	— —	— —	1.2 0.16	Vdc
On State Drain Current (V _{DS} = 25 V, V _{GS} = 10 V) (V _{DS} = 25 V, V _{GS} = 5 V)	I _{D(on)}	500 250	700	—	mA
Forward Transconductance (V _{DS} = 15 V, I _D = 0.5 A)	g _{fs}	100	300	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	—	60	70	pF
Output Capacitance (V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{oss}	—	49	60	pF
Reverse Transfer Capacitance (V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{rss}	—	13	18	pF
SWITCHING CHARACTERISTICS*					
Turn-On Time See Figure 1	t _{on}	—	7	15	ns
Turn-Off Time See Figure 1	t _{off}	—	7	15	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

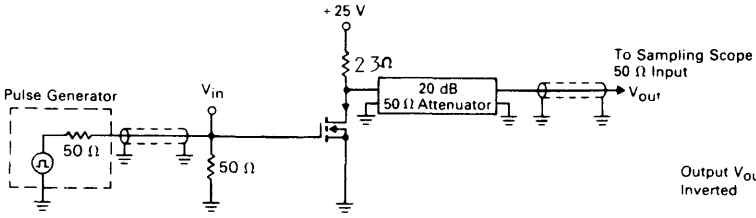
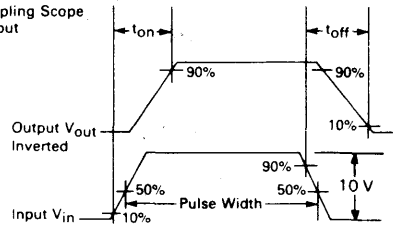


FIGURE 2 — SWITCHING WAVEFORMS



MPF4093

CASE 29-03, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Gate-Source Voltage	V_{GS}	-40	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 3.0	mW mW/ $^\circ\text{C}$
Lead Temperature (1/16" from Case for 10 Seconds)	T_L	300	$^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{A}, V_{DS} = 0$)	$V_{(BR)GSS}$	-40	—	Vdc
Gate Reverse Current ($V_{DG} = -20 \text{ V}, I_S = 0$)	I_{DGO}	—	1.0	nA
Drain-Gate Leakage ($V_{DG} = -20 \text{ V}, I_S = 0, T_A = 150^\circ\text{C}$)	I_{DGO}	—	400	nA
Drain Cutoff Current ($V_{DS} = 20 \text{ V}, V_{GS} = -6.0 \text{ V}$)	$I_{D(off)}$	—	1.0	nA
Drain-Gate "OFF" Current ($V_{DS} = 20 \text{ V}, V_{GS} = -6.0 \text{ V}, T_A = 150^\circ\text{C}$)	$I_{D(off)}$	—	400	nA
Gate 1 to Source Cutoff Voltage ($V_{DS} = 20 \text{ V}, I_D = 1.0 \text{ nA}$)	$V_{G1S(off)}$	-1.0	-5.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 20 \text{ V}, V_{GS} = 0$)	I_{DSS}	8.0	—	mA
Drain-Source On-Voltage ($V_{GS} = 0, I_D = 2.5 \text{ mA}$)	$V_{DS(on)}$	—	0.2	Vdc
Static Drain-Source On Resistance ($V_{GS} = 0, I_D = 1.0 \text{ mA}$) ($V_{GS} = 0, I_D = 0, f = 1.0 \text{ kHz}$)	$r_{DS(on)}$	— —	80 80	Ω
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance ($V_{DS} = 20 \text{ V}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	16	pF
Reverse Transfer Capacitance ($V_{DS} = 0, V_{GS} = -20 \text{ V}, f = 1.0 \text{ MHz}$)	C_{rss}	—	5.0	pF
SWITCHING CHARACTERISTICS				
Delay Time	t_d	—	20	ns
Rise Time	t_r	—	40	ns
Turn-Off Time	t_{off}	—	80	ns

MPF4117,A MPF4118,A MPF4119,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
DC AMPLIFIER TRANSISTOR
N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	- 40	Vdc
Drain-Gate Voltage	V_{DG}	- 40	Vdc
Gate Current	I_G	50	mAdc
Total Device Dissipation (at $T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	300 2.0	mW mW/°C
Storage Channel Temperature Range	T_{stg}	- 65 to + 125	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($V_{DS} = 0, I_G = -1.0 \mu\text{Adc}$)	$V_{(BR)GSS}$	- 40	—	Vdc	
Gate Reverse Current ($V_{GS} = 20 \text{ Vdc}, V_{DS} = 0$)	I_{GSS}	—	- 10	pAdc	
		MPF4117, 4118, 4119 MPF4117A, 4118A, 4119A	—		- 1.0
($V_{GS} = 20 \text{ Vdc}, V_{DS} = 0, T_A = 125^\circ\text{C}$)	I_{GSS}	—	- 25	nAdc	
		MPF4117, 4118, 4119 MPF4117A, 4118A, 4119A	—		- 2.5
Gate Source Cutoff Voltage ($V_{DS} = 10 \text{ Vdc}, I_D = 1.0 \text{ nAdc}$)	$V_{GS(off)}$	- 0.6 - 1.0 - 2.0	- 1.8 - 3.0 - 6.0	Vdc	
	MPF4117,A MPF4118,A MPF4119,A				
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 10 \text{ Vdc}, V_{GS} = 0$)	I_{DSS}	0.03 0.08 0.20	0.09 0.24 0.60	mAdc	
	MPF4117,A MPF4118,A MPF4119,A				
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance ($V_{DS} = 10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{iss}	—	3.0	pF	
Reverse Transfer Capacitance ($V_{DS} = 10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ MHz}$)	C_{rss}	—	1.5	pF	
Common-Source Forward Transconductance ($V_{DS} = 10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	g_{fs}	70	210	μmhos	
		MPF4117,A MPF4118,A MPF4119,A	80 100		250 330
Common-Source Output Conductance ($V_{DS} = 10 \text{ Vdc}, V_{GS} = 0, f = 1.0 \text{ kHz}$)	g_{os}	—	3.0	μmhos	
		MPF4117,A MPF4118,A MPF4119,A	— — —		5.0 10

(1) I_{DSS} is measured during a 2.0 ms interval 100 ms after power is applied.

MPF4117,A, MPF4118,A, MPF4119,A

FIGURE 1 — TRANSFER CHARACTERISTICS

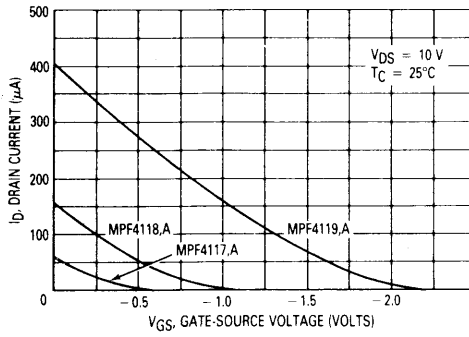


FIGURE 2 — TRANSCONDUCTANCE CHARACTERISTICS

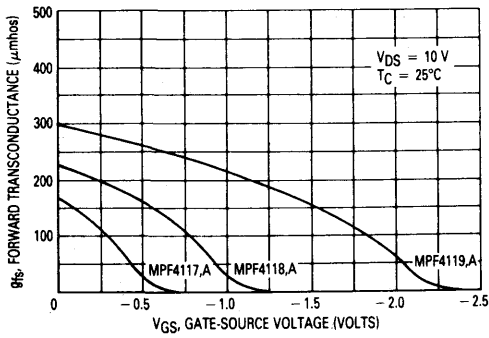
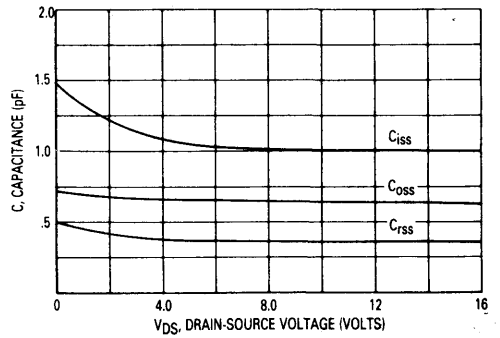


FIGURE 3 — CAPACITANCE versus DRAIN-SOURCE VOLTAGE



6

MPF4220,A MPF4221,A MPF4222,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
LOW-FREQUENCY

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation (at $T_A = 25^\circ\text{C}$ Derate above 25°C)	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -10 \mu\text{A}$, $V_{DS} = 0 \text{ V}$)	$V_{(BR)GSS}$	-30	—	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ V}$, $V_{DS} = 0 \text{ V}$)	I_{GSS}	—	-100	pA
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ V}$, $I_D = 0.1 \text{ nA}$)	$V_{GS(off)}$	— — —	-4.0 -6.0 -8.0	Vdc
Gate Source Voltage ($V_{DS} = 15 \text{ V}$, $I_D = 50 \mu\text{A}$) ($V_{DS} = 15 \text{ V}$, $I_D = 200 \mu\text{A}$) ($V_{DS} = 15 \text{ V}$, $I_D = 500 \mu\text{A}$)	V_{GS}	-0.5 -1.0 -2.0	-2.5 -5.0 -6.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current ($V_{DS} = 15 \text{ Volts}$, $V_{GS} = 0 \text{ V}$)	I_{DSS}^*	+0.5 +2.0 +5.0	+3.0 +6.0 +15.0	mA
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SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ kHz}$, $V_{GS} = 0 \text{ V}$)	$ y_{fs} ^*$	1000 2000 2500	4000 5000 6000	μmhos
Output Admittance ($V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ kHz}$, $V_{GS} = 0 \text{ V}$)	$ y_{os} $	— — —	10 20 40	μmhos
Input Capacitance ($V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ V}$, $f = 1.0 \text{ MHz}$)	C_{rss}	—	2.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 15 \text{ V}$, $f = 100 \text{ Hz}$, $R_G = 1.0 \text{ M}\Omega$)	NF	—	2.5	dB
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*Pulse Width $\leq 100 \text{ msec}$, Duty Cycle $\leq 10\%$.

MPF4391
MPF4392
MPF4393

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Operating and Storage Channel Temperature Range	T_{channel} , T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	—	—	Vdc
Gate Reverse Current ($V_{GS} = 15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = 15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	—	—	1.0 0.2	nAdc μAdc
Drain-Cutoff Current ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$, $T_A = 100^\circ\text{C}$)	$I_{D(off)}$	—	—	1.0 0.1	nAdc μAdc
Gate Source Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 10 \text{ nAdc}$)	V_{GS}	4.0 2.0 0.5	— — —	10 5.0 3.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	60 25 5.0	— — —	130 75 30	mAdc
Drain-Source On-Voltage ($I_D = 12 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 6.0 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 3.0 \text{ mAdc}$, $V_{GS} = 0$)	$V_{DS(on)}$	— — —	— — —	0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance ($I_D = 1.0 \text{ mAdc}$, $V_{GS} = 0$)	$r_{DS(on)}$	— — —	— — —	30 60 100	Ohms

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $I_D = 60 \text{ mAdc}$, $f = 1.0 \text{ kHz}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 25 \text{ mAdc}$, $f = 1.0 \text{ kHz}$) ($V_{DS} = 15 \text{ Vdc}$, $I_D = 5.0 \text{ mAdc}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	— — —	20 17 12	— — —	mmhos
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	— — —	— — —	30 60 100	Ohms
Input Capacitance ($V_{GS} = 15 \text{ Vdc}$, $V_{DS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	6.0	10	pF

MPF4391, MPF4392, MPF4393

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Transfer Capacitance ($V_{GS} = 12\text{ Vdc}$, $V_{DS} = 0$, $f = 1.0\text{ MHz}$) ($V_{DS} = 15\text{ Vdc}$, $I_D = 10\text{ mAdc}$, $f = 1.0\text{ MHz}$)	C_{rss}	—	2.5 3.2	3.5 —	pF
SWITCHING CHARACTERISTICS					
Rise Time (See Figure 2) ($I_{D(on)} = 12\text{ mAdc}$) ($I_{D(on)} = 6.0\text{ mAdc}$) ($I_{D(on)} = 3.0\text{ mAdc}$)	t_r	—	1.2 2.0 2.5	5.0 5.0 5.0	ns
Fall Time (See Figure 4) ($V_{GS(off)} = 12\text{ Vdc}$) ($V_{GS(off)} = 7.0\text{ Vdc}$) ($V_{GS(off)} = 5.0\text{ Vdc}$)	t_f	—	7.0 15 29	15 20 35	ns
Turn-On Time (See Figures 1 and 2) ($I_{D(on)} = 12\text{ mAdc}$) ($I_{D(on)} = 6.0\text{ mAdc}$) ($I_{D(on)} = 3.0\text{ mAdc}$)	t_{on}	—	3.0 4.0 6.5	15 15 15	ns
Turn-Off Time (See Figures 3 and 4) ($V_{GS(off)} = 12\text{ Vdc}$) ($V_{GS(off)} = 7.0\text{ Vdc}$) ($V_{GS(off)} = 5.0\text{ Vdc}$)	t_{off}	—	10 20 37	20 35 55	ns

(1) Pulse Test: Pulse Width $\leq 100\ \mu\text{s}$, Duty Cycle $\leq 1.0\%$.

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 – TURN-ON DELAY TIME

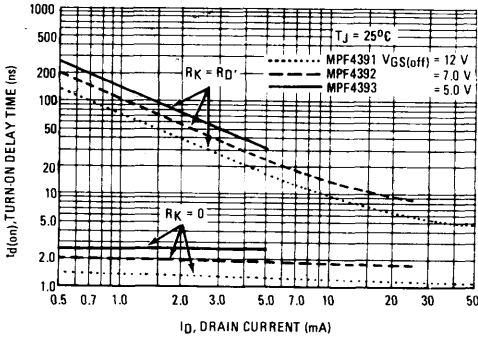


FIGURE 2 – RISE TIME

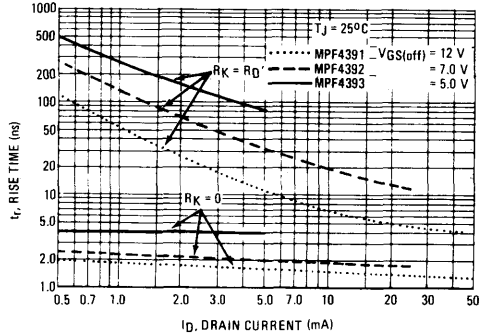


FIGURE 3 – TURN-OFF DELAY TIME

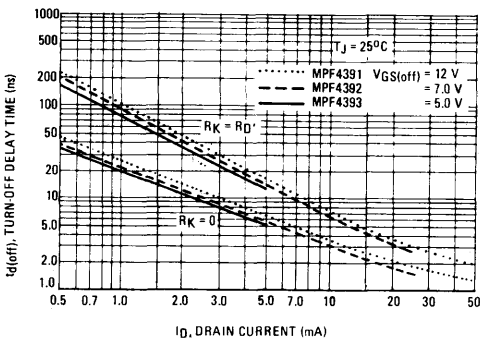
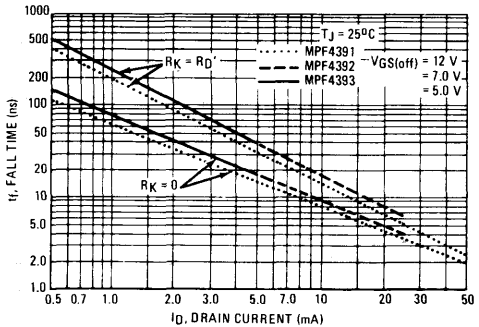
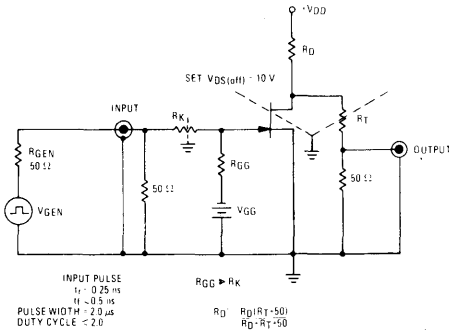


FIGURE 4 – FALL TIME



MPF4391, MPF4392, MPF4393

FIGURE 5 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 5. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($-V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{GEN} and R_K . C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds} , turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions: 1) R_K is equal to R'_D which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

FIGURE 6 – TYPICAL FORWARD TRANSFER ADMITTANCE

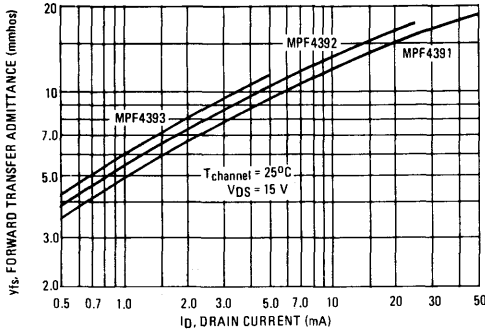


FIGURE 7 – TYPICAL CAPACITANCE

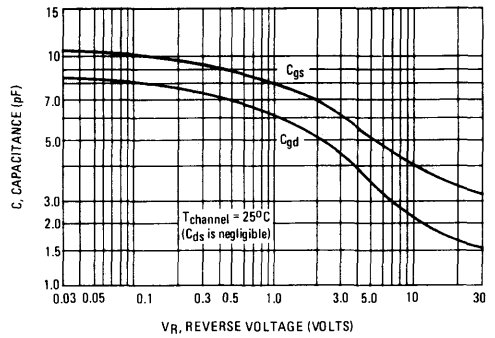


FIGURE 8 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

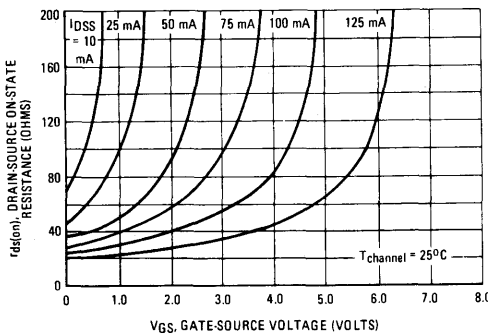
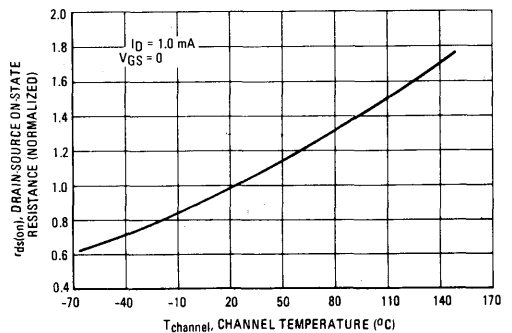
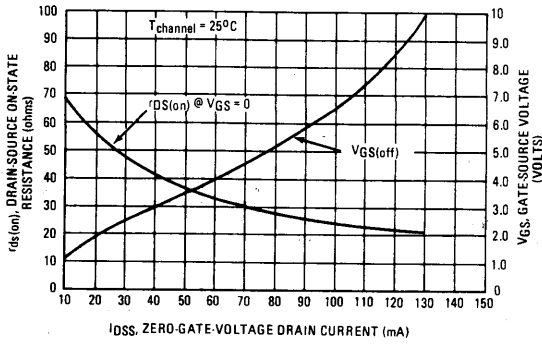


FIGURE 9 – EFFECT OF TEMPERATURE ON DRAIN-SOURCE ON-STATE RESISTANCE



MPF4391, MPF4392, MPF4393

FIGURE 10 - EFFECT OF I_{DSS} ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE



NOTE 2

The Zero-Gate-Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 10 shows the relationship of Gate-Source Off Voltage ($V_{GS(off)}$) and Drain-Source On Resistance ($r_{ds(on)}$) to I_{DSS} . Most of the devices will be within $\pm 10\%$ of the values shown in Figure 10. This data will be useful in predicting the characteristic variations for a given part number.

For example:

Unknown

$r_{ds(on)}$ and V_{GS} range for an MPF4392

The electrical characteristics table indicates that an MPF4392 has an I_{DSS} range of 25 to 75 mA. Figure 10, shows $r_{ds(on)}$ = 52 Ohms for I_{DSS} = 25 mA and 30 Ohms for I_{DSS} = 75 mA. The corresponding V_{GS} values are 2.2 volts and 4.8 volts.

MPF4416,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH-FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Gate-Source Voltage	V_{GS}	-30 -35	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Lead Temperature	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{A}$)	MPF4416 MPF4416A	$V_{(BR)GSS}$	-30 -35	—	Vdc
Gate Reverse Current ($V_{GS} = -20 \text{ V}$)		I_{GSS}	—	-250	pA
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ V}, I_D = 1.0 \text{ nA}$)	MPF4416 MPF4416A	$V_{GS(off)}$	— -2.5	-6.0 -6.0	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current* ($V_{DS} = 15 \text{ V}$)		I_{DSS}	5.0	15	mA
---	--	-----------	-----	----	----

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ V}, f = 1.0 \text{ kHz}$)		$ y_{fs} $	4500	7500	μmhos
Input Admittance ($V_{DS} = 15 \text{ V}, f = 100 \text{ MHz}$) ($V_{DS} = 15 \text{ V}, f = 400 \text{ MHz}$)		$\text{Re}(y_{is})$	— —	100 1000	μmhos
Output Admittance ($V_{DS} = 15 \text{ V}, f = 1.0 \text{ kHz}$)		$ y_{os} $	—	50	μmhos
Output Conductance ($V_{DS} = 15 \text{ V}, f = 100 \text{ MHz}$) ($V_{DS} = 15 \text{ V}, f = 400 \text{ MHz}$)		$\text{Re}(y_{os})$	— —	75 100	μmhos
Forward Transconductance* ($V_{DS} = 15 \text{ V}, f = 400 \text{ MHz}$)		$\text{Re}(y_{fs})$	4000	—	μmhos
Input Capacitance ($V_{DS} = 15 \text{ V}, f = 1.0 \text{ MHz}$)		C_{iss}	—	4.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ V}, f = 1.0 \text{ MHz}$)		C_{rss}	—	0.8	pF
Output Capacitance ($V_{DS} = 15 \text{ V}, f = 1.0 \text{ MHz}$)		C_{oss}	—	2.0	pF

FUNCTIONAL CHARACTERISTICS

Noise Figure ($V_{DS} = 15 \text{ V}, I_D = 5.0 \text{ mA}, R_G = 1.0 \text{ k}\Omega, f = 100 \text{ MHz}$) ($V_{DS} = 15 \text{ V}, I_D = 5.0 \text{ mA}, R_G = 1.0 \text{ k}\Omega, f = 400 \text{ MHz}$)		NF	— —	2.0 4.0	dB
Common Source Power Gain ($V_{DS} = 15 \text{ V}, I_D = 5.0 \text{ mA}, f = 100 \text{ MHz}$) ($V_{DS} = 15 \text{ V}, I_D = 5.0 \text{ mA}, f = 400 \text{ MHz}$)		G_{ps}	18 10	— —	dB

*Pulse Test Duration = 2.0 msec.

MPF4856,A thru MPF4861,A

**CASE 29-02, STYLE 5
TO-92 (TO-226AA)**

**JFET
SWITCHING**

N-CHANNEL — DEPLETION

Refer to 2N4856 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPF4856,A MPF4857,A MPF4858,A	MPF4859,A MPF4860,A MPF4861,A	Unit
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	-40	-30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.4		mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +150		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	MPF4856,A, MPF4857,A, MPF4858,A MPF4859,A, MPF4860,A, MPF4861,A	$V_{(BR)GSS}$	-40 -30	— —	Vdc
Gate Reverse Current ($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	MPF4856,A, MPF4857,A, MPF4858,A MPF4859,A, MPF4860,A, MPF4861,A MPF4856,A, MPF4857,A, MPF4858,A MPF4859,A, MPF4860,A, MPF4861,A	I_{GSS}	— — — —	0.25 0.25 0.5 0.5	nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 0.5 \text{ nAdc}$)	MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	$V_{GS(off)}$	-4.0 -2.0 -0.8	-10 -6.0 -4.0	Vdc
Drain Cutoff Current ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -10 \text{ Vdc}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -10 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)		$I_{D(off)}$	— —	0.25 0.5	nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	I_{DSS}	50 20 8.0	— 100 80	mAdc
Drain-Source On-Voltage ($I_D = 20 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 10 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 5.0 \text{ mAdc}$, $V_{GS} = 0$)	MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	$V_{DS(on)}$	— — —	0.75 0.5 0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	$r_{ds(on)}$	— — —	25 40 60	Ohms
Input Capacitance ($V_{DS} = 0$, $V_{GS} = -10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	MPF4856 thru MPF4861 MPF4856A thru MPF4861A	C_{iss}	— —	18 10	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = -10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	MPF4856 thru MPF4861 MPF4856A, MPF4859A MPF4857A, MPF4858A, MPF4860A, MPF4861A	C_{rss}	— — —	8.0 4.0 3.5	pF

MPF4856,A thru MPF4861,A

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	Conditions for MPF4856,A, MPF4859,A: $(V_{DD} = 10 \text{ Vdc}, I_{D(on)} = 20 \text{ mAdc}, V_{GS(on)} = 0, V_{GS(off)} = -10 \text{ Vdc})$	MPF4856, MPF4859	—	6.0	ns
		MPF4856A, MPF4859A	—	5.0	
		MPF4857, MPF4860	—	6.0	
		MPF4857A, MPF4860A	—	6.0	
		MPF4858, MPF4861	—	10	
		MPF4858A, MPF4861A	—	8.0	
Rise Time	Conditions for MPF4857,A, MPF4860,A: $(V_{DD} = 10 \text{ Vdc}, I_{D(on)} = 10 \text{ mAdc}, V_{GS(on)} = 0, V_{GS(off)} = -6.0 \text{ Vdc})$	MPF4856,A, MPF4859,A	—	3.0	ns
		MPF4857,A, MPF4860,A	—	4.0	
		MPF4858, MPF4861	—	10	
		MPF4858A, MPF4861A	—	8.0	
Turn-Off Time	Conditions for MPF4858,A, MPF4861,A: $(V_{DD} = 10 \text{ Vdc}, I_{D(on)} = 5.0 \text{ mAdc}, V_{GS(on)} = 0, V_{GS(off)} = -4.0 \text{ Vdc})$	MPF4856, MPF4859	—	25	ns
		MPF4856A, MPF4859A	—	20	
		MPF4857, MPF4860	—	50	
		MPF4857A, MPF4860A	—	40	
		MPF4858, MPF4861	—	100	
		MPF4858A; MPF4861A	—	80	

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle \leq 10%.

(2) The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

U308 U309 U310

**CASE 27-02, STYLE 4
TO-52 (TO-206AC)**

**JFET
VHF/UHF AMPLIFIER
N-CHANNEL — DEPLETION**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	20	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	500 4.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{A}, V_{DS} = 0$)	$V_{(BR)GSS}$	-25	—	—	V
Gate Reverse Current ($V_{GS} = -15 \text{ V}$) ($V_{GS} = 0, T_A = 125^\circ\text{C}$)	I_{GSS}	— —	— —	-150 -150	pA nA
Gate Source Cutoff Voltage ($V_{DS} = 10 \text{ V}, I_D = 1.0 \text{ nA}$)	$V_{GS(off)}$	-1.0 -1.0 -2.5	— — —	-6.0 -4.0 -6.0	V
	U308 U309 U310				

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 10 \text{ V}, V_{GS} = 0$)	I_{DSS}	12 12 24	— — —	60 30 60	mA
	U308 U309 U310				
Gate-Source Forward Voltage ($I_G = 10 \text{ mA}, V_{DS} = 0$)	$V_{GS(f)}$	—	—	1.0	V

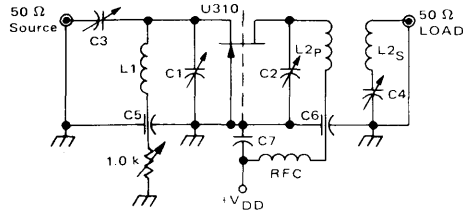
SWITCHING CHARACTERISTICS

Common-Gate Forward Transconductance(1) ($V_{DS} = 10 \text{ V}, I_D = 10 \text{ mA}, f = 1.0 \text{ kHz}$)	g_{fg}	10 10 10	— — —	20 20 18	mmhos
	U308 U309 U310				
Common-Gate Output Conductance ($V_{DS} = 10 \text{ V}, I_D = 10 \text{ mA}, f = 1.0 \text{ kHz}$)	g_{og}	—	150	—	μmhos
Drain-Gate Capacitance ($V_{GS} = -10 \text{ V}, V_{DS} = 10 \text{ V}, f = 1.0 \text{ MHz}$)	C_{gd}	—	—	2.5	pF
Gate-Source Capacitance ($V_{GS} = -10 \text{ V}, V_{DS} = 10 \text{ V}, f = 1.0 \text{ MHz}$)	C_{gs}	—	—	5.0	pF
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = 10 \text{ V}, I_D = 10 \text{ mA}, f = 100 \text{ Hz}$)	\bar{e}_n	—	10	—	nV/ $\sqrt{\text{Hz}}$

(1) Pulse test duration = 2.0 ms.

(2) See Figures 10 and 11 for Noise Figure and Power Gain information.

FIGURE 1 - 450 MHz COMMON-GATE AMPLIFIER TEST CIRCUIT



C1 = C2 = 0.8 - 10 pF, JFD #MVM010W.
 C3 = C4 = 8.35 pF Erie #539 002D.
 C5 = C6 = 5000 pF Erie (2443 000).
 C7 = 1000 pF, Allen Bradley #FAS.C.
 RFC = 0.33 μH Miller #9230-30.
 L1 = One Turn #16 Cu, 1/4" I.D. (Air Core).
 L2p = One Turn #16 Cu, 1/4" I.D. (Air Core).
 L2s = One Turn #16 Cu, 1/4" I.D. (Air Core).

FIGURE 2 - DRAIN CURRENT and TRANSFER CHARACTERISTICS versus GATE-SOURCE VOLTAGE

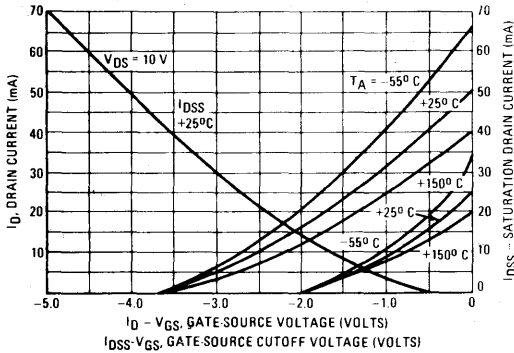


FIGURE 3 - FORWARD TRANSDUCTANCE versus GATE-SOURCE VOLTAGE

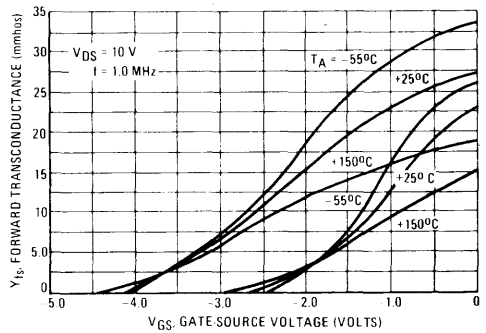


FIGURE 4 - COMMON-SOURCE OUTPUT ADMITTANCE and FORWARD TRANSDUCTANCE versus DRAIN CURRENT

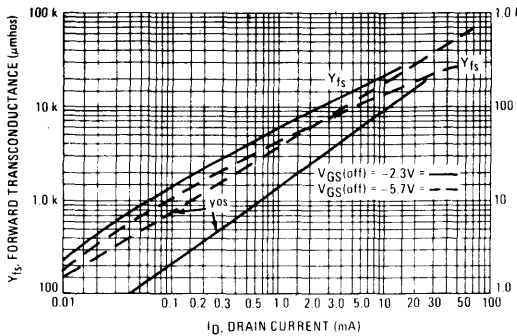


FIGURE 5 - ON RESISTANCE and JUNCTION CAPACITANCE versus GATE-SOURCE VOLTAGE

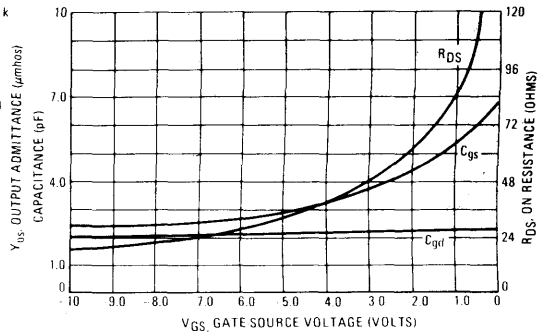


FIGURE 6 – COMMON-GATE Y PARAMETER MAGNITUDE versus FREQUENCY

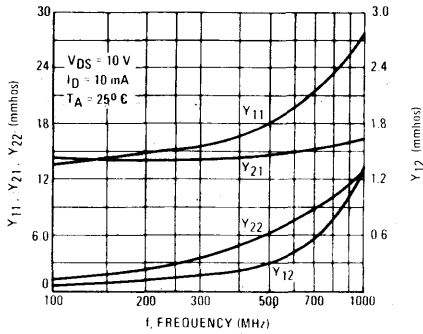


FIGURE 7 – COMMON-GATE S PARAMETER MAGNITUDE versus FREQUENCY

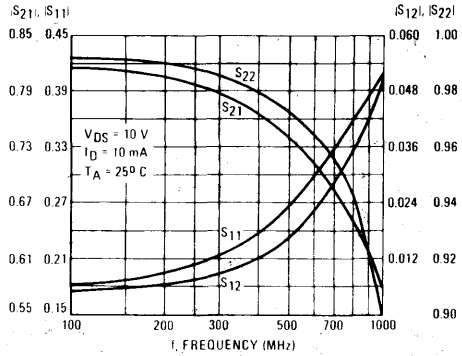


FIGURE 8 – COMMON-GATE Y PARAMETER PHASE-ANGLE versus FREQUENCY

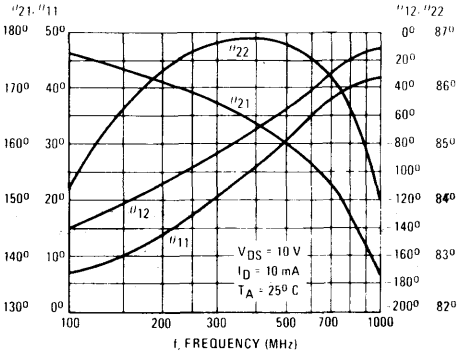


FIGURE 9 – S PARAMETER PHASE-ANGLE versus FREQUENCY

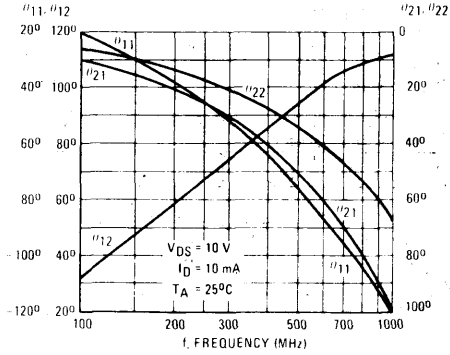


FIGURE 10 – NOISE FIGURE and POWER GAIN versus DRAIN CURRENT

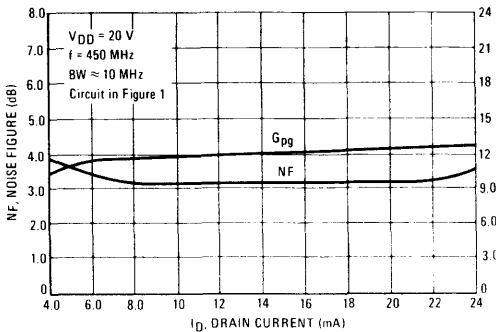


FIGURE 11 – NOISE FIGURE and POWER GAIN versus FREQUENCY

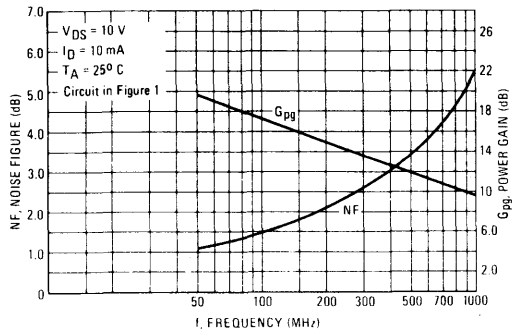
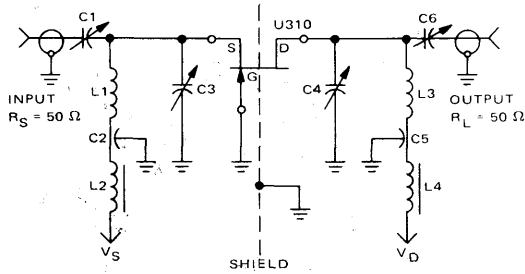


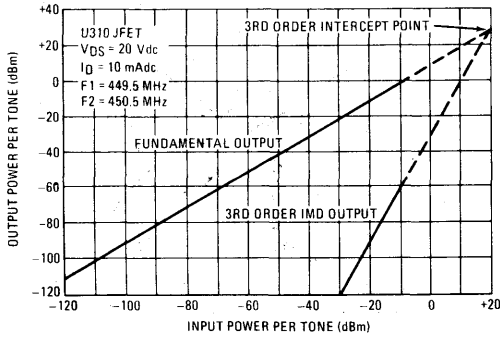
FIGURE 12 – 450 MHz IMD EVALUATION AMPLIFIER



- B_W (3dB) = 36.5 MHz
- I_D = 10 mAdc
- V_{DS} = 20 Vdc
- Device case grounded
- IM test tones = f₁ = 449.5 MHz, f₂ = 450.5 MHz
- C1 = 1-10 pf Johanson Air variable trimmer.
- C2, C5 = 100 pf feed thru button capacitor.
- C3, C4, C6 = 0.5-6 pf Johanson Air variable trimmer.
- L1 = 1/8" x 1/32" x 1 5/8" copper bar
- L2, L4 = Ferroxcube Vκ200 choke.
- L3 = 1/8" x 1/32" x 1 7/8" copper bar.

Amplifier power gain and IMD products are a function of the load impedance. For the amplifier design shown above with C4 and C6 adjusted to reflect a load to the drain resulting in a nominal power gain of 9 dB, the 3rd order intercept point (IP) value is 29 dBm. Adjusting C4, C6 to provide larger load values will result in higher gain, smaller bandwidth and lower IP values. For example, a nominal gain of 13 dB can be achieved with an intercept point of 19 dBm.

FIGURE 13 – TWO TONE 3RD ORDER INTERCEPT POINT



Example of intercept point plot use:
 Assume two in-band signals of -20 dBm at the amplifier input. They will result in a 3rd order IMD signal at the output of -90 dBm. Also, each signal level at the output will be -11 dBm, showing an amplifier gain of 9.0 dB and an intermodulation ratio (IMR) capability of 79 dB. The gain and IMR values apply only for signal levels below compression.

RF Transistors

7

2N2857 2N3839

2N2857
JAN, JTX, JTXV AVAILABLE
CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	40	mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.72	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* ($I_C = 3.0 \text{ mA}_{dc}$, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0 \text{ mA}_{dc}$, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ mA}_{dc}$, $I_C = 0$)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	0.01 1.0	μA_{dc}
	Both Types 2N3839				

ON CHARACTERISTICS

DC Current Gain ($I_C = 3.0 \text{ mA}_{dc}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30	—	150	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) ($I_C = 5.0 \text{ mA}_{dc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N2857 2N3839	f_T	1000 1000	— —	1900 2000	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 0.1$ to 1.0 MHz)		C_{cb}	—	0.7	1.0	pF
Small Signal Current Gain ($I_C = 2.0 \text{ mA}_{dc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)		h_{fe}	50	—	220	—
Collector Base Time Constant ($I_E = 2.0 \text{ mA}_{dc}$, $V_{CB} = 6.0 \text{ Vdc}$, $f = 31.9 \text{ MHz}$)	2N2857 2N3839	$rb'C_c$	4.0 1.0	— —	15 15	ps
Noise Figure (Figure 1) ($I_E = 0.1 \text{ mA}_{dc}$, $V_{CE} = 1.0 \text{ Vdc}$, $R_S = 50 \text{ ohms}$, $f = 450 \text{ MHz}$)(2) Both Types ($I_C = 1.5 \text{ mA}_{dc}$, $V_{CE} = 6.0 \text{ Vdc}$, $R_S = 50 \text{ ohms}$, $f = 450 \text{ MHz}$)	2N2857 2N3839	NF	— — —	5.8 4.1 —	— 4.5 3.9	dB

FUNCTIONAL TEST

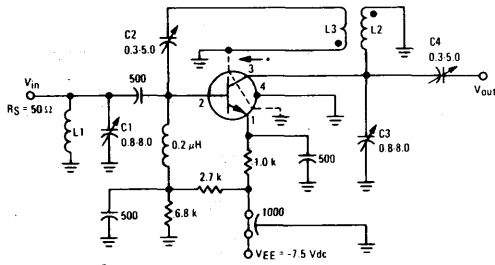
Common-Emitter Amplifier Power Gain (Figure 1) ($I_E = 0.1 \text{ mA}_{dc}$, $V_{CE} = 1.0 \text{ Vdc}$, $f = 450 \text{ MHz}$, $R_S = 50\Omega$)(2) ($I_C = 1.5 \text{ mA}_{dc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 450 \text{ MHz}$, $R_S = 50\Omega$)	G_{pe}	— 12.5	11 —	— 19	dB
Power Output (Figure 2) ($I_E = 12 \text{ mA}_{dc}$, $V_{CB} = 10 \text{ Vdc}$, $f = 500 \text{ MHz}$)	P_{out}	30	—	—	mW

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

(2) Micro-Power Specifications.

*Indicates Data in addition to JEDEC Requirements.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.

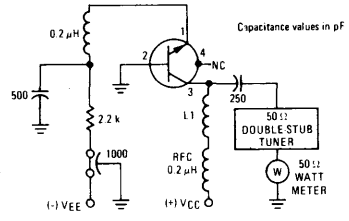
– External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with $R_S = 50$ ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

FIGURE 2 – TEST CIRCUIT FOR OSCILLATOR POWER OUTPUT



L1 – 3 turns #16 AWG wire, 3/8" O.D. 1-1/4" long.

- (C) Apply V_{EE} and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.
- (D) Interchange connections to signal generator and RF voltmeter.
- (E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.
- (F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 3 – NOISE FIGURE versus FREQUENCY

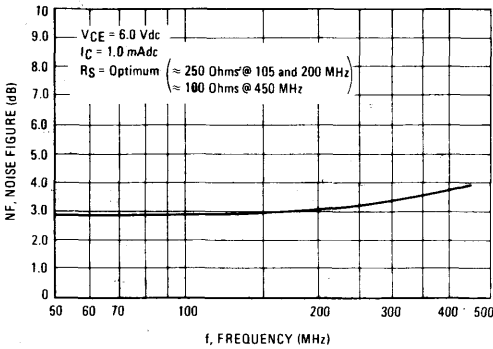


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

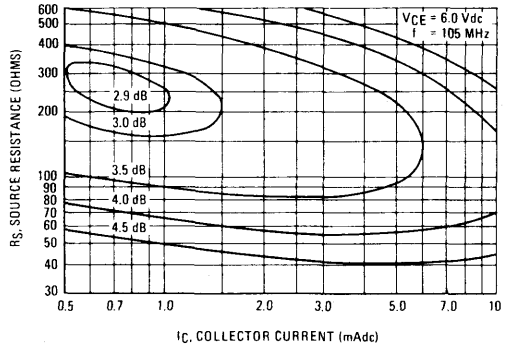


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

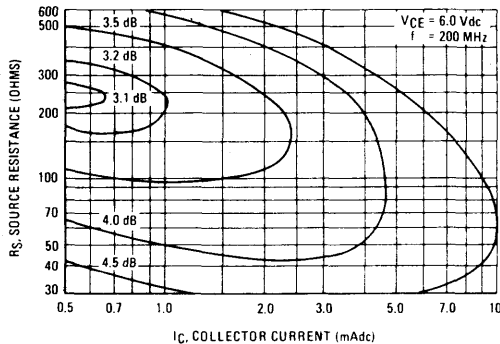


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

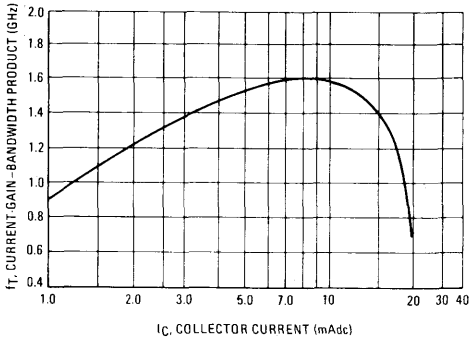


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

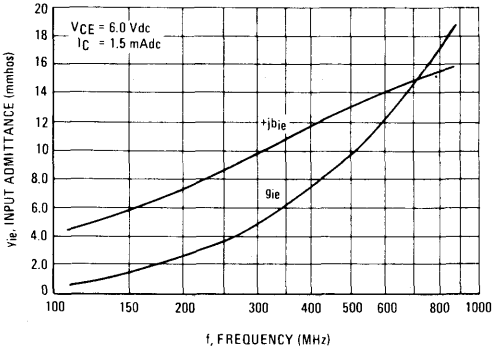


FIGURE 10 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

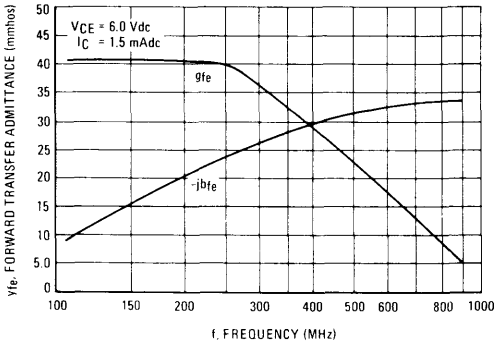


FIGURE 7 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

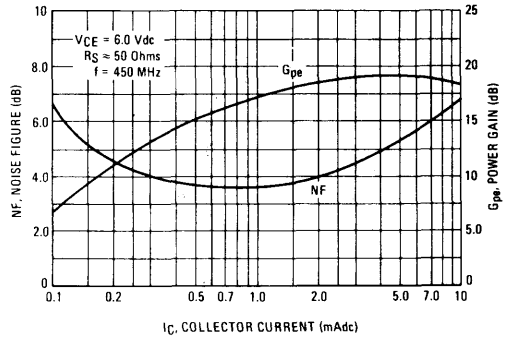


FIGURE 9 – OUTPUT ADMITTANCE versus FREQUENCY

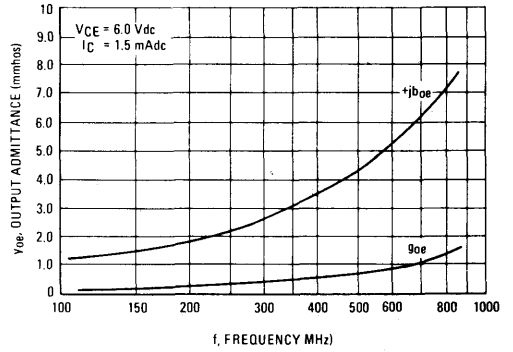
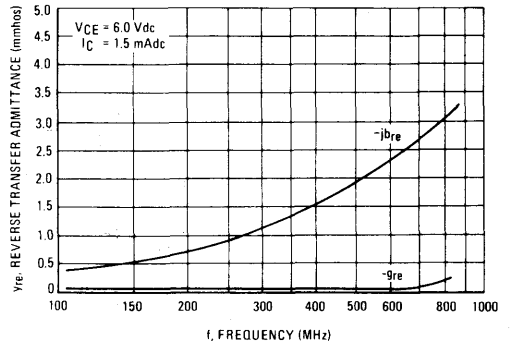


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



7

FIGURE 12 – S_{11} , INPUT REFLECTION COEFFICIENT

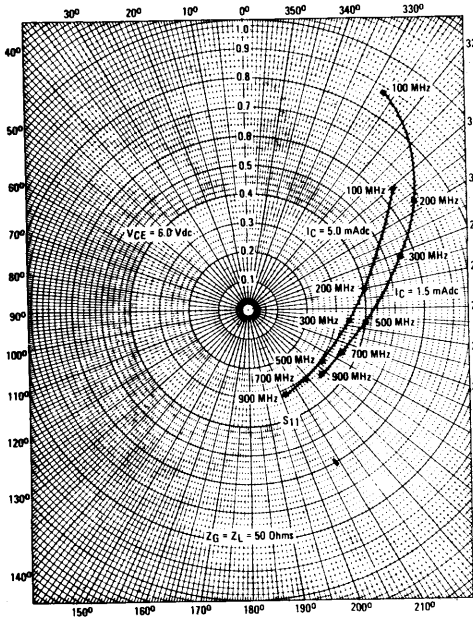


FIGURE 13 – S_{22} , OUTPUT REFLECTION COEFFICIENT

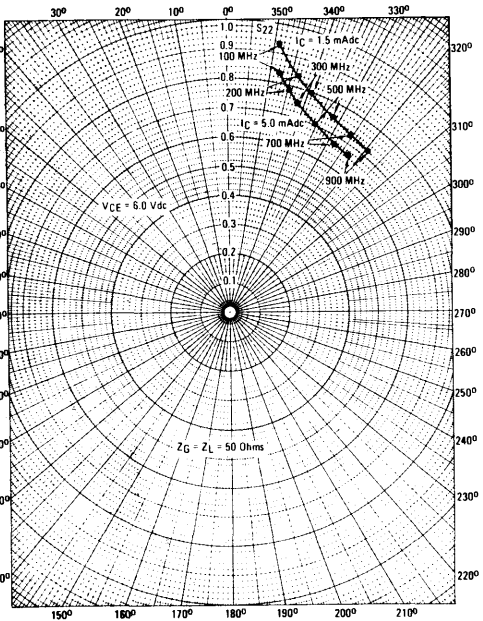


FIGURE 14 – S_{12} , REVERSE TRANSMISSION COEFFICIENT

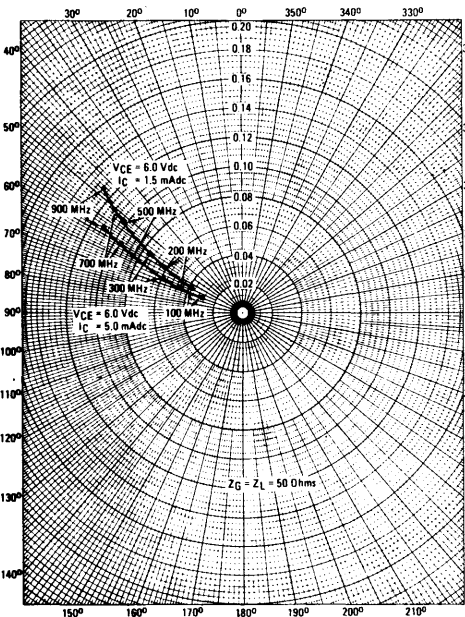


FIGURE 15 – S_{21} , FORWARD TRANSMISSION COEFFICIENT

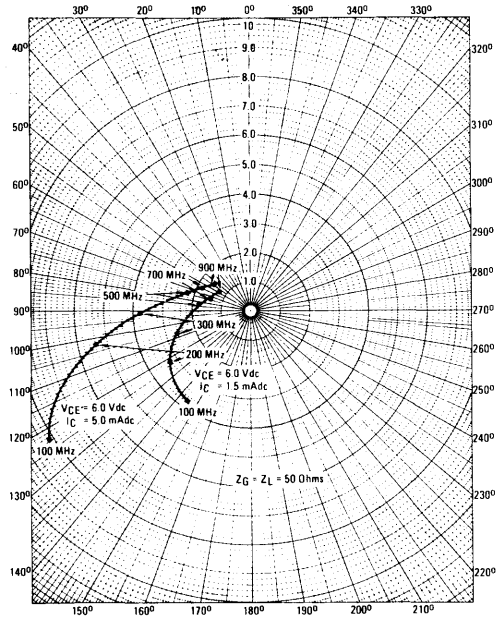
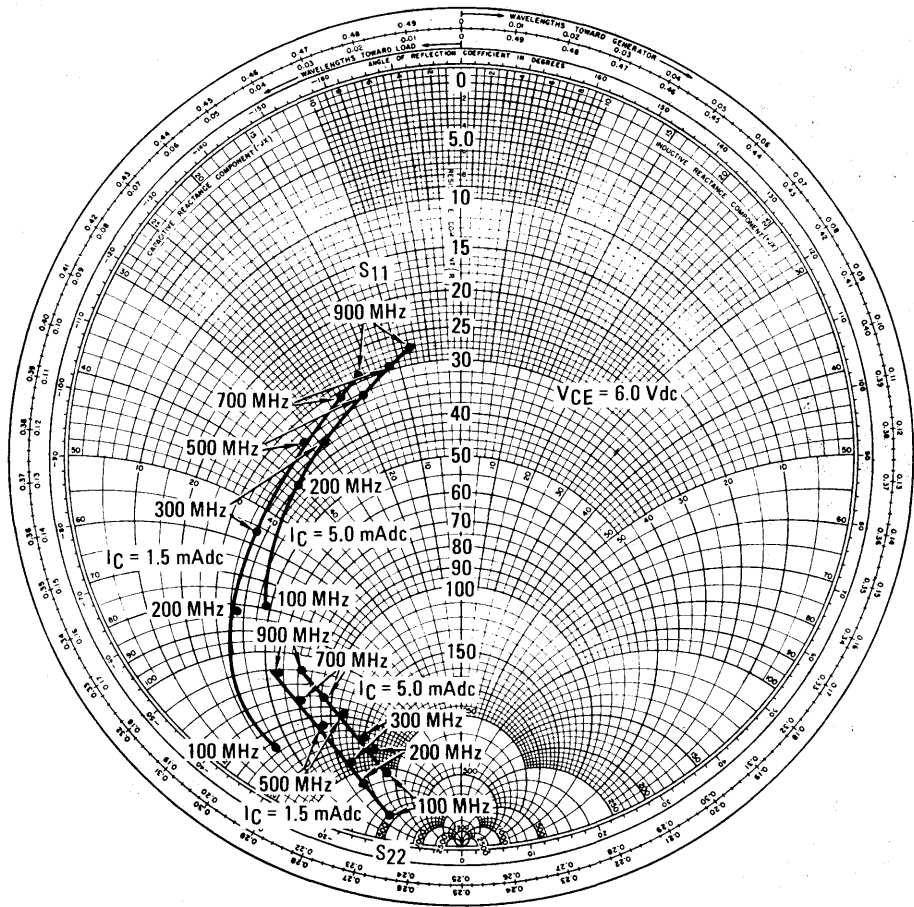


FIGURE 16 – S_{11} , INPUT REFLECTION COEFFICIENT AND S_{22} , OUTPUT REFLECTION COEFFICIENT



7

2N3553

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	40	Vdc
Collector-Base Voltage	V_{CB0}	65	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) ($I_C = 200 \text{ mAdc}, I_B = 0$)	$V_{CE0(sus)}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}, I_B = 0$)	I_{CE0}	—	—	0.1	mAdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}, T_C = 200^\circ\text{C}$) ($V_{CE} = 65 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}$)	I_{CEX}	— —	— —	5.0 1.0	mAdc
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	0.1	mAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 250 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	10	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 250 \text{ mAdc}, I_B = 50 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	1.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 100 \text{ mAdc}, V_{CE} = 28 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	—	500	—	MHz
Output Capacitance ($V_{CB} = 30 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	8.0	10	pF

FUNCTIONAL TEST (FIGURE 2)

Amplifier Power Gain ($V_{CE} = 28 \text{ Vdc}, P_{out} = 2.5 \text{ Watts}, f = 175 \text{ MHz}$)	G_{pe}	10	—	—	dB
Collector Efficiency ($V_{CE} = 28 \text{ Vdc}, P_{out} = 2.5 \text{ Watts}, f = 175 \text{ MHz}$)	η	50	—	—	%
Power Input ($V_{CE} = 28 \text{ Vdc}, P_{out} = 2.5 \text{ Watts}, f = 175 \text{ MHz}$)	P_{in}	—	—	0.25	Watt

(1) Pulsed thru a 25 mH inductor.

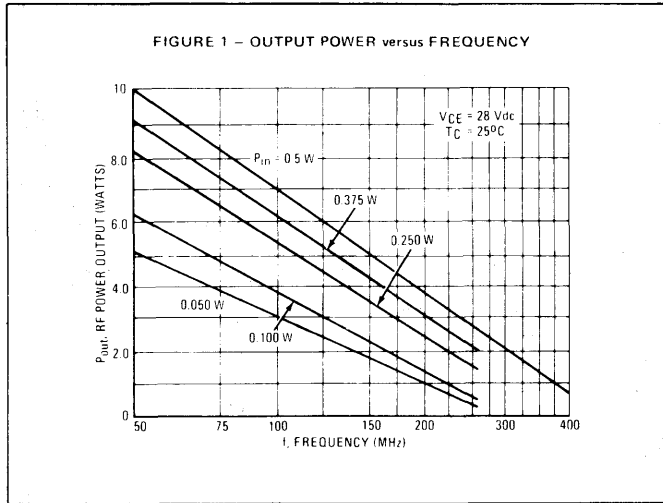
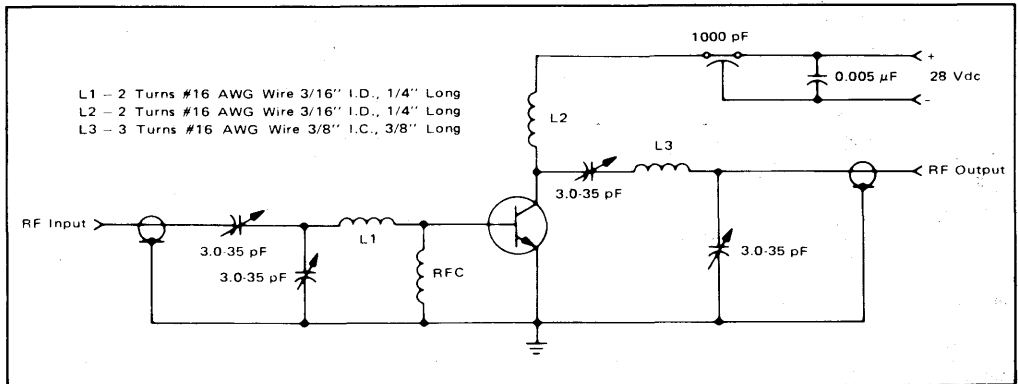


FIGURE 2 – 175 MHz TEST CIRCUIT SCHEMATIC



2N3866 2N3866A

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $R_{BE} = 10 \Omega$)	$V_{CER(sus)}$	55	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current ($V_{CE} = 28$ Vdc, $I_B = 0$)	I_{CEO}	—	0.02	mAdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = -1.5$ Vdc (Rev.), $T_C = 200^\circ\text{C}$) ($V_{CE} = 55$ Vdc, $V_{BE} = -1.5$ Vdc (Rev.))	I_{CEX}	—	5.0 0.1	mAdc
Emitter Cutoff Current ($V_{BE} = 3.5$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	mAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 360$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	Both 2N3866 2N3866A	h_{FE}	5.0 10 25	— 200 200	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 20$ mAdc)		$V_{CE(sat)}$	—	1.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, $f = 200$ MHz)	2N3866 2N3866A	f_T	500 800	— —	MHz
Output Capacitance ($V_{CB} = 28$ Vdc, $I_E = 0$, $f = 1.0$ MHz)		C_{obo}	—	3.0	pF

FUNCTIONAL TEST (FIGURE 1)

Amplifier Power Gain ($V_{CC} = 28$ Vdc, $P_{out} = 1.0$ W, $f = 400$ MHz)		G_{pe}	10	—	dB
Collector Efficiency ($V_{CC} = 28$ Vdc, $P_{out} = 1.0$ W, $f = 400$ MHz)		η	45	—	%

FIGURE 1 - 400 MHz TEST CIRCUIT SCHEMATIC

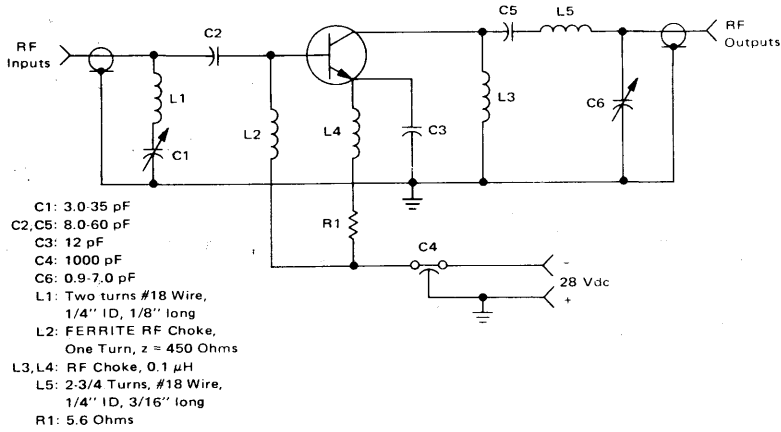


FIGURE 2 - POWER OUTPUT versus FREQUENCY (Class C)

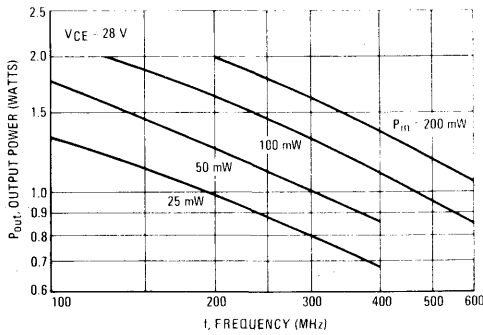


FIGURE 3 - CURRENT GAIN - BANDWIDTH PRODUCT

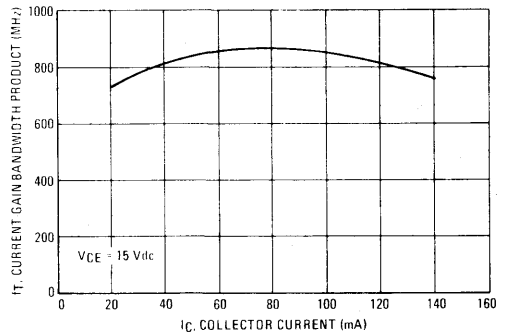


FIGURE 4 - COLLECTOR-BASE TIME CONSTANT

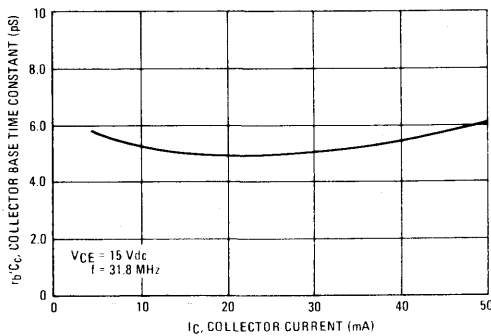
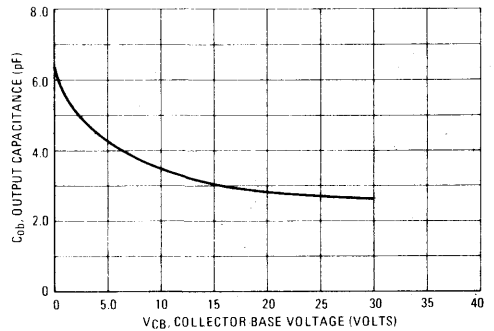


FIGURE 5 - OUTPUT CAPACITANCE



2N3866 • 2N3866A

FIGURE 6 – OUTPUT POWER versus INPUT POWER (CLASS C)

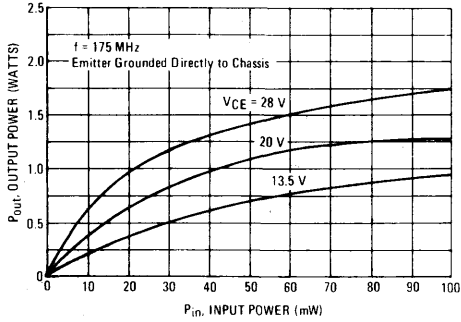


FIGURE 7 – SMALL-SIGNAL CURRENT GAIN

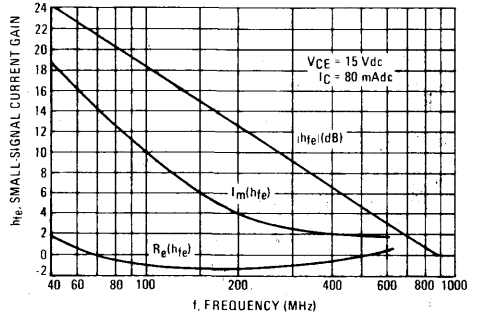


FIGURE 8 – LARGE-SIGNAL SERIES EQUIVALENT IMPEDANCES

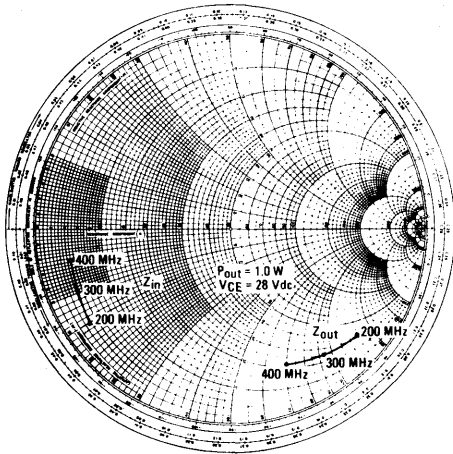


FIGURE 9 – S_{11} AND S_{22} versus FREQUENCY

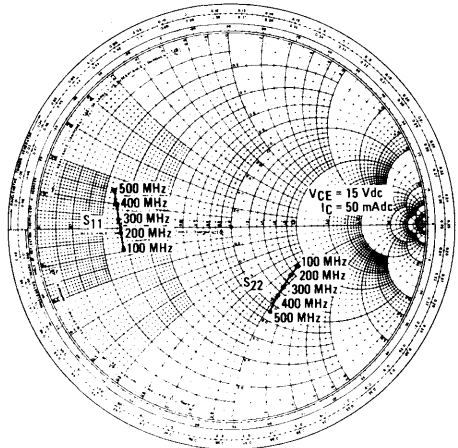


FIGURE 10 – S_{21} versus FREQUENCY

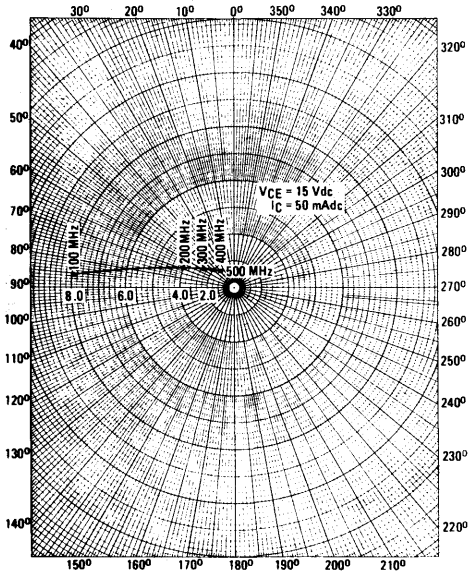
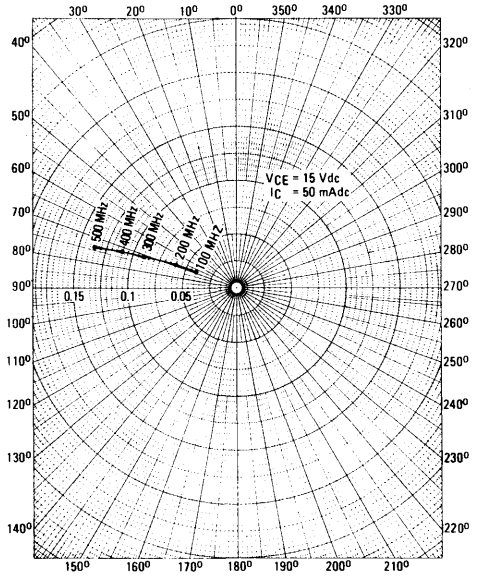


FIGURE 11 – S_{12} versus FREQUENCY



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2N3948

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	20	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ($I_C = 5.0 \text{ mAdc}, I_E = 0$)	$V_{CE0(sus)}$	20	—	Vdc	
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}, I_E = 0$)	$V_{(BR)CBO}$	36	—	Vdc	
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	3.5	—	Vdc	
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}, I_E = 0$) ($V_{CB} = 15 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.1 100	μAdc	
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	15	—	—	
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_E = 50 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 200 \text{ MHz}$)	f_T	700	—	MHz	
Output Capacitance ($V_{CB} = 15 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	4.5	pF	
FUNCTIONAL TEST (FIGURE 1)					
Power Gain	$(V_{CC} = 13.6 \text{ Vdc}, f = 400 \text{ MHz}, P_{in} = 0.25 \text{ W})$	G_{pe}	6.0	—	dB
Output Power		P_{out}	1.0	—	Watt
Collector Efficiency		η	45	—	%

FIGURE 1 - 400 MHz RF AMPLIFIER TEST CIRCUIT

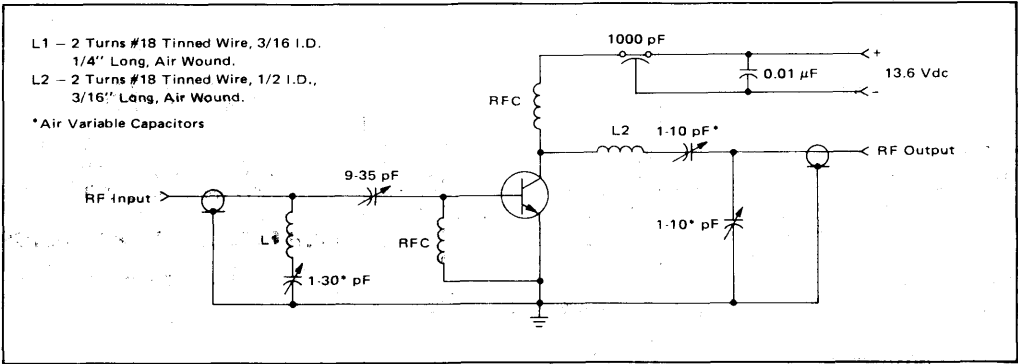


FIGURE 2 - OUTPUT POWER versus FREQUENCY

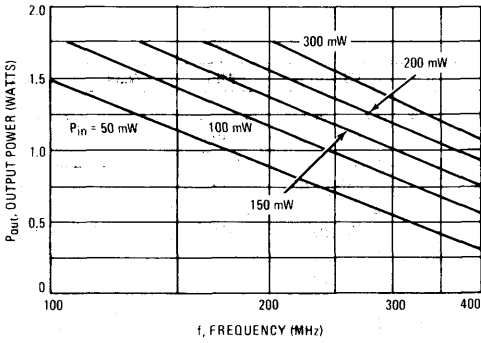
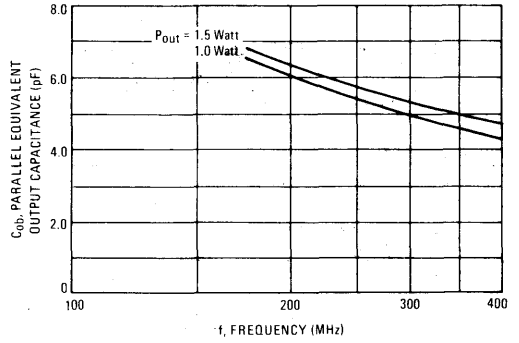


FIGURE 3 - PARALLEL EQUIVALENT OUTPUT CAPACITANCE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	12	Vdc
Collector-Base Voltage	V _{CBO}	20	Vdc
Emitter-Base Voltage	V _{EBO}	4.5	Vdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	400 2.3	mW mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	750 4.3	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	0.233	°C/mW
Thermal Resistance, Junction to Ambient	R _{θJA}	0.436	°C/mW

2N3959 2N3960

JAN, JTX, JTXV AVAILABLE
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mA _{dc} , I _B = 0)	V _{(BR)CEO}	12	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{(BR)CBO}	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	4.5	—	—	Vdc
Collector Cutoff Current (V _{CE} = 10 Vdc, V _{EB} = 2.0 Vdc) (V _{CE} = 10 Vdc, V _{EB} = 2.0 Vdc, T _A = 150°C)	I _{CEX}	—	—	0.005 5.0	μA _{dc}
Collector Forward Current (V _{CE} = 5.0 Vdc, V _{BE} = 0.4 Vdc)	I _{CEX}	—	—	1.0	μA _{dc}
Base Cutoff Current (V _{CE} = 10 Vdc, V _{EB} = 2.0 Vdc)	I _{BL}	—	—	0.005	μA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mA _{dc} , V _{CE} = 1.0 Vdc) (I _C = 10 mA _{dc} , V _{CE} = 1.0 Vdc) (I _C = 30 mA _{dc} , V _{CE} = 1.0 Vdc)	h _{FE}	25 40 25	— — —	— 400 —	—
Collector-Emitter Saturation Voltage (I _C = 1.0 mA _{dc} , I _B = 0.1 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 3.0 mA _{dc})	V _{CE(sat)}	— —	— —	0.2 0.3	Vdc
Base-Emitter On Voltage (I _C = 1.0 mA _{dc} , V _{CE} = 1.0 Vdc) (I _C = 30 mA _{dc} , V _{CE} = 1.0 Vdc)	V _{BE(on)}	— —	— —	0.8 1.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 5.0 mA _{dc} , V _{CE} = 4.0 Vdc, f = 100 MHz)	2N3959 2N3960	f _T	1000 1300	— —	— —	MHz
(I _C = 10 mA _{dc} , V _{CE} = 10 Vdc, f = 100 MHz)	2N3959 2N3960		1300 1600	— —	— —	
(I _C = 30 mA _{dc} , V _{CE} = 4.0 Vdc, f = 100 MHz)	2N3959 2N3960		1000 1200	— —	— —	
Output Capacitance (V _{CB} = 4.0 Vdc, I _E = 0, f = 1.0 MHz)		C _{obo}	—	2.0	2.5	pF

2N3959 • 2N3960

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Capacitance (V _{EB} = 0.5 Vdc, I _C = 0, f = 100 MHz)	C _{ibo}	—	1.5	2.5	pF
Collector Base Time Constant (I _C = 5.0 mA, V _{CE} = 4.0 Vdc)	r _b 'C _C	—	—	30	ps
				50	
(I _C = 10 mA, V _{CE} = 10 Vdc)				25	
				40	
(I _C = 30 mA, V _{CE} = 4.0 Vdc)	2N3959	—	—	30	ps
				2N3960	

SWITCHING CHARACTERISTICS (FIGURE 7)

Turn-On Delay Time (I _C = 10 mA, V _{out} = 1.0 Vdc) (I _C = 30 mA, V _{out} = 1.0 Vdc)	t _{d(on)}	—	2.4 2.0	—	ns
Rise Time (I _C = 10 mA, V _{out} = 1.0 Vdc) (I _C = 30 mA, V _{out} = 1.0 Vdc)	t _r	Both Devices	3.0 2.2 1.7	—	ns
Turn-Off Delay Time (I _C = 10 mA, V _{out} = 1.0 Vdc) (I _C = 30 mA, V _{out} = 1.0 Vdc)	t _{d(off)}	—	1.6 1.6	—	ns
Fall Time (I _C = 10 mA, V _{out} = 1.0 Vdc) (I _C = 30 mA, V _{out} = 1.0 Vdc)	t _f	Both Devices	3.3 2.3 1.9	—	ns

FIGURE 1 – TYPICAL DC CURRENT GAIN

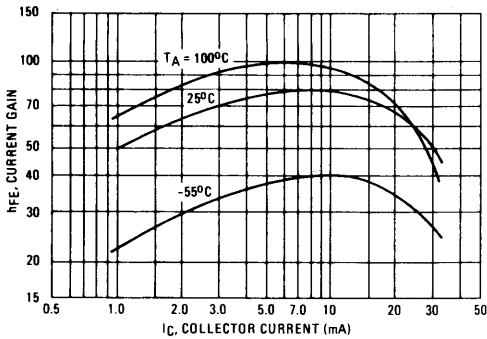


FIGURE 2 – TYPICAL CURRENT-GAIN – BANDWIDTH PRODUCT

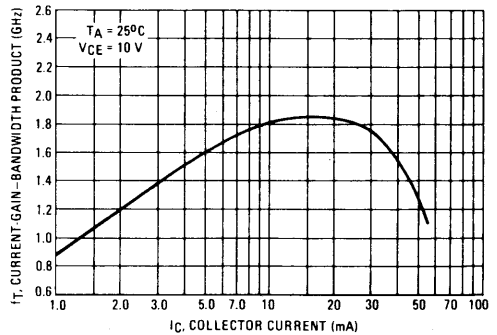


FIGURE 3 – TYPICAL COLLECTOR-BASE TIME CONSTANT

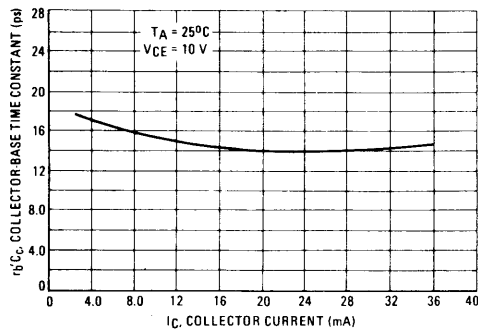
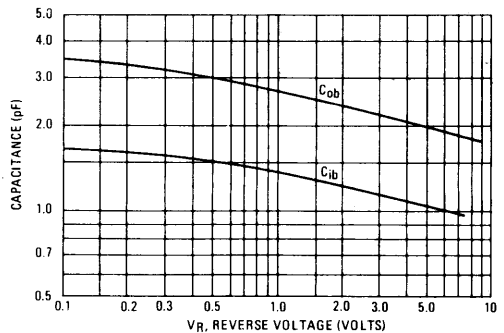


FIGURE 4 – TYPICAL JUNCTION CAPACITANCE



TURN-ON AND TURN-OFF TIMES

FIGURE 5 - $V_{out} = 1.0 \text{ Vdc}$

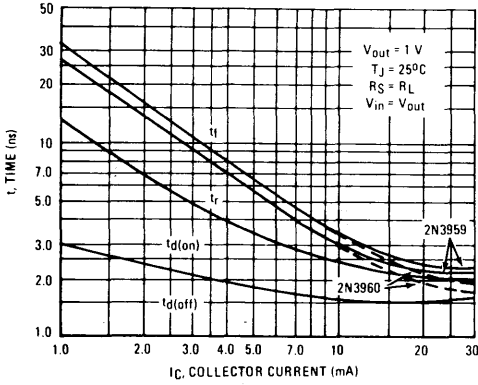


FIGURE 6 - $V_{out} = 2.0 \text{ Vdc}$

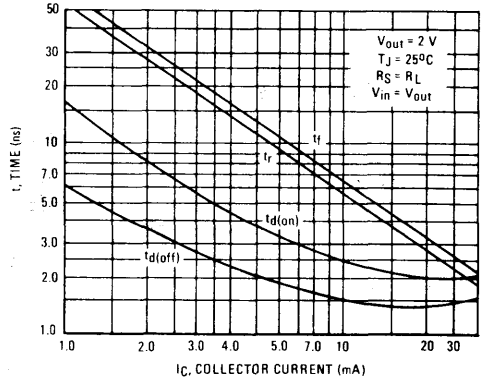
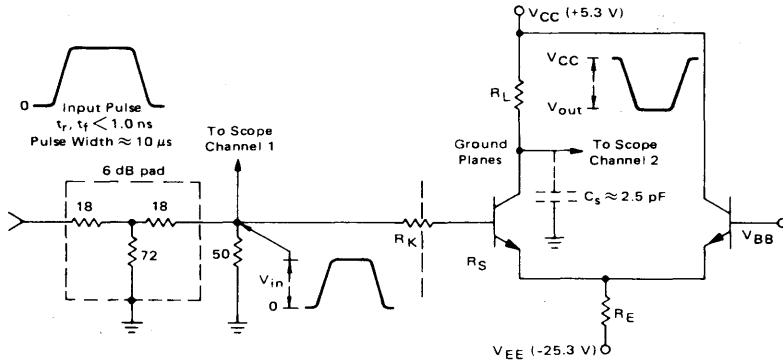


FIGURE 7 - SWITCHING TIMES TEST CIRCUIT



This test set up is designed to simulate a cascade of identical stages. The source resistance (R_S) equals the load resistance (R_L). Values used in the test are shown in the table.

For $V_{in} = V_{out} = 1 \text{ V}$, $V_{BB} = +0.5 \text{ V}$, R_L & R_K values appropriately reduced.

$V_{in} = V_{out} = 2 \text{ volts}, V_{BB} = +1.0 \text{ V}$			
i_C (mA)	R_E (k Ω)	R_L (Ω)	R_K (Ω)
1.0	24.0	2.0 k	2.0 k
3.0	8.2	680	680
10	2.4	200	180
30	0.8	68	36

2N4427

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Base Current	I_B	400	mAdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.5 20	Watts mW/°C
Storage Temperature	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ($I_C = 5.0$ mAdc, $R_{BE} = 10$ ohms)	$V_{CER(sus)}$	40	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	20	—	Vdc
Collector Cutoff Current ($V_{CE} = 12$ Vdc, $I_B = 0$)	I_{CEO}	—	0.02	mAdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $V_{BE} = -1.5$ Vdc) ($V_{CE} = 12$ Vdc, $V_{BE} = -1.5$ Vdc, $T_C = +150^\circ\text{C}$)	I_{CEV}	—	0.1 5.0	mAdc
Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	mAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 360$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	10 5.0	200 —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 20$ mAdc)	$V_{CE(sat)}$	—	0.5	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, $f = 200$ MHz)	f_T	500	—	MHz
Output Capacitance ($V_{CB} = 12$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	4.0	pF

FUNCTIONAL TEST (FIGURE 2)

Common-Emitter Amplifier Power Gain ($P_{in} = 100$ mW, $V_{CC} = 12$ Vdc, $f = 175$ MHz)	G_{pe}	10	—	dB
Collector Efficiency ($P_{out} = 1.0$ W, $V_{CC} = 12$ Vdc, $f = 175$ MHz)	η	50	—	%
Power Input ($P_{out} = 1.0$ W, $V_{CC} = 12$ Vdc, $f = 175$ MHz)	P_{in}	—	100	mW

FIGURE 1 – POWER OUTPUT versus FREQUENCY

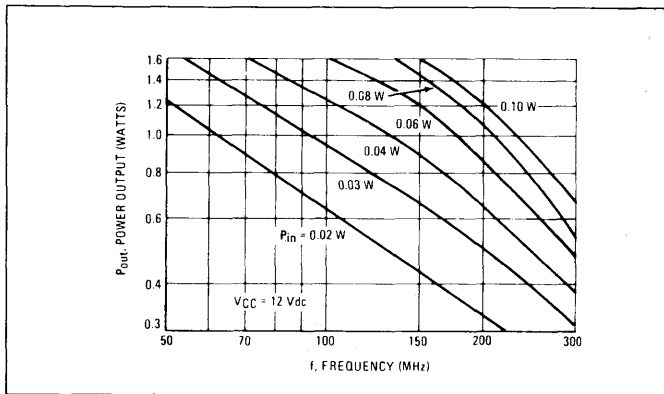
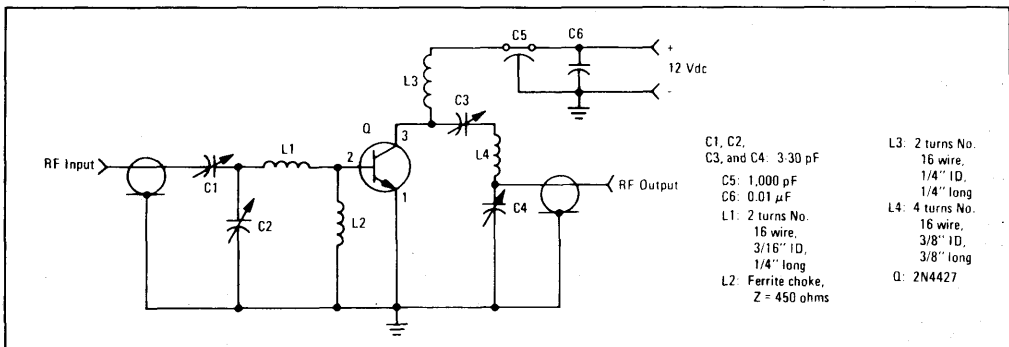


FIGURE 2 – 175 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST



- C1, C2, C3, and C4: 3-30 pF
- C5: 1,000 pF
- C6: 0.01 μF
- L1: 2 turns No. 16 wire, 3/16" ID, 1/4" long
- L2: Ferrite choke, Z = 450 ohms

- L3: 2 turns No. 16 wire, 1/4" ID, 1/4" long
- L4: 4 turns No. 16 wire, 3/8" ID, 3/8" long
- Q: 2N4427

**2N4957
2N4958
2N4959
2N5829**

**2N4957
JAN, JTX, JTXV AVAILABLE
CASE 20-03, STYLE 10
TO-72 (TO-206AF)**

HIGH FREQUENCY TRANSISTOR

PNP SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$) ($V_{CB} = 10$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	0.1 100	μ Adc

ON CHARACTERISTICS

DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	40	150	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) ($I_E = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	2N4957, 2N5829 2N4958, 2N4959	f_T	1200 1000	1600 1500	2500 2500	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)		C_{cb}	—	0.4	0.8	pF
Small Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)		h_{fe}	20	—	200	—
Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 10$ Vdc, $f = 63.6$ MHz)		$rb' C_C$	1.0	—	8.0	ps
Noise Figure (Figure 1) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 450$ MHz)	2N5829 2N4957 2N4958 2N4959	NF	— — — —	2.3 2.6 2.9 3.2	2.5 3.0 3.3 3.8	dB

FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain (Figure 1) ($V_{CE} = 10$ Vdc, $I_C = 2.0$ mAdc, $f = 450$ MHz)	2N4957, 2N5829 2N4958 2N4959	G_{pe}	17 16 15	— — —	25 25 25	dB
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(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – NOISE FIGURE AND POWER GAIN TEST CIRCUIT

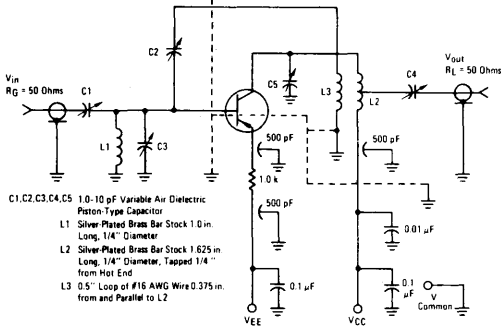


FIGURE 2 – UNILATERALIZED POWER GAIN versus FREQUENCY

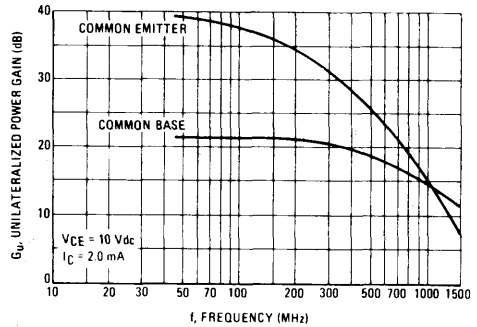


FIGURE 3 – NOISE FIGURE versus FREQUENCY

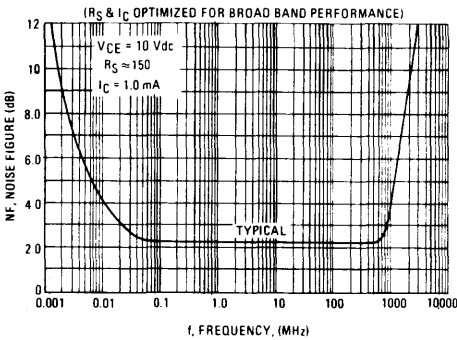


FIGURE 4 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

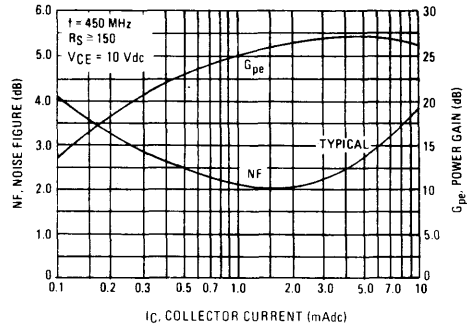


FIGURE 5 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

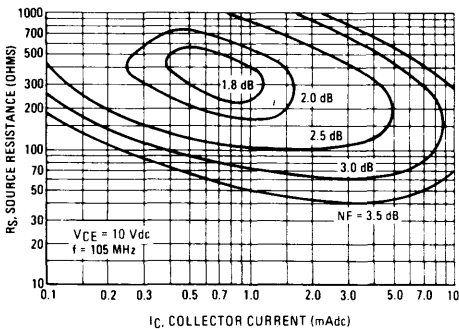
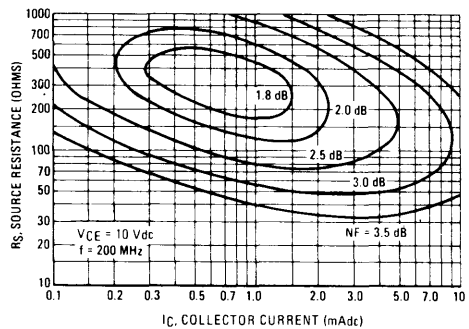


FIGURE 6 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT



COMMON EMITTER CIRCUIT DESIGN DATA

($V_{CE} = 10$ Vdc, $I_C = 2.0$ mA dc)

FIGURE 7 – TRANSDUCER GAIN versus FREQUENCY

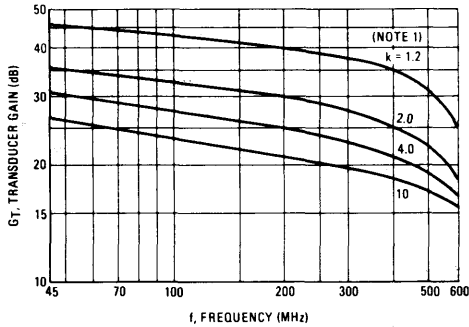


FIGURE 8 – LINVILL STABILITY FACTOR versus FREQUENCY

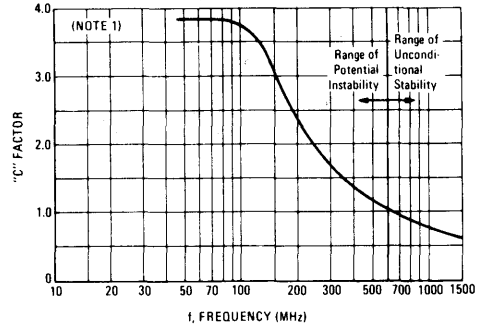


FIGURE 9 – LOAD ADMITTANCE versus FREQUENCY (REAL)

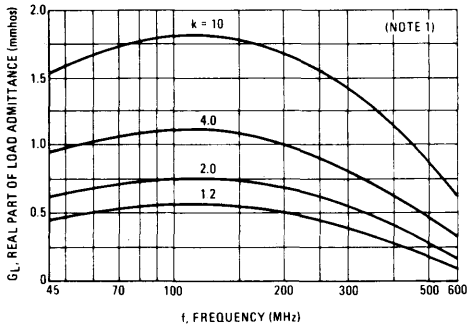


FIGURE 10 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

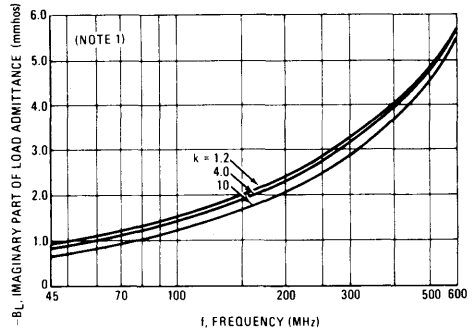


FIGURE 11 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

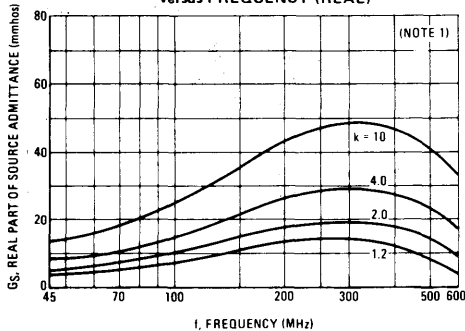
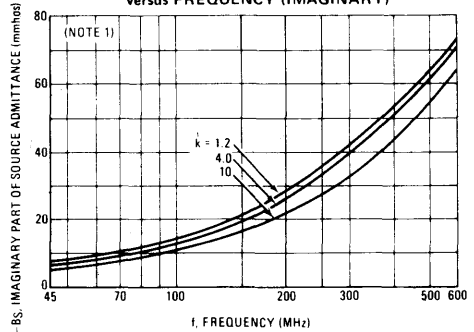


FIGURE 12 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



NOTE 1

Figures 7 through 12 are included to assist the circuit designer in determining the stability of his particular circuit. Two stability criteria are given in these figures.

The Linvill "C" factor* is a measure of transistor stability when the input and output are terminated in the worst case (open circuit) condition. When

* "Transistors and Active Circuits," Linvill and Gibbons, McGraw-Hill, 1961.

"C" is less than 1.0, the circuit is unconditionally stable. When "C" is greater than 1.0, the circuit is potentially unstable.

The Stern "K" factor† has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN 215A.

† "Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967.

COMMON BASE CIRCUIT DESIGN DATA

($V_{CB} = 10 \text{ Vdc}$, $I_C = 2.0 \text{ mAdc}$)

FIGURE 13 – TRANSDUCER GAIN versus FREQUENCY

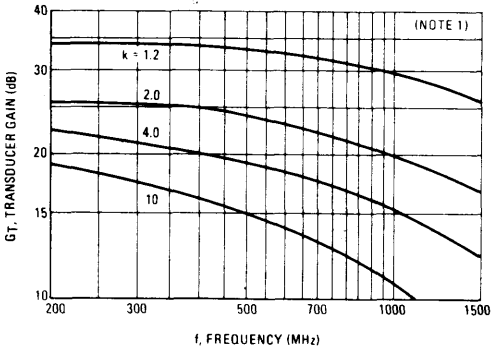


FIGURE 14 – LINVILL STABILITY FACTOR versus FREQUENCY

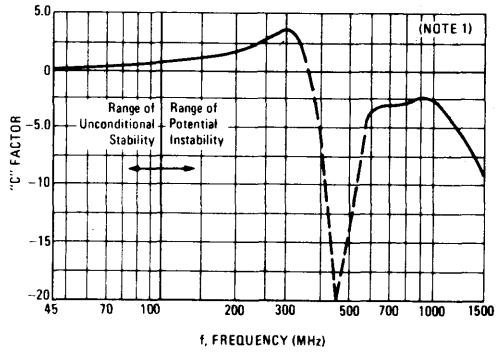


FIGURE 15 – LOAD ADMITTANCE versus FREQUENCY (REAL)

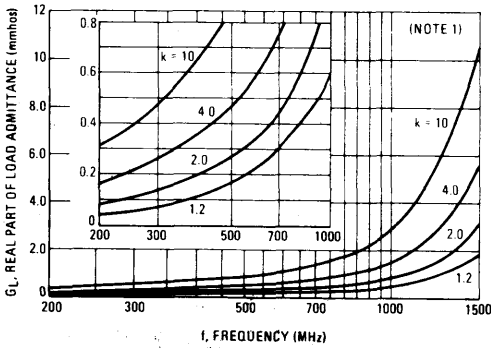


FIGURE 16 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

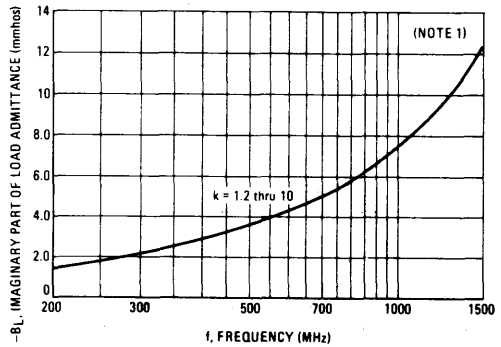


FIGURE 17 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

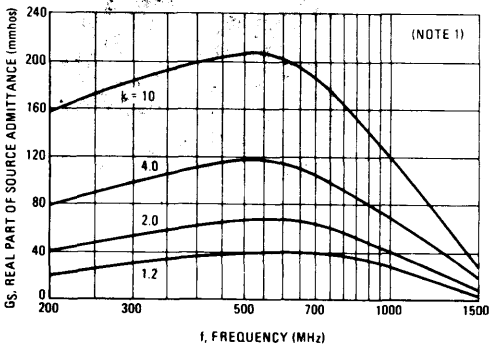
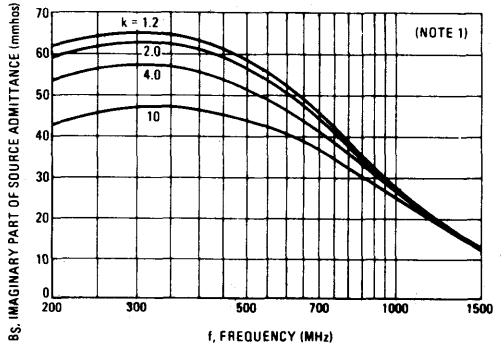


FIGURE 18 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



7

FIGURE 19 – SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

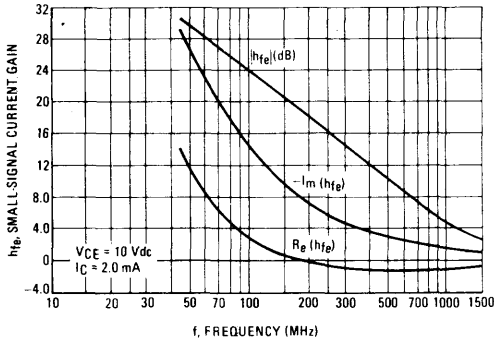


FIGURE 20 – POLAR h_{fe}

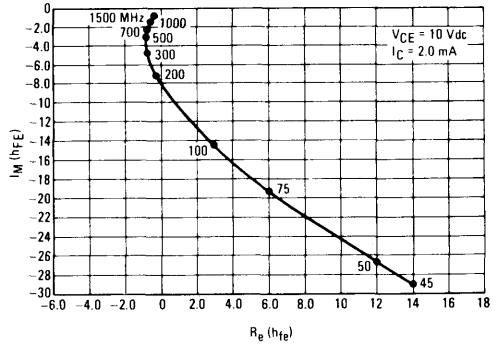


FIGURE 21 – f_T versus COLLECTOR CURRENT

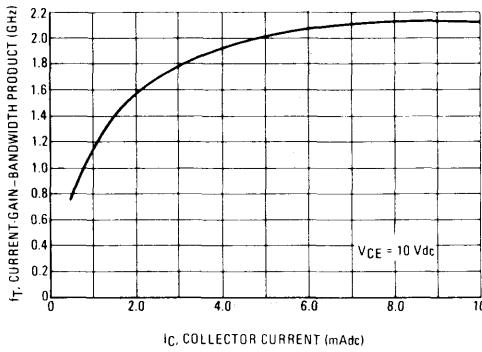


FIGURE 22 – DC CURRENT GAIN

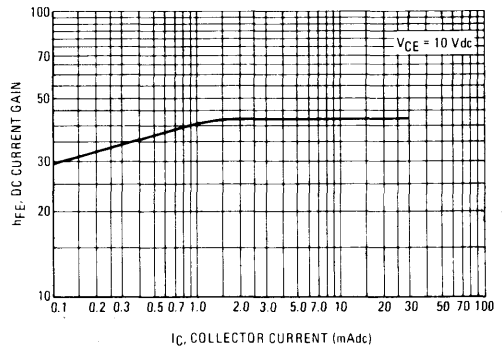


FIGURE 23 – CAPACITANCE

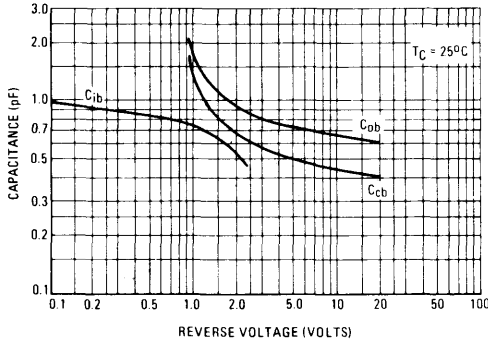
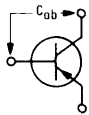
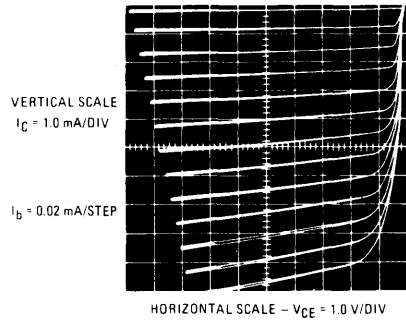
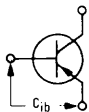


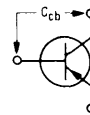
FIGURE 24 – COLLECTOR CHARACTERISTICS



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is open.



Apply reverse bias between emitter and base and measure capacitance between these terminals. Collector is open.



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is guarded.

Y PARAMETERS versus CURRENT
(f = 450 MHz)

COMMON BASE

$V_{CB} = 10 \text{ Vdc}$ ——— $V_{CB} = 15 \text{ Vdc}$ - - -

FIGURE 25 – INPUT ADMITTANCE

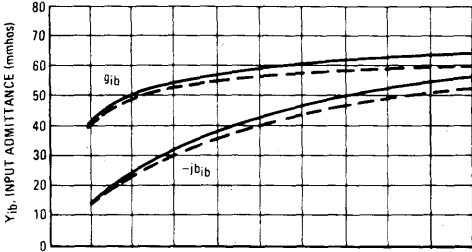


FIGURE 27 – FORWARD TRANSFER ADMITTANCE

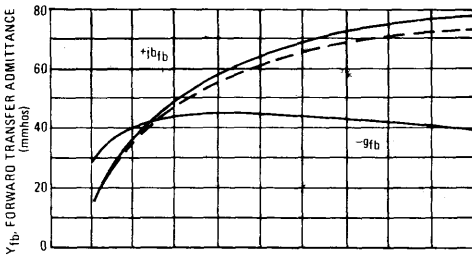


FIGURE 29 – OUTPUT ADMITTANCE

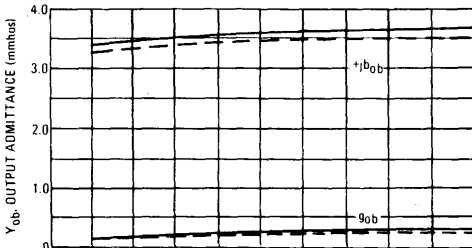
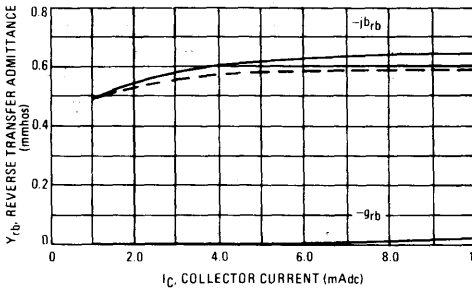


FIGURE 31 – REVERSE TRANSFER ADMITTANCE



COMMON EMITTER

$V_{CE} = 10 \text{ Vdc}$ ——— $V_{CE} = 15 \text{ Vdc}$ - - -

FIGURE 26 – INPUT ADMITTANCE

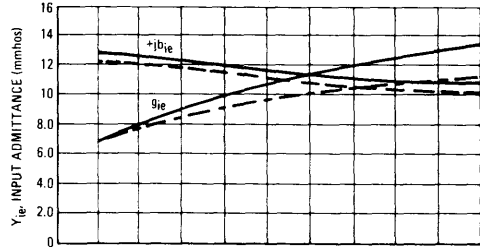


FIGURE 28 – FORWARD TRANSFER ADMITTANCE

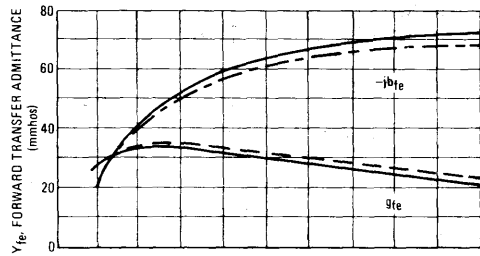


FIGURE 30 – OUTPUT ADMITTANCE

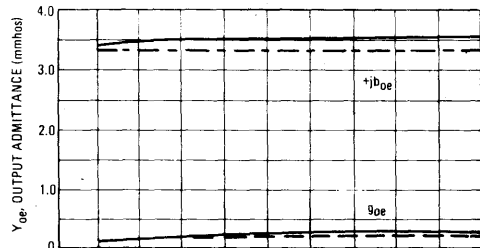
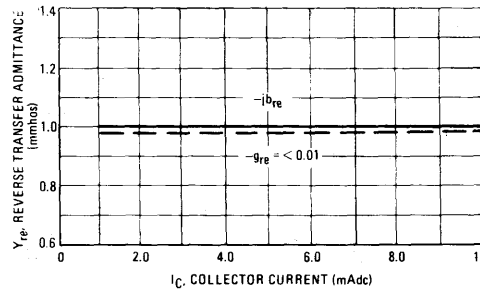


FIGURE 32 – REVERSE TRANSFER ADMITTANCE



COMMON BASE y PARAMETER VARIATIONS

($V_{CB} = 10$ Vdc, $I_C = 2.0$ mAdc)

y PARAMETERS versus FREQUENCY

FIGURE 33 - y_{ib} INPUT ADMITTANCE

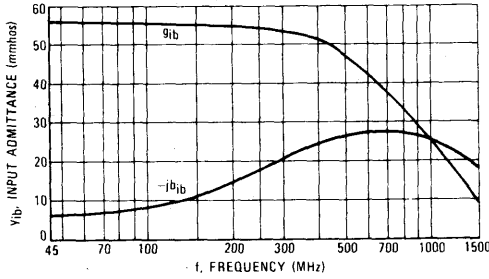


FIGURE 35 - y_{fb} FORWARD TRANSFER ADMITTANCE

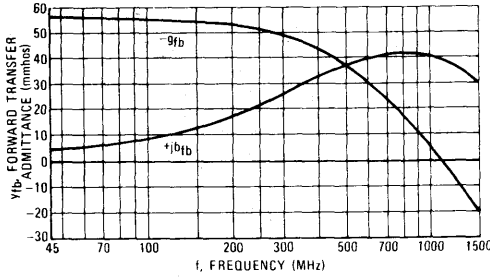


FIGURE 37 - y_{ob} OUTPUT ADMITTANCE

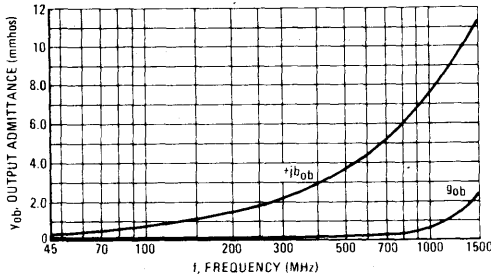
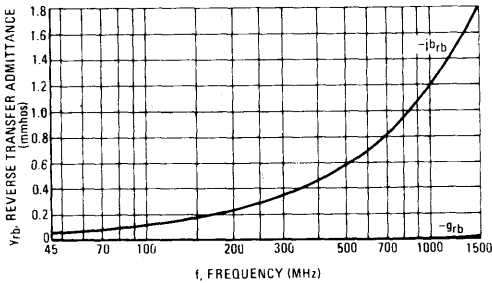


FIGURE 39 - y_{rb} REVERSE TRANSFER ADMITTANCE



POLAR y PARAMETERS versus FREQUENCY

FIGURE 34 - y_{ib} INPUT ADMITTANCE

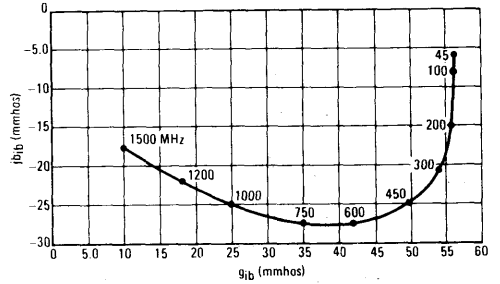


FIGURE 36 - y_{fb} FORWARD TRANSFER ADMITTANCE

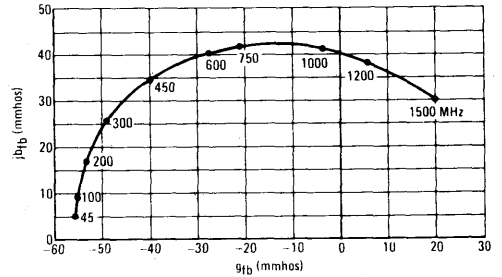


FIGURE 38 - y_{ob} OUTPUT ADMITTANCE

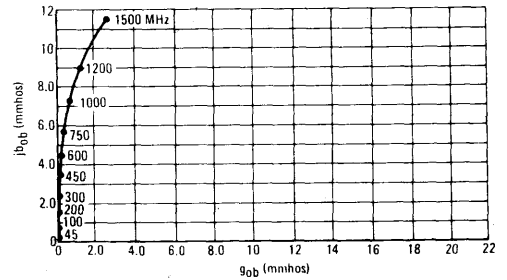
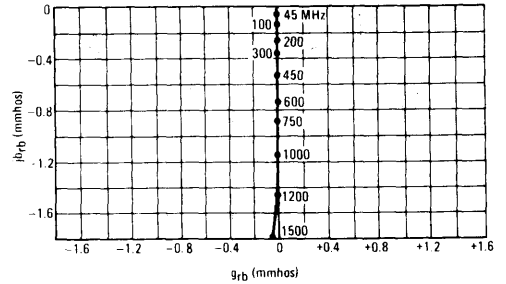


FIGURE 40 - y_{rb} REVERSE TRANSFER ADMITTANCE

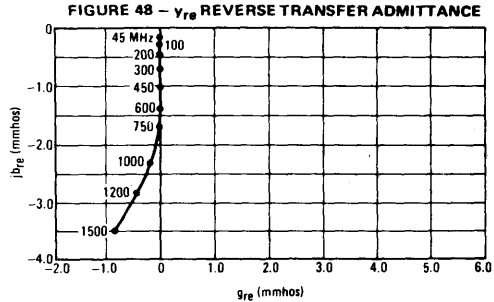
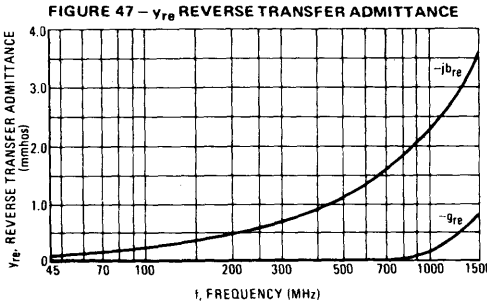
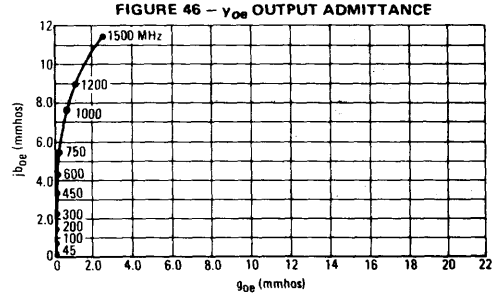
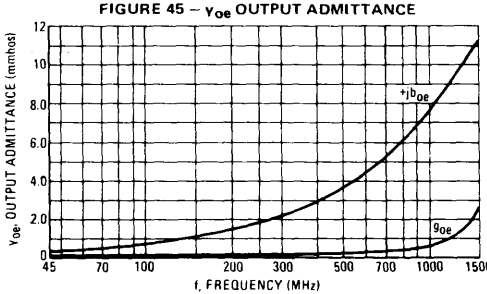
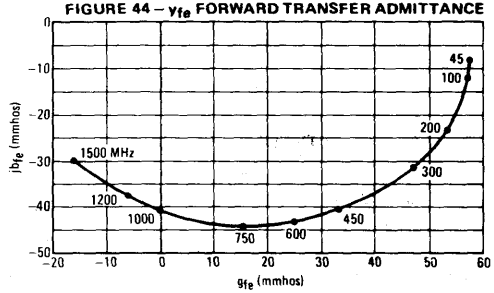
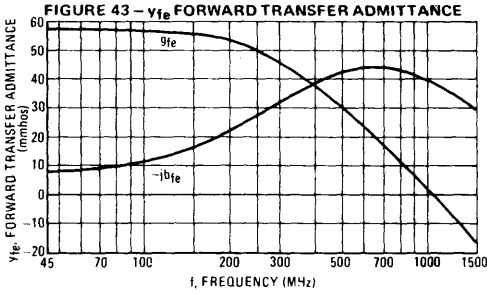
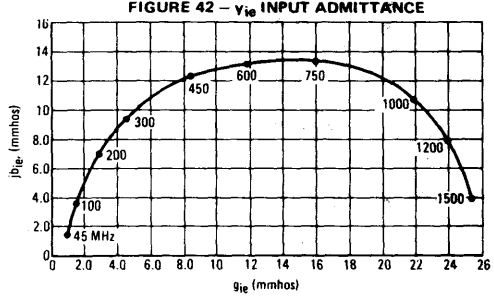
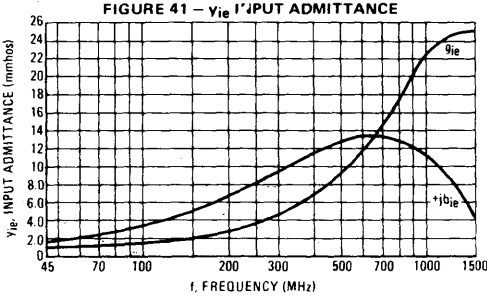


COMMON EMITTER y PARAMETER VARIATIONS

($V_{CE} = 10 \text{ Vdc}$, $I_C = 2.0 \text{ mAdc}$)

y PARAMETERS versus FREQUENCY

POLAR y PARAMETERS versus FREQUENCY



2N5031 2N5032

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	10	Vdc
Collector-Base Voltage	V_{CB0}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	20	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	PD	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 65 to + 200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	10	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01 \text{ mAdc}, I_E = 0$)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.01 \text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 6.0 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	1.0	10	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 6.0 \text{ Vdc}$)	h_{FE}	25	—	300	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0 \text{ mAdc}, V_{CE} = 6.0 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	1000	—	3500	MHz
Collector-Base Capacitance ($V_{CE} = 6.0 \text{ Vdc}, I_E = 0, f = 0.1 \text{ MHz}$)	C_{cb}	—	1.3	1.5	pF
Collector Base Time Constant ($I_C = 6.0 \text{ mAdc}, V_{CE} = 6.0 \text{ Vdc}, f = 31.8 \text{ MHz}$)	$rb' C_c$	—	5.0	—	ps
Noise Figure (Figure 1) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 6.0 \text{ Vdc}, f = 450 \text{ MHz}$)	NF	—	—	2.5 3.0	dB
	2N5031	—	—	2.5	
	2N5032	—	—	3.0	
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) ($V_{CE} = 6.0 \text{ Vdc}, I_C = 1.0 \text{ mAdc}, f = 450 \text{ MHz}$)	G_{pe}	14	17	25	dB

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT

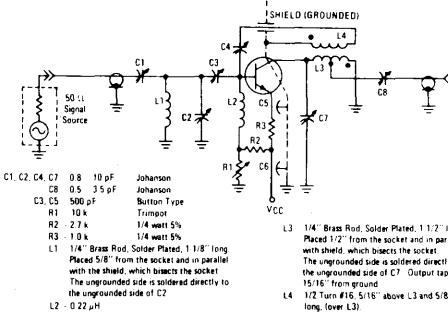


FIGURE 2 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

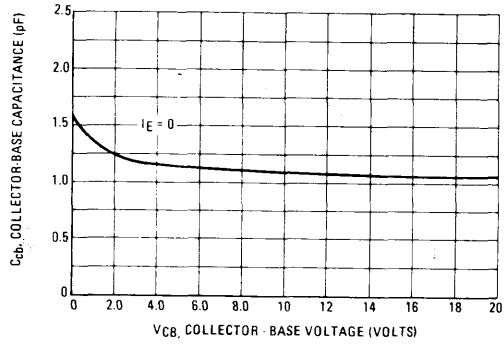


FIGURE 3 – CURRENT-GAIN-BANDWIDTH PRODUCT

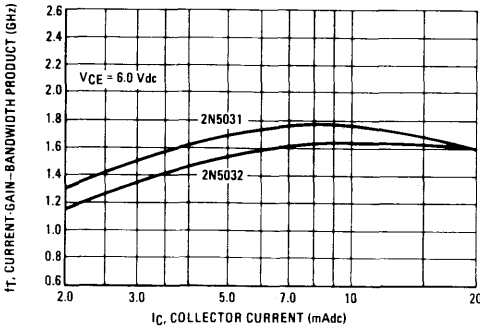


FIGURE 4 – S₁₁ AND S₂₂

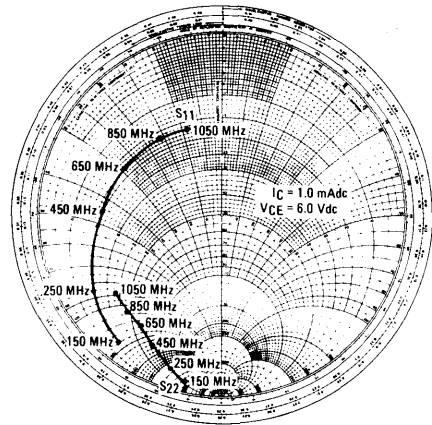


FIGURE 5 – S₁₂

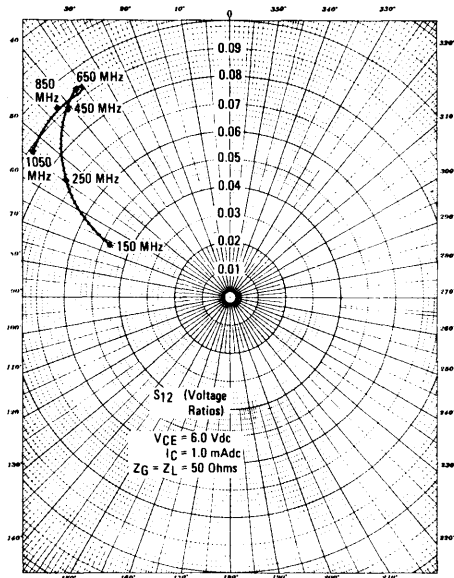
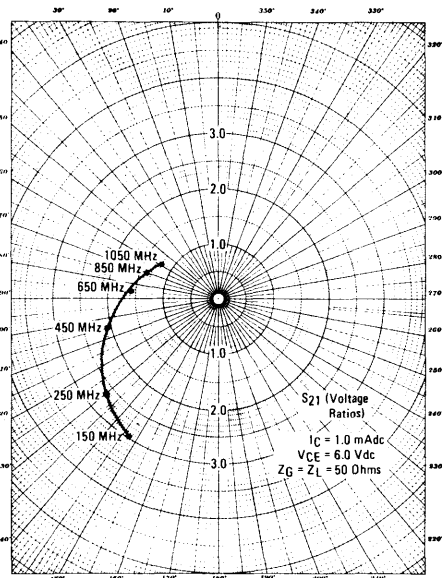


FIGURE 6 – S₂₁



2N5031 • 2N5032

FIGURE 7 – NOISE FIGURE versus FREQUENCY

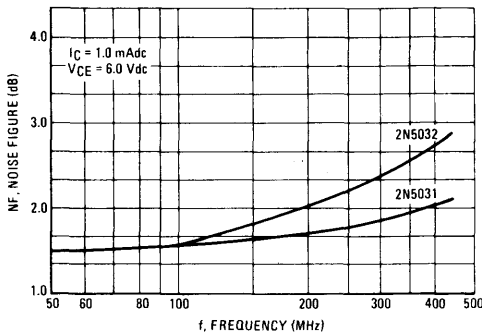


FIGURE 8 – POWER GAIN versus FREQUENCY

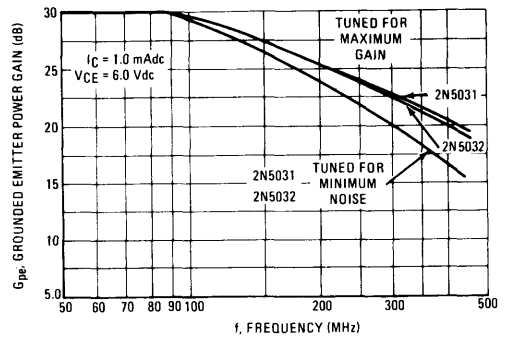


FIGURE 9 – INPUT ADMITTANCE versus FREQUENCY

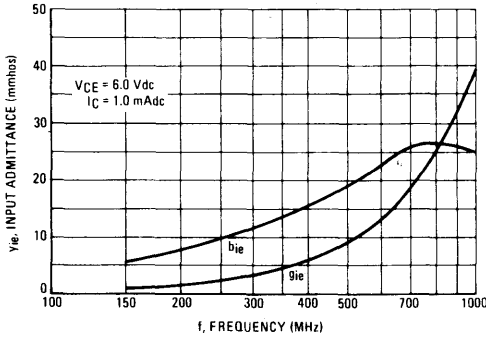


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

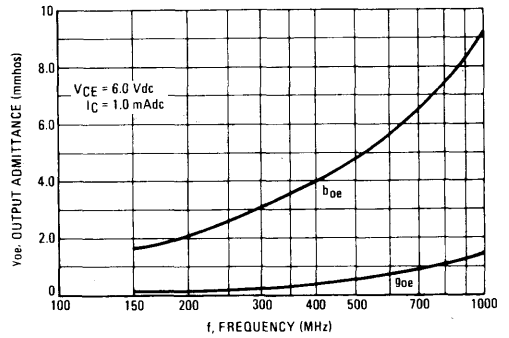


FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

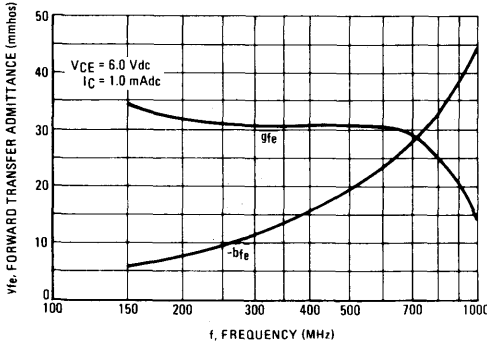
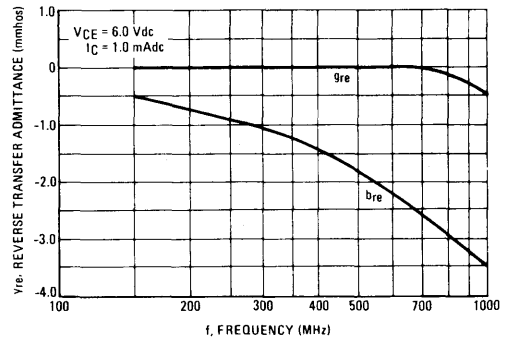


FIGURE 12 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



2N5108

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	30	Vdc
Collector-Emitter Voltage ($R_{BE} = 10\Omega$)	V_{CER}	55	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.5 0.02	Watts $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}$, $R_{BE} = 10 \text{ ohms}$)	$V_{(BR)CER}$	55	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}$, $I_E = 0$)	$V_{(BR)CBO}$	55	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current ($V_{CE} = 50 \text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 15 \text{ Vdc}$, $V_{BE} = 0$, $T_C = 150^\circ\text{C}$)	I_{CES}	—	—	1.0 10	μAdc mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}$, $I_B = 10 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.5	Vdc

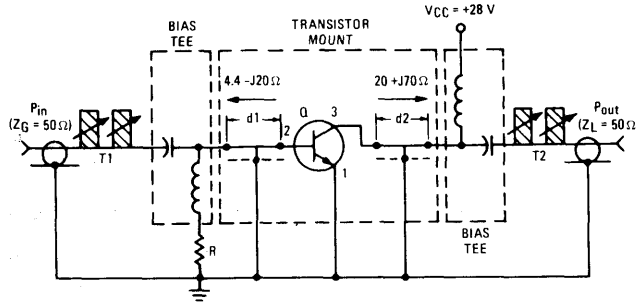
SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 15 \text{ Vdc}$, $f = 200 \text{ MHz}$)	f_T	1200	—	—	MHz
Output Capacitance ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	1.3	3.0	pF

FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain (Figure 1) ($P_{out} = 1.0 \text{ W}$, $V_{CC} = 28 \text{ Vdc}$, $I_C = 102 \text{ mAdc}$, $f = 1.0 \text{ GHz}$)	G_{PE}	5.0	—	—	dB
Power Output (Figure 1) ($P_{in} = 316 \text{ mW}$, $V_{CE} = 28 \text{ Vdc}$, $f = 1.0 \text{ GHz}$)	P_{out}	1.0	—	—	Watt
Collector Efficiency (Figure 1) ($P_{in} = 316 \text{ mW}$, $V_{CE} = 28 \text{ Vdc}$, $f = 1.0 \text{ GHz}$)	η	35	—	—	%
Power Output (Oscillator) (Figure 2) ($V_{CE} = 20 \text{ Vdc}$, $V_{EB} = 1.5 \text{ Vdc}$, $f = 1.68 \text{ GHz}$) (Minimum Efficiency = 15%)	P_{out}	—	0.3	—	Watt

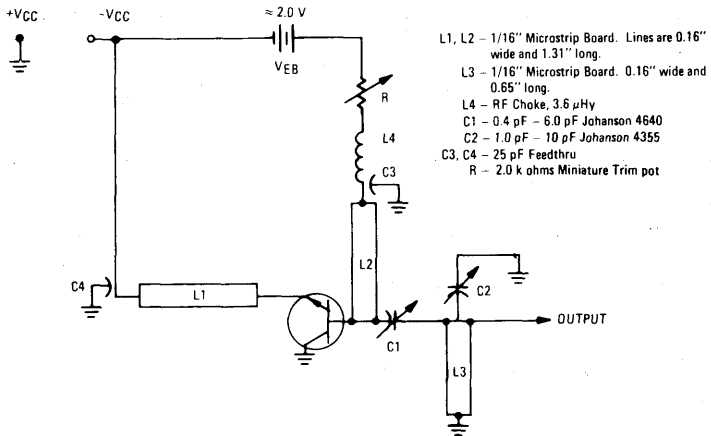
FIGURE 1 - 1 GHz RF AMPLIFIER OUTPUT POWER TEST CIRCUIT



- d1: 1" Input line, center conductor width = 0.280"
- d2: 1" Output line, center conductor width = 0.125"
- Q: 2N5108
- R: 3.9 ohms
- T1, T2: Microlab Double Stub Tuner, or Equivalent
- Bias Tee: Microlab 08N, or Equivalent
- Transistor Mount: 1/32" Microstrip board

Note: Impedance measurements are made at transistor socket pins.

FIGURE 2 - 1.68 GHz RF OSCILLATOR OUTPUT POWER TEST CIRCUIT



- L1, L2 - 1/16" Microstrip Board. Lines are 0.16" wide and 1.31" long.
- L3 - 1/16" Microstrip Board. 0.16" wide and 0.65" long.
- L4 - RF Choke, 3.6 μHy
- C1 - 0.4 pF - 6.0 pF Johanson 4640
- C2 - 1.0 pF - 10 pF Johanson 4355
- C3, C4 - 25 pF Feedthru
- R - 2.0 k ohms Miniature Trim pot

FIGURE 3 – OUTPUT POWER versus INPUT POWER

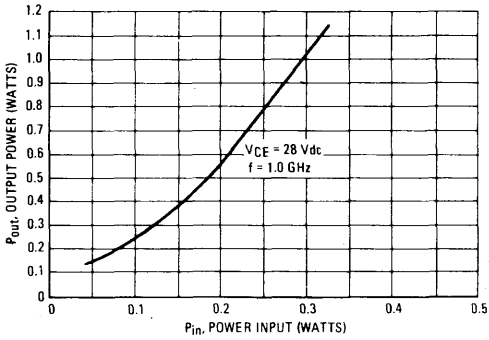


FIGURE 4 – OUTPUT POWER versus FREQUENCY

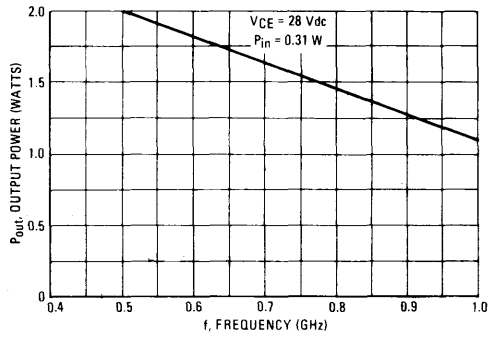


FIGURE 5 – OUTPUT POWER versus COLLECTOR-EMITTER VOLTAGE

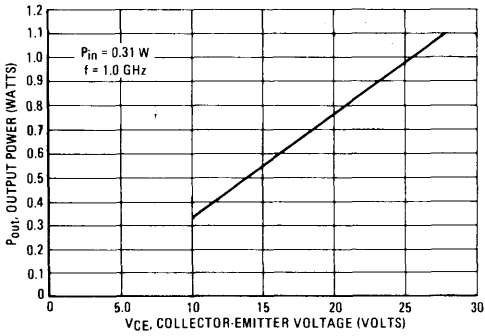


FIGURE 6 – OSCILLATOR OUTPUT POWER versus COLLECTOR CURRENT

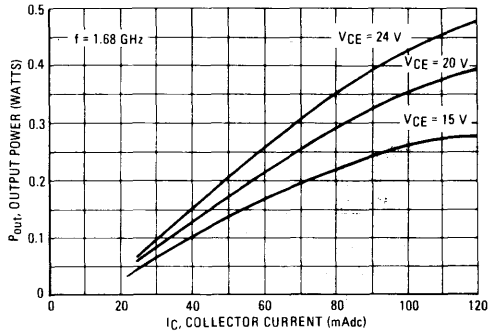


FIGURE 7 – CURRENT-GAIN-BANDWIDTH PRODUCT versus CURRENT

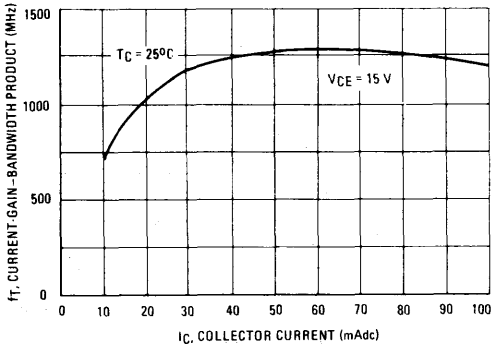
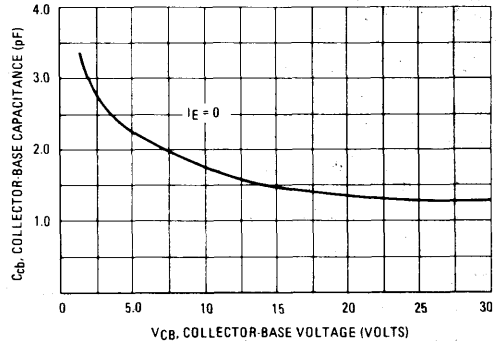


FIGURE 8 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE



7

2N5109

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	Vdc
Collector-Base Voltage	V _{CBO}	40	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Base Current	I _B	400	mAdc
Collector Current — Continuous	I _C	400	mAdc
Total Device Dissipation @ T _C = 75°C(1) Derate above 25°C	P _D	2.5 20	Watt mW/°C
Storage Temperature	T _{stg}	- 65 to +200	°C

(1) Total Device Dissipation at T_A = 25°C is 1.0 Watt.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(2) (I _C = 5.0 mAdc, R _{BE} = 10 Ω)	V _{(BR)CER}	40	—	—	Vdc
Collector-Emitter Sustaining Voltage (I _C = 5.0 mAdc, I _B = 0)	V _{(BR)CEO}	20	—	—	Vdc
Collector Cutoff Current (V _{CE} = 15 Vdc, I _B = 0)	I _{CEO}	—	—	20	μAdc
Collector Cutoff Current (V _{CE} = 15 Vdc, V _{BE} = -1.5 V, T _C = 150°C) (V _{CE} = 35 Vdc, V _{BE} = -1.5 V)	I _{CEX}	—	—	5.0 5.0	mAdc mAdc
Emitter Cutoff Current (V _{BE} = 3.0 Vdc, I _C = 0)	I _{EBO}	—	—	100	μAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 360 mAdc, V _{CE} = 5.0 Vdc) (I _C = 50 mAdc, V _{CE} = 15 Vdc)	h _{FE}	5.0 40	— —	— 120	— —
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mAdc, V _{CE} = 15 Vdc, f = 200 MHz)	f _T	1200	—	—	MHz
Collector-Base Capacitance (V _{CB} = 15 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	1.8	3.5	pF
Noise Figure (I _C = 10 mAdc, V _{CE} = 15 Vdc, f = 200 MHz)	NF	—	3.0	—	dB

FUNCTIONAL TEST.

Common-Emitter Amplifier Voltage Gain (Figure 1) (I _C = 50 mAdc, V _{CC} = 15 Vdc, f = 50 to 216 MHz)	G _{ve}	11	—	—	dB
Power Input (Figure 2) (I _C = 50 mAdc, V _{CC} = 15 Vdc, R _S = 50 ohms, P _{out} = 1.26 mW, f = 200 MHz)	P _{in}	—	—	0.1	mW

(2) Pulsed thru a 25 mH Inductor; 50% Duty Cycle.

FIGURE 1 - RF AMPLIFIER FOR VOLTAGE GAIN TEST CIRCUIT

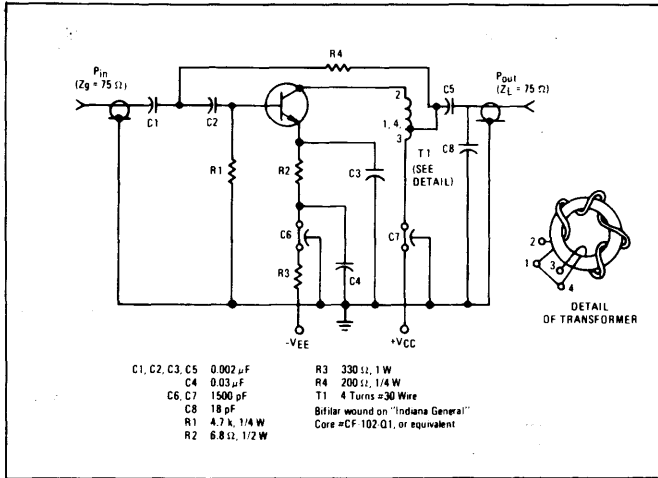
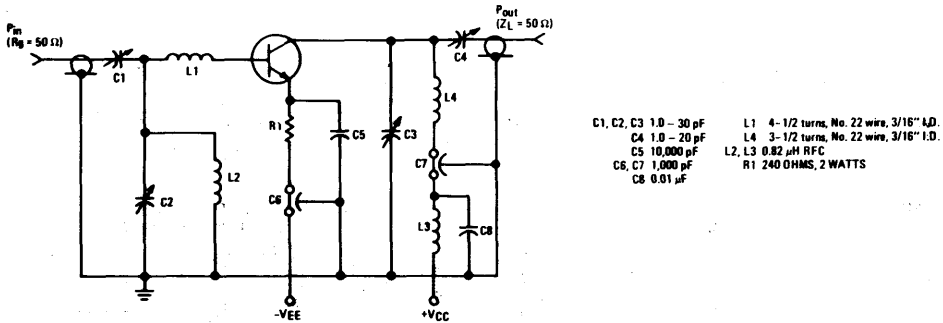


FIGURE 2 - 200 MHz TEST CIRCUIT



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FIGURE 3 - CURRENT-GAIN - BANDWIDTH PRODUCT

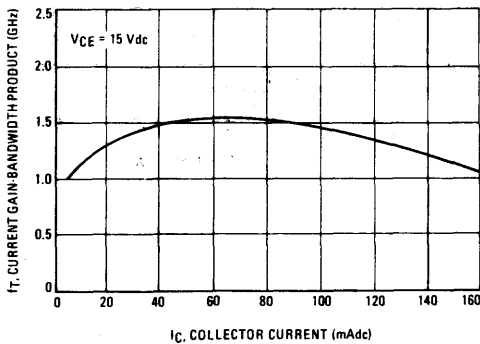


FIGURE 4 - COLLECTOR-BASE TIME CONSTANT

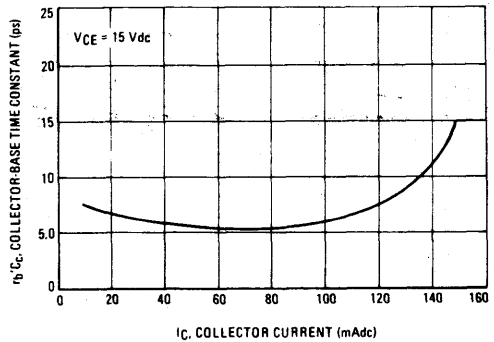


FIGURE 5 - SATURATION VOLTAGES

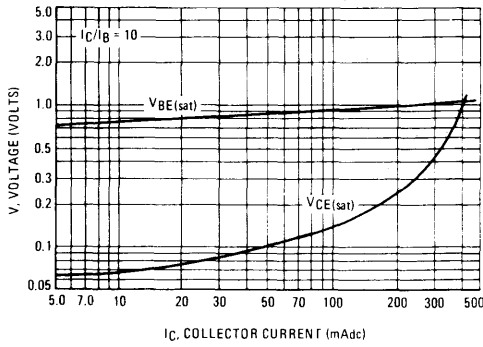


FIGURE 6 - CAPACITANCES versus REVERSE VOLTAGE

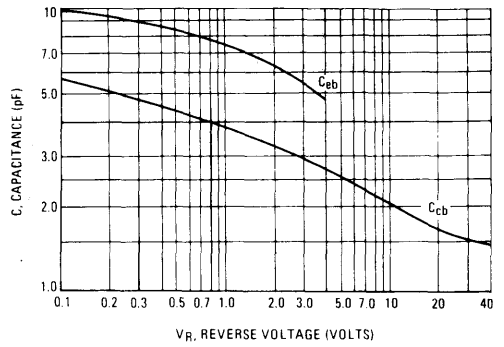


FIGURE 7 - INPUT ADMITTANCE versus FREQUENCY

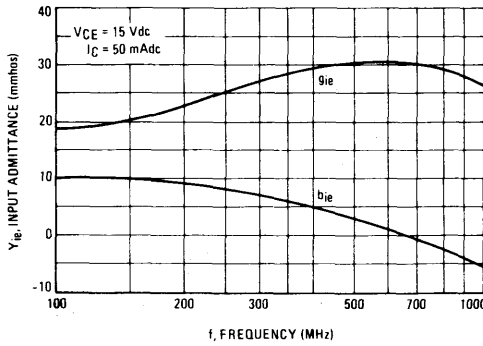


FIGURE 8 - INPUT ADMITTANCE versus COLLECTOR CURRENT

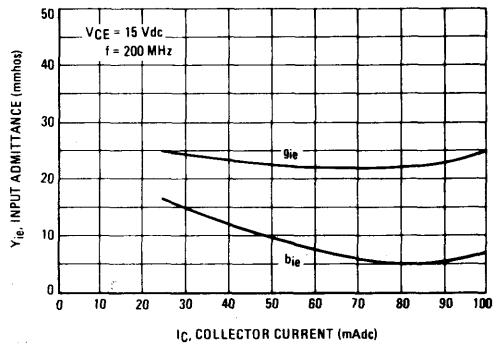


FIGURE 9 - REVERSE TRANSFER ADMITTANCE versus FREQUENCY

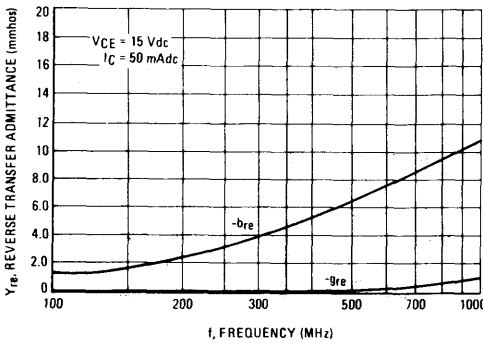
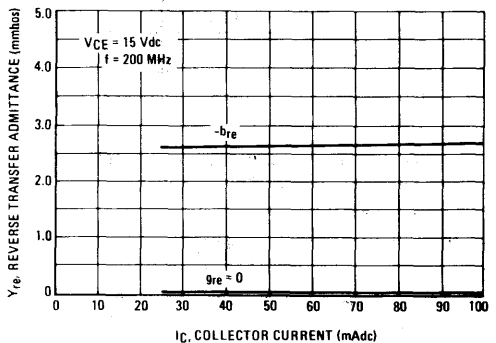


FIGURE 10 - REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT



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FIGURE 11 - FORWARD TRANSFER ADMITTANCE versus FREQUENCY

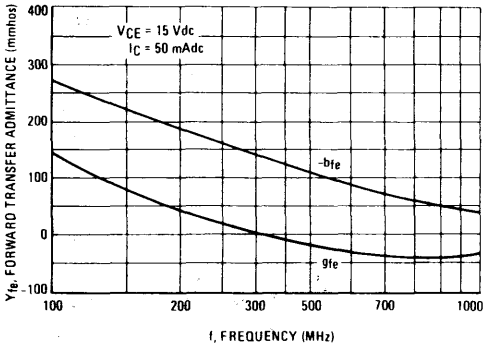


FIGURE 12 - FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

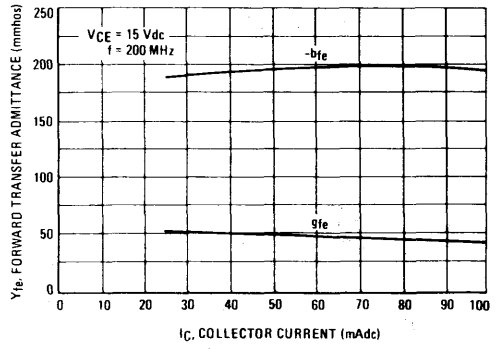


FIGURE 13 - OUTPUT ADMITTANCE versus FREQUENCY

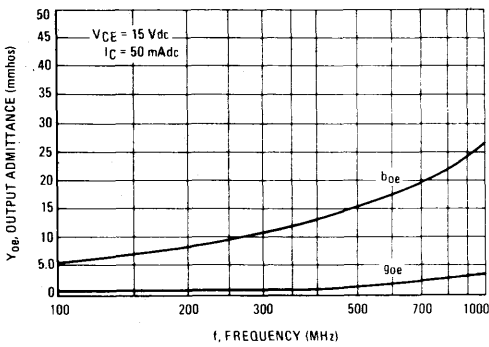


FIGURE 14 - OUTPUT ADMITTANCE versus COLLECTOR CURRENT

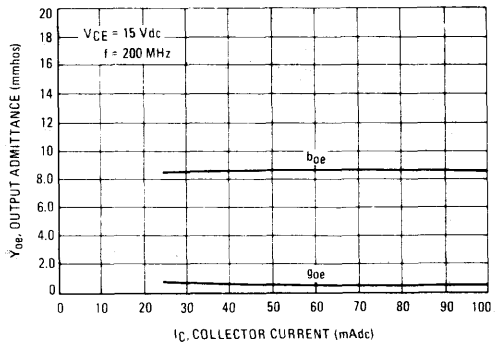


FIGURE 15 - INPUT REFLECTION COEFFICIENT versus FREQUENCY

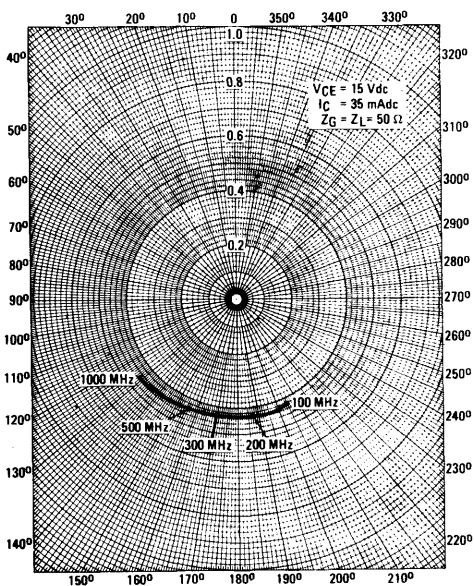


FIGURE 16 - OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

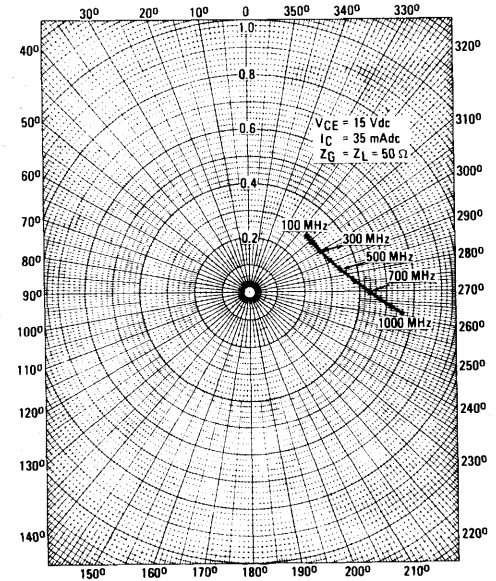


FIGURE 17 – REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

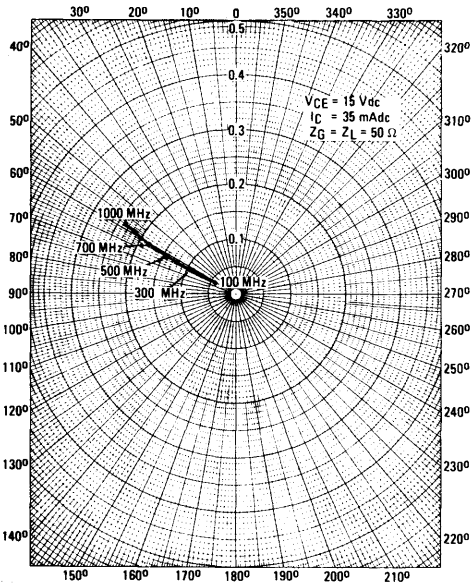


FIGURE 18 – FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

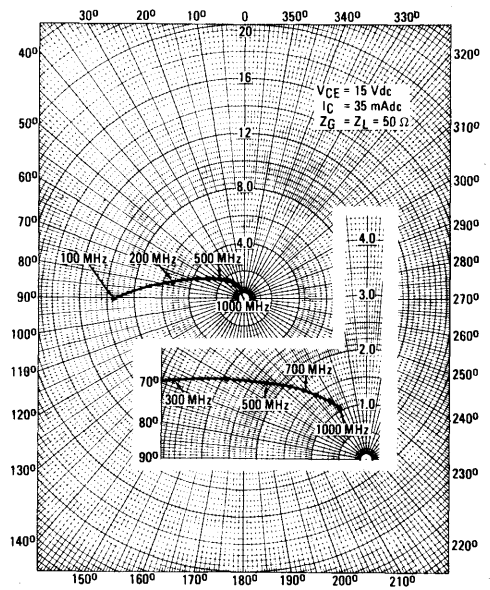
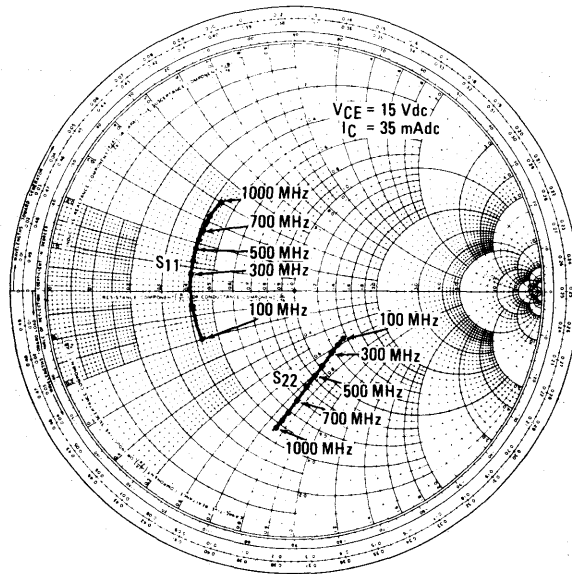


FIGURE 19 – INPUT REFLECTION COEFFICIENT AND OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



2N5160

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ($I_C = 5.0 \text{ mAdc}, I_B = 0$)	$V_{CE0(sus)}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 28 \text{ Vdc}, I_B = 0$)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current ($V_{CE} = 60 \text{ Vdc}, V_{BE} = 0$)	I_{CES}	—	—	0.1	mAdc
Collector Cutoff Current ($V_{CB} = 28 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	10	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 200 \text{ MHz}$)	f_T	500	900	—	MHz
Collector-Base Capacitance ($V_{CB} = 28 \text{ Vdc}, I_E = 0, f = 0.1 \text{ to } 1.0 \text{ MHz}$)	C_{cb}	—	2.5	4.0	pF
FUNCTIONAL TEST					
Amplifier Power Gain ($V_{CE} = 28 \text{ Vdc}, P_{in} = 0.16 \text{ Watt}, f = 400 \text{ MHz}$) ($V_{CE} = 28 \text{ Vdc}, P_{in} = 50 \text{ mW}, f = 175 \text{ MHz}$)	G_{pe}	8.0 —	8.8 14.5	— —	dB
Power Output ($V_{CE} = 28 \text{ Vdc}, P_{in} = 0.16 \text{ Watt}, f = 400 \text{ MHz}$) ($V_{CE} = 28 \text{ Vdc}, P_{in} = 50 \text{ mW}, f = 175 \text{ MHz}$)	P_{out}	1.0 —	1.2 1.4	— —	Watt
Collector Efficiency ($V_{CE} = 28 \text{ Vdc}, P_{in} = 0.16 \text{ Watt}, f = 400 \text{ MHz}$)	η	45	55	—	%

FIGURE 1 – 400-MHz TEST CIRCUIT

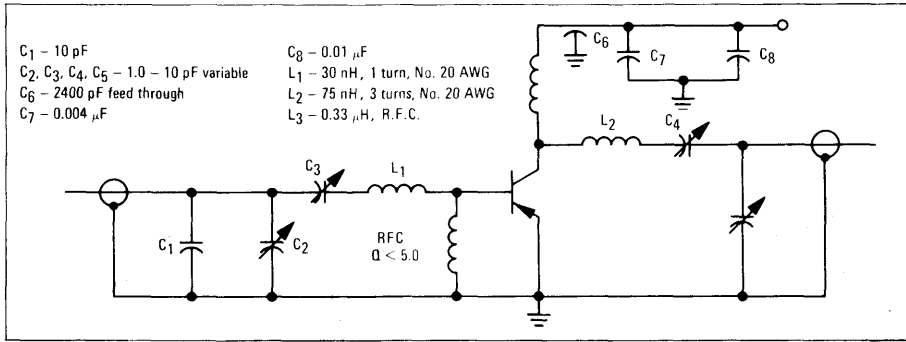


FIGURE 2

POWER OUTPUT

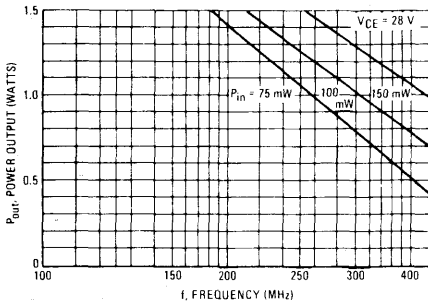


FIGURE 3

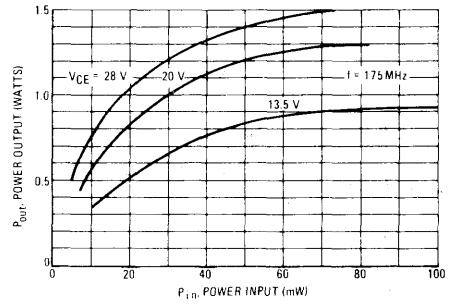


FIGURE 4

PARALLEL INPUT

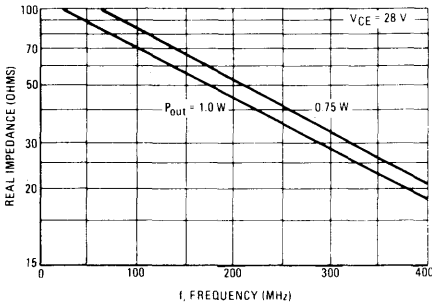


FIGURE 5

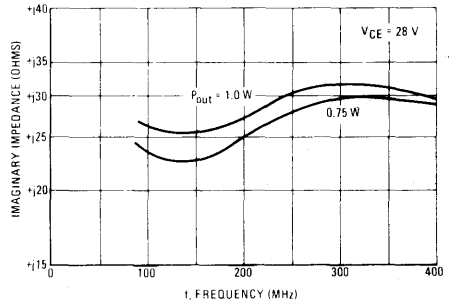


FIGURE 6 – PARALLEL OUTPUT CAPACITANCE versus FREQUENCY

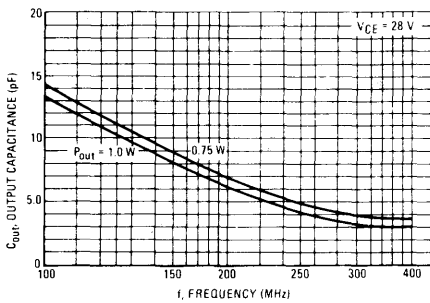
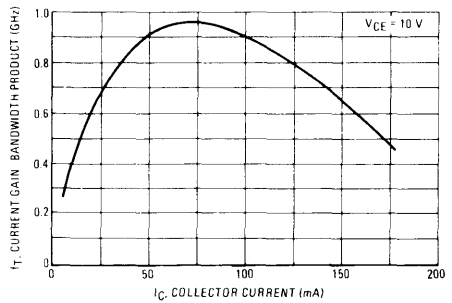


FIGURE 7 – CURRENT-GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT



2N5179

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage Applicable 1.0 to 2.0 mAdc	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.71	mW mW/°C
Storage Temperature	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.001$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.01$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.02 1.0	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	25	250	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	1.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, $f = 100$ MHz)	f_T	900	2000	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 0.1$ to 1.0 MHz)	C_{cb}	—	1.0	pF
Small Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 6.0$ Vdc, $f = 1.0$ kHz)	h_{fe}	25	300	—
Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 6.0$ Vdc, $f = 31.9$ MHz)	$r_b' C_C$	3.0	14	ps
Noise Figure (Figure 1) ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50$ ohms, $f = 200$ MHz)	NF	—	4.5	dB

FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain (Figure 1) ($V_{CE} = 6.0$ Vdc, $I_C = 5.0$ mAdc, $f = 200$ MHz)	G_{pe}	15	—	dB
Power Output (Figure 2) ($V_{CB} = 10$ Vdc, $I_E = 12$ mAdc, $f \geq 500$ MHz)	P_{out}	20	—	mW

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 - 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT

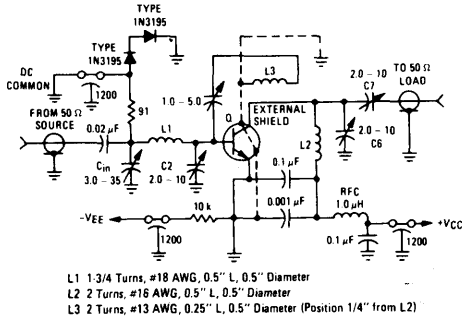


FIGURE 2 - 500 MHz OSCILLATOR CIRCUIT

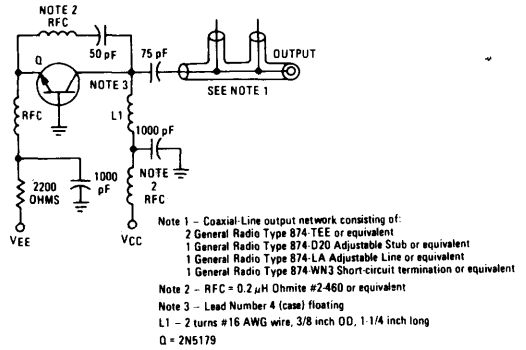


FIGURE 3 - NOISE FIGURE versus FREQUENCY

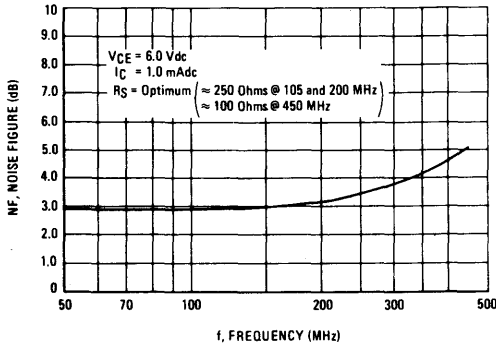


FIGURE 4 - NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

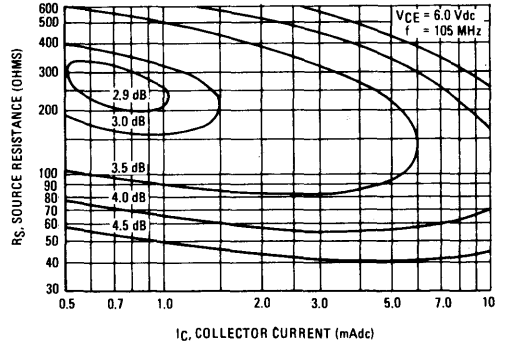


FIGURE 5 - NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

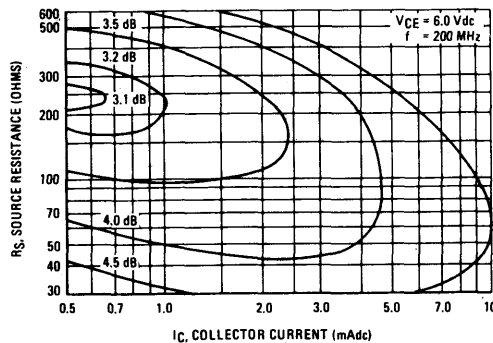


FIGURE 6 - CURRENT-GAIN-BANDWIDTH PRODUCT

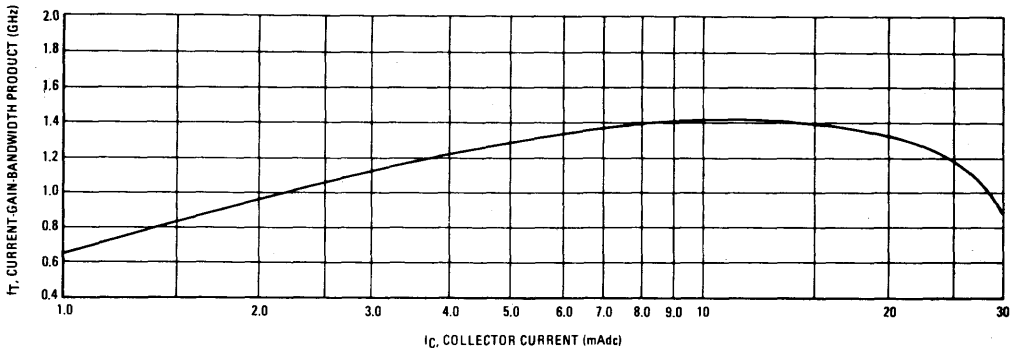


FIGURE 7 - INPUT ADMITTANCE versus FREQUENCY

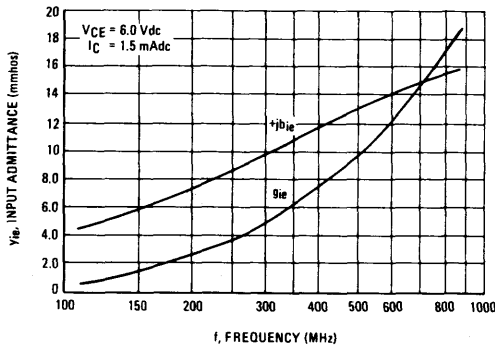


FIGURE 8 - OUTPUT ADMITTANCE versus FREQUENCY

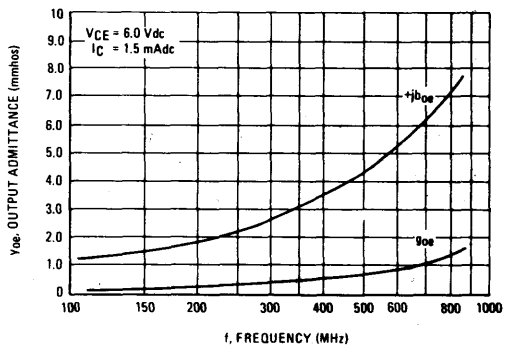


FIGURE 9 - FORWARD TRANSFER ADMITTANCE versus FREQUENCY

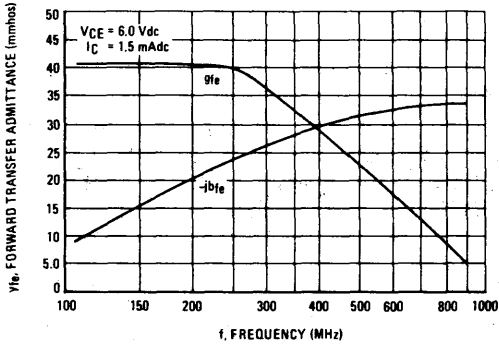


FIGURE 10 - REVERSE TRANSFER ADMITTANCE versus FREQUENCY

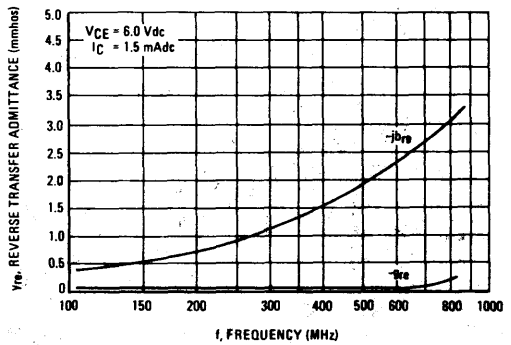


FIGURE 11 - S_{11} , INPUT REFLECTION COEFFICIENT

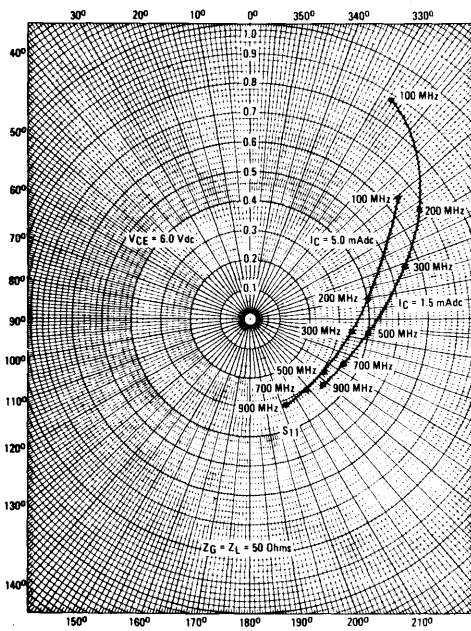


FIGURE 12 - S_{22} , OUTPUT REFLECTION COEFFICIENT

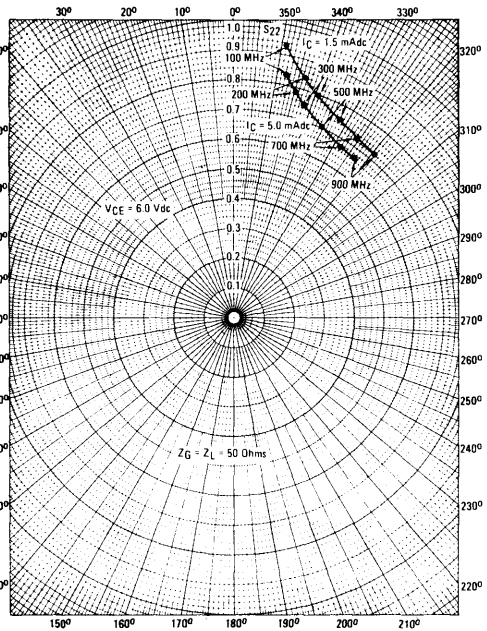


FIGURE 13 - S_{12} , REVERSE TRANSMISSION COEFFICIENT

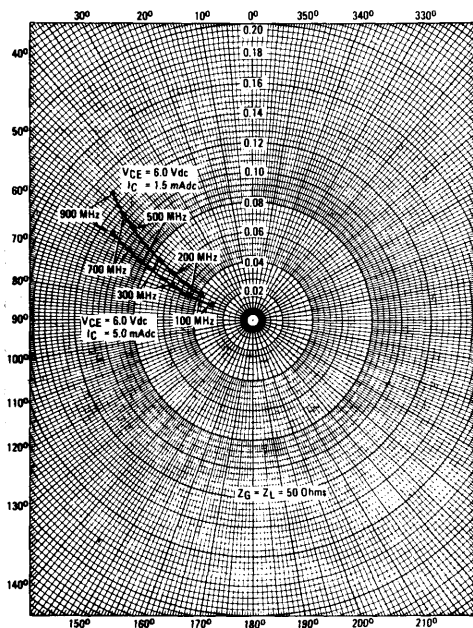
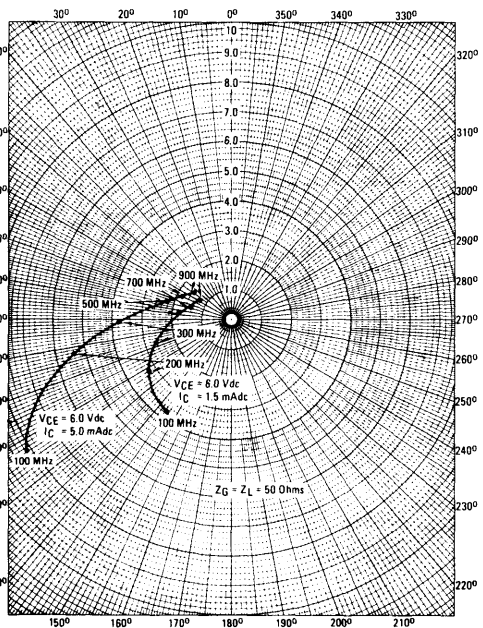
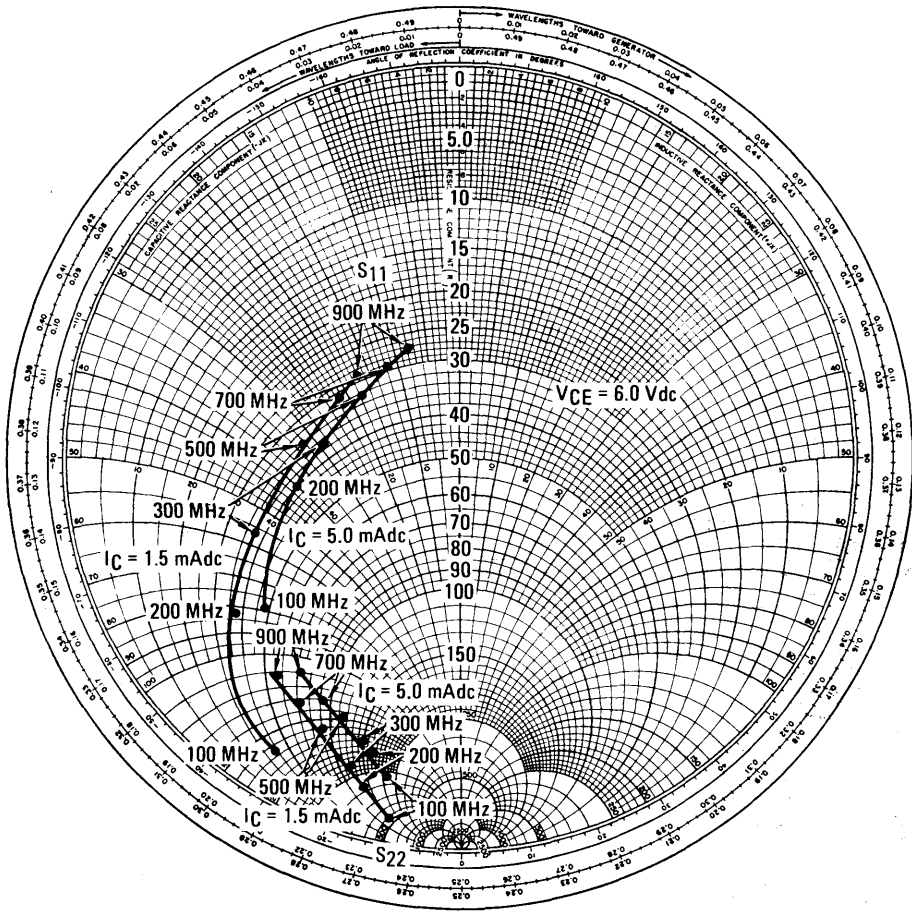


FIGURE 14 - S_{21} , FORWARD TRANSMISSION COEFFICIENT



7

FIGURE 15— S_{11} , INPUT REFLECTION COEFFICIENT AND S_{22} , OUTPUT REFLECTION COEFFICIENT



7

2N5583

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	0.5	μ Adc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 40$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 300$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20 25 15	40 40 22	— 100 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	—	0.6	0.8	Vdc
Base-Emitter On Voltage(1) ($I_C = 100$ mAdc, $V_{CE} = 2.0$ Vdc)	$V_{BE(on)}$	—	0.84	1.8	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 40$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz) ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)	f_T	1000 1300	1300 1500	— —	MHz
Collector-Base Capacitance ($V_{CB} = 15$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{cb}	—	2.5	5.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 100$ kHz)	C_{eb}	—	18	35	pF
Collector Base Time Constant ($I_C = 50$ mAdc, $V_{CB} = 10$ Vdc, $f = 63.6$ MHz)	$rb'C_c$	—	8.0	—	ps

SWITCHING CHARACTERISTICS (FIGURE 10)

Turn-On Delay Time	$V_{CC} = 31.4$ Vdc, $I_C = 150$ mAdc, $R_C = 160$ Ohms, $R_E = 26.6$ Ohms	t_d	—	1.0	—	ns
Rise Time		t_r	—	2.1	—	ns
Fall Time		t_f	—	1.8	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.

FIGURE 1 - DC CURRENT GAIN

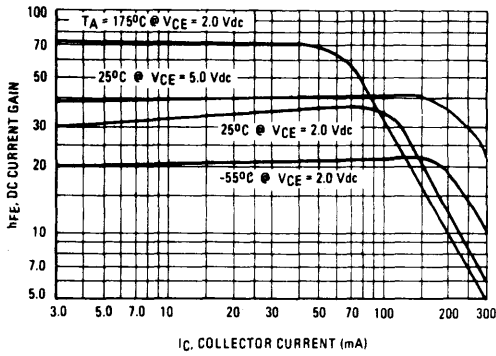


FIGURE 2 - COLLECTOR SATURATION REGION

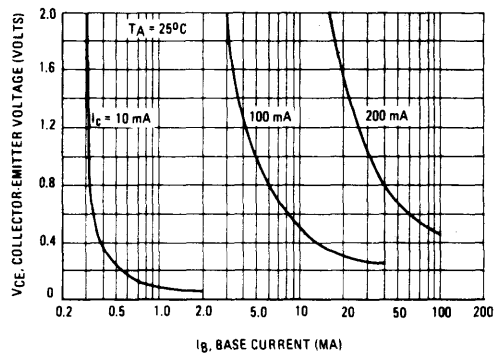


FIGURE 3 - "ON" VOLTAGES

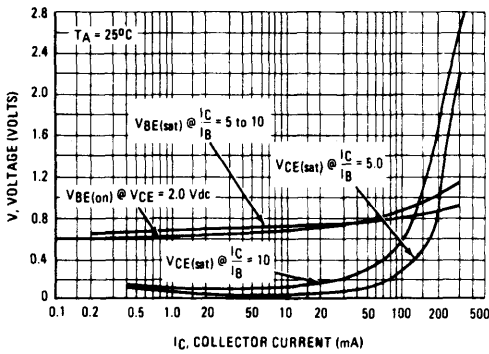


FIGURE 4 - COLLECTOR CURRENT versus BASE VOLTAGE

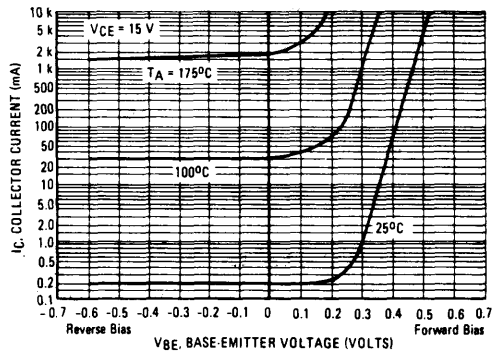


FIGURE 5 - CAPACITANCES

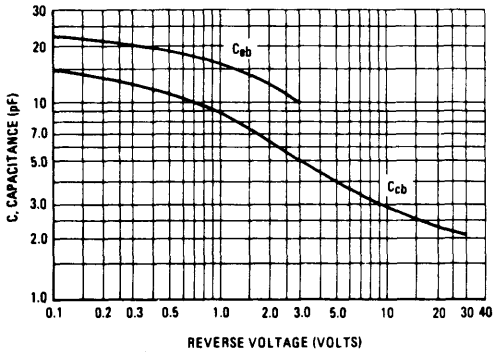


FIGURE 6 - TEMPERATURE COEFFICIENTS

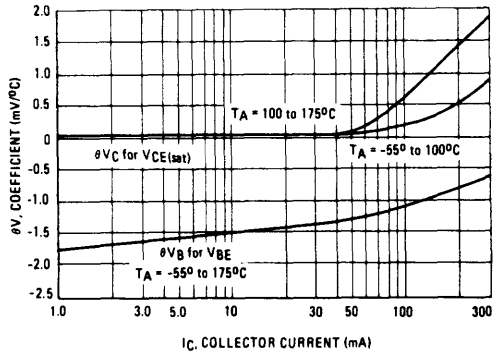


FIGURE 7 – CURRENT-GAIN-BANDWIDTH PRODUCT

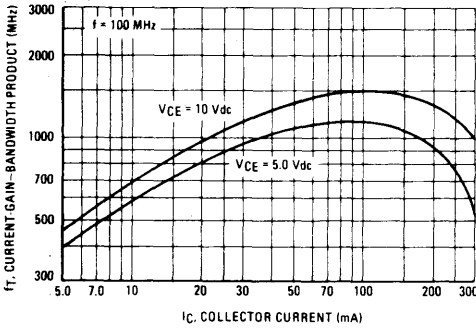


FIGURE 8 – COLLECTOR-BASE TIME CONSTANT

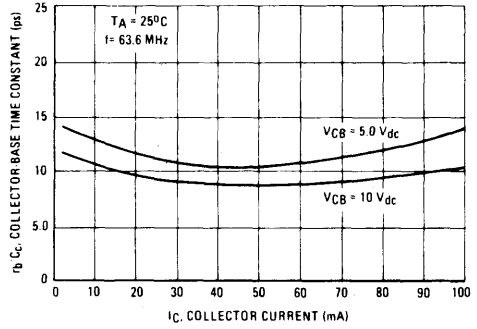


FIGURE 9 – SWITCHING TIMES

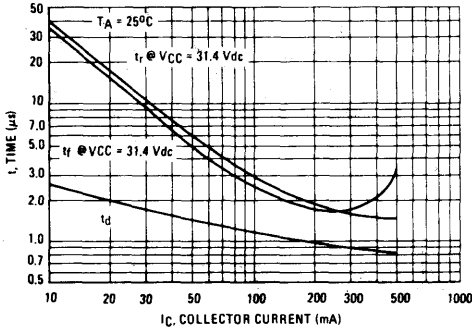
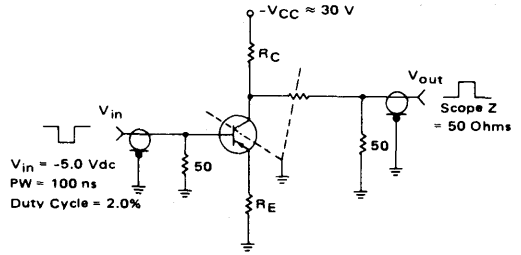


FIGURE 10 – SWITCHING TIMES TEST CIRCUIT



I_C mA	R_C Ohms	R_E Ohms	V_{CC} Volts
50	526	80	34.4
150	160	26.6	31.4
300	78	13.3	30.6
500	46.5	8.0	30.3

7

2N5835 2N5836 2N5837

2N5835
CASE 20-03, STYLE 10
TO-72 (TO-206AF)

2N5836, 2N5837
CASE 26-03, STYLE 1
TO-46 (TO-206AB)

HIGH FREQUENCY TRANSISTOR



NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	2N5835	2N5836	2N5837	Unit
Collector-Emitter Voltage	V_{CE0}	10	10	5.0	Vdc
Collector-Base Voltage	V_{CBO}	15	15	10	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	3.5	3.5	Vdc
Collector Current — Continuous	I_C	15	200	300	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	— —	— —	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	— —	2.0 11.43	2.0 11.43	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200			$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	2N5835	$V_{(BR)CBO}$	15	—	—	Vdc
($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	2N5836 2N5837		15 10	—	—	
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}$, $I_C = 0$)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 7.5 \text{ Vdc}$, $I_E = 0$)	2N5835	I_{CBO}	—	—	0.01	μAdc
($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$)	2N5836		—	—	10	
($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$)	2N5837		—	—	10	
Emitter Cutoff Current ($V_{EB} = 3.0 \text{ Vdc}$, $I_C = 0$)		I_{EBO}	—	—	100	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$)	2N5835	h_{FE}	25	—	—	—
($I_C = 50 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$)	2N5836		25	—	—	
($I_C = 100 \text{ mAdc}$, $V_{CE} = 3.0 \text{ Vdc}$)	2N5837		25	—	—	
Base-Emitter On Voltage ($I_C = 10 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$)	2N5835	$V_{BE(on)}$	—	—	0.9	Vdc
($I_C = 50 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$)	2N5836		—	—	0.9	
($I_C = 100 \text{ mAdc}$, $V_{CE} = 3.0 \text{ Vdc}$)	2N5837		—	—	0.9	

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product(1) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 200 \text{ MHz}$)	2N5835	f_T	2.5	—	—	GHz
($I_C = 50 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 200 \text{ MHz}$)	2N5836		2.0	—	—	
($I_C = 100 \text{ mAdc}$, $V_{CE} = 3.0 \text{ Vdc}$, $f = 200 \text{ MHz}$)	2N5837		1.7	—	—	
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 0.1$ to 1.0 MHz)	2N5835 2N5836	C_{cb}	—	—	0.8 3.5	pF
($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 0.1$ to 1.0 MHz)	2N5837		—	—	5.0	
Collector Base Time Constant(2) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 63.6 \text{ MHz}$)	2N5835	$r_b' C_c$	—	5.0	—	ps
($I_C = 50 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 63.6 \text{ MHz}$)	2N5836		—	6.0	—	
($I_C = 100 \text{ mAdc}$, $V_{CE} = 3.0 \text{ Vdc}$, $f = 63.6 \text{ MHz}$)	2N5837		—	6.0	—	

2N5835 • 2N5836 • 2N5837

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS(2)					
Rise Time (Figure 1) (I _C = 10 mAdc)	t _r	—	250	—	ns
(I _C = 40 mAdc)					
(I _C = 100 mAdc)					
2N5835	—	250	—	ns	
2N5836	—	320	—	ns	
2N5837	—	650	—	ns	

(1) t_r is defined as the frequency at which |h_{fe}| extrapolates to unity.
 (2) Typical values shown in addition to JEDEC Registered Data.

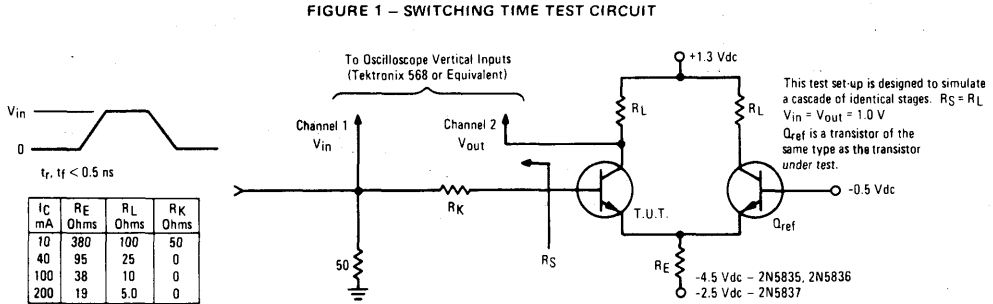


FIGURE 2 – SWITCHING TIME

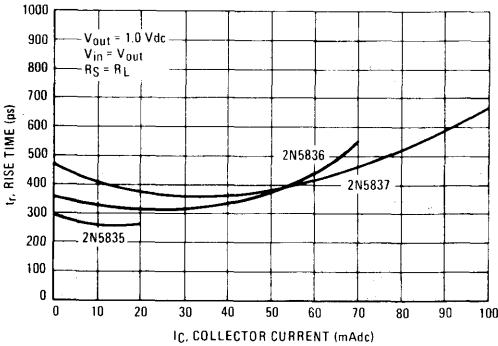


FIGURE 3 – CURRENT-GAIN-BANDWIDTH PRODUCT

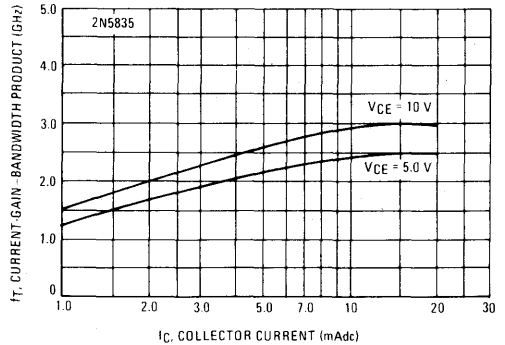


FIGURE 4 – CURRENT-GAIN-BANDWIDTH PRODUCT

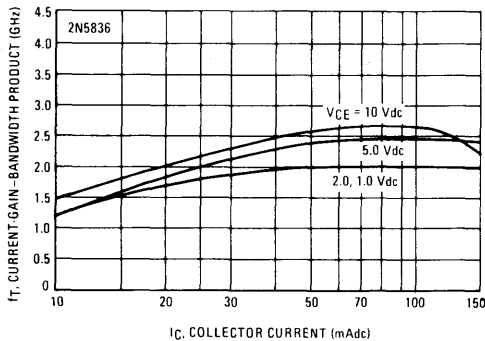
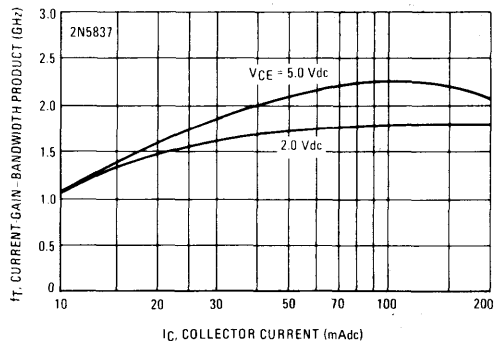


FIGURE 5 – CURRENT-GAIN-BANDWIDTH PRODUCT



2N5835 • 2N5836 • 2N5837

FIGURE 6 – COLLECTOR-BASE TIME CONSTANT

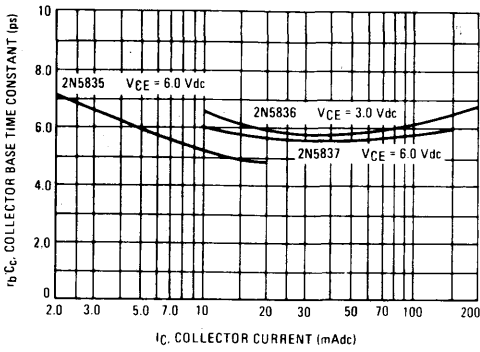
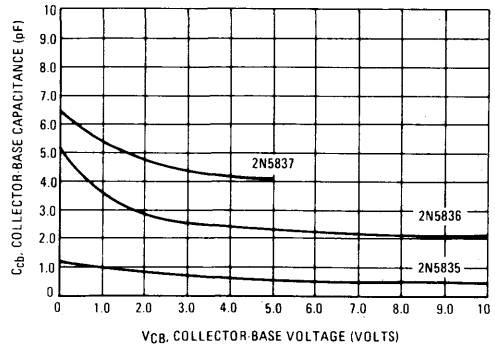


FIGURE 7 – COLLECTOR-BASE CAPACITANCE



2N5835 SCATTERING PARAMETERS
 ($I_C = 5.0$ mA, $V_{CE} = 6.0$ V, $Z_G = Z_L = 50$ Ohms)

FIGURE 8 – S_{11} , INPUT REFLECTION COEFFICIENT

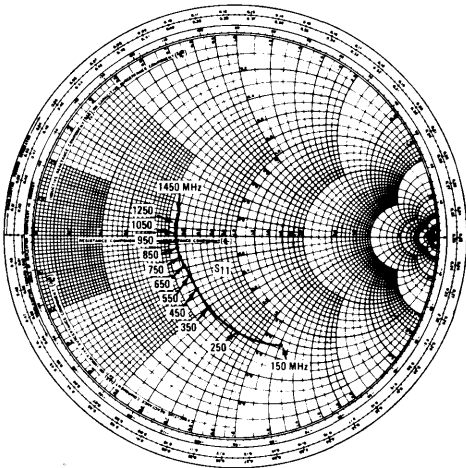
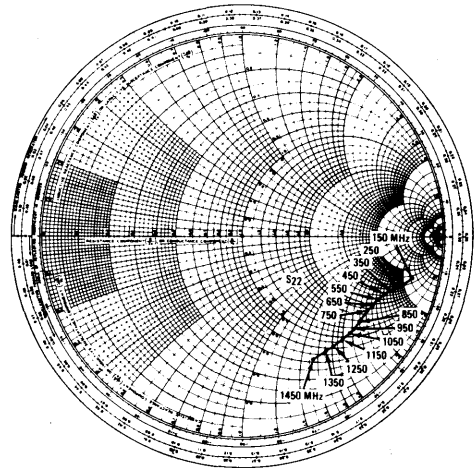


FIGURE 9 – S_{22} , OUTPUT REFLECTION COEFFICIENT



2N5835 • 2N5836 • 2N5837

FIGURE 10 — S_{12} , REVERSE TRANSMISSION COEFFICIENT

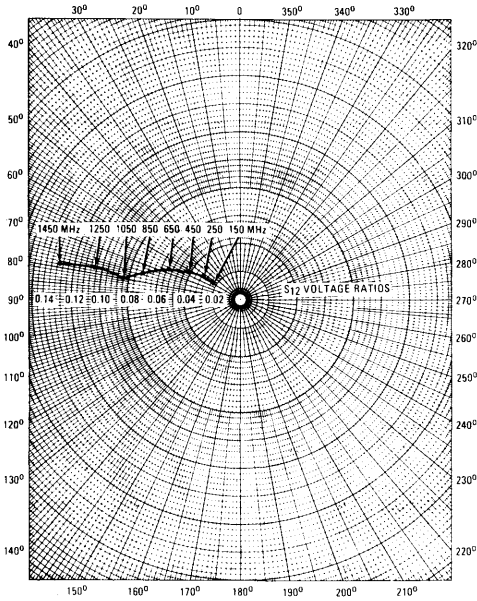
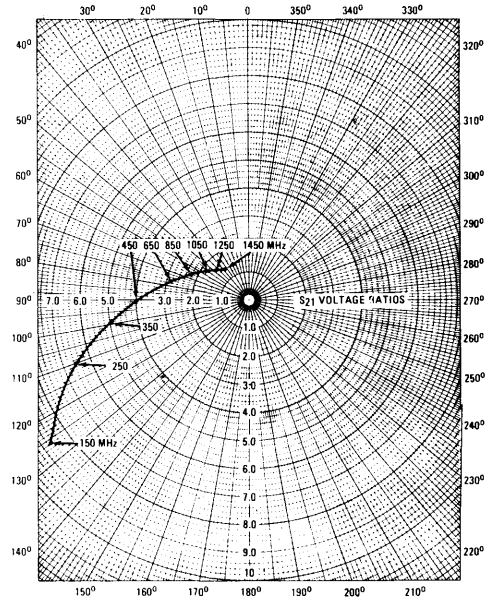


FIGURE 11 — S_{21} , FORWARD TRANSMISSION COEFFICIENT



7

2N5836 SCATTERING PARAMETERS
 ($I_C = 100 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $Z_G = Z_L = 50 \text{ Ohms}$)

FIGURE 12 — S_{11} , INPUT REFLECTION COEFFICIENT

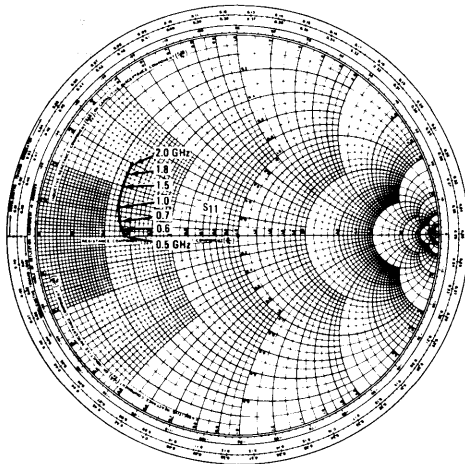


FIGURE 13 — S_{22} , OUTPUT REFLECTION COEFFICIENT

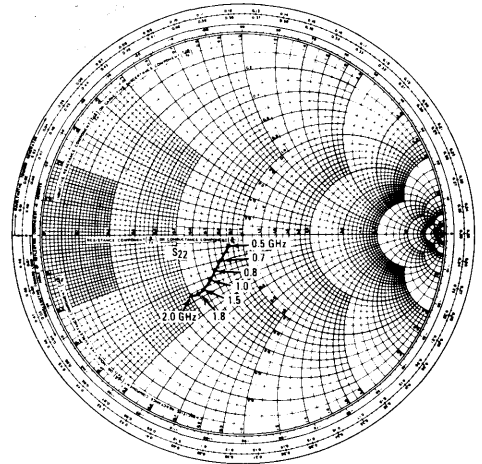


FIGURE 14 – S_{12} , REVERSE TRANSMISSION COEFFICIENT

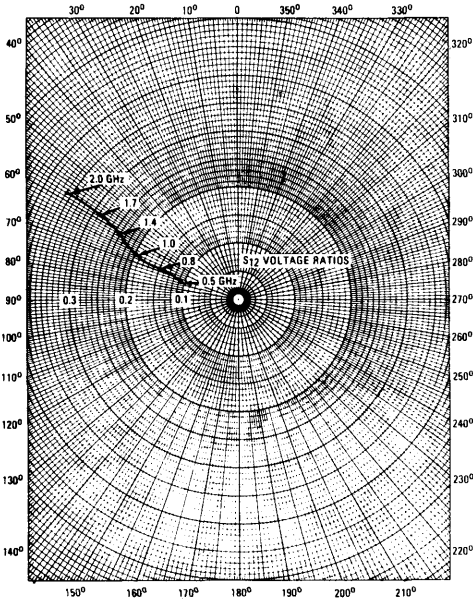
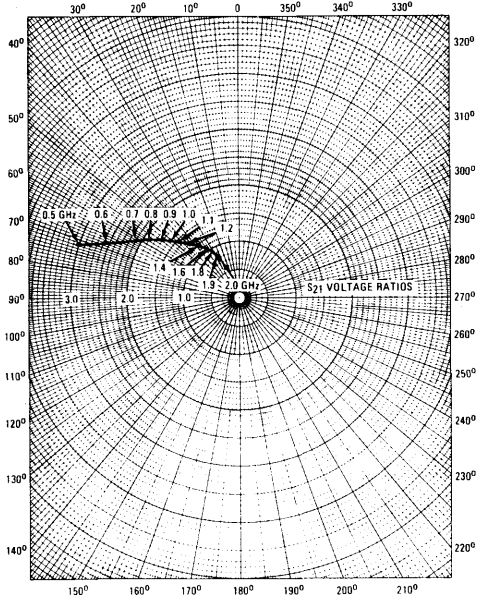


FIGURE 15 – S_{21} , FORWARD TRANSMISSION COEFFICIENT



2N5837 SCATTERING PARAMETERS

($I_C = 100 \text{ mAdc}$, $V_{CE} = 3.0 \text{ Vdc}$, $Z_G = Z_L = 50 \text{ Ohms}$)

FIGURE 16 – S_{11} , INPUT REFLECTION COEFFICIENT

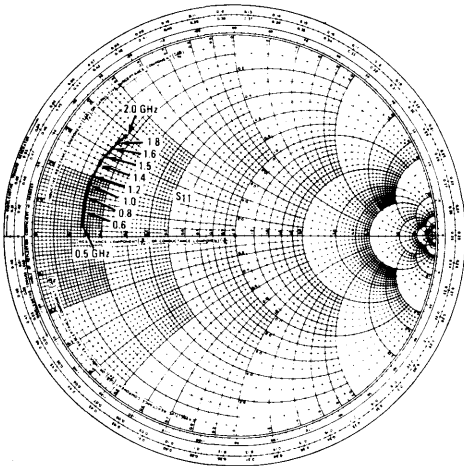


FIGURE 17 – S_{22} , OUTPUT REFLECTION COEFFICIENT

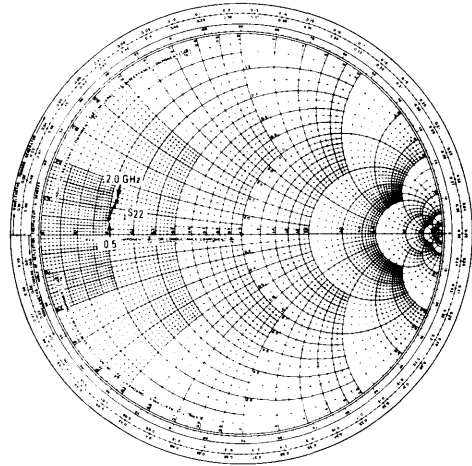


FIGURE 18 – S_{12} , REVERSE TRANSMISSION COEFFICIENT

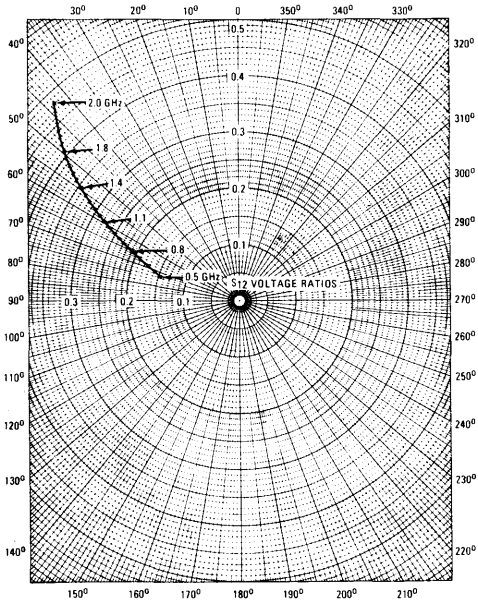
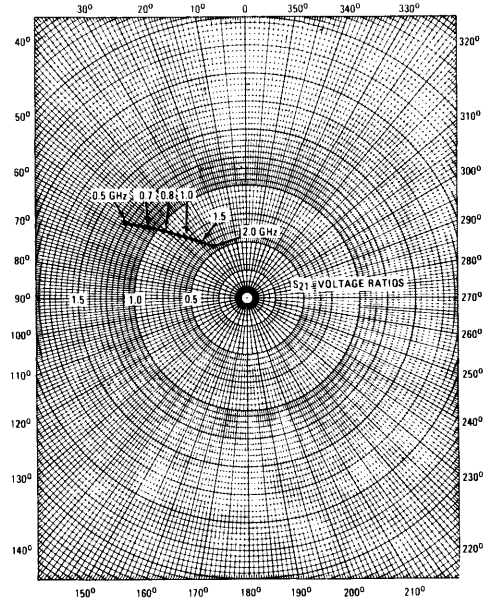


FIGURE 19 – S_{21} , FORWARD TRANSMISSION COEFFICIENT



2N5943

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.5 0.02	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $I_B = 0$)	I_{CEO}	—	—	50	μ Adc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	10	μ Adc

ON CHARACTERISTICS

DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc)	h_{FE}	25	—	300	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	—	0.15	0.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{BE(sat)}$	—	0.88	1.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 25$ mAdc, $V_{CE} = 15$ Vdc, $f = 200$ MHz) ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, $f = 200$ MHz) ($I_C = 100$ mAdc, $V_{CE} = 15$ Vdc, $f = 200$ MHz)	f_T	1000 1200 1000	1350 1550 1425	— 2400 —	MHz
Collector-Base Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, $f = 100$ kHz)	C_{cb}	1.0	1.6	2.5	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 100$ kHz)	C_{eb}	—	8.4	15	pF
Small Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, $f = 1.0$ kHz)	h_{fe}	25	—	350	—
Collector Base Time Constant ($I_E = 50$ mAdc, $V_{CB} = 15$ Vdc, $f = 31.8$ MHz)	$r_b' C_c$	2.0	5.5	20	ps
Noise Figure ($I_C = 30$ mAdc, $V_{CE} = 15$ Vdc, $f = 200$ MHz) (Figure 1) ($I_C = 35$ mAdc, $V_{CE} = 15$ Vdc, $f = 200$ MHz) (Figure 6)	NF	— —	3.4 6.8	— 8.0	dB

FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain ($I_C = 10$ mAdc, $V_{CE} = 15$ Vdc, $f = 200$ MHz) (Figure 1) ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, $f = 250$ MHz) (Figure 6)	G_{pe}	— 7.0	11.4 7.6	— —	dB
Intermodulation Distortion ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, $V_{out} = +50$ dBmV)	IM	—	—	-50	dB
Cross Modulation Distortion ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, $V_{out} = +40$ dBmV) ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, $V_{out} = +50$ dBmV)	XM	— —	-67 -45	— -42	dB

7

FIGURE 1 - NARROW-BAND TEST CIRCUIT

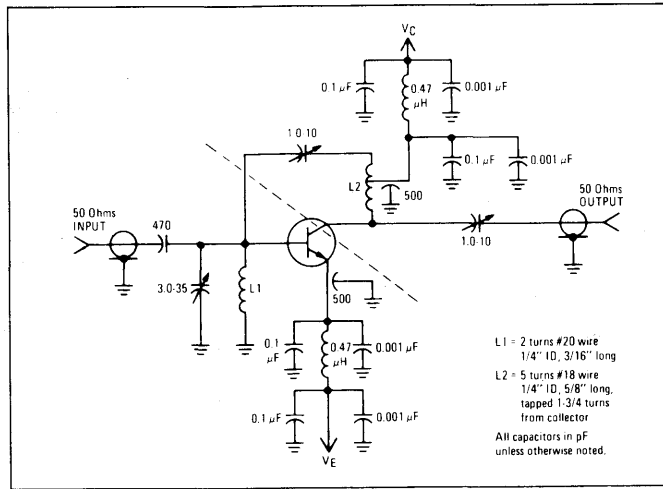


FIGURE 2 - CURRENT-GAIN - BANDWIDTH PRODUCT

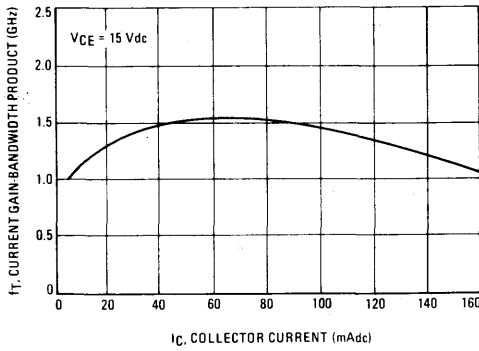


FIGURE 3 - COLLECTOR-BASE TIME CONSTANT

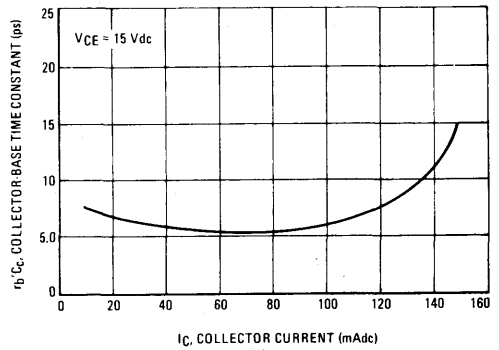


FIGURE 4 - SATURATION VOLTAGES

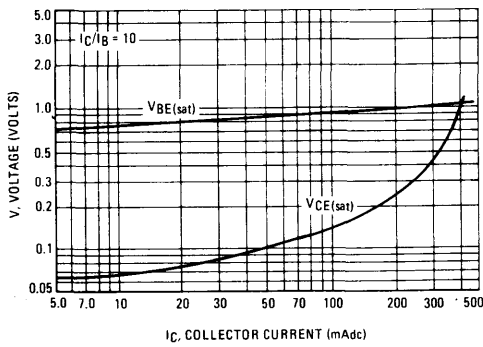


FIGURE 5 - CAPACITANCES versus REVERSE VOLTAGE

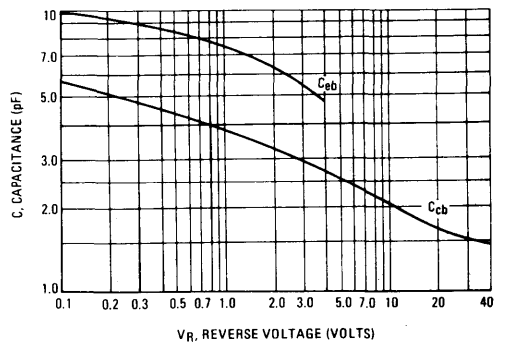
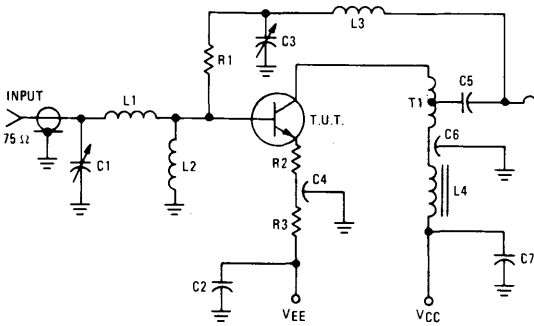


FIGURE 6 - BROADBAND TEST CIRCUIT



- C1 1.0-10 pF JOHANSON 2951 OR EQUIVALENT
 - C2, C7 0.01 μF
 - C3 0.5-6.0 pF JOHANSON 4642 OR EQUIVALENT
 - C4, C6 1500 pF
 - C5 470 pF
 - L1 2 TURNS AWG #26, 5/32" I.D.
 - L2 1 μH MOLDED CHOKE
 - L3 5 TURNS AWG #26, 3/32" I.D.
 - L4 FERRITE CHOKE, 3 TURNS #30 ON STACKPOLE 57-0156 BEAD
 - L5 2 TURNS AWG #26, 3/32" I.D.
 - T1 AWG #30 TRIFILAR WOUND 1-9-9 ON STACKPOLE 57-0985, #11 TOROID
 - R1 270 OHMS
 - R2 18 OHMS
 - R3 150 OHMS
- GARLOCK TEFLON SOCKET

FIGURE 7 - CROSS-MODULATION DISTORTION versus COLLECTOR CURRENT

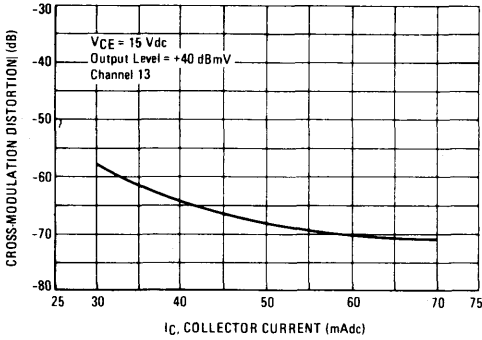


FIGURE 8 - CROSS-MODULATION DISTORTION versus OUTPUT LEVEL

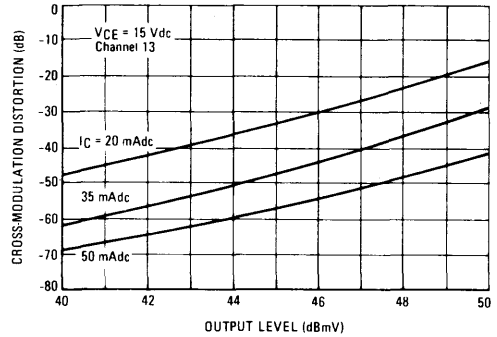


FIGURE 9 - NARROWBAND NOISE FIGURE versus COLLECTOR CURRENT

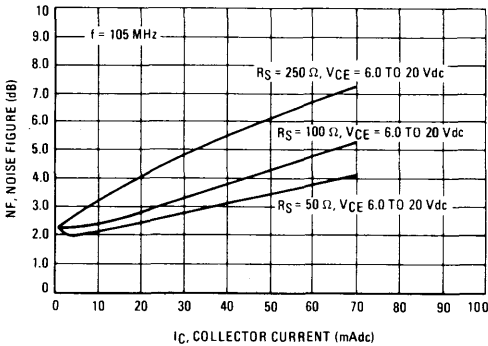


FIGURE 10 - NARROWBAND NOISE FIGURE versus COLLECTOR CURRENT

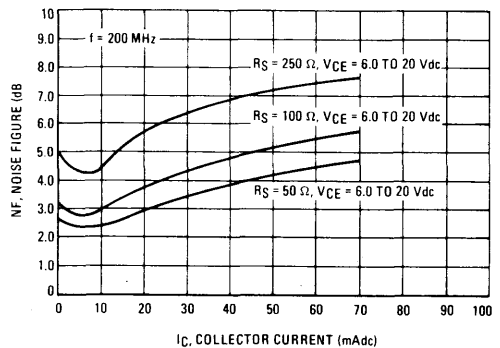


FIGURE 11 - BROADBAND NOISE FIGURE versus COLLECTOR CURRENT

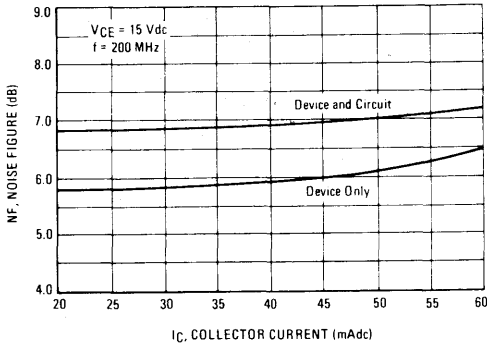


FIGURE 12 - NARROWBAND NOISE FIGURE versus FREQUENCY

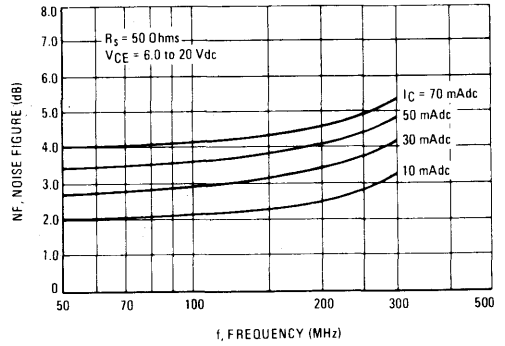


FIGURE 13 - INPUT ADMITTANCE versus FREQUENCY

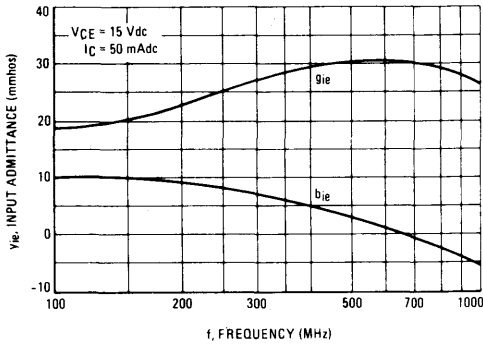


FIGURE 14 - INPUT ADMITTANCE versus COLLECTOR CURRENT

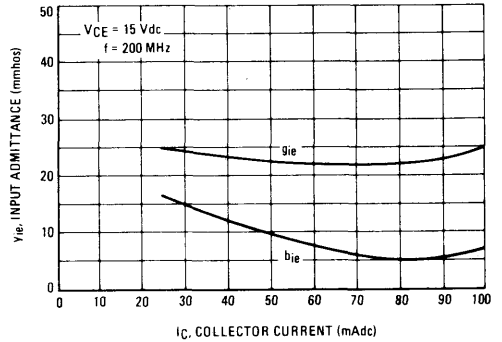


FIGURE 15 - REVERSE TRANSFER ADMITTANCE versus FREQUENCY

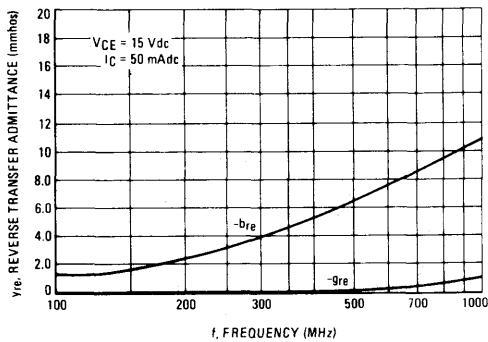
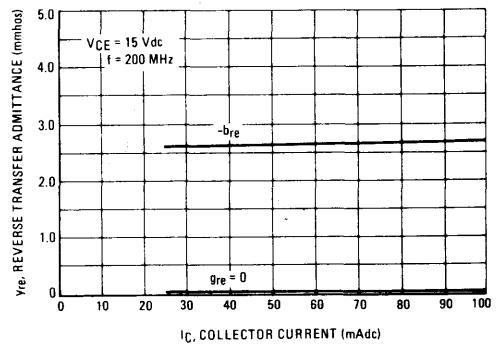


FIGURE 16 - REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT



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FIGURE 17 - FORWARD TRANSFER ADMITTANCE versus FREQUENCY

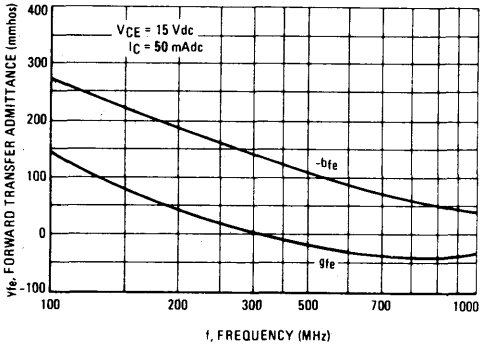


FIGURE 18 - FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

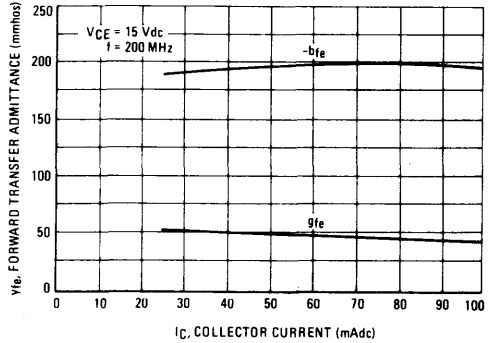


FIGURE 19 - OUTPUT ADMITTANCE versus FREQUENCY

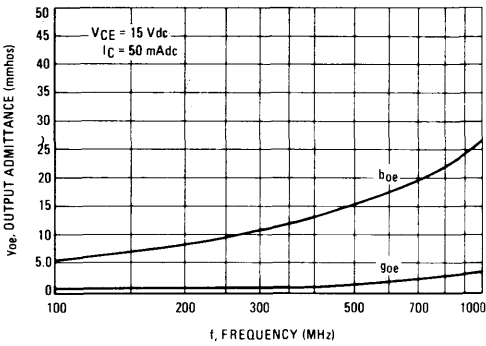


FIGURE 20 - OUTPUT ADMITTANCE versus COLLECTOR CURRENT

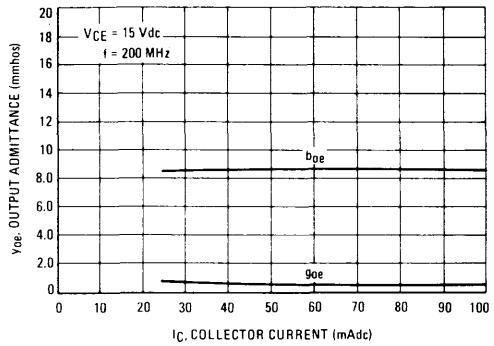


FIGURE 21 - INPUT REFLECTION COEFFICIENT versus FREQUENCY

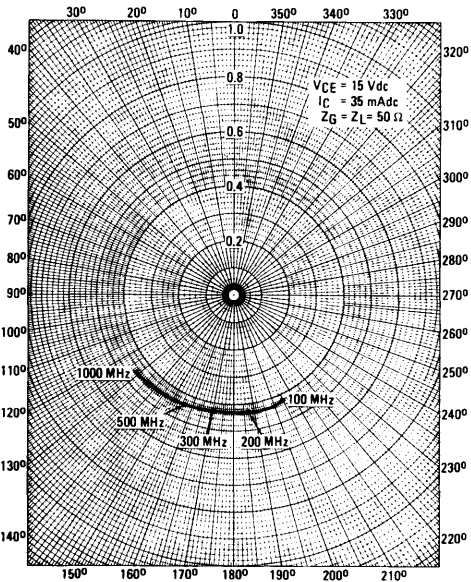


FIGURE 22 - OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

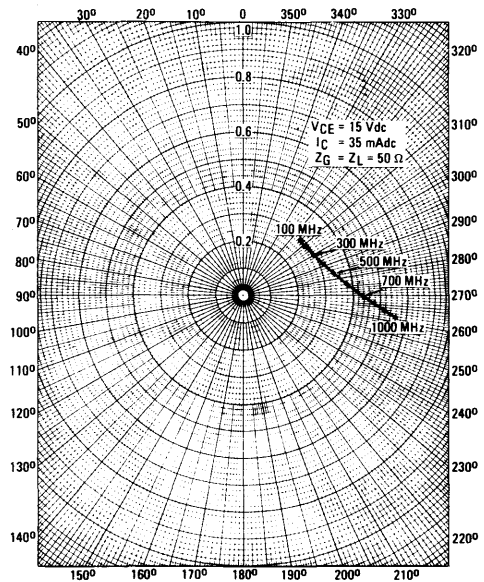


FIGURE 23 – REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

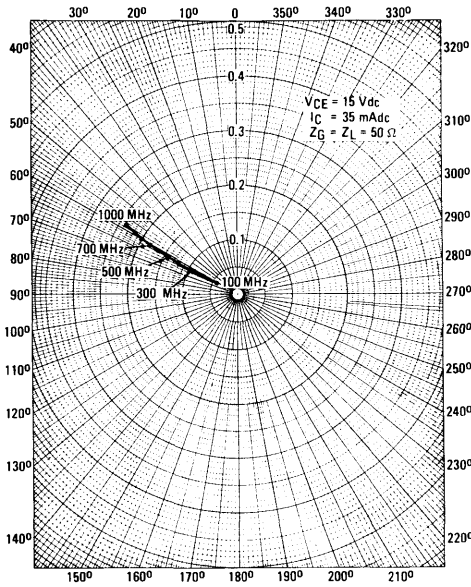


FIGURE 24 – FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

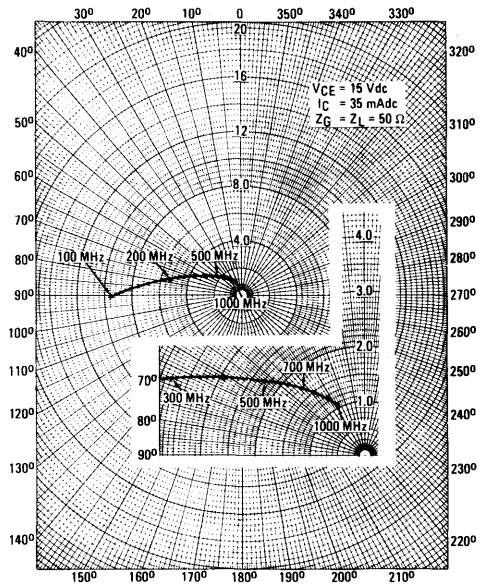
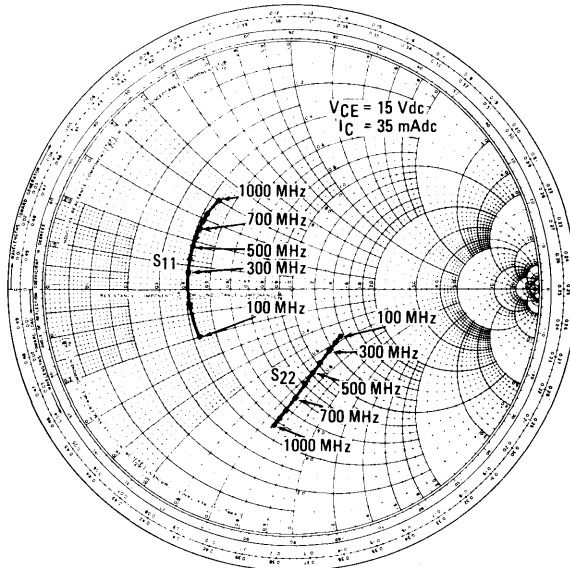


FIGURE 25 – INPUT REFLECTION COEFFICIENT AND OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



2N5947

CASE 244A-01, STYLE 1
TO-117 (TO-232AA)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mA _{dc}
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 20 \text{ mA}_{dc}$, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}_{dc}$, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}_{dc}$, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 28 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	—	100	μA_{dc}
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	10	μA_{dc}
Emitter Cutoff Current ($V_{BE} = 3.5 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	100	μA_{dc}

ON CHARACTERISTICS

DC Current Gain ($I_C = 75 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$)	h_{FE}	25	—	250	—
Collector-Emitter Saturation Voltage ($I_C = 200 \text{ mA}_{dc}$, $I_B = 20 \text{ mA}_{dc}$)	$V_{CE(sat)}$	—	0.2	0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 200 \text{ mA}_{dc}$, $I_B = 20 \text{ mA}_{dc}$)	$V_{BE(sat)}$	—	1.0	1.5	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 75 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 200 \text{ MHz}$)	f_T	1100	1500	—	MHz
Collector-Base Capacitance ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{cb}	—	1.5	4.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{eb}	—	8.2	12	pF
Small Signal Current Gain ($I_C = 75 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	25	—	300	—
Collector Base Time Constant ($I_E = 75 \text{ mA}_{dc}$, $V_{CB} = 20 \text{ Vdc}$, $f = 31.8 \text{ MHz}$)	$rb'C_c$	2.0	—	20	ps
Noise Figure ($I_C = 50 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 200 \text{ MHz}$) (Figure 1)	NF	—	3.8	—	dB
($I_C = 50 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 200 \text{ MHz}$)(1) (Figure 2)		—	7.2	8.5	
($I_C = 75 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 200 \text{ MHz}$)(1) (Figure 2)		—	7.8	—	

FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain (Figure 2) ($I_C = 75 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 250 \text{ MHz}$)	G_{pe}	10	11	—	dB
Intermodulation Distortion (Figure 2) ($I_C = 75 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $V_{out} = +50 \text{ dBmV}$)	IM	—	-55	-50	dB
Cross Modulation Distortion (Figure 2) ($I_C = 75 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $V_{out} = +50 \text{ dBmV}$)	XM	—	-60	-57	dB

(1) Includes noise figure of post-amplifier and matching pad.

FIGURE 1 - NARROWBAND TEST CIRCUIT

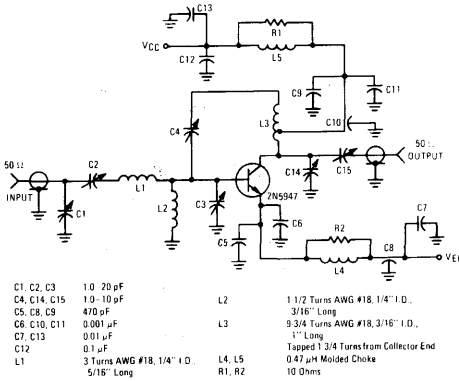


FIGURE 2 - BROADBAND TEST CIRCUIT

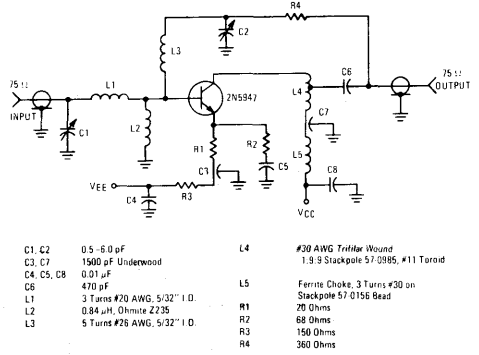


FIGURE 3 - CURRENT-GAIN-BANDWIDTH PRODUCT

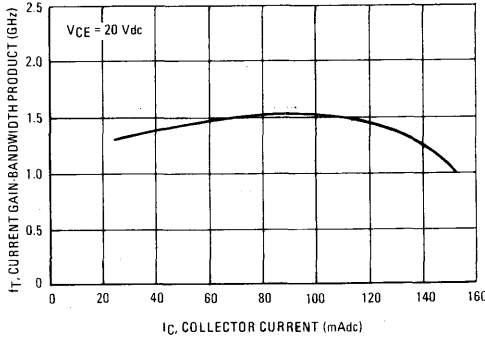


FIGURE 4 - CAPACITANCES

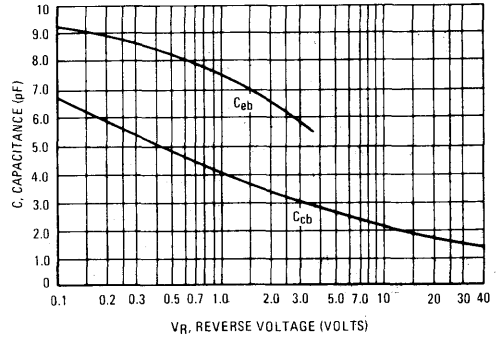


FIGURE 5 - COLLECTOR-EMITTER SATURATION VOLTAGE

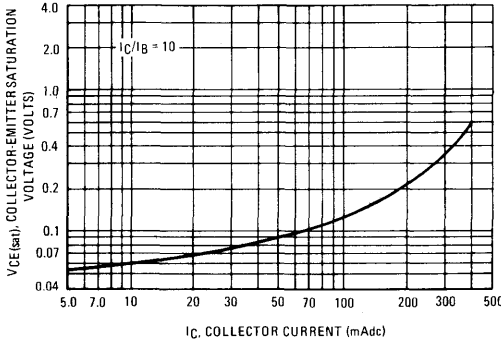


FIGURE 6 - BASE-EMITTER SATURATION VOLTAGE

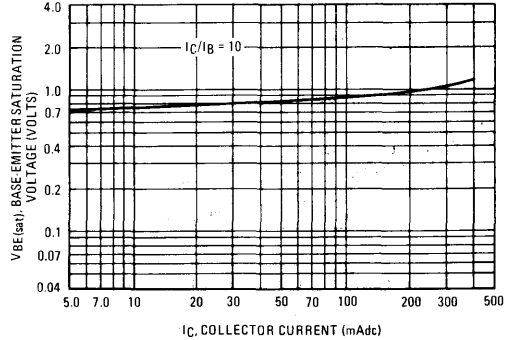


FIGURE 7 – NARROWBAND NOISE FIGURE versus CURRENT

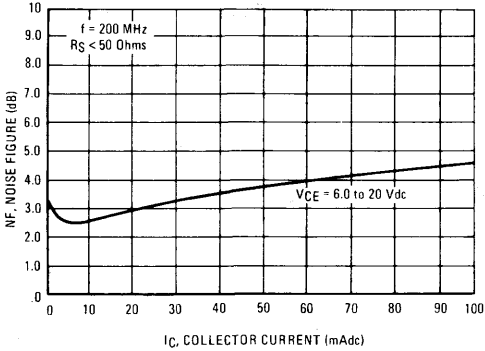


FIGURE 8 – BROADBAND NOISE FIGURE versus CURRENT

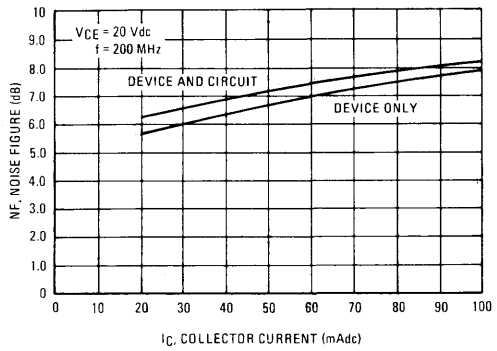
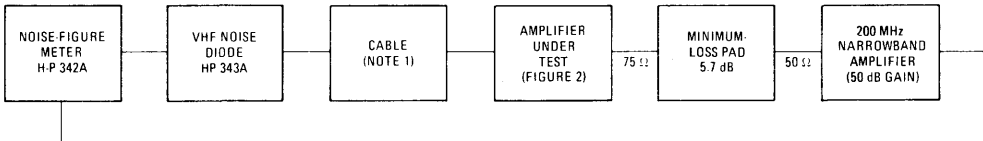


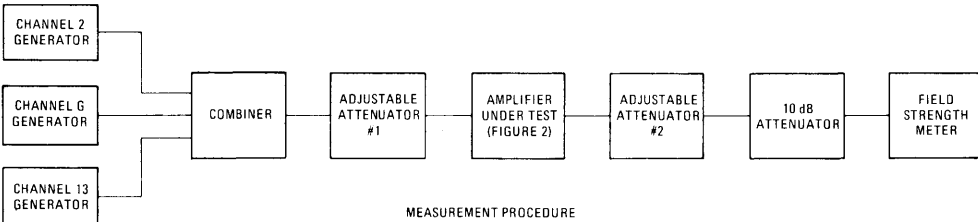
FIGURE 9 – NOISE FIGURE TEST SETUP



NOTE 1. RG-59 CABLE WITH ORIGINAL CENTER CONDUCTOR REPLACED WITH #30 WIRE. OVERALL LENGTH, INCLUDING BNC CONNECTORS, IS A QUARTER-WAVELENGTH AT 200 MHz (APPROX. 11 INCHES). USED TO MATCH IMPEDANCE OF NOISE DIODE TO AMPLIFIER UNDER TEST.

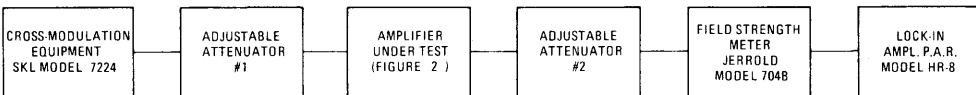
THE NOISE FIGURE OF THE POST-AMPLIFIERS AND MINIMUM LOSS PAD IS 8.4 dB.

FIGURE 10 – INTERMODULATION DISTORTION TEST SETUP



- MEASUREMENT PROCEDURE
1. ADJUST CHANNEL 2 GENERATOR FOR RATED OUTPUT FROM TEST AMPLIFIER (CHANNELS G & 13 OFF).
 2. REPEAT FOR CHANNEL G (2 & 13 OFF) AND CHANNEL 13 (2 & G OFF). NOTE FOR REFERENCE THE FIELD STRENGTH METER READING FOR CHANNEL 13 (2 & G OFF).
 3. TURN CHANNEL 13 OFF AND DRIVE THE TEST AMPLIFIER WITH CHANNELS 2 & G. MEASURE THE LEVEL OF INTERMODULATION DISTORTION AT CHANNEL 13 RELATIVE TO THE REFERENCE LEVEL IN STEP 2.

FIGURE 11 – CROSS MODULATION DISTORTION TEST SETUP



- MEASUREMENT PROCEDURE
1. ADJUST THE CROSSMODULATION EQUIPMENT FOR +50 dBmV OUTPUT FROM EACH CHANNEL.
 2. ADJUST ATTENUATOR #1 FOR THE DESIRED OUTPUT LEVEL FROM THE TEST AMPLIFIER. ADJUST ATTENUATOR #2 TO MAINTAIN THE FIELD STRENGTH METER INPUT AT +10 dBmV.
 3. WITH THE FIELD STRENGTH METER SELECT CHANNEL 13. USING THE WAVE ANALYZER MEASURE THE LEVEL OF THE MODULATION ON CHANNEL 13 DUE TO CROSS-MODULATION OF CHANNELS 2-12.

FIGURE 12 – CROSS MODULATION DISTORTION
versus OUTPUT LEVEL

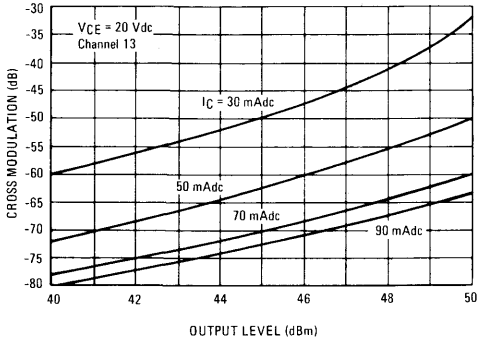
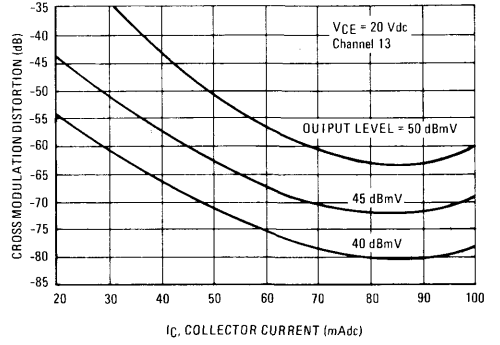


FIGURE 13 – CROSS MODULATION DISTORTION
versus CURRENT



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2N6255

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.5	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	0.25	mAdc
Collector Cutoff Current ($V_{CE} = 15 \text{ Vdc}$, $V_{BE} = 0$, $T_C = 55^\circ\text{C}$)	I_{CES}	—	—	5.0	mAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 250 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	5.0	—	—	—
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SMALL SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 12.5 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	15	20	pF
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FUNCTIONAL TEST (FIGURE 1)

Common-Emitter Amplifier Power Gain ($P_{out} = 3.0 \text{ W}$, $V_{CC} = 12.5 \text{ Vdc}$, $f = 175 \text{ MHz}$)	GPE	7.8	—	—	dB
Collector Efficiency ($P_{out} = 3.0 \text{ W}$, $V_{CC} = 12.5 \text{ Vdc}$, $f = 175 \text{ MHz}$)	η	50	—	—	%

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FIGURE 1 - 175 MHz CIRCUIT

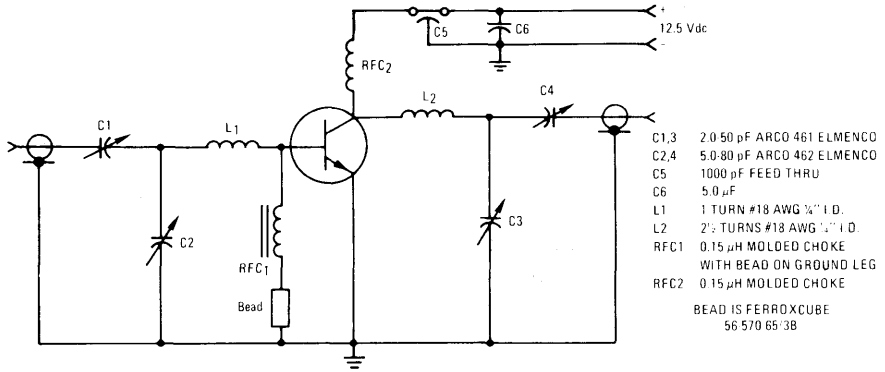


FIGURE 2 - OUTPUT POWER versus INPUT POWER

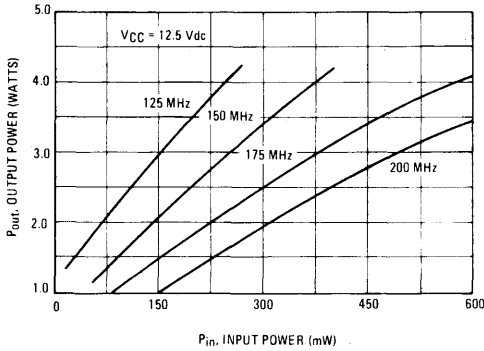


FIGURE 3 - OUTPUT POWER versus SUPPLY VOLTAGE

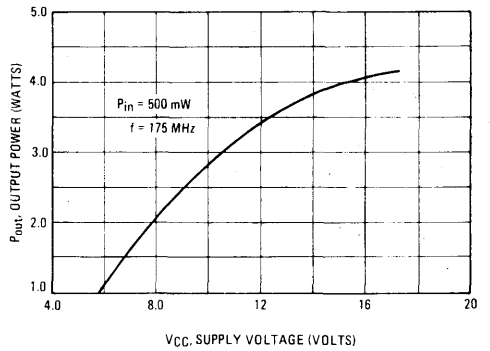


FIGURE 4 - COLLECTOR LOAD versus FREQUENCY

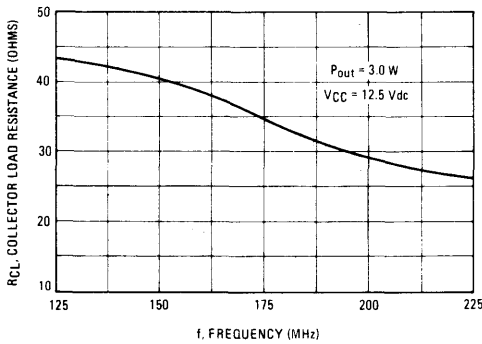
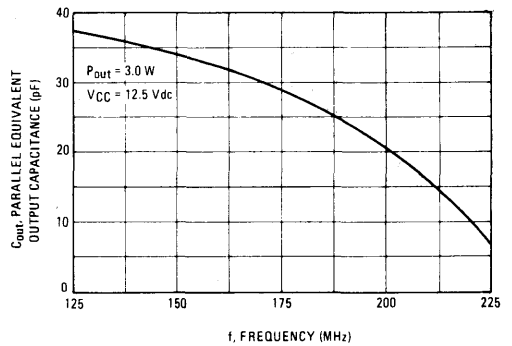


FIGURE 5 - PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



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FIGURE 6 – PARALLEL EQUIVALENT
INPUT CAPACITANCE versus FREQUENCY

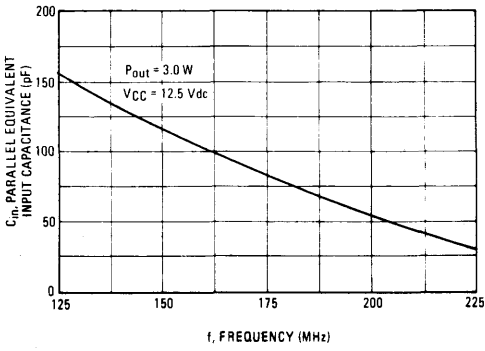
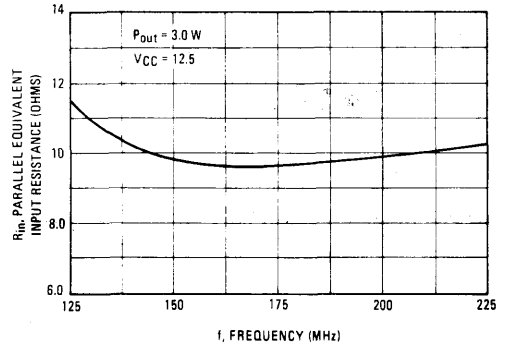


FIGURE 7 – PARALLEL EQUIVALENT
INPUT RESISTANCE versus FREQUENCY



2N6256

CASE 249-05, STYLE 1

UHF AMPLIFIER TRANSISTOR

NPN SILICON

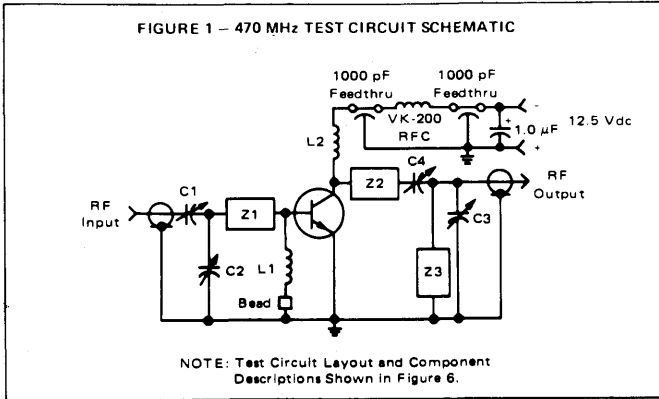


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0 11.4	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}, V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	0.5	mAdc
Collector Cutoff Current ($V_{CE} = 15 \text{ Vdc}, V_{BE} = 0, T_A = 125^\circ\text{C}$)	I_{CES}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	20	80	200	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 12.5 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	6.0	8.0	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain ($P_{out} = 0.5 \text{ W}, V_{CC} = 12.5 \text{ Vdc}, f = 470 \text{ MHz}$)	(Figures 1, 6) G_{PE}	7.0	9.0	—	dB
Collector Efficiency ($P_{out} = 0.5 \text{ W}, V_{CC} = 12.5 \text{ Vdc}, f = 470 \text{ MHz}$)	(Figures 1, 6) η	60	70	—	%



Typical Output Power curves were measured in circuit shown in Figure 6.

FIGURE 2 - OUTPUT POWER versus FREQUENCY

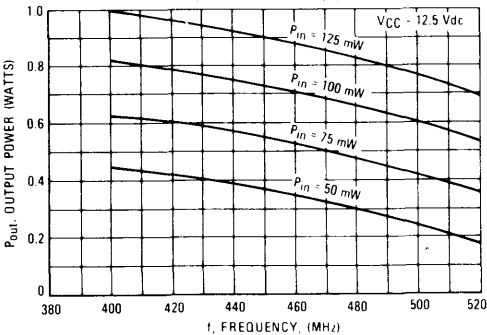


FIGURE 3 - OUTPUT POWER versus INPUT POWER

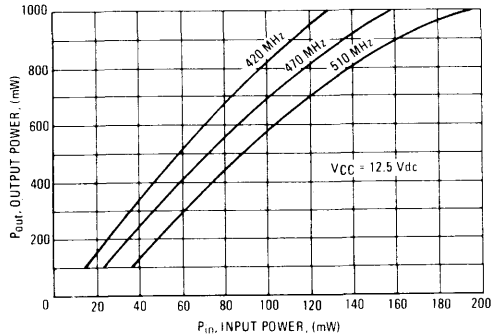


FIGURE 4 - OUTPUT POWER versus SUPPLY VOLTAGE

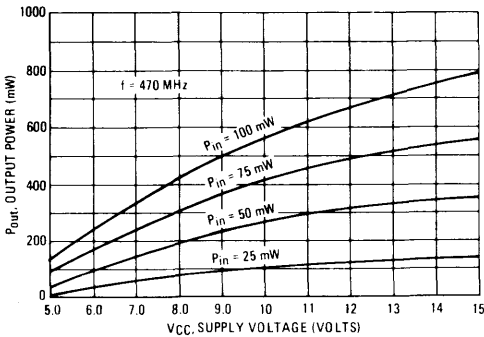


FIGURE 5 - SERIES EQUIVALENT INPUT and OUTPUT IMPEDANCE

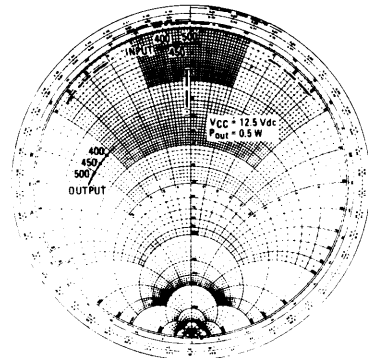


FIGURE 6 - 470 MHz TEST CIRCUIT LAYOUT
(See Figure 1 for Schematic Diagram)

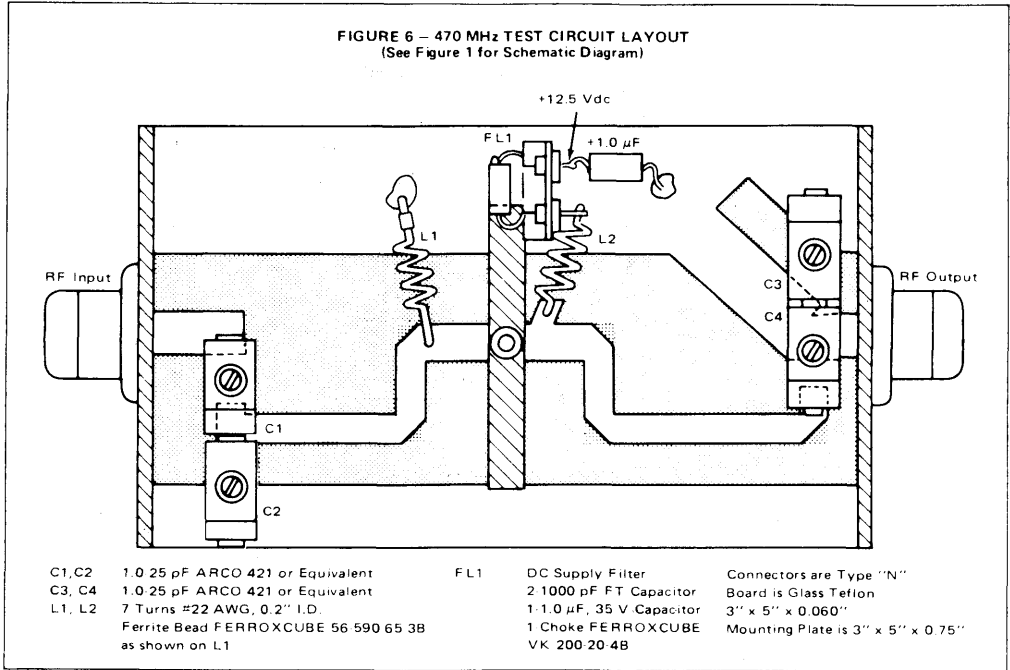
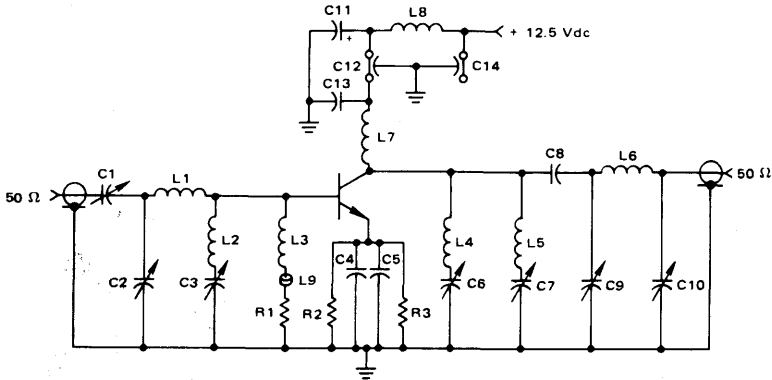


FIGURE 7 - 150 MHz to 450 MHz
TRIPLER USING 2N6256



- | | | |
|----------------------------------|----------------------|---------------------------------------|
| C1, C2, C3, C9, C10 | C13 | L4 |
| 1.7 pF ARCO 400 or Equivalent | 0.1 μF Ceramic | 5 Turns 1/4" I.D. |
| C6, C7 | R1 | L5 |
| 1.5-20 pF ARCO 402 or Equivalent | 20 Ohm | 6 Turns 1/8" I.D. |
| C4, C5 | R2, R3 | L7 |
| 470 pF ATC Type 100-B-420-m-ms | 160 Ohm | 1 μH Molded Choke |
| C8 | L1 | L8 |
| 1000 pF UNDERWOOD Type J-101 | 7 Turns 1/4" I.D. | FERROXCUBE VK200-20/4B |
| C11 | L2 | L9 |
| 0.47 μF TANTALUM | 6.4 Turns 1/8" I.D. | Ferrite Bead, FERROXCUBE 56-590-65/3B |
| C12, C14 | L3 | |
| 470 pF Feedthru | 0.68 μH Molded Choke | |

NOTE: All coils air core space wound with #20 AWG Wire, unless otherwise specified.

Figure 7 shows the 2N6256 in a 150 MHz to 450 MHz tripler circuit. This circuit will typically produce 85 mW at 450 MHz with 30 mW at 150 MHz input (4.5 dB gain). Collector efficiency is 25% and all unwanted harmonics are at least 30 dB down from the 450 MHz output level.

It is important that each emitter lead be bypassed separately with a good hi-quality capacitor. The emitter resistor is likewise split in two with one-half on each emitter lead.

The input network is a modified "TEE" consisting of C1, C2, and L1, which matches the 50 Ohm input to the transistor impedance at 150 mc; this is roughly 18-j20 Ohms. The combination of L2 and C3 form a 450 MHz idler to provide a base return for third harmonic current. L4, C6 and L5, C7 are 150 MHz and 300 MHz output idlers respectively. The output matching section is a pi network made up of L6, C9 and C10. All coils are air core space-wound (turns one wire diameter apart) with #20 AWG wire.

2N6304 2N6305

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_E = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 5.0$ Vdc, $I_E = 0$)	I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 100$ MHz)	f_T	1400 1200	— —	— —	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	0.8	1.0	pF
Small Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 1.0$ kHz)	h_{fe}	25	—	250	—
Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 5.0$ Vdc, $f = 31.8$ MHz)	$rb'C_C$	2.0 2.0	— —	12 15	ps
Noise Figure ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 50$ ohms, $f = 450$ MHz) (Figure 1)	NF	— —	— —	4.5 5.5	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 450$ MHz) (Figure 1)	G_{pe}	15 12	— —	— —	dB

FIGURE 1 - TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN

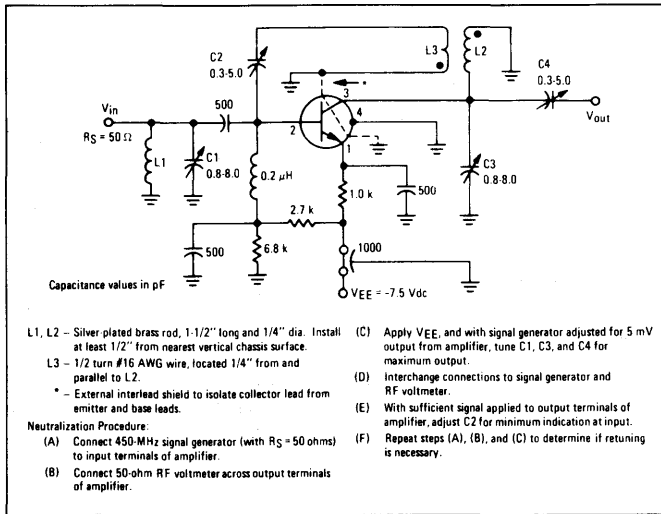


FIGURE 2 - COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

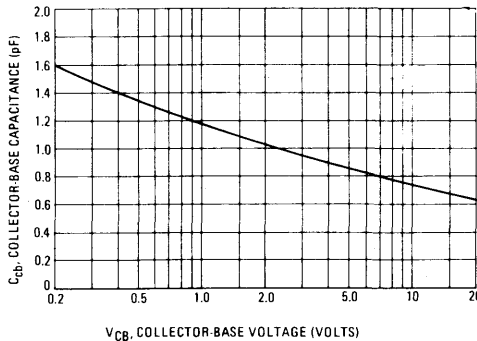


FIGURE 3 - CURRENT-GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

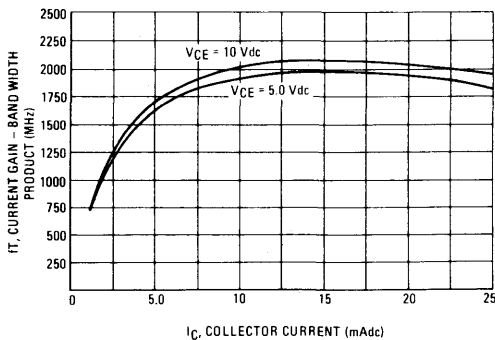


FIGURE 4 - COLLECTOR-BASE TIME CONSTANT versus EMITTER CURRENT

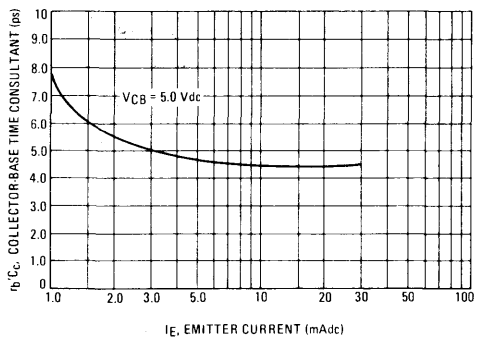


FIGURE 5 - REVERSE TRANSFER ADMITTANCE versus FREQUENCY

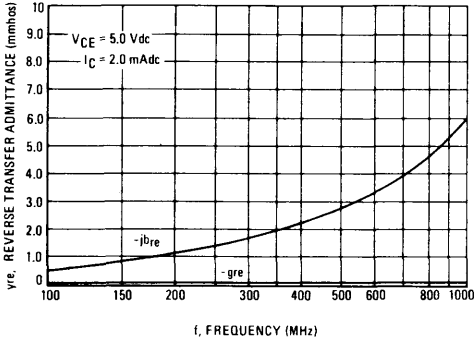


FIGURE 6 - INPUT ADMITTANCE versus FREQUENCY

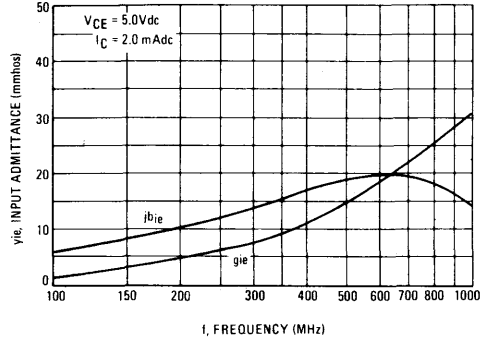


FIGURE 7 - OUTPUT ADMITTANCE versus FREQUENCY

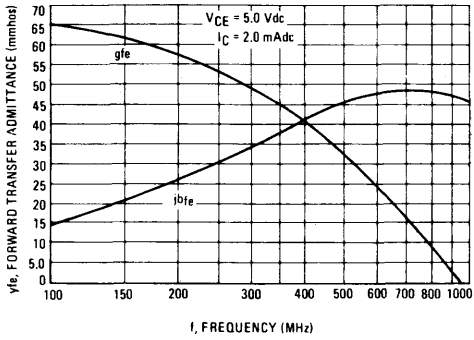


FIGURE 8 - FORWARD TRANSFER ADMITTANCE versus FREQUENCY

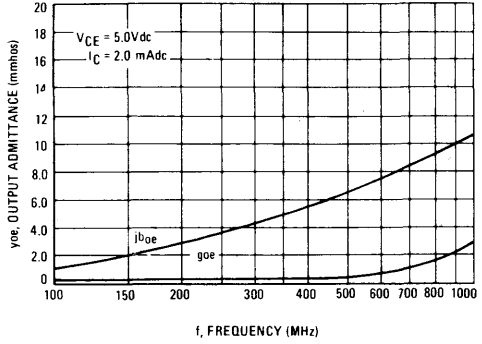


FIGURE 9 - S_{11} , INPUT REFLECTION COEFFICIENT

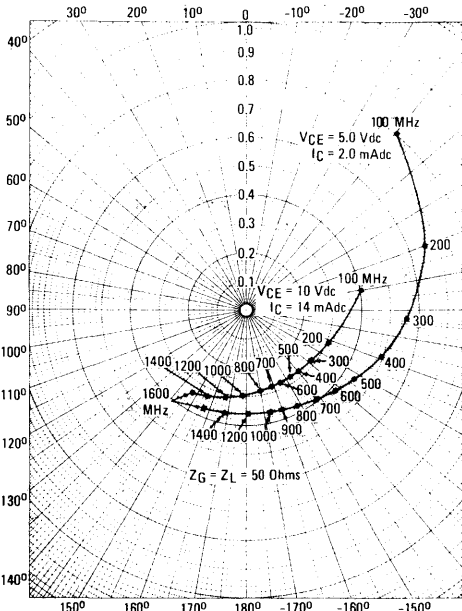


FIGURE 10 - S_{22} , OUTPUT REFLECTION COEFFICIENT

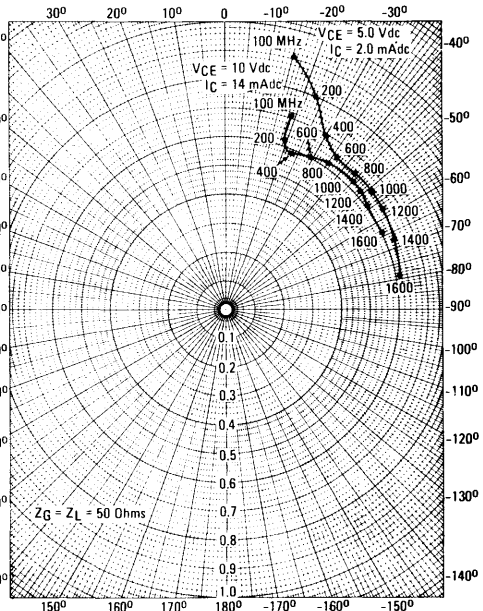


FIGURE 11 - S_{12} , REVERSE TRANSMISSION COEFFICIENT

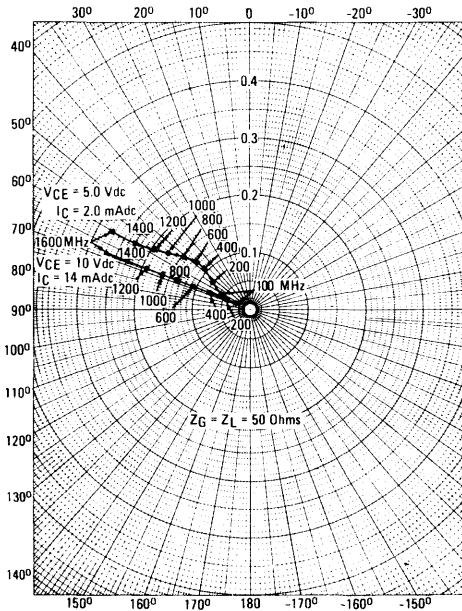
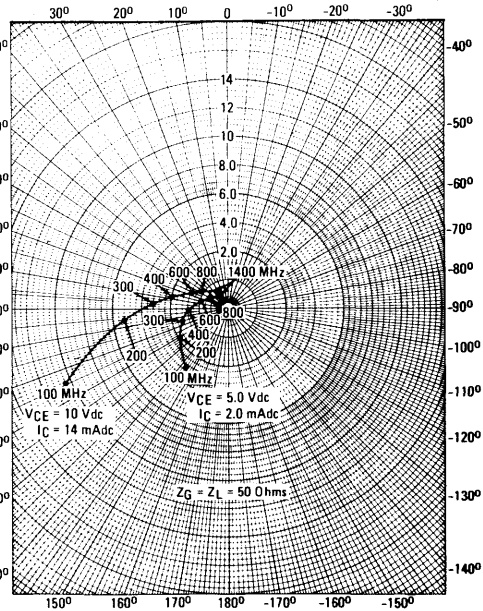
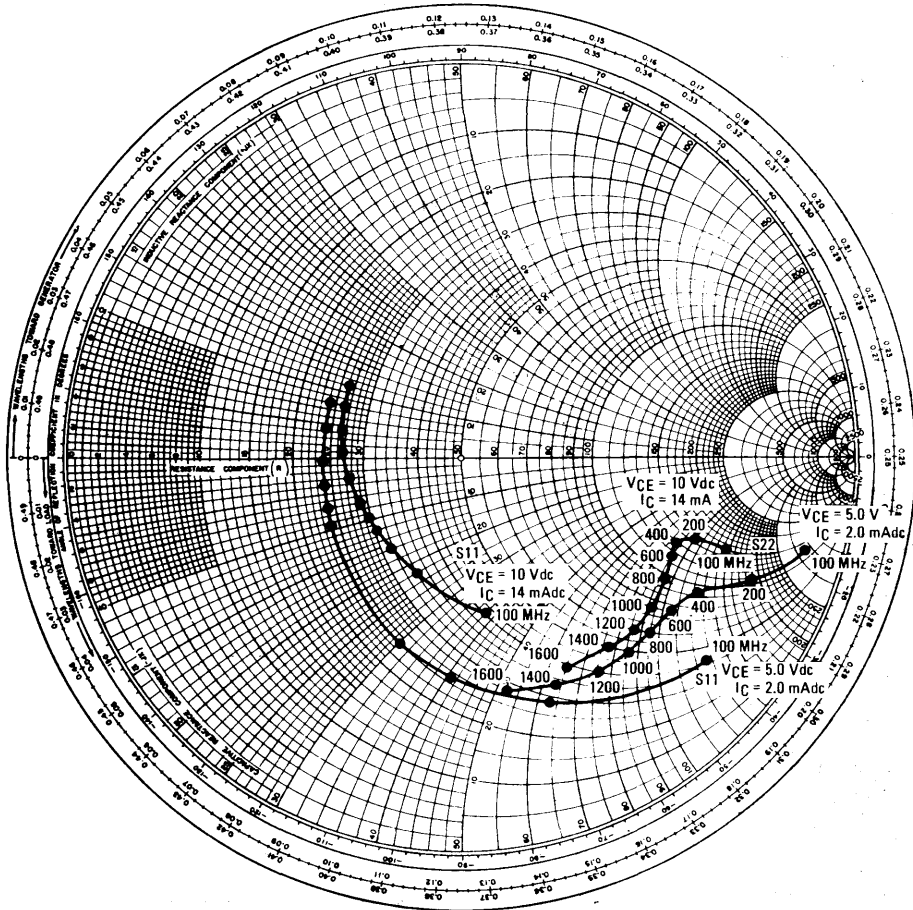


FIGURE 12 - S_{21} , FORWARD TRANSMISSION COEFFICIENT



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FIGURE 13 - S_{11} , INPUT REFLECTION COEFFICIENT AND S_{22} , OUTPUT REFLECTION COEFFICIENT



7

2N6603

JAN, JTX, JTXV AVAILABLE
CASE 303-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS (T_A = 25°C Free Air Temperature)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	15	Vdc
Collector-Base Voltage	V _{CBO}	25	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Continuous	I _C	30	mAdc
Total Device Dissipation @ T _C = 125°C Derate above 125°C	P _D	400 5.33	mW mW/°C
Storage Temperature	T _{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	15	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0)	V _{(BR)CBO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 15 mAdc, V _{CE} = 10 Vdc)	h _{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Collector-Base Capacitance(1) (V _{CB} = 10 Vdc, I _E = 0, 0.1 MHz ≤ f ≤ 1.0 MHz)	C _{cb}	0.25	—	0.75	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (V _{CE} = 10 Vdc, I _C = 15 mA, f = 1.0 GHz)	G _{pe}	15	—	21	dB
Spot Noise Figure (R _S = Optimum) (Figure 1) (V _{CE} = 10 Vdc, I _C = 5.0 mA, f = 1.0 GHz)	NF	1.0	—	2.5	dB
Power Gain at Optimum Noise Figure (Figure 1) (V _{CE} = 10 Vdc, I _C = 5.0 mA, f = 1.0 GHz)	G _{NF}	10	—	—	dB
TYPICAL 2 GHz PERFORMANCE					
Maximum Available Gain (Figure 1)(2) (V _{CE} = 10 Vdc, I _C = 15 mA, f = 2.0 GHz)	MAG	—	11	—	dB
Noise Figure (R _S = Optimum) (Figure 1) (V _{CE} = 10 Vdc, I _C = 5.0 mA, f = 2.0 GHz)	NF	—	2.9	—	dB

(1) C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal of the bridge.

(2) MAG is calculated from the S-Parameters using the equation $MAG = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 – BLOCK DIAGRAM FOR POWER GAIN AND NOISE FIGURE

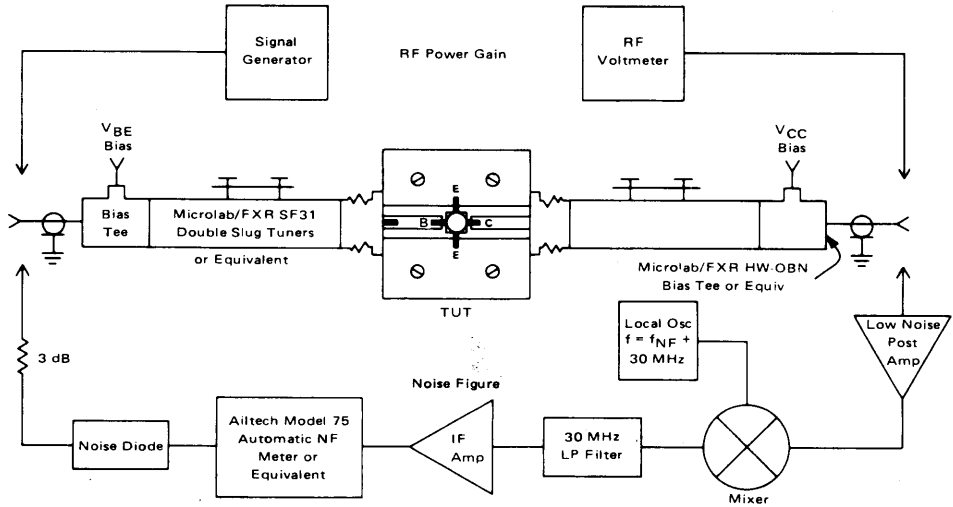


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

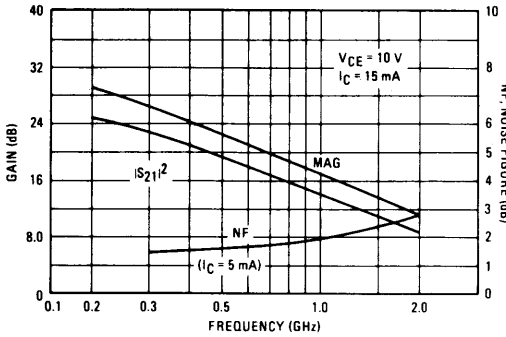


FIGURE 3 – OUTPUT CAPACITANCE versus VOLTAGE

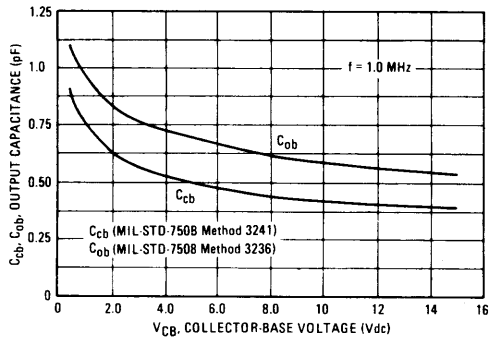


FIGURE 4 – CURRENT GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

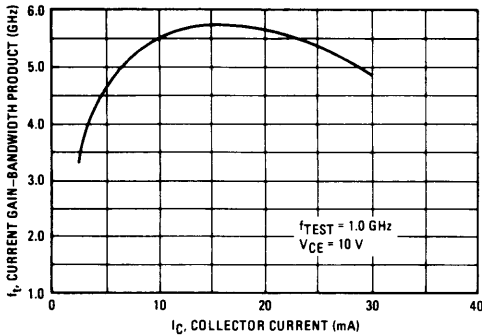


FIGURE 5 – POWER GAIN versus COLLECTOR CURRENT

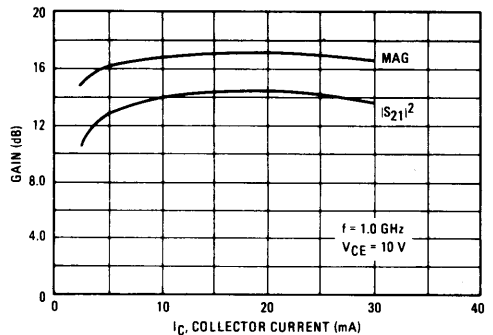
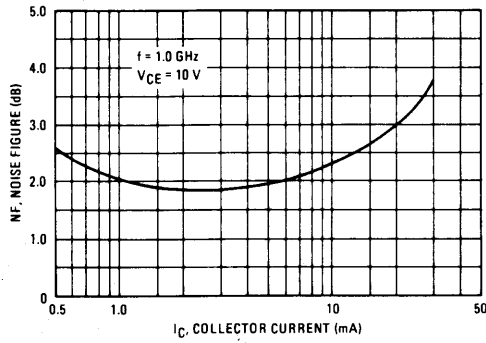


FIGURE 6 – NOISE FIGURE versus COLLECTOR CURRENT



COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 – INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY

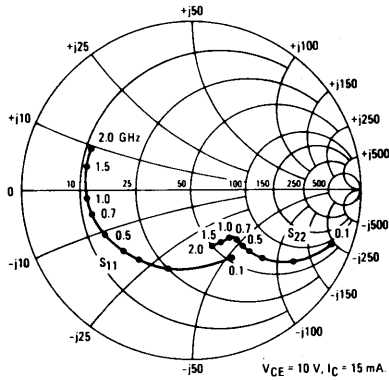
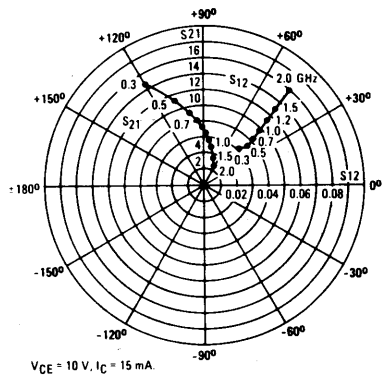


FIGURE 8 – FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



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S - PARAMETERS

VCE (Volts)	IC (mA)	Frequency (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
5.0	5	100	0.69	-30	12.16	160	0.026	72	0.95	-16
		200	0.65	-61	11.03	143	0.046	59	0.84	-31
		500	0.63	-122	7.05	111	0.074	36	0.56	-54
		1000	0.64	-158	4.13	88	0.087	28	0.39	-68
		2000	0.65	170	2.14	61	0.107	29	0.33	-91
	10	100	0.52	-50	18.74	154	0.022	69	0.91	-22
		200	0.54	-92	15.53	135	0.037	53	0.74	-40
		500	0.62	-146	8.49	104	0.052	38	0.43	-62
		1000	0.65	-172	4.66	84	0.065	37	0.29	-75
		2000	0.67	162	2.38	60	0.084	42	0.26	-97
	15	100	0.42	-70	22.72	150	0.019	66	0.87	-26
		200	0.51	-113	17.72	130	0.030	50	0.68	-44
		500	0.63	-157	8.96	100	0.042	41	0.38	-64
		1000	0.66	-178	4.80	82	0.056	44	0.26	-75
		2000	0.69	159	2.43	59	0.090	48	0.24	-97
	30	100	0.39	-116	24.57	142	0.014	62	0.80	-29
		200	0.55	-145	17.17	120	0.021	49	0.58	-42
		500	0.67	-171	7.96	95	0.030	49	0.34	-49
		1000	0.69	175	4.18	78	0.047	56	0.29	-56
		2000	0.71	157	2.13	55	0.084	58	0.29	-81
10	5	100	0.71	-27	12.01	161	0.021	73	0.96	-13
		200	0.67	-55	11.10	145	0.039	60	0.87	-25
		500	0.63	-115	7.44	114	0.064	39	0.62	-44
		1000	0.64	-153	4.43	90	0.077	30	0.46	-55
		2000	0.64	172	2.27	62	0.094	31	0.39	-76
	10	100	0.55	-43	18.77	155	0.018	71	0.92	-18
		200	0.55	-83	16.00	137	0.031	54	0.78	-32
		500	0.60	-140	9.06	106	0.046	39	0.49	-48
		1000	0.63	-168	5.02	85	0.058	39	0.36	-56
		2000	0.65	164	2.55	60	0.084	43	0.33	-76
	15	100	0.46	-60	23.14	152	0.016	68	0.90	-21
		200	0.51	-103	18.39	131	0.027	52	0.72	-36
		500	0.61	-152	9.67	102	0.037	42	0.43	-49
		1000	0.64	-175	5.21	83	0.049	45	0.33	-54
		2000	0.66	161	2.61	59	0.079	51	0.31	-74
	30	100	0.39	-98	27.29	144	0.013	63	0.83	-24
		200	0.53	-135	19.38	122	0.019	50	0.63	-35
		500	0.64	-167	9.11	96	0.027	48	0.41	-39
		1000	0.66	177	4.77	79	0.042	55	0.36	-45
		2000	0.69	157	2.41	56	0.074	58	0.35	-67

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2N6604

JAN, JTX, JTXV AVAILABLE
CASE 303-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS (T_A = 25°C Free Air Temperature)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	15	Vdc
Collector-Base Voltage	V _{CBO}	25	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Continuous	I _C	50	mAdc
Total Device Dissipation @ T _C = 125°C Derate above 125°C	P _D	500 6.66	mW mW/°C
Storage Temperature	T _{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	15	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0)	V _{(BR)CBO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 30 mAdc, V _{CE} = 10 Vdc)	h _{FE}	30	—	200	—
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SMALL SIGNAL CHARACTERISTICS

Collector-Base Capacitance(1) (V _{CB} = 10 Vdc, I _E = 0, 0.1 MHz ≤ f ≤ 1.0 MHz)	C _{cb}	0.30	—	0.80	pF
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FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain (Figure 1) (V _{CE} = 10 Vdc, I _C = 30 mAdc, f = 1.0 GHz)	G _{pe}	15	—	21	dB
Spot Noise Figure (R _S = Optimum) (Figure 1) (V _{CE} = 10 Vdc, I _C = 5.0 mAdc, f = 1.0 GHz)	NF	1.5	—	3.0	dB
Power Gain at Optimum Noise Figure (Figure 1) (V _{CE} = 10 Vdc, I _C = 5.0 mAdc, f = 1.0 GHz)	G _{NF}	9.0	—	—	dB

TYPICAL 2 GHz PERFORMANCE

Maximum Available Gain (Figure 1)(2) (V _{CE} = 10 Vdc, I _C = 30 mAdc, f = 2.0 GHz)	MAG	—	10	—	dB
Noise Figure (R _S = Optimum) (Figure 1) (V _{CE} = 10 Vdc, I _C = 5.0 mAdc, f = 2.0 GHz)	NF	—	4.3	—	dB

(1) C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal of the bridge.

(2) MAG is calculated from the S-Parameters using the equation $MAG = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 – BLOCK DIAGRAM FOR POWER GAIN AND NOISE FIGURE

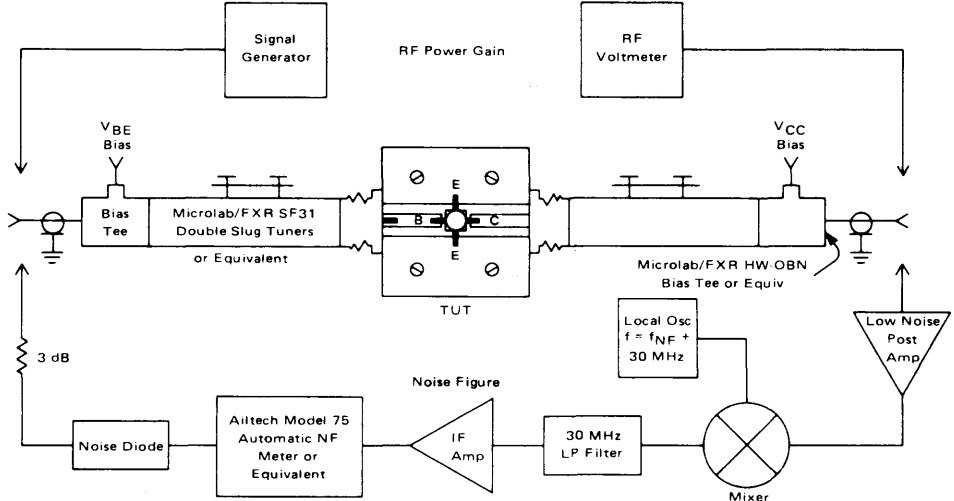


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

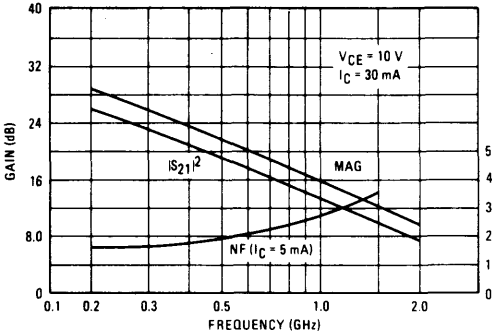


FIGURE 3 – OUTPUT CAPACITANCE versus VOLTAGE

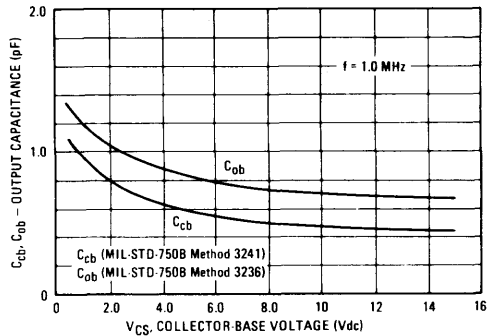


FIGURE 4 – CURRENT GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

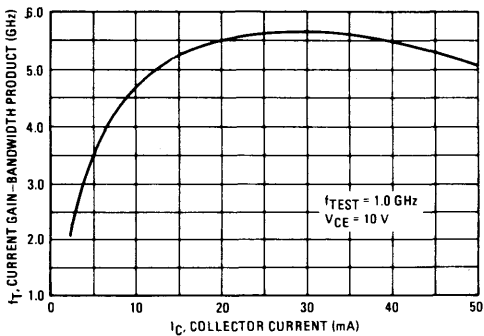


FIGURE 5 – POWER GAIN versus COLLECTOR CURRENT

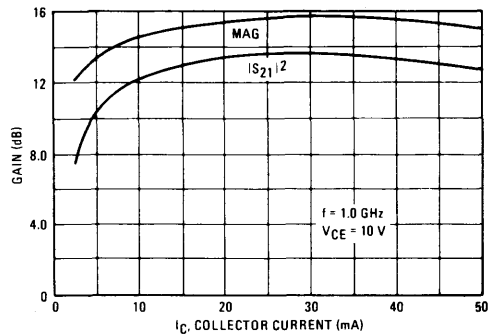
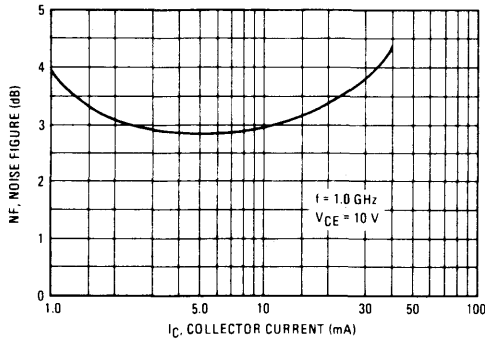


FIGURE 6 - NOISE FIGURE versus COLLECTOR CURRENT



COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 - INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY

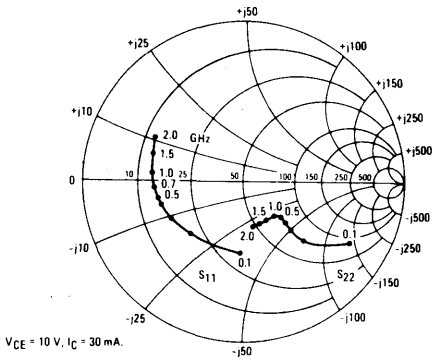
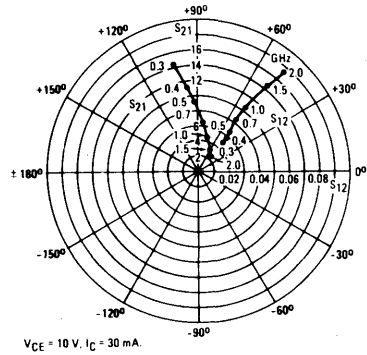


FIGURE 8 - FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



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S - PARAMETERS

VCE (Volts)	I _C (mA)	Frequency (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
5.0	5	100	0.72	-40	12.37	153	0.028	67	0.91	-18
		200	0.65	-78	10.38	133	0.048	51	0.76	-32
		500	0.61	-137	5.75	100	0.067	34	0.50	-45
		1000	0.61	-168	3.13	78	0.082	31	0.41	-54
		2000	0.63	161	1.58	47	0.112	30	0.41	-80
	10	100	0.57	-60	19.54	146	0.024	63	0.85	-27
		200	0.55	-105	14.70	125	0.038	47	0.64	-43
		500	0.59	-155	7.12	95	0.051	39	0.37	-55
		1000	0.61	-178	3.77	76	0.069	40	0.29	-62
		2000	0.64	156	1.91	50	0.106	39	0.30	-86
	30	100	0.43	-111	30.58	135	0.016	57	0.72	-39
		200	0.53	-145	19.35	114	0.022	49	0.46	-57
		500	0.62	-173	8.42	91	0.035	51	0.24	-69
		1000	0.63	172	4.36	75	0.058	54	0.18	-76
		2000	0.67	151	2.19	52	0.099	49	0.21	-99
	50	100	0.46	-134	32.34	129	0.013	57	0.64	-42
		200	0.57	-158	19.19	110	0.018	51	0.40	-56
		500	0.64	-178	8.13	89	0.031	57	0.22	-62
		1000	0.65	170	4.17	74	0.053	58	0.19	-70
		2000	0.70	150	2.10	52	0.092	54	0.22	-97
10	5	100	0.74	-36	12.34	154	0.023	69	0.93	-15
		200	0.67	-71	10.56	135	0.040	54	0.81	-25
		500	0.59	-131	6.09	102	0.058	37	0.57	-36
		1000	0.58	-164	3.32	79	0.073	33	0.50	-44
		2000	0.60	164	1.67	48	0.098	32	0.49	-69
	10	100	0.60	-52	19.75	148	0.020	65	0.87	-21
		200	0.56	-95	15.30	127	0.032	49	0.69	-33
		500	0.56	-149	7.69	97	0.044	41	0.45	-41
		1000	0.58	-174	4.07	77	0.061	42	0.39	-47
		2000	0.61	159	2.03	50	0.095	40	0.39	-70
	30	100	0.44	-94	32.03	136	0.014	59	0.75	-31
		200	0.50	-135	20.76	115	0.021	49	0.52	-41
		500	0.57	-168	9.13	91	0.032	52	0.33	-43
		1000	0.59	175	4.71	75	0.052	54	0.29	-48
		2000	0.64	154	2.34	52	0.089	49	0.30	-72
	50	100	0.44	-117	33.56	129	0.012	59	0.68	-31
		200	0.52	-150	19.94	109	0.017	50	0.47	-36
		500	0.59	-174	8.52	89	0.028	56	0.34	-35
		1000	0.61	173	4.38	75	0.049	57	0.32	-43
		2000	0.66	152	2.21	51	0.083	52	0.34	-70

BFR90

CASE 317A-01, STYLE 2 HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mA _{dc}
Total Device Dissipation @ $T_A = 60^\circ\text{C}$ Derate above 60°C	P_D	180 2.0	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mA _{dc} , $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mA _{dc} , $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mA _{dc} , $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nA _{dc}

ON CHARACTERISTICS

DC Current Gain ($I_C = 14$ mA _{dc} , $V_{CE} = 10$ Vdc)	h_{FE}	25	—	250	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 14$ mA _{dc} , $V_{CE} = 10$ Vdc, $f = 0.5$ GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	0.5	1.0	pF

FUNCTIONAL TEST

Noise Figure ($I_C = 2.0$ mA _{dc} , $V_{CE} = 10$ Vdc, $f = 0.5$ GHz) ($I_C = 2.0$ mA _{dc} , $V_{CE} = 10$ Vdc, $f = 1.0$ GHz)	NF	—	2.4 3.0	—	dB
Power Gain at Optimum Noise Figure ($I_C = 2.0$ mA _{dc} , $V_{CE} = 10$ Vdc, $f = 0.5$ GHz) ($I_C = 2.0$ mA _{dc} , $V_{CE} = 10$ Vdc, $f = 1.0$ GHz)	G_{NF}	—	15 10	—	dB
Maximum Available Power(1) ($I_C = 14$ mA _{dc} , $V_{CE} = 10$ Vdc, $f = 0.5$ GHz) ($I_C = 14$ mA _{dc} , $V_{CE} = 10$ Vdc, $f = 1.0$ GHz)	G_{max}	—	18 12	—	dB

$$(1) G_{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$$

FIGURE 1 – POWER DERATING

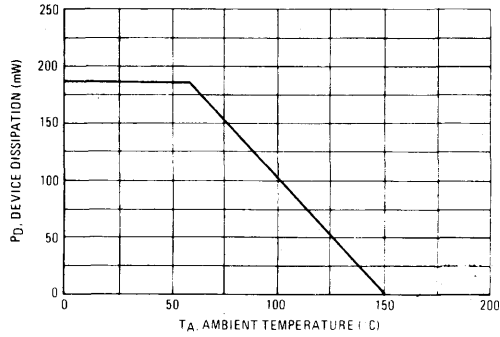


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

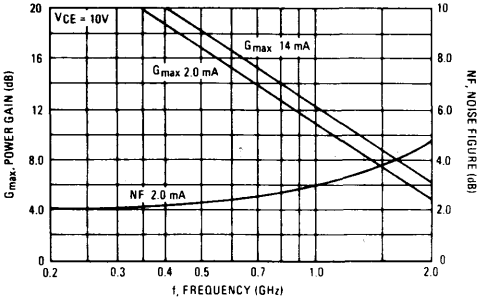


FIGURE 3 – POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

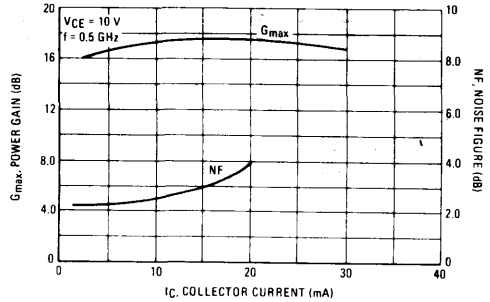


FIGURE 4 – S₁₁ PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V _{CE} (Volts)	I _C (mA)	S ₁₁	L _φ	S ₁₁	L _φ	S ₁₁	L _φ	S ₁₁	L _φ	S ₁₁	L _φ
5.0	2.0	0.77	-45	0.48	-90	0.33	-125	0.27	-160	0.28	170
	5.0	0.52	-60	0.25	-110	0.18	-150	0.18	170	0.21	145
	10	0.33	-75	0.15	-125	0.13	-175	0.15	150	0.20	130
	20	0.20	-95	0.12	-155	0.14	165	0.17	145	0.22	130
10	30	0.17	-116	0.14	-170	0.17	160	0.21	145	0.26	130
	2.0	0.79	-40	0.50	-80	0.33	-115	0.26	-150	0.25	175
	5.0	0.56	-55	0.27	-95	0.16	-135	0.13	-175	0.17	150
	10	0.39	-65	0.16	-105	0.10	-150	0.10	165	0.15	140
20	0.25	-75	0.10	-120	0.09	-175	0.12	150	0.18	130	
	0.25	-75	0.10	-120	0.09	-175	0.12	150	0.18	130	

FIGURE 5 – S₂₂ PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V _{CE} (Volts)	I _C (mA)	S ₂₂	L _φ	S ₂₂	L _φ	S ₂₂	L _φ	S ₂₂	L _φ	S ₂₂	L _φ
5.0	2.0	0.89	-20	0.69	-30	0.61	-35	0.55	-35	0.52	-45
	5.0	0.75	-25	0.55	-30	0.50	-30	0.47	-30	0.43	-40
	10	0.64	-25	0.49	-25	0.45	-25	0.43	-30	0.40	-35
	20	0.57	-25	0.47	-20	0.44	-25	0.43	-25	0.40	-35
10	30	0.55	-20	0.47	-20	0.46	-20	0.44	-25	0.42	-35
	2.0	0.91	-15	0.74	-25	0.66	-30	0.62	-35	0.59	-40
	5.0	0.79	-20	0.61	-25	0.56	-25	0.54	-30	0.51	-35
	10	0.70	-20	0.56	-20	0.53	-25	0.51	-25	0.48	-35
20	0.63	-20	0.54	-25	0.53	-20	0.51	-25	0.49	-35	
	0.63	-15	0.56	-15	0.55	-20	0.54	-25	0.52	-35	

FIGURE 6 - S₂₁ PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
VCE (Volts)	I _C (mA)	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ
5.0	2.0	5.76	140	3.81	105	2.73	90	2.20	75	1.70	60
	5.0	9.92	125	5.24	95	3.50	80	2.80	70	2.10	60
	10	12.33	115	5.82	90	3.79	75	2.90	65	2.20	55
	20	13.62	105	6.00	85	3.88	75	2.95	65	2.25	55
	30	13.41	105	5.80	80	3.74	75	2.85	65	2.15	55
10	2.0	5.77	145	3.88	110	2.80	90	2.25	75	1.75	60
	5.0	10.05	130	5.42	95	3.60	80	2.85	70	2.10	60
	10	12.56	115	6.00	90	3.90	80	3.05	70	2.25	55
	20	13.77	110	6.13	85	3.92	75	3.05	65	2.20	55
	30	13.23	105	5.79	85	3.70	75	2.85	65	2.15	55

FIGURE 7 - S₁₂ PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
VCE (Volts)	I _C (mA)	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ
5.0	2.0	0.06	65	0.10	55	0.12	55	0.14	55	0.17	60
	5.0	0.05	65	0.08	65	0.12	65	0.15	65	0.19	65
	10	0.04	65	0.08	70	0.12	70	0.15	70	0.20	65
	20	0.04	75	0.08	75	0.12	75	0.15	70	0.20	70
	30	0.03	75	0.07	75	0.11	75	0.15	75	0.19	70
10	2.0	0.05	70	0.03	55	0.11	55	0.12	55	0.15	60
	5.0	0.04	65	0.07	65	0.10	65	0.13	65	0.17	70
	10	0.04	65	0.07	70	0.10	70	0.13	70	0.17	70
	20	0.03	70	0.07	75	0.10	75	0.13	75	0.17	70
	30	0.03	75	0.06	75	0.10	75	0.13	75	0.17	70

BFR91

CASE 317A-01, STYLE 2 HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	12	V _{dc}
Collector-Base Voltage	V _{CBO}	15	V _{dc}
Emitter-Base Voltage	V _{EBO}	3.0	V _{dc}
Collector Current — Continuous	I _C	35	mAdc
Total Device Dissipation @ T _A = 60°C Derate above 60°C	P _D	180 2.0	mW mW/°C
Storage Temperature	T _{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	12	—	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0)	V _{(BR)CBO}	15	—	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	—	V _{dc}
Collector Cutoff Current (V _{CB} = 5.0 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 30 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	25	—	250	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 30 mAdc, V _{CE} = 5.0 Vdc, f = 0.5 GHz)	f _T	—	5.0	—	GHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	0.7	1.0	pF

FUNCTIONAL TEST

Noise Figure (I _C = 2.0 mAdc, V _{CE} = 5.0 Vdc, f = 0.5 GHz) (I _C = 2.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 GHz)	NF	— —	1.9 2.5	— —	dB
Power Gain at Optimum Noise Figure (I _C = 2.0 mAdc, V _{CE} = 5.0 Vdc, f = 0.5 GHz) (I _C = 2.0 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 GHz)	G _{NF}	— —	11 8.0	— —	dB
Maximum Available Power(1) (I _C = 30 mAdc, V _{CE} = 5.0 Vdc, f = 0.5 GHz) (I _C = 30 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 GHz)	G _{max}	— —	16 10	— —	dB

$$(1) G_{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$$

FIGURE 1 - POWER DERATING

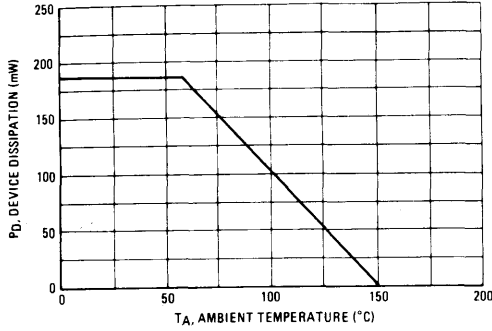


FIGURE 2 - POWER GAIN AND NOISE FIGURE versus FREQUENCY

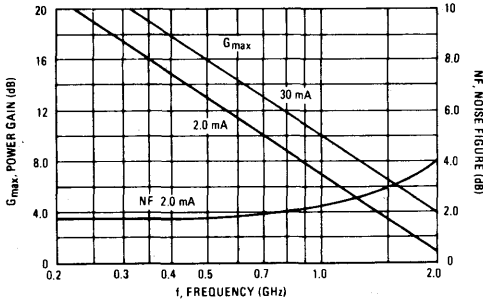


FIGURE 3 - POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

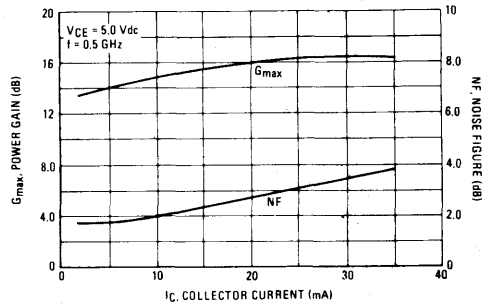


FIGURE 4 - S₁₁ PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
VCE (Volts)	I _c (mA)	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ
5.0	2.0	0.72	-65	0.51	-125	0.46	-165	0.47	170	0.51	145
	5.0	0.49	-90	0.35	-150	0.34	175	0.36	155	0.41	135
	10	0.34	-110	0.28	-165	0.29	165	0.32	145	0.36	130
	20	0.26	-130	0.24	180	0.27	155	0.30	140	0.34	125
	30	0.24	-145	0.24	175	0.27	155	0.30	140	0.34	125
10	2.0	0.74	-60	0.51	-120	0.45	-160	0.45	170	0.49	150
	5.0	0.52	-80	0.33	-140	0.31	-175	0.32	160	0.37	145
	10	0.36	-95	0.24	-155	0.24	170	0.27	155	0.31	140
	20	0.25	-115	0.19	-170	0.21	160	0.24	145	0.29	130
	30	0.22	-120	0.19	-175	0.21	160	0.25	145	0.20	130

FIGURE 5 - S₂₂ PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
VCE (Volts)	I _c (mA)	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ
5.0	2.0	0.83	-25	0.62	-35	0.55	-40	0.51	-45	0.49	-60
	5.0	0.66	-30	0.45	-35	0.40	-40	0.37	-40	0.34	-50
	10	0.52	-35	0.36	-35	0.32	-35	0.30	-35	0.27	-50
	20	0.42	-35	0.30	-30	0.27	-30	0.26	-30	0.22	-45
	30	0.38	-35	0.28	-25	0.26	-30	0.25	-30	0.21	-40
10	2.0	0.86	-20	0.67	-30	0.62	-35	0.58	-40	0.56	-50
	5.0	0.71	-25	0.53	-30	0.48	-30	0.45	-35	0.43	-45
	10	0.59	-30	0.45	-25	0.41	-30	0.40	-30	0.37	-40
	20	0.50	-25	0.40	-25	0.38	-25	0.37	-30	0.34	-40
	30	0.47	-25	0.40	-20	0.38	-25	0.37	-30	0.34	-35

FIGURE 6 – S₂₁ PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V _{CE} (Volts)	I _C (mA)	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ
5.0	2.0	5.25	130	3.06	95	2.10	75	1.70	65	1.20	50
	5.0	8.72	120	4.34	90	2.84	75	2.30	65	1.60	50
	10	10.85	110	4.92	85	3.22	70	2.60	65	1.80	50
	20	12.13	105	5.34	80	3.44	70	2.75	60	1.90	50
	30	12.50	100	5.42	80	3.47	70	2.75	60	1.90	50
10	2.0	5.36	135	3.20	95	2.20	80	1.85	65	1.30	50
	5.0	9.05	120	4.55	90	3.00	75	2.45	65	1.65	50
	10	11.37	110	5.22	85	3.40	75	2.65	65	1.85	50
	20	12.83	105	5.64	80	3.63	70	2.75	60	2.00	50
	30	13.10	100	5.62	80	3.63	70	2.75	60	2.00	50


FIGURE 7 – S₁₂ PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V _{CE} (Volts)	I _C (mA)	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ
5.0	2.0	0.08	55	0.11	45	0.12	50	0.14	55	0.17	65
	5.0	0.06	55	0.09	60	0.13	65	0.17	65	0.22	65
	10	0.05	60	0.09	65	0.14	70	0.19	65	0.24	65
	20	0.05	70	0.07	70	0.15	70	0.19	70	0.25	65
	30	0.04	75	0.10	75	0.15	70	0.19	70	0.25	65
10	2.0	0.06	60	0.09	45	0.10	50	0.12	60	0.15	70
	5.0	0.05	60	0.08	60	0.11	65	0.15	65	0.19	70
	10	0.05	65	0.08	65	0.12	70	0.16	70	0.21	70
	20	0.04	70	0.08	70	0.13	70	0.17	70	0.22	70
	30	0.04	70	0.08	75	0.13	70	0.17	70	0.22	70

BFR96

 CASE 317A-01, STYLE 2


MRF961

 CASE 317-01, STYLE 2

MRF962

 CASE 303-01, STYLE 1

MRF965

 CASE 26-03, STYLE 1
TO-46 (TO-206AB)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BRF96 MRF961	MRF962 MRF965	Unit
Collector-Emitter Voltage	V _{CEO}	15	15	Vdc
Collector-Base Voltage	V _{CBO}	20	20	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	3.0	Vdc
Collector Current — Continuous	I _C	100	100	mAdc
Total Device Dissipation @ T _C = 100°C Derate above 100°C	P _D	0.5 5.0	0.75 7.5	Watts mW/°C
Storage Temperature	T _{stg}	-65 to +150	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	15	—	—	Vdc	
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	20	—	—	Vdc	
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	—	Vdc	
Collector Cutoff Current (V _{CB} = 10 Vdc, I _E = 0)	I _{CBO}	—	—	100	nAdc	
ON CHARACTERISTICS						
DC Current Gain (I _C = 50 mAdc, V _{CE} = 10 Vdc)	h _{FE}	30	—	200	—	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz)	f _T	—	4.5	—	GHz	
Collector-Base Capacitance (V _{CB} = 10 Vdc, Emitter Guarded)	C _{cb}	—	1.2	1.5	pF	
		—	1.6	2.0		
FUNCTIONAL TEST						
Noise Figure (I _C = 10 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz)	NF	—	2.0	—	dB	
Maximum Available Gain/Insertion Gain (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz)	MAG/ S ₂₁ ²	BFR96, MRF965 MRF961 MRF962	-/12 -/13.5 -/15	14.5/13 17/15 20.5/16.5	— — —	dB

NOTE 1. $MAG = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 - MAXIMUM AVAILABLE GAIN versus FREQUENCY

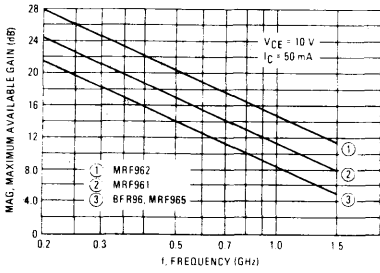


FIGURE 2 - S_{21}^2 versus FREQUENCY

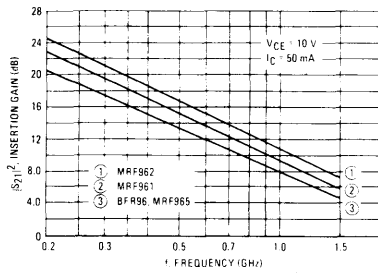


FIGURE 3 - MAXIMUM AVAILABLE GAIN versus COLLECTOR CURRENT

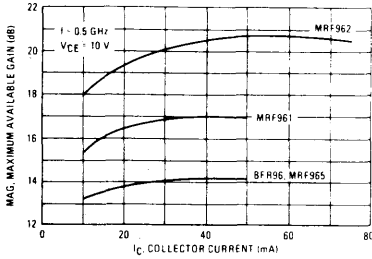


FIGURE 4 - GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

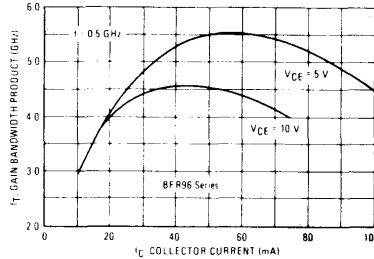


FIGURE 5 - NOISE FIGURE versus FREQUENCY

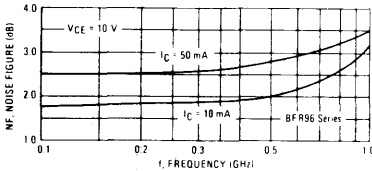


FIGURE 6 - NOISE FIGURE versus COLLECTOR CURRENT

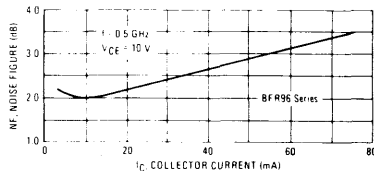


FIGURE 7 - COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

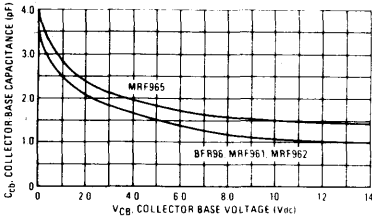


FIGURE 8 - OUTPUT POWER AND EFFICIENCY versus INPUT POWER (MRF965)

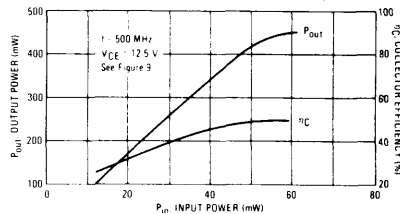
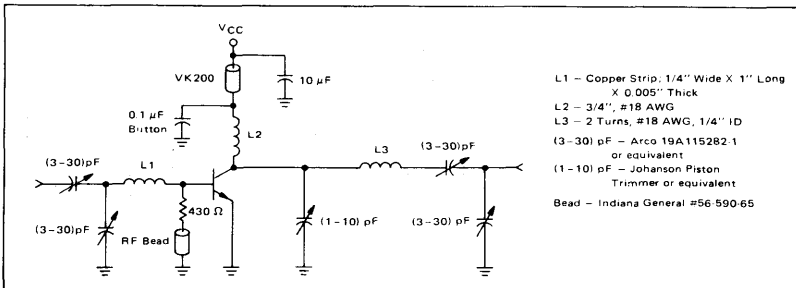


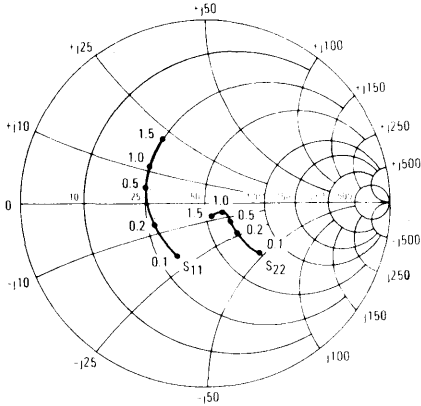
FIGURE 9 - MRF965 CLASS C AMPLIFIER @ 500 MHz, 400 mW



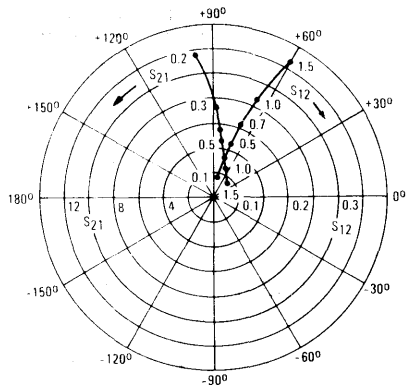
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BFR96 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION
COEFFICIENTS versus FREQUENCY
($V_{CE} = 10\text{ V}$, $I_C = 50\text{ mA}$)



FORWARD/REVERSE TRANSMISSION
COEFFICIENTS versus FREQUENCY
($V_{CE} = 10\text{ V}$, $I_C = 50\text{ mA}$)

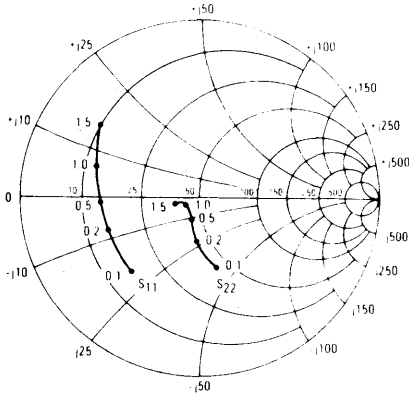


V _{CE} (Volts)	I _C (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ
5.0	10	100	0.51	-95	15.04	121	0.047	54	0.58	-48
		300	0.43	-163	5.87	92	0.082	58	0.26	-63
		500	0.46	174	3.61	79	0.120	63	0.19	-63
		700	0.48	162	2.65	68	0.161	63	0.15	-64
		1000	0.48	146	1.92	57	0.220	63	0.12	-79
	1500	0.54	121	1.40	43	0.320	58	0.13	-118	
	25	100	0.39	-122	19.41	112	0.037	60	0.42	-68
		300	0.39	-176	6.81	89	0.079	68	0.16	-94
		500	0.42	166	4.11	78	0.129	70	0.10	-103
		700	0.44	156	3.05	69	0.176	68	0.06	-119
		1000	0.44	142	2.20	59	0.244	64	0.06	-159
	1500	0.49	118	1.62	45	0.348	57	0.10	177	
	50	100	0.35	-140	21.10	106	0.032	64	0.33	-81
		300	0.38	176	7.11	88	0.081	72	0.13	-116
		500	0.42	162	4.28	78	0.133	72	0.09	-136
700		0.43	153	3.16	70	0.183	69	0.07	-163	
1000		0.42	140	2.28	60	0.252	65	0.08	165	
1500	0.47	116	1.66	47	0.357	57	0.12	155		
10	10	100	0.53	-83	15.96	124	0.039	58	0.65	-36
		300	0.38	-154	6.44	94	0.070	59	0.35	-41
		500	0.41	-179	3.98	81	0.102	64	0.30	-39
		700	0.42	166	2.94	70	0.138	65	0.27	-39
		1000	0.42	151	2.12	60	0.191	66	0.24	-47
	1500	0.49	125	1.50	44	0.278	63	0.22	-72	
	25	100	0.38	-104	20.85	115	0.032	60	0.48	-48
		300	0.32	-169	7.54	91	0.070	68	0.23	-48
		500	0.35	170	4.61	80	0.109	71	0.19	-43
		700	0.37	160	3.37	70	0.152	69	0.16	-39
		1000	0.37	146	2.43	61	0.210	67	0.13	-44
	1500	0.43	121	1.73	47	0.304	61	0.10	-74	
	50	100	0.33	-119	22.59	109	0.029	63	0.39	-51
		300	0.30	-176	7.74	88	0.069	72	0.19	-47
		500	0.34	166	4.70	79	0.113	73	0.16	-40
700		0.36	158	3.45	70	0.156	70	0.14	-35	
1000		0.36	144	2.46	61	0.217	66	0.11	-39	
1500	0.42	119	1.75	47	0.310	60	0.08	-72		

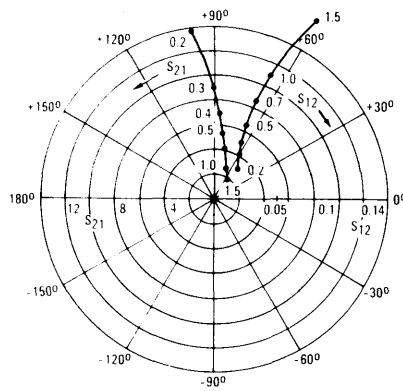
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MRF961 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION
COEFFICIENTS versus FREQUENCY
($V_{CE} = 10\text{ V}$, $I_C = 50\text{ mA}$)



FORWARD/REVERSE TRANSMISSION
COEFFICIENTS versus FREQUENCY
($V_{CE} = 10\text{ V}$, $I_C = 50\text{ mA}$)

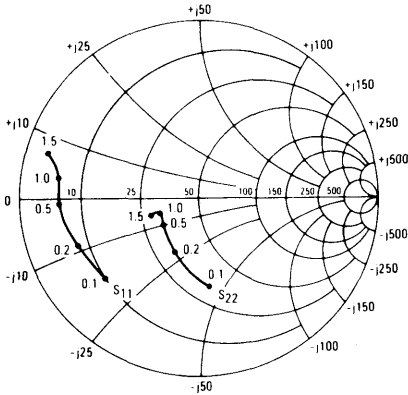


VCE (Volts)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	∠	S21	∠	S12	∠	S22	∠
5.0	10	100	0.65	-101	16.61	125	0.047	46	0.61	-56
		300	0.64	-160	6.61	96	0.064	39	0.27	-87
		500	0.66	-178	4.01	83	0.078	45	0.19	-98
		700	0.68	171	2.93	73	0.093	49	0.16	-108
		1000	0.68	160	2.07	63	0.119	53	0.16	-124
		1500	0.72	143	1.43	50	0.158	54	0.21	-141
	25	100	0.60	-129	22.41	115	0.034	44	0.49	-84
		300	0.63	-172	7.94	93	0.049	50	0.26	-132
		500	0.66	174	4.78	83	0.071	58	0.21	-150
		700	0.67	166	3.45	75	0.092	60	0.20	-164
		1000	0.67	156	2.46	66	0.124	61	0.21	-177
		1500	0.71	140	1.73	54	0.173	60	0.24	175
	50	100	0.59	-147	25.12	109	0.025	46	0.42	-104
		300	0.64	-178	8.47	91	0.046	60	0.28	-151
		500	0.67	171	5.05	83	0.070	65	0.26	-167
		700	0.68	164	3.67	75	0.093	65	0.25	-178
		1000	0.67	154	2.60	67	0.128	65	0.26	170
		1500	0.72	138	1.83	56	0.178	62	0.29	163
10	10	100	0.65	-90	17.47	128	0.040	50	0.67	-41
		300	0.61	-154	7.31	97	0.057	41	0.33	-57
		500	0.62	-174	4.46	84	0.069	46	0.25	-58
		700	0.64	175	3.27	74	0.084	50	0.22	-60
		1000	0.64	163	2.33	64	0.106	54	0.20	-72
		1500	0.69	145	1.56	50	0.140	57	0.22	-96
	25	100	0.57	-116	24.36	119	0.030	48	0.51	-62
		300	0.58	-167	8.10	94	0.045	52	0.20	-89
		500	0.61	178	5.43	83	0.070	58	0.14	-97
		700	0.63	169	3.93	75	0.084	60	0.10	-106
		1000	0.62	159	2.78	66	0.112	61	0.09	-124
		1500	0.67	142	1.91	53	0.156	60	0.12	-140
	50	100	0.55	-132	26.97	112	0.024	47	0.40	-73
		300	0.57	-173	9.32	91	0.042	59	0.16	-104
		500	0.60	174	5.58	82	0.064	64	0.11	-115
		700	0.62	167	4.04	74	0.086	64	0.08	-128
		1000	0.61	158	2.85	66	0.115	64	0.08	-149
		1500	0.67	141	1.96	55	0.158	61	0.12	-158

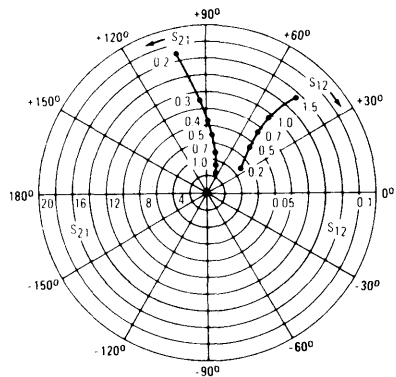
BFR96 • MRF961 • MRF962 • MRF965

MRF962 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY
($V_{CE} = 10\text{ V}$, $I_C = 50\text{ mA}$)



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY
($V_{CE} = 10\text{ V}$, $I_C = 50\text{ mA}$)

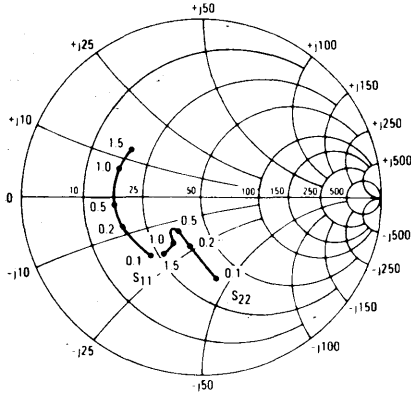


V _{CE} (Volts)	I _C (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ
5.0	10	100	0.70	-102	17.42	128	0.044	43	0.65	-57
		300	0.75	-156	7.11	98	0.058	24	0.32	-97
		500	0.78	-170	4.36	86	0.064	25	0.26	-110
		700	0.78	-176	3.16	77	0.071	26	0.23	-117
		1000	0.78	176	2.26	67	0.078	27	0.24	-126
		1500	0.79	167	1.51	54	0.092	29	0.31	-133
	25	100	0.69	-131	24.24	118	0.029	38	0.56	-87
		300	0.77	-167	8.76	95	0.039	32	0.35	-137
		500	0.79	-176	5.26	85	0.046	36	0.32	-150
		700	0.80	178	3.82	78	0.055	40	0.31	-158
		1000	0.79	173	2.72	70	0.067	42	0.32	-164
		1500	0.81	164	1.82	59	0.086	42	0.34	-167
	50	100	0.71	-147	27.72	113	0.021	37	0.53	-107
		300	0.78	-173	9.59	94	0.030	40	0.41	-152
		500	0.81	179	5.72	85	0.038	46	0.39	-163
700		0.81	176	4.09	78	0.048	50	0.38	-169	
1000		0.81	171	2.89	71	0.061	51	0.38	-175	
1500		0.82	163	1.96	62	0.082	49	0.40	-177	
10	10	100	0.71	-92	18.77	131	0.037	47	0.70	-44
		300	0.74	-150	8.09	100	0.051	28	0.34	-69
		500	0.75	-166	5.01	87	0.056	28	0.27	-75
		700	0.76	-174	3.62	78	0.064	28	0.24	-79
		1000	0.76	179	2.58	69	0.071	30	0.24	-88
		1500	0.77	168	1.72	55	0.085	31	0.31	-104
	25	100	0.67	-120	27.10	122	0.027	42	0.57	-68
		300	0.73	-163	10.27	97	0.035	36	0.27	-110
		500	0.76	-174	6.21	86	0.043	39	0.22	-124
		700	0.77	-179	4.48	78	0.051	41	0.20	-132
		1000	0.77	175	3.19	71	0.062	43	0.20	-139
		1500	0.78	166	2.13	59	0.080	42	0.25	-142
	50	100	0.68	-137	31.53	116	0.020	37	0.49	-85
		300	0.74	-169	11.17	95	0.028	40	0.27	-131
		500	0.77	-177	6.69	85	0.037	46	0.24	-144
700		0.77	178	4.82	78	0.047	48	0.23	-152	
1000		0.77	173	3.42	71	0.059	50	0.23	-158	
1500		0.79	165	2.30	61	0.078	47	0.27	-159	

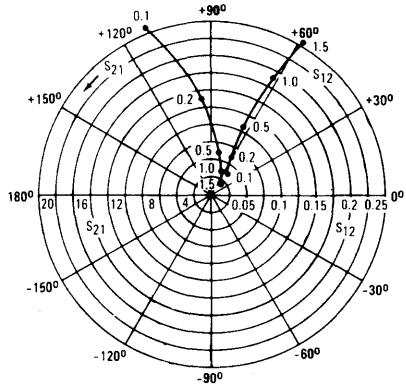
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MRF965 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY
(V_{CE} = 10 V, I_C = 50 mA)



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY
(V_{CE} = 10 V, I_C = 50 mA)



V _{CE} (Volts)	I _C (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ
5.0	10	100	0.56	-102	13.87	121	0.054	48	0.58	-62
		300	0.57	-158	5.47	90	0.084	46	0.32	-94
		500	0.56	-169	3.40	77	0.110	52	0.27	-106
		700	0.52	178	2.53	69	0.136	54	0.39	-115
		1000	0.55	167	1.79	57	0.181	56	0.35	-112
		1500	0.54	150	1.27	42	0.242	57	0.43	-122
	25	100	0.48	-129	17.61	112	0.041	51	0.47	-85
		300	0.55	-169	6.38	89	0.076	57	0.30	-125
		500	0.54	-176	3.97	77	0.111	62	0.27	-138
		700	0.50	172	2.94	71	0.114	61	0.30	-143
		1000	0.53	162	2.08	61	0.198	60	0.32	-135
		1500	0.50	146	1.50	47	0.267	57	0.37	-140
	50	100	0.47	-144	19.34	107	0.035	56	0.42	-100
		300	0.55	-173	6.72	87	0.073	63	0.31	-138
		500	0.53	-179	4.17	77	0.112	66	0.29	-150
		700	0.50	168	3.10	71	0.147	64	0.33	-153
		1000	0.53	159	2.19	62	0.206	61	0.32	-146
		1500	0.50	143	1.59	49	0.277	58	0.36	-149
10	10	100	0.56	-92	14.67	123	0.047	50	0.63	-50
		300	0.53	-152	6.00	92	0.077	47	0.34	-73
		500	0.53	-165	3.74	78	0.100	53	0.29	-82
		700	0.49	-177	2.76	70	0.124	56	0.31	-93
		1000	0.52	170	1.96	57	0.166	58	0.38	-94
		1500	0.51	153	1.36	42	0.221	59	0.46	-108
	25	100	0.46	-117	19.10	115	0.036	53	0.49	-68
		300	0.50	-164	7.09	90	0.071	57	0.26	-99
		500	0.49	-172	4.39	78	0.102	62	0.23	-110
		700	0.45	175	3.25	71	0.133	61	0.25	-119
		1000	0.49	164	2.28	60	0.181	61	0.30	-112
		1500	0.47	148	1.61	46	0.246	59	0.37	-120
	50	100	0.42	-131	20.99	110	0.033	56	0.41	-79
		300	0.49	-169	7.46	88	0.069	62	0.24	-111
		500	0.48	-175	4.63	78	0.103	65	0.21	-123
		700	0.45	172	3.40	71	0.136	64	0.25	-129
		1000	0.48	162	2.39	61	0.188	62	0.29	-119
		1500	0.45	146	1.70	48	0.251	59	0.35	-126



BFW92A

CASE 317A-01, STYLE 2 HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	35	mA _{dc}
Total Device Dissipation @ $T_C = 105^\circ\text{C}$ Derate above 105°C	P_D	180 4.0	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to 150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case(1)	$R_{\theta JC}$	250	$^\circ\text{C/W}$

(1) Case temperature measured on collector lead immediately adjacent to body of package.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mA}_{dc}$, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mA}_{dc}$, $I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mA}_{dc}$, $I_C = 0$)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	50	nA _{dc}

ON CHARACTERISTICS

DC Current Gain ($I_C = 2.0 \text{ mA}_{dc}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	20	50	150	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 0.5 \text{ GHz}$)	f_T	—	4.5	—	GHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$, Emitter Guarded)	C_{cb}	—	0.5	1.0	pF

FUNCTIONAL PERFORMANCE

Optimum Noise Figure (Tuned) ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 0.5 \text{ GHz}$)	NF_{opt}	—	2.7	—	dB
Noise Figure (Untuned, $R_S = R_L = 50 \Omega$) ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 0.5 \text{ GHz}$)	NF	—	3.0	—	dB
Maximum Available Gain(2) ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 0.5 \text{ GHz}$)	MAG	—	16	—	dB
Insertion Gain ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 0.5 \text{ GHz}$)	$ S_{21} ^2$	—	14	—	dB

$$(2) G_{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$$

FIGURE 1 — 30-900 MHz BROADBAND AMPLIFIER

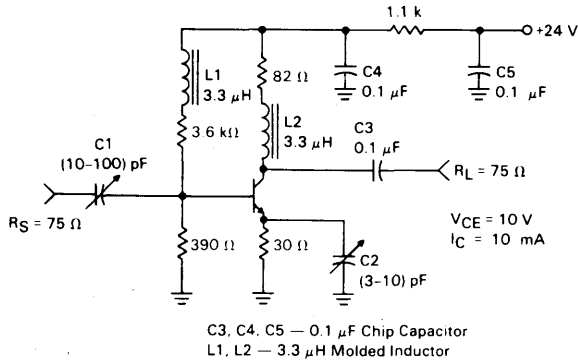


FIGURE 2 — BROADBAND GAIN (Circuit Figure 1)

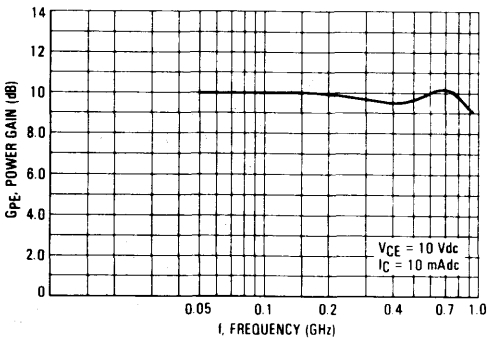


FIGURE 3 — 2nd AND 3rd ORDER INTERCEPT POINTS

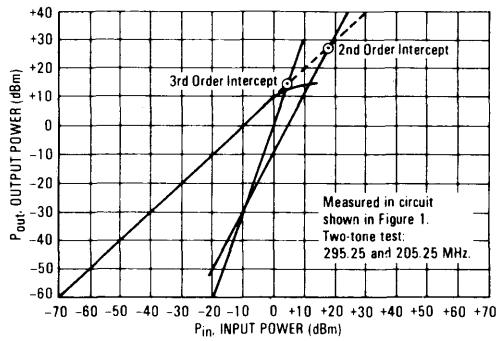


FIGURE 4 — MAXIMUM AVAILABLE GAIN versus FREQUENCY

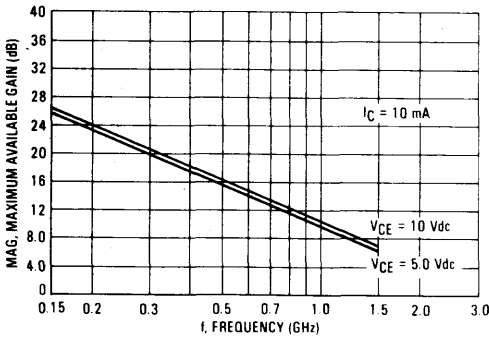


FIGURE 5 — $|S_{21}|^2$ versus FREQUENCY

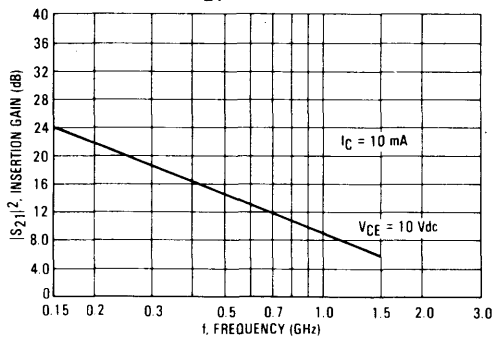


FIGURE 6 — MAXIMUM AVAILABLE GAIN versus COLLECTOR CURRENT

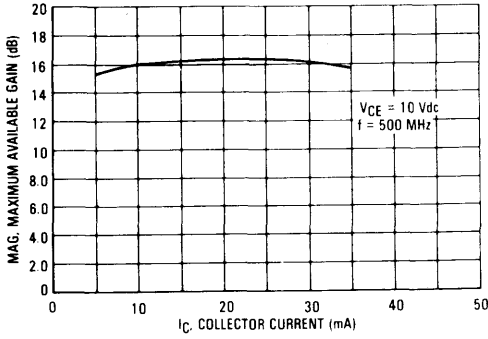


FIGURE 7 — GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

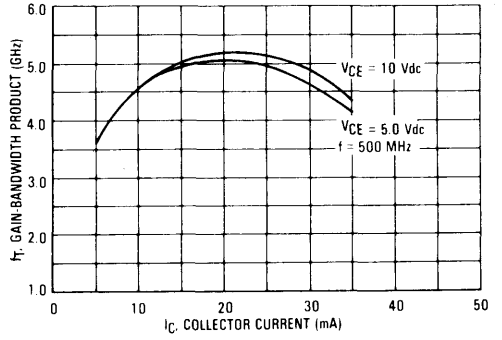


FIGURE 8 — NOISE FIGURE versus COLLECTOR CURRENT

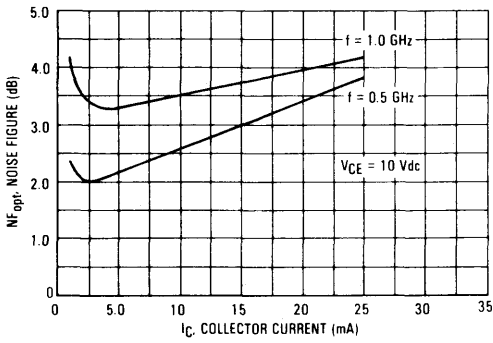


FIGURE 9 — NOISE FIGURE versus COLLECTOR CURRENT
Untuned, $R_S = R_L = 50 \Omega$

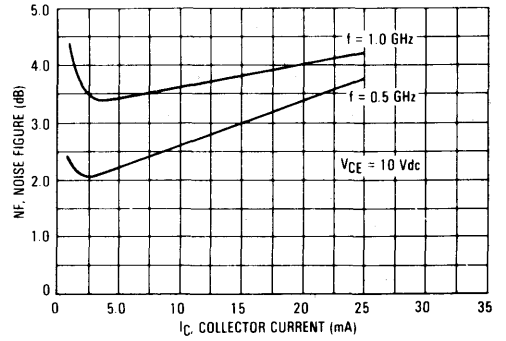


FIGURE 10 — NOISE FIGURE versus FREQUENCY

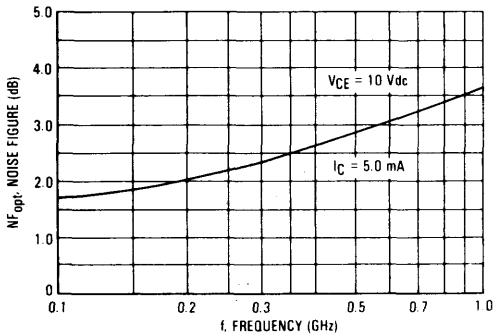
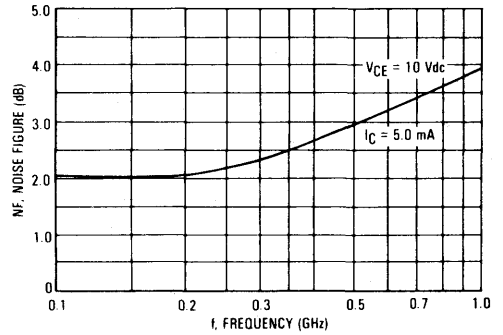


FIGURE 11 — NOISE FIGURE versus FREQUENCY
Untuned $R_S = R_L = 50 \Omega$



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FIGURE 12 — C_{ib} INPUT CAPACITANCE versus EMITTER BASE VOLTAGE

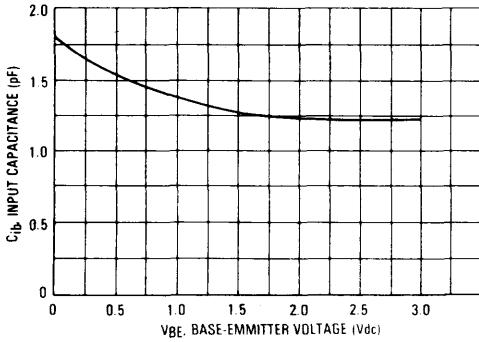
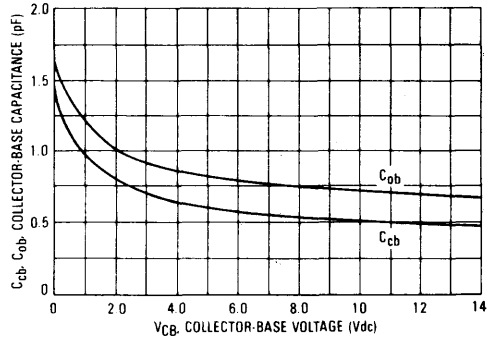
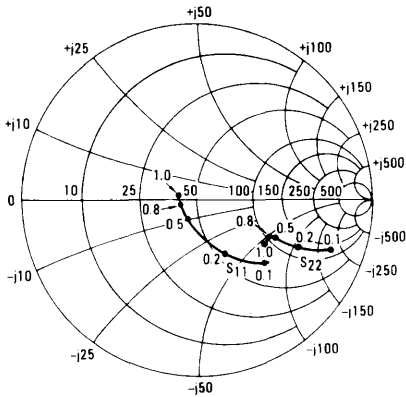


FIGURE 13 — COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

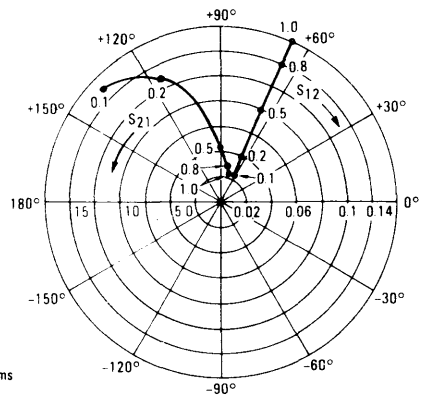


BFW92A COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY
($V_{CE} = 10$ V, $I_C = 10$ mA)



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY
($V_{CE} = 10$ V, $I_C = 10$ mA)



Coordinates in Ohms

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BFW92A COMMON-EMITTER S-PARAMETERS

VCE (Volts)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
5.0	5.0	100	0.71	-33	11.2	145	0.031	69	0.87	-18
		200	0.49	-60	8.6	122	0.052	62	0.70	-26
		500	0.21	-119	4.5	92	0.094	61	0.48	-30
		800	0.17	-161	3.0	78	0.137	60	0.44	-36
		1000	0.16	176	2.5	71	0.164	60	0.44	-40
	10	100	0.52	-46	16.6	135	0.027	67	0.78	-23
		200	0.31	-75	11.2	113	0.044	65	0.58	-29
		500	0.14	-150	5.2	88	0.089	67	0.40	-29
		800	0.15	173	3.3	76	0.135	65	0.37	-34
		1000	0.16	154	2.8	70	0.164	64	0.37	-38
	15	100	0.40	-55	19.7	129	0.025	69	0.72	-26
		200	0.22	-88	12.1	109	0.041	68	0.52	-29
		500	0.14	-170	5.4	86	0.087	70	0.36	-27
		800	0.16	161	3.5	76	0.134	68	0.34	-33
		1000	0.17	145	2.9	69	0.164	66	0.35	-37
	20	100	0.33	-62	21.1	125	0.023	69	0.68	-27
		200	0.18	-99	12.5	106	0.039	69	0.49	-28
		500	0.14	178	5.5	85	0.086	72	0.35	-26
		800	0.17	155	3.5	75	0.133	69	0.33	-32
		1000	0.18	142	2.9	69	0.164	67	0.34	-37
25	100	0.27	-69	21.9	122	0.022	70	0.65	-27	
	200	0.15	-111	12.7	104	0.038	71	0.47	-27	
	500	0.16	172	5.5	85	0.085	73	0.35	-25	
	800	0.19	153	3.5	75	0.132	70	0.33	-31	
	1000	0.20	140	2.9	69	0.163	68	0.33	-36	
10	5.0	100	0.73	-30	11.1	146	0.026	71	0.90	-14
		200	0.53	-52	8.8	124	0.044	63	0.75	-21
		500	0.21	-98	4.7	94	0.082	62	0.57	-25
		800	0.14	-136	3.1	80	0.120	62	0.53	-30
		1000	0.11	-161	2.6	73	0.143	62	0.53	-34
	10	100	0.57	-39	16.7	137	0.023	70	0.82	-18
		200	0.35	-62	11.5	115	0.038	66	0.65	-23
		500	0.12	-117	5.4	89	0.078	69	0.50	-23
		800	0.09	-163	3.5	78	0.118	67	0.47	-28
		1000	0.09	168	2.9	71	0.144	66	0.48	-32
	15	100	0.46	-46	19.9	130	0.021	70	0.77	-20
		200	0.26	-68	12.6	110	0.035	68	0.60	-22
		500	0.09	-137	5.6	87	0.076	71	0.47	-21
		800	0.09	177	3.7	77	0.117	69	0.45	-27
		1000	0.10	153	3.0	71	0.143	68	0.46	-31
	20	100	0.39	-50	21.5	126	0.020	70	0.74	-21
		200	0.21	-73	13.0	107	0.034	71	0.58	-21
		500	0.08	-154	5.7	86	0.075	72	0.46	-20
		800	0.10	168	3.7	76	0.117	70	0.45	-27
		1000	0.11	148	3.0	71	0.142	69	0.45	-31
25	100	0.34	-54	22.3	123	0.019	70	0.71	-20	
	200	0.17	-79	13.0	105	0.033	71	0.57	-20	
	500	0.08	-166	5.7	86	0.075	73	0.47	-19	
	800	0.11	162	3.7	76	0.116	70	0.45	-26	
	1000	0.13	144	3.0	70	0.141	69	0.46	-30	

7

BFX89 BFY90

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Continuous Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ mAdc}$, $I_E = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc	
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	10	nAdc	
ON CHARACTERISTICS						
DC Current Gain ($I_C = 2.0\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 25\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	25 20	— —	150 125	—	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) ($I_C = 2.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 500\text{ MHz}$)	BFX89 BFY90	f_T	— 1.0	1.0 —	— —	GHz
($I_C = 25\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 500\text{ MHz}$)	BFX89 BFY90		— 1.3	1.1 —	— —	
Emitter-Base Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	BFY90	C_{ibo}	—	—	2.0	pF
Collector-Base Capacitance(2) ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	BFX89 BFY90	C_{cb}	— —	0.85 0.85	1.7 1.5	pF
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain(1) ($V_{CE} = 10\text{ Vdc}$, $I_C = 8.0\text{ mA}$, $f = 200\text{ MHz}$)	BFX89 BFY90	G_{pe}	19 —	— 21	— —	dB
Spot Noise Figure ($R_S = \text{Optimum}$)(1) ($V_{CE} = 5.0\text{ Vdc}$, $I_C = 2.0\text{ mA}$, $f = 500\text{ MHz}$)	BFX89 BFY90	NF	— —	2.5 2.5	6.5 5.0	dB

(1) Pin 4 is grounded.

(2) Pin 4 is not grounded.

FIGURE 1 — POWER GAIN versus FREQUENCY

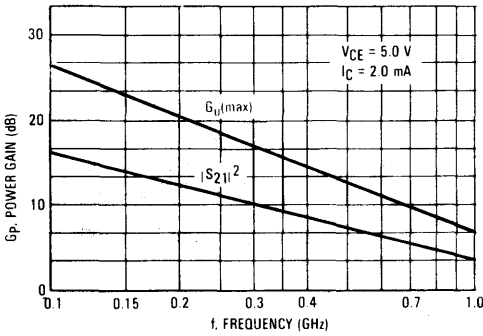


FIGURE 2 — POWER GAIN versus COLLECTOR CURRENT

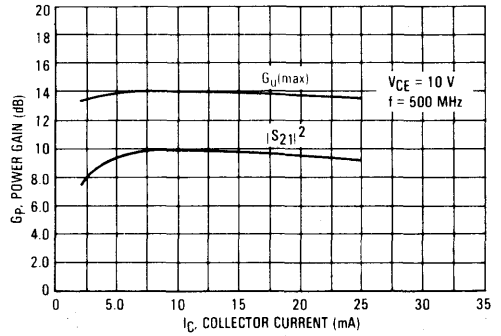


FIGURE 3 — NOISE FIGURE versus FREQUENCY

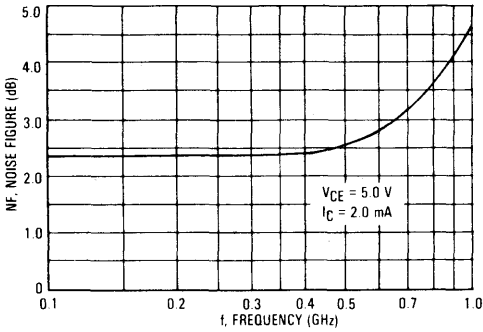


FIGURE 4 — NOISE FIGURE versus COLLECTOR CURRENT

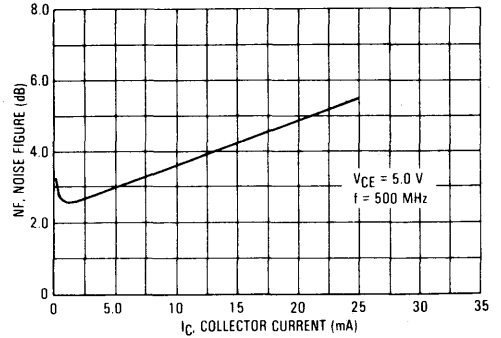


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

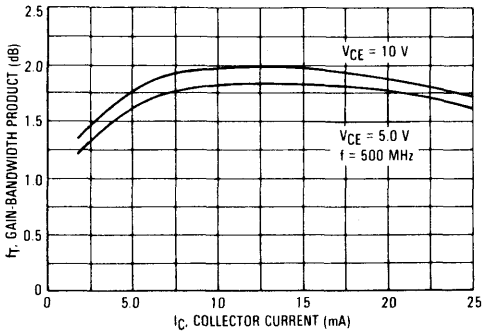
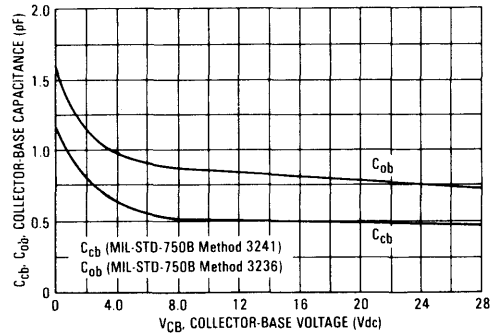


FIGURE 6 — OUTPUT CAPACITANCE versus VOLTAGE



7

COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 — INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY

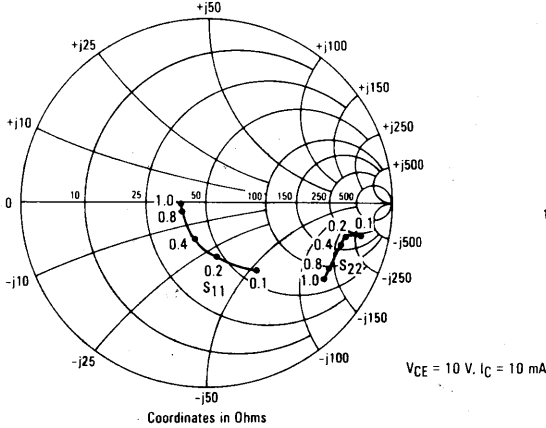
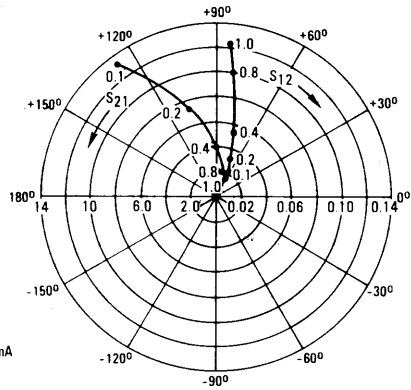


FIGURE 8 — FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



V_{CE} = 10 V, I_C = 10 mA

S — PARAMETERS

V _{CE} (Volts)	I _C (mA)	Frequency (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ
5.0	2.0	100	0.81	-37	5.76	148	0.031	72	0.95	-11
		200	0.64	-66	4.56	127	0.050	63	0.87	-17
		400	0.41	-105	2.91	102	0.071	62	0.79	-23
		800	0.26	-157	1.63	77	0.105	74	0.75	-34
		1000	0.23	179	1.38	68	0.129	80	0.74	-41
	5.0	100	0.60	-54	9.73	133	0.026	68	0.87	-13
		200	0.41	-84	6.33	112	0.040	66	0.78	-17
		400	0.26	-121	3.54	92	0.064	72	0.73	-21
		800	0.19	-169	1.89	72	0.112	80	0.72	-31
		1000	0.17	168	1.59	64	0.140	82	0.71	-39
	10	100	0.71	-66	12.13	122	0.022	70	0.81	-14
		200	0.28	-96	7.11	104	0.036	71	0.73	-15
		400	0.19	-133	3.85	88	0.064	77	0.70	-19
		800	0.18	-178	2.00	69	0.115	83	0.71	-30
		1000	0.17	160	1.66	61	0.143	84	0.70	-37
25	100	0.26	-88	12.79	112	0.019	73	0.76	-13	
	200	0.20	-122	7.04	97	0.034	76	0.71	-13	
	400	0.20	-156	3.68	83	0.062	81	0.70	-18	
	800	0.23	165	1.88	65	0.114	86	0.71	-30	
	1000	0.24	146	1.56	58	0.145	88	0.70	-38	
10	2.0	100	0.83	-34	5.82	150	0.025	73	0.96	-9
		200	0.66	-61	4.60	129	0.042	65	0.89	-15
		400	0.42	-97	2.98	104	0.059	64	0.83	-20
		800	0.25	-147	1.69	79	0.088	77	0.80	-31
		1000	0.20	-172	1.42	70	0.108	82	0.79	-38
	5.0	100	0.63	-48	9.94	135	0.021	70	0.90	-11
		200	0.43	-76	6.54	114	0.034	68	0.82	-15
		400	0.26	-108	3.72	94	0.054	73	0.77	-19
		800	0.16	-155	1.98	74	0.095	83	0.77	-24
		1000	0.14	180	1.65	66	0.119	85	0.76	-36
	10	100	0.47	-57	12.42	125	0.019	70	0.85	-12
		200	0.30	-83	7.43	106	0.031	72	0.78	-14
		400	0.19	-113	4.04	90	0.054	78	0.75	-18
		800	0.14	-160	2.09	71	0.098	84	0.75	-28
		1000	0.13	173	1.73	64	0.121	86	0.75	-35
25	100	0.32	-71	13.05	114	0.017	72	0.81	-11	
	200	0.21	-99	7.27	99	0.029	76	0.77	-12	
	400	0.16	-135	3.81	85	0.052	81	0.76	-16	
	800	0.17	177	1.96	68	0.096	87	0.76	-28	
	1000	0.18	154	1.62	61	0.120	89	0.76	-35	



MD4957

CASE 654-02, STYLE 1
TO-78

DUAL
HIGH FREQUENCY TRANSISTOR

PNP SILICON



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current	I_C	30		mAdc
		One Side	Both Sides	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.15	400 2.3	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ mAdc}, I_E = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20	—	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 2.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	1000	1500	—	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{cb}	—	0.4	0.8	pF
Small Signal Current Gain ($I_C = 2.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	h_{fe}	20	—	200	—
Collector Base Time Constant ($I_E = 2.0 \text{ mAdc}, V_{CB} = 10 \text{ Vdc}, f = 63.6 \text{ MHz}$)	$rb'C_c$	—	4.0	8.0	ps
Noise Figure ($I_C = 2.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 450 \text{ MHz}$) (Figure 1) ($I_C = 2.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, R_S = 50 \text{ ohms}, f = 1.0 \text{ GHz}$)	NF	—	2.6 5.0	—	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain ($V_{CE} = 10 \text{ Vdc}, I_C = 2.0 \text{ mAdc}, f = 450 \text{ MHz}$) (Figure 1) ($V_{CE} = 10 \text{ Vdc}, I_C = 2.0 \text{ mAdc}, R_S = 50 \text{ ohms}, f = 1.0 \text{ GHz}$)	G_{pe}	—	18 13	—	dB

TYPICAL NOISE FIGURE vs. FREQUENCY

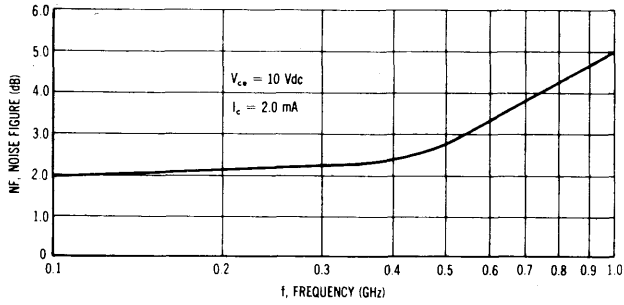
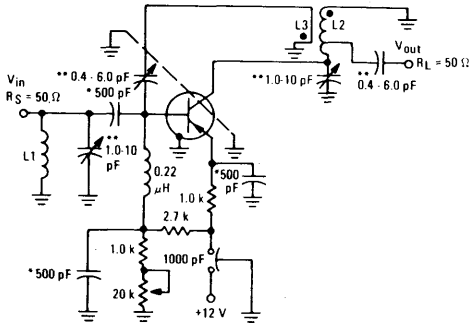


FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT

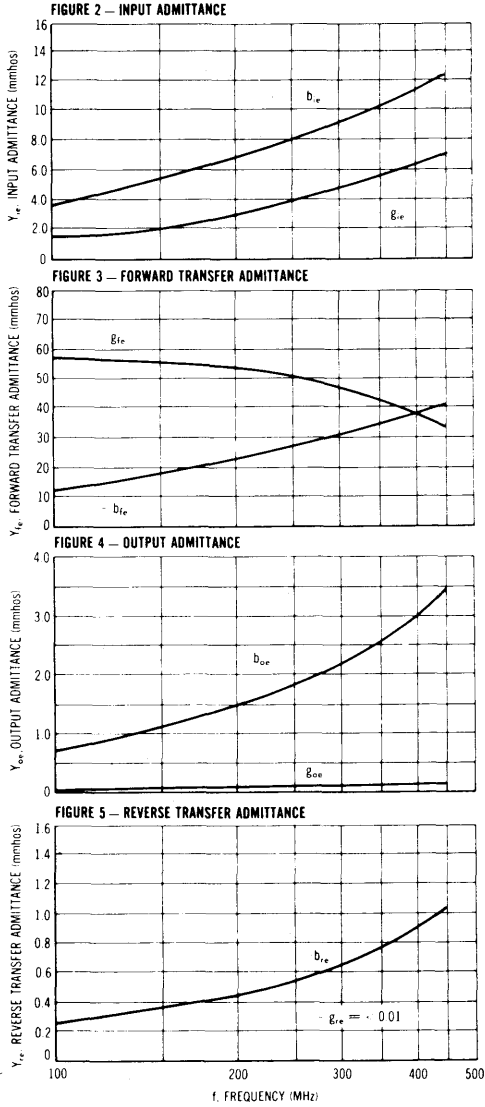


- * Button type capacitors
 - ** Variable air piston type capacitors
1. L1 silver plated brass bar, 1.0 in. lg by 0.25 in od.
 2. L2 silver plated brass bar, 1.5 in. lg by 0.25 in od. Tap is 0.25 in. from collector.
 3. L3 1/2 turn of AWG No. 16 wire 0.25 in. from and parallel to L2.
 4. The noise source is a hot-cold body (All type 70 or equivalent) with a test receiver (All type 136 or equivalent).

COMMON EMITTER Y PARAMETER VARIATIONS

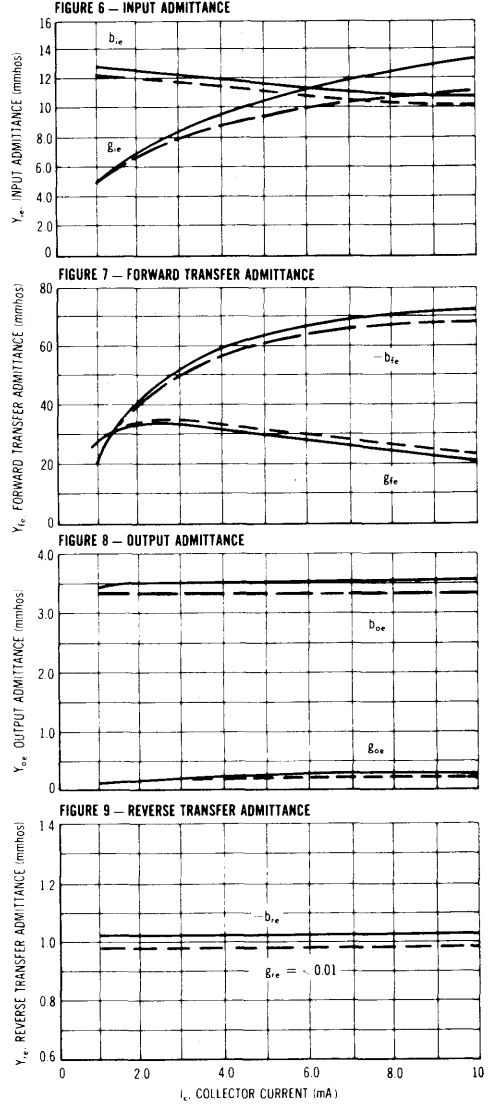
Y PARAMETERS VS FREQUENCY

$V_{CE} = 10 \text{ Vdc}$
 $I_C = 2.0 \text{ mA}$



Y PARAMETERS VS CURRENT

$V_{CE} = 10 \text{ Vdc}$ ——— $V_{CE} = 15 \text{ Vdc}$ - - - -
 $f = 450 \text{ MHz}$



7

COMMON BASE Y PARAMETER VARIATIONS

Y PARAMETERS versus FREQUENCY

$V_{CB} = 10 \text{ Vdc}$

$I_C = 2.0 \text{ mA}$

FIGURE 10 - INPUT ADMITTANCE

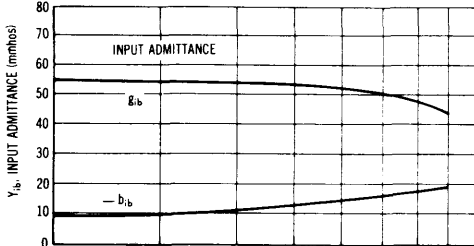


FIGURE 11 - FORWARD TRANSFER ADMITTANCE

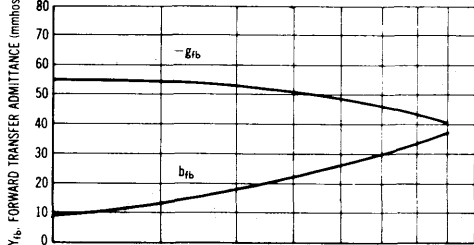


FIGURE 12 - OUTPUT ADMITTANCE

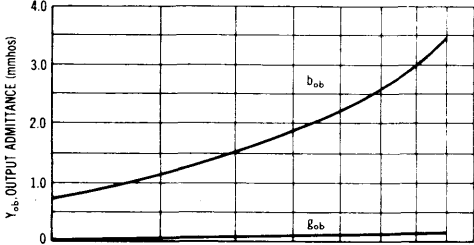
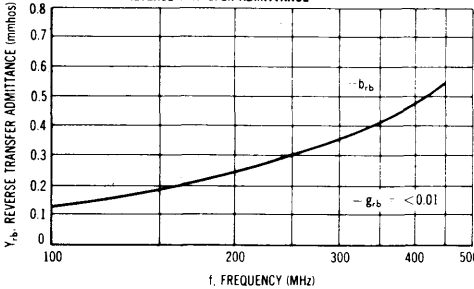


FIGURE 13 - REVERSE TRANSFER ADMITTANCE



Y PARAMETERS versus CURRENT

$V_{CB} = 10 \text{ Vdc}$

$V_{CB} = 15 \text{ Vdc}$

$f = 450 \text{ MHz}$

FIGURE 14 - INPUT ADMITTANCE

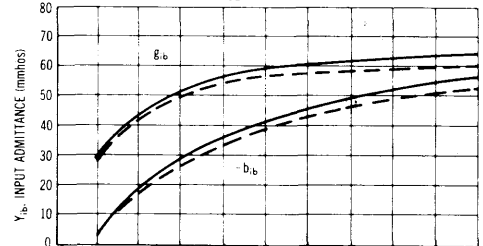


FIGURE 15 - FORWARD TRANSFER ADMITTANCE

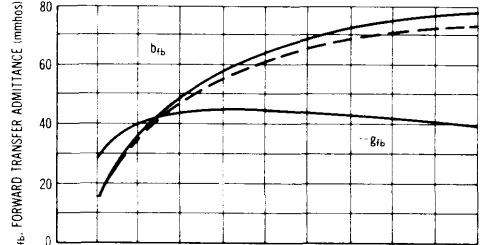


FIGURE 16 - OUTPUT ADMITTANCE

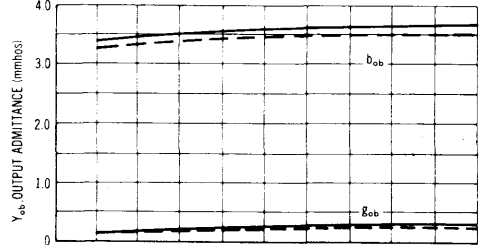
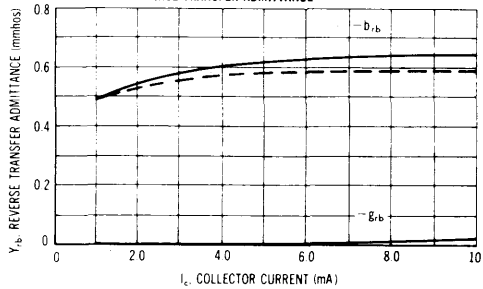


FIGURE 17 - REVERSE TRANSFER ADMITTANCE



MHW590

CASE 714-02

WIDEBAND HYBRID AMPLIFIER



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	28	Vdc
Input Power	P_{in}	5.0	dBm
Operating Case Temperature Range	T_C	-20 to +90	°C
Storage Temperature Range	T_{stg}	-40 to +100	°C

ELECTRICAL CHARACTERISTICS ($V_{DC} = 24$ Vdc, $Z_0 = 50 \Omega$, $T_C = 25^\circ\text{C}$. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	10	—	400	MHz
Power Gain	G_p	31.5	34	35.5	dB
Gain Flatness	F	—	—	± 1.5	dB
Voltage Standing Wave Ratio, In/Out (f = 10–300 MHz) (f = 300–400 MHz)	VSWR	—	1.5:1 2:1	—	—
1 dB Compression (f = 10 MHz) (f = 200 MHz) (f = 400 MHz)	P_1	— 700 —	800 800 300	— — —	mW
Reverse Isolation	P_{RI}	43	50	—	dB
2nd Harmonic ($P_{out} = 10$ mW)	d_{s0}	—	-66	—	dB
Third Order Intercept	I_{TO}	—	43	—	dBm
Peak Envelope Power for -32 dB Distortion	PEP	—	500	—	mW
Noise Figure (f = 60 MHz) (f = 300 MHz)	NF	— —	4.0 3.5	— 5.5	dB
DC Voltage	V_{DC}	—	24	28	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 – POWER GAIN AND RETURN LOSS versus FREQUENCY

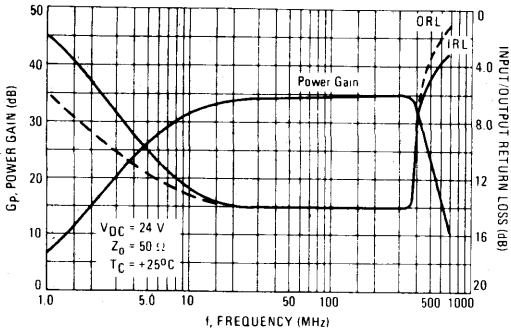


FIGURE 2 – POWER GAIN versus FREQUENCY

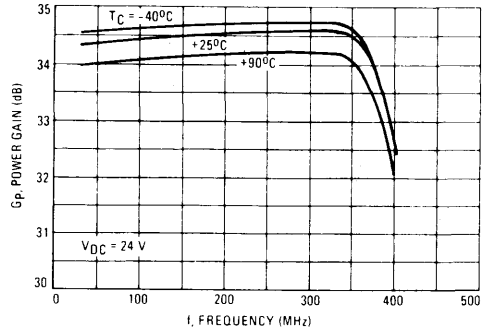


FIGURE 3 – POWER GAIN versus SUPPLY VOLTAGE

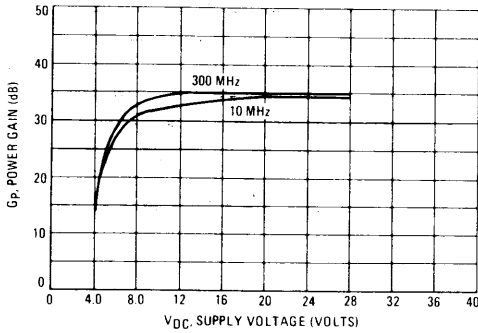


FIGURE 4 – NOISE FIGURE versus SUPPLY VOLTAGE

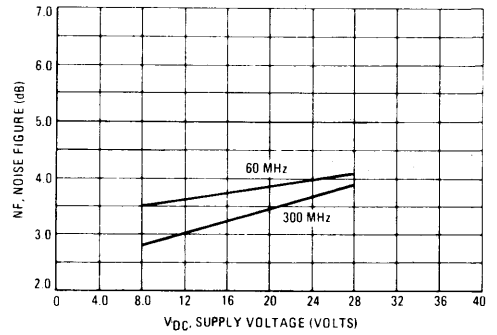


FIGURE 5 – OUTPUT POWER versus INPUT POWER

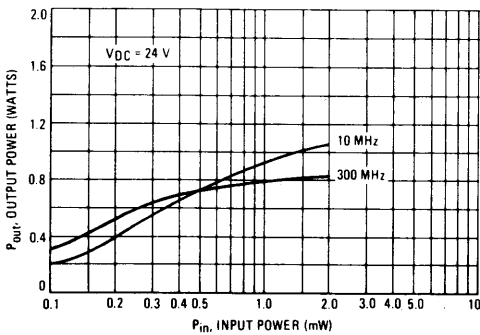


FIGURE 6 – OUTPUT POWER versus INPUT POWER

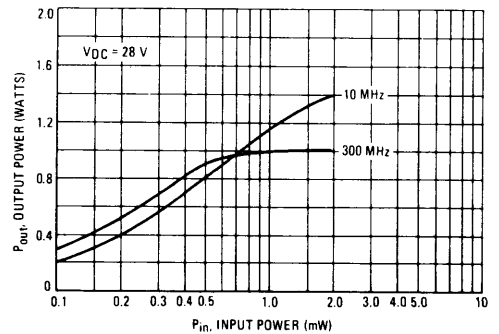


FIGURE 7 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

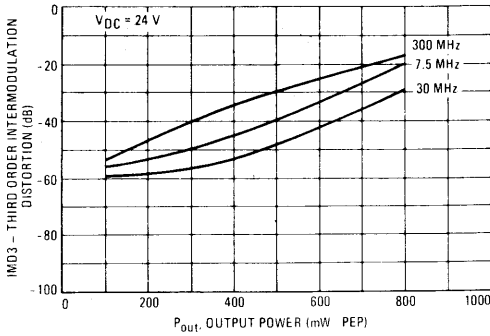


FIGURE 8 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

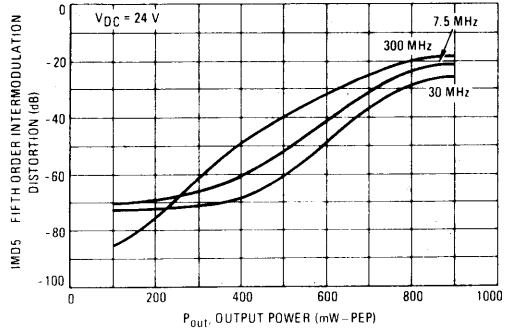


FIGURE 9 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

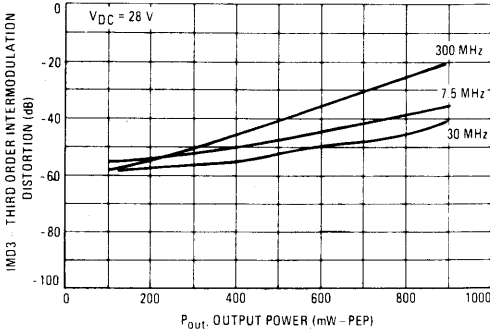


FIGURE 10 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

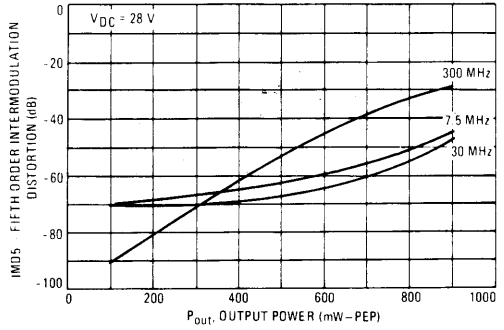
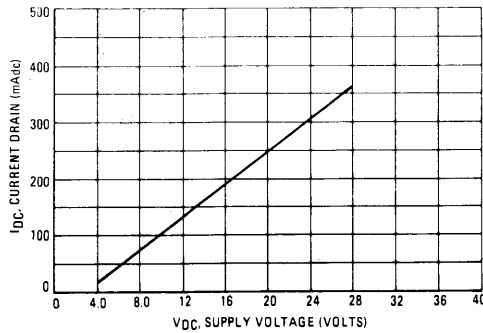


FIGURE 11 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



MHW591

CASE 714-02

WIDEBAND HYBRID AMPLIFIER



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	16	Vdc
Input Power	P_{in}	3.0	dBm
Operating Case Temperature Range	T_C	-20 to +90	°C
Storage Temperature Range	T_{stg}	-40 to +100	°C

ELECTRICAL CHARACTERISTICS ($V_{DC} = 13.6$ Vdc, $Z_o = 50 \Omega$, $T_C = 25^\circ\text{C}$. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	1.0	—	250	MHz
Power Gain	G_p	34.5	36.5	38	dB
Gain Flatness	F	—	—	± 1.5	dB
Voltage Standing Wave Ratio, In/Out (f = 1.0–30 MHz) (f = 30–250 MHz)	VSWR	—	1.5:1 2:1	—	—
1 dB Compression (f = 30 MHz) (f = 100 MHz) (f = 250 MHz)	P_1	650	800	—	mW
Peak Envelope Power (IMD3 = -30 dB, f = 30 MHz) (IMD3 = -30 dB, f = 100 MHz) (IMD3 = -30 dB, f = 250 MHz)	PEP	700	850 600 300	—	mW
Noise Figure (f = 30 MHz) (f = 100 MHz) (f = 250 MHz)	NF	—	3.7 3.7 4.5	5.0	dB
DC Voltage	V_{DC}	—	13.6	16	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 - POWER GAIN versus FREQUENCY

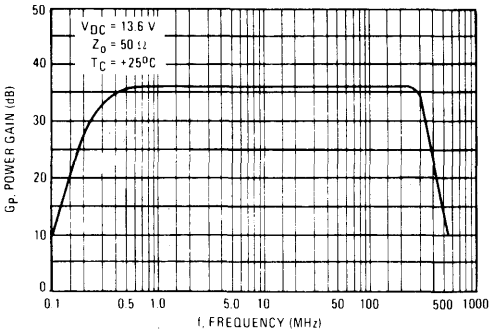


FIGURE 2 - POWER GAIN versus FREQUENCY

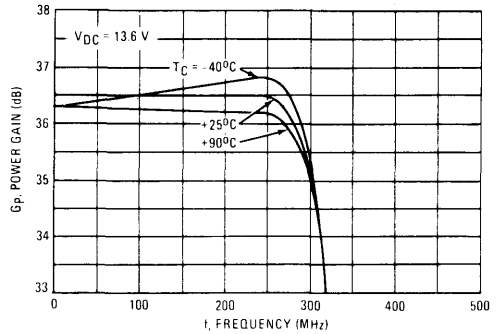


FIGURE 3 - POWER GAIN versus SUPPLY VOLTAGE

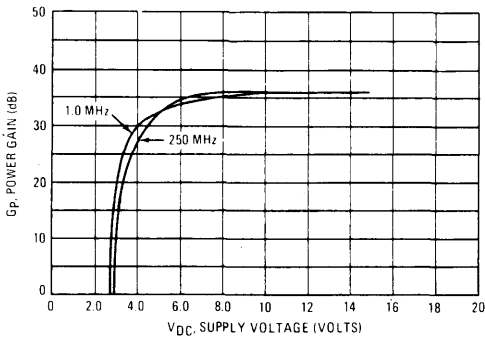


FIGURE 4 - NOISE FIGURE versus SUPPLY VOLTAGE

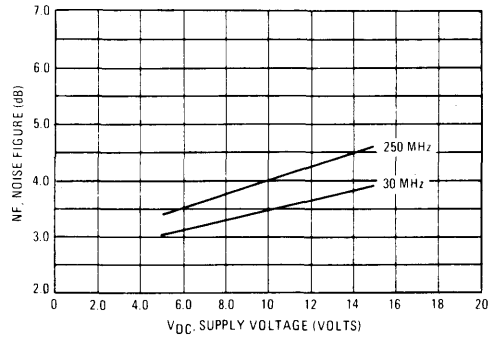


FIGURE 5 - OUTPUT POWER versus INPUT POWER

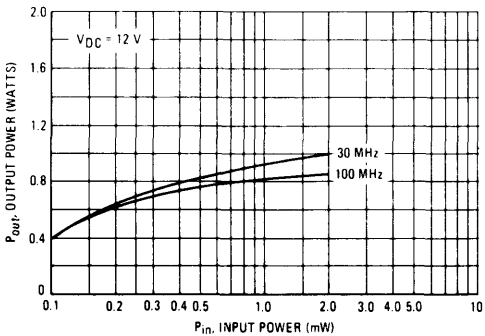
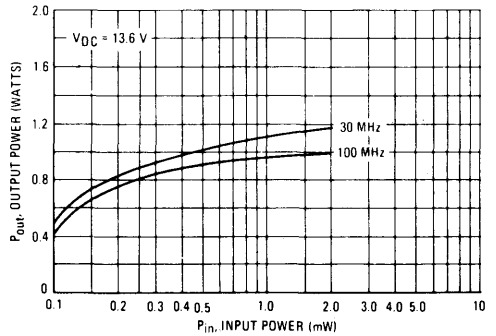


FIGURE 6 - OUTPUT POWER versus INPUT POWER



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FIGURE 7 – INTERMODULATION DISTORTION versus OUTPUT POWER

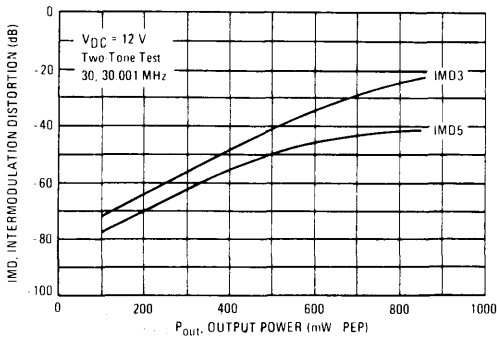


FIGURE 8 – INTERMODULATION DISTORTION versus OUTPUT POWER

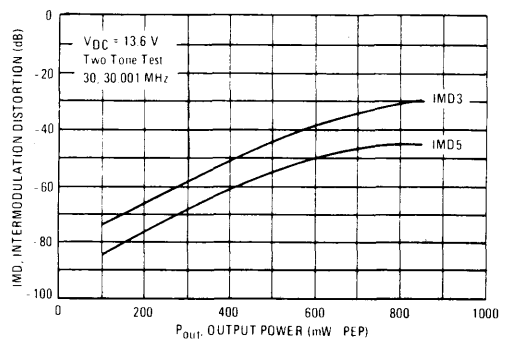
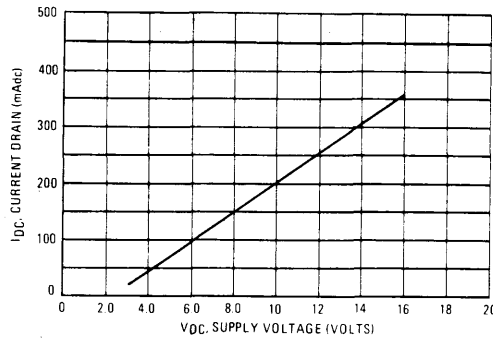


FIGURE 9 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



MHW592

CASE 714-02

WIDEBAND HYBRID AMPLIFIER



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	28	Vdc
Input Power	P_{in}	5.0	dBm
Operating Case Temperature Range	T_C	- 20 to + 90	°C
Storage Temperature Range	T_{stg}	- 40 to + 100	°C

ELECTRICAL CHARACTERISTICS ($V_{DC} = 24$ Vdc, $Z_o = 50 \Omega$, $T_C = 25^\circ\text{C}$. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	1.0	—	250	MHz
Power Gain	G_p	33.5	35	36.5	dB
Gain Flatness	F	—	—	± 1.0	dB
Voltage Standing Wave Ratio, In/Out (f = 1.0–30 MHz) (f = 30–250 MHz)	VSWR	—	1.5:1 2:1	—	—
1 dB Compression (f = 30 MHz) (f = 100 MHz) (f = 250 MHz)	P1	750	900 900 750	—	mW
Peak Envelope Power (IMD3 = -30 dB, f = 30 MHz) (IMD3 = -30 dB, f = 100 MHz) (IMD3 = -30 dB, f = 250 MHz)	PEP	700	850 850 600	—	mW
Noise Figure (f = 30 MHz) (f = 100 MHz) (f = 250 MHz)	NF	—	3.6 3.7 3.9	5.0	dB
DC Voltage	V_{DC}	—	24	28	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 - POWER GAIN versus FREQUENCY

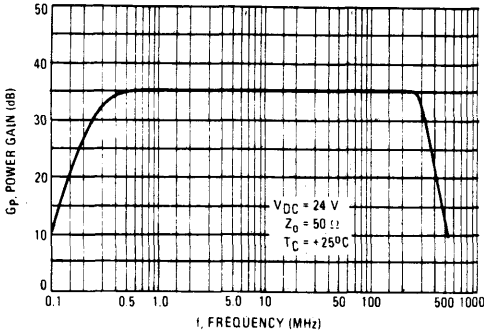


FIGURE 2 - POWER GAIN versus FREQUENCY

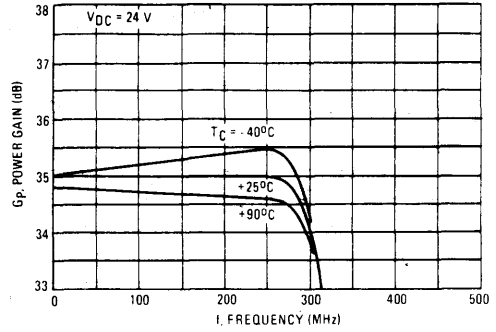


FIGURE 3 - POWER GAIN versus SUPPLY VOLTAGE

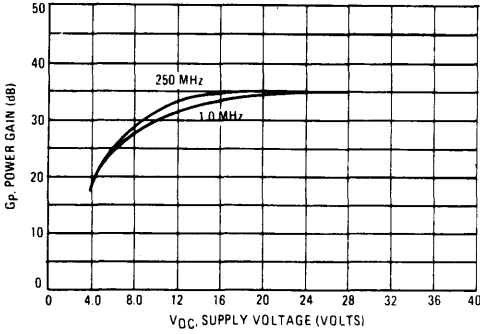


FIGURE 4 - NOISE FIGURE versus SUPPLY VOLTAGE

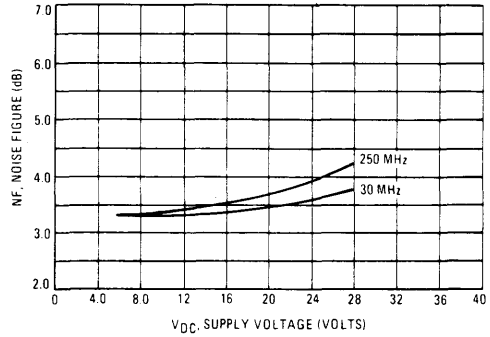


FIGURE 5 - OUTPUT POWER versus INPUT POWER

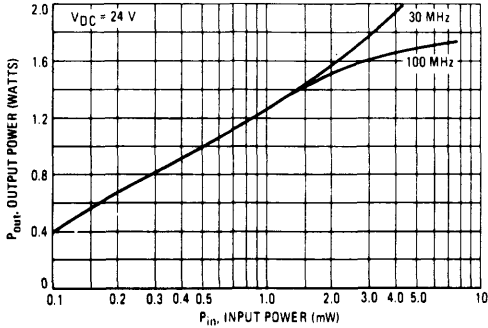


FIGURE 6 - OUTPUT POWER versus INPUT POWER

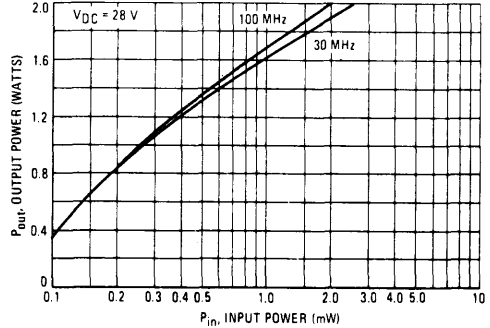


FIGURE 7 – INTERMODULATION DISTORTION versus OUTPUT POWER

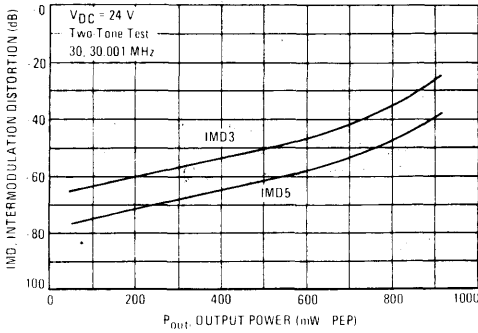


FIGURE 8 – INTERMODULATION DISTORTION versus OUTPUT POWER

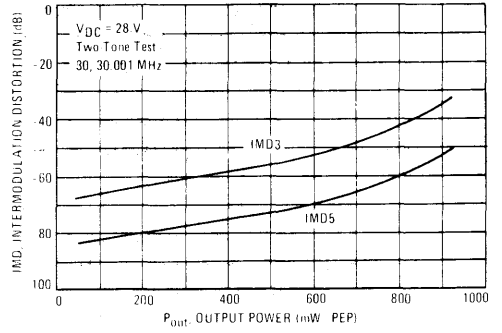
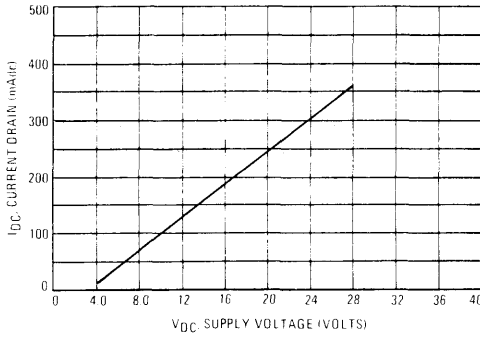


FIGURE 9 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



7

MHW593

CASE 714-02

WIDEBAND HYBRID AMPLIFIER



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	16	Vdc
Input Power	P_{in}	3.0	dBm
Operating Case Temperature Range	T_C	-20 to +90	°C
Storage Temperature Range	T_{stg}	-40 to +100	°C

ELECTRICAL CHARACTERISTICS ($V_{DC} = 13.6$ Vdc, $Z_o = 50 \Omega$, $T_C = 25^\circ\text{C}$. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	10	—	400	MHz
Power Gain	G_p	33	34.5	36	dB
Gain Flatness	F	—	—	± 1.0	dB
Voltage Standing Wave Ratio, In/Out (f = 10–300 MHz) (f = 300–400 MHz)	VSWR	—	1.5:1 2:1	—	—
1 dB Compression (f = 10 MHz) (f = 200 MHz) (f = 400 MHz)	P_1	— 500 —	600 600 200	—	mW
Reverse Isolation	P_{RI}	45	50	—	dB
2nd Harmonic ($P_{out} = 10$ mW)	d_{so}	—	-55	—	dB
Third Order Intercept	I_{TO}	—	38	—	dBm
Peak Envelope Power for -32 dB Distortion	PEP	—	300	—	mW
Noise Figure (f = 60 MHz) (f = 300 MHz)	NF	—	3.7 4.0	— 5.5	dB
DC Voltage	V_{DC}	—	13.6	16	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 – POWER GAIN AND RETURN LOSS versus FREQUENCY

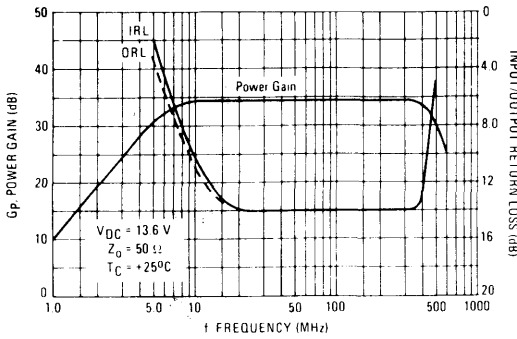


FIGURE 2 – POWER GAIN versus FREQUENCY

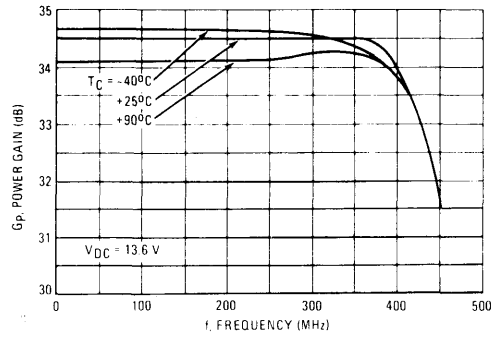


FIGURE 3 – POWER GAIN versus SUPPLY VOLTAGE

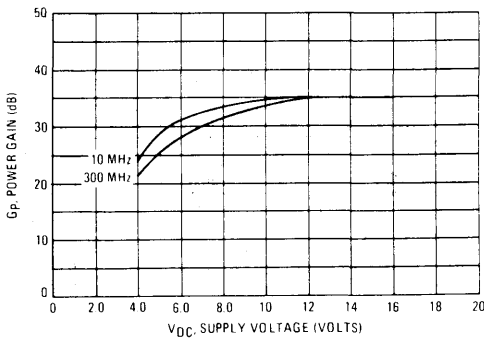


FIGURE 4 – NOISE FIGURE versus SUPPLY VOLTAGE

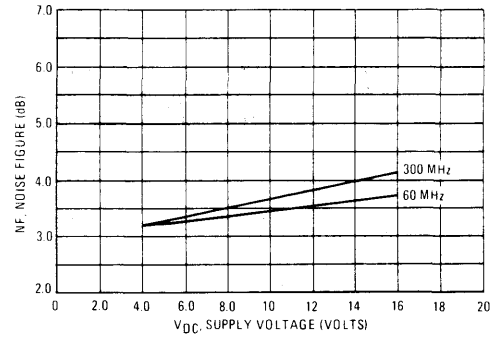


FIGURE 5 – OUTPUT POWER versus INPUT POWER

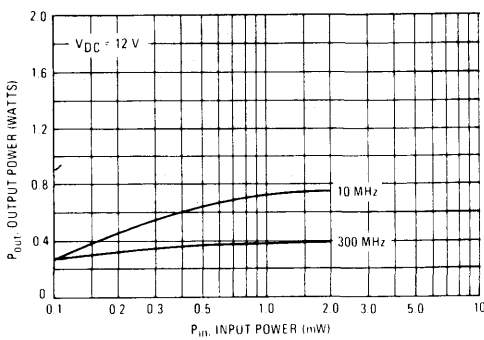
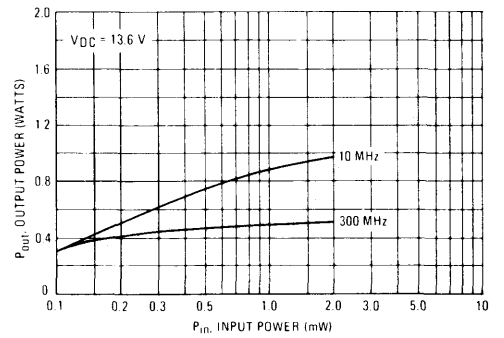


FIGURE 6 – OUTPUT POWER versus INPUT POWER



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FIGURE 7 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

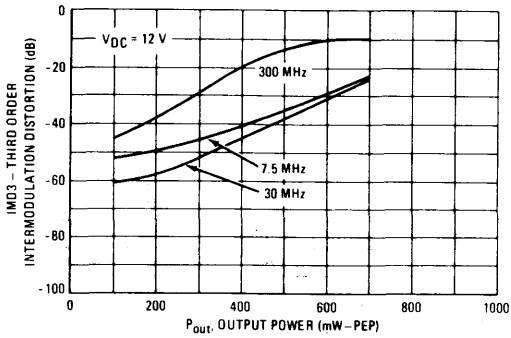


FIGURE 8 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

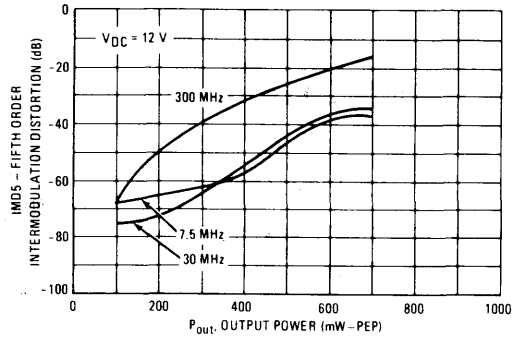


FIGURE 9 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

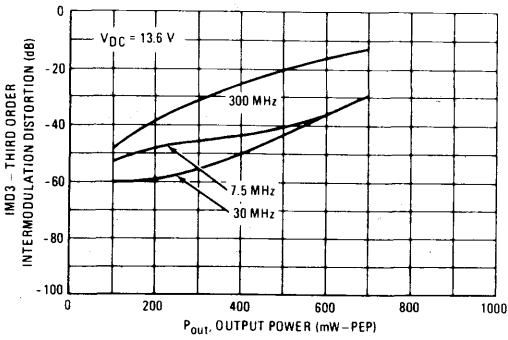


FIGURE 10 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

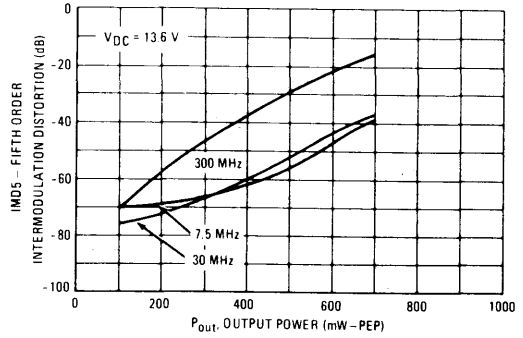
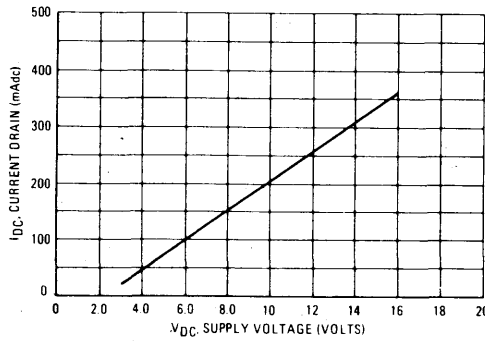


FIGURE 11 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



MM4018

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	20	Vdc
Collector-Base Voltage	V_{CB0}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 5.0 \text{ mAdc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15 \text{ Vdc}, I_B = 0$)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	—	10	μAdc
Collector Cutoff Current ($V_{CE} = 40 \text{ Vdc}, V_{BE} = 0$)	I_{CES}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	10	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	—	900	—	MHz
Output Capacitance ($V_{CB} = 12.5 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	3.5	—	pF
FUNCTIONAL TEST					
Power Output (Figure 1) ($P_{in} = 50 \text{ mW}, V_{CC} = 12.5 \text{ Vdc}, f = 175 \text{ MHz}$)	P_{out}	0.5	—	—	Watt
Collector Efficiency (Figure 1) ($P_{in} = 50 \text{ mW}, V_{CC} = 12.5 \text{ Vdc}, f = 175 \text{ MHz}$)	η	45	55	—	%

FIGURE 1 – 175 MHz OUTPUT POWER TEST CIRCUIT

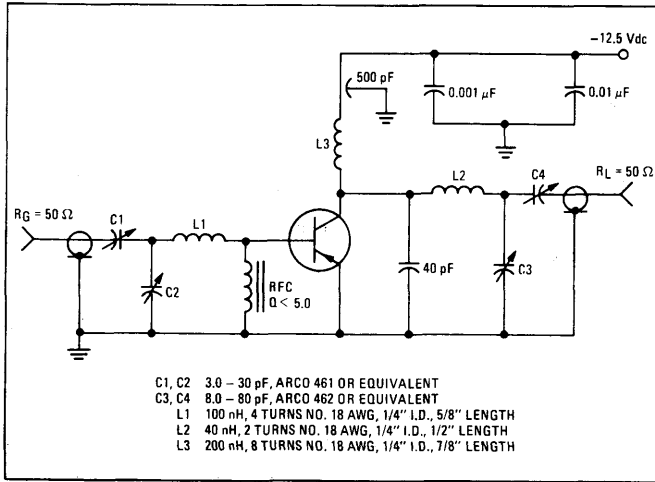


FIGURE 2 – POWER OUTPUT versus POWER INPUT

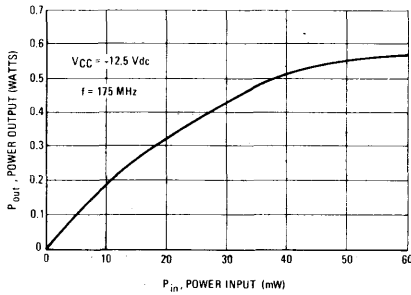


FIGURE 3 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

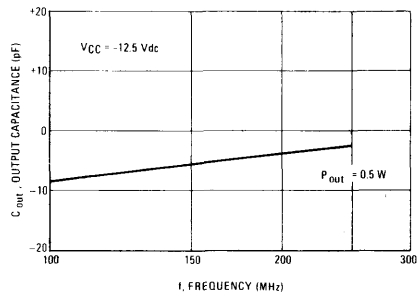


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

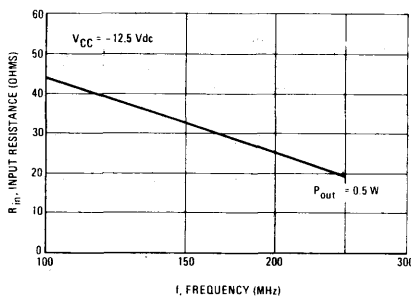
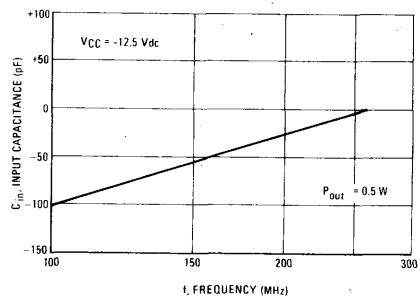


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



MM4019

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON



Refer to 2N5160 for graphs.

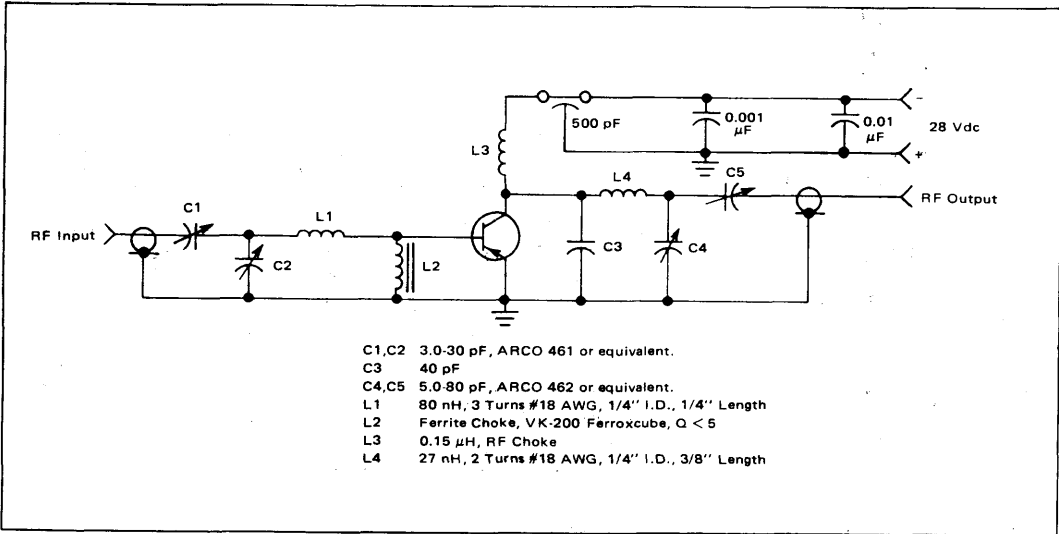
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ mAdc}, I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}, I_B = 0$)	I_{CEO}	—	—	0.1	mAdc
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 250 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	10	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 250 \text{ mAdc}, I_B = 50 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 100 \text{ mAdc}, V_{CE} = 28 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	—	750	—	MHz
Output Capacitance ($V_{CB} = 30 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$)	C_{obo}	—	7.5	—	pF
FUNCTIONAL TEST					
Power Output ($P_{in} = 0.5 \text{ W}, V_{CC} = 28 \text{ Vdc}, f = 400 \text{ MHz}$)	P_{out}	—	2.0	—	Watts
Collector Efficiency ($P_{out} = 2.5 \text{ W}, V_{CC} = 28 \text{ Vdc}, f = 175 \text{ MHz}$)	η	50	—	—	%
Power Input ($P_{out} = 2.5 \text{ W}, V_{CC} = 28 \text{ Vdc}, f = 175 \text{ MHz}$)	P_{in}	—	—	0.25	Watt

FIGURE 1 - 175 MHz TEST CIRCUIT



MM4049 MRF534 MRF536



MRF534
CASE 22-03, STYLE 1
TO-206AA



MRF536
CASE 317-01, STYLE 2



MM4049
CASE 20-03, STYLE 2
TO-206AF

HIGH FREQUENCY TRANSISTOR

PNP SILICON

		MM4049 Case 20-03 TO-206AF	MRF534 Case 22-03 TO-206AA	MRF536 Case 317-01 Macro-X	
MAXIMUM RATINGS					
Collector-Emitter Voltage	V _{CEO}	10	10	10	Vdc
Collector-Base Voltage	V _{CBO}	15	15	15	Vdc
Emitter-Base Voltage	V _{EBO}	4.5	4.5	4.5	Vdc
Collector Current — Continuous	I _C	30	30	30	mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	200 1.14	300 1.71	300 2.40	mW mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	-65 to +200	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 2.0 mAdc, I _B = 0)	V _{(BR)CEO}	10	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μAdc, I _E = 0)	V _{(BR)CBO}	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μAdc, I _C = 0)	V _{(BR)EBO}	4.5	—	—	Vdc
Collector Cutoff Current (V _{CB} = 10 Vdc, I _E = 0)	I _{CBO}	—	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 25 mAdc, V _{CE} = 2.0 Vdc)	h _{FE}	20	—	200	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 20 mAdc, V _{CE} = 5.0 Vdc, f = 500 MHz)	f _T	4.0 5.0	— —	— —	GHz
Collector-Base Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	—	1.3	pF
FUNCTIONAL TEST					
Maximum Available Gain (I _C = 15 mAdc, V _{CE} = 5.0 Vdc, f = 500 MHz) (I _C = 15 mAdc, V _{CE} = 5.0 Vdc, f = 500 MHz) (I _C = 15 mAdc, V _{CE} = 5.0 Vdc, f = 1.0 GHz)	MAG	10 11.5 8.5	12 13 10	— — —	dB

MM4049 • MRF534 • MRF536

FIGURE 1 — CURRENT GAIN — BANDWIDTH PRODUCT versus CURRENT

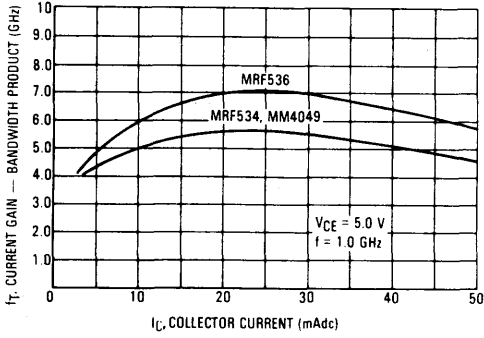


FIGURE 2 — MAXIMUM AVAILABLE GAIN versus COLLECTOR CURRENT

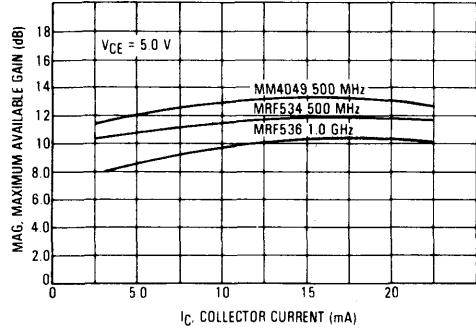
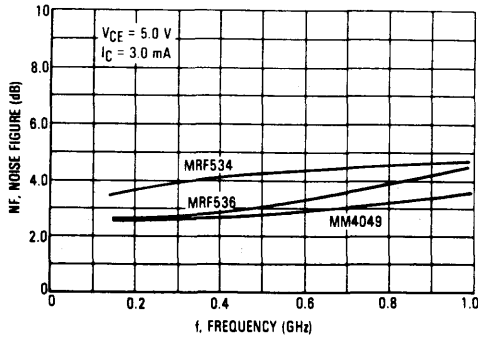


FIGURE 3 — NOISE FIGURE versus FREQUENCY



MM4049 COMMON-EMITTER S-PARAMETERS

VCE (Volts)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
5.0	5.0	200	0.634	-31	6.37	120	0.060	69	0.711	-23
		400	0.469	-34	3.95	93	0.107	65	0.602	-30
		600	0.379	-40	2.90	77	0.147	62	0.587	-33
		800	0.368	-51	2.32	65	0.183	56	0.55	-36
		1000	0.381	-54	1.93	55	0.223	50	0.528	-44
	10	200	0.523	-29	7.79	112	0.056	72	0.632	-23
		400	0.418	-28	3.74	89	0.104	68	0.543	-29
		600	0.344	-34	3.20	74	0.146	65	0.542	-32
		800	0.345	-46	2.54	64	0.184	58	0.513	-34
		1000	0.366	-50	2.09	54	0.225	52	0.493	-42
	20	200	0.454	-25	8.43	106	0.065	73	0.584	-21
		400	0.390	-23	4.67	85	0.105	70	0.513	-27
		600	0.325	-30	3.31	72	0.148	66	0.620	-30
		800	0.327	-44	2.61	62	0.188	59	0.497	-32
		1000	0.351	-48	2.15	52	0.231	52	0.476	-41
10	5.0	200	0.731	-25	5.83	121	0.053	70	0.736	-18
		400	0.589	-30	3.65	95	0.096	67	0.654	-26
		600	0.502	-38	2.71	79	0.132	64	0.645	-29
		800	0.496	-49	2.21	68	0.164	57	0.612	-33
		1000	0.499	-54	1.83	58	0.198	51	0.592	-42
	10	200	0.643	-25	7.37	114	0.051	71	0.668	-18
		400	0.542	-27	4.28	90	0.094	69	0.060	-25
		600	0.466	-34	3.10	76	0.132	65	0.603	-28
		800	0.465	-46	2.49	66	0.166	59	0.577	-31
		1000	0.476	-51	2.05	57	0.202	53	0.557	-40
	20	200	0.57	-23	8.44	109	0.049	73	0.621	-18
		400	0.496	-24	4.73	88	0.093	71	0.562	-24
		600	0.427	-31	3.38	75	0.131	67	0.572	-27
		800	0.427	-43	2.69	66	0.165	60	0.551	-30
		1000	0.445	-47	2.21	57	0.203	54	0.532	-38

MRF534 COMMON-EMITTER S-PARAMETERS

VCE (Volts)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
5.0	5.0	200	0.734	-22	3.70	126	0.066	66	0.507	-39
		400	0.580	-28	2.56	108	0.116	65	0.409	-48
		600	0.444	-37	2.09	95	0.158	62	0.403	-52
		800	0.400	-47	1.80	86	0.195	56	0.364	-56
		1000	0.366	-47	1.55	79	0.234	51	0.348	-69
	10	200	0.645	-27	5.36	124	0.058	69	0.394	-43
		400	0.503	-33	3.44	106	0.109	71	0.316	-52
		600	0.376	-43	2.68	93	0.153	69	0.323	-52
		800	0.333	-54	2.24	84	0.192	65	0.290	-55
		1000	0.295	-54	1.91	77	0.233	61	0.276	-71
	20	200	0.586	-28	5.90	122	0.053	70	0.338	-52
		400	0.454	-34	3.73	105	0.099	73	0.259	-60
		600	0.329	-46	2.87	93	0.143	72	0.267	-58
		800	0.289	-59	2.38	85	0.181	68	0.240	-59
		1000	0.248	-58	2.04	77	0.221	65	0.235	-75
10	5.0	200	0.752	-21	4.28	125	0.066	70	0.550	-28
		400	0.624	-26	2.77	107	0.123	68	0.495	-38
		600	0.512	-34	2.19	94	0.168	65	0.503	-44
		800	0.476	-44	1.86	86	0.207	60	0.464	-51
		1000	0.447	-45	1.60	79	0.246	55	0.443	-64
	10	200	0.685	-24	5.47	123	0.060	71	0.442	-33
		400	0.553	-28	3.46	105	0.113	71	0.385	-42
		600	0.433	-37	2.68	93	0.156	68	0.397	-46
		800	0.391	-49	2.25	85	0.194	63	0.362	-51
		1000	0.359	-47	1.92	78	0.233	59	0.342	-65
	20	200	0.621	-26	6.38	121	0.055	71	0.372	-40
		400	0.488	-31	3.97	104	0.103	72	0.316	-48
		600	0.365	-41	3.04	93	0.145	70	0.332	-50
		800	0.323	-52	2.51	85	0.182	66	0.301	-54
		1000	0.290	-50	2.13	79	0.219	63	0.288	-68

MRF536 COMMON-EMITTER S-PARAMETERS

VCE (Volts)	IC (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ
5.0	5.0	400	0.401	-74	5.38	108	0.09	54	0.49	-48
		800	0.181	-102	3.03	86	0.138	51	0.35	-64
		1200	0.136	-157	2.13	70	0.181	48	0.32	-70
		1600	0.151	175	1.68	59	0.21	45	0.27	-80
		2000	0.16	148	1.44	52	0.24	41	0.269	-100
	10	400	0.289	-94	6.58	103	0.076	56	0.379	-56
		800	0.14	-137	3.55	84	0.122	55	0.266	-73
		1200	0.174	169	2.46	70	0.165	53	0.238	-77
		1600	0.196	154	1.93	60	0.196	50	0.198	-87
		2000	0.227	130	1.65	51	0.230	46	0.202	-110
	20	400	0.233	-118	7.28	99	0.066	60	0.296	-65
		800	0.163	-169	3.88	82	0.110	59	0.204	-84
		1200	0.233	156	2.65	69	0.153	57	0.179	-84
		1600	0.253	144	2.06	59	0.186	55	0.143	-96
		2000	0.290	123	1.75	50	0.220	51	0.160	-121
10	5.0	400	0.478	-54	5.14	109	0.086	58	0.535	-39
		800	0.279	-66	2.90	88	0.141	53	0.420	-55
		1200	0.166	-97	2.08	73	0.184	48	0.388	-62
		1600	0.151	-123	1.67	64	0.209	44	0.33	-72
		2000	0.110	-158	1.44	55	0.243	39	0.313	-90
	10	400	0.356	-67	6.59	105	0.075	59	0.418	-47
		800	0.182	-84	3.59	86	0.124	56	0.311	-62
		1200	0.119	-141	2.53	73	0.166	52	0.284	-67
		1600	0.131	-166	2.00	62	0.193	49	0.230	-76
		2000	0.135	154	1.72	55	0.226	45	0.222	-98
	20	400	0.26	-85	7.66	101	0.066	61	0.328	-53
		800	0.124	122	4.09	84	0.111	59	0.236	-69
		1200	0.148	172	2.83	72	0.152	56	0.216	-71
		1600	0.172	158	2.22	62	0.182	54	0.172	-80
		2000	0.201	130	1.88	54	0.214	50	0.171	-104

MM8000
MM8001
MM8002

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.5 20	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	- 65 to + 200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ($I_C = 5.0 \text{ mAdc}, I_B = 0$)	$V_{CE0(sus)}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}, I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 28 \text{ Vdc}, I_B = 0$)	I_{CEO}	—	—	20	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 50 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}$)	h_{FE}	30	—	—	—
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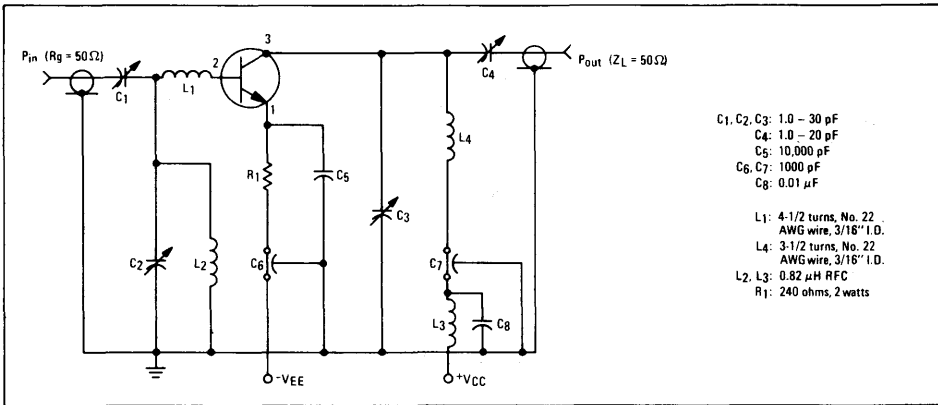
SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 25 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 200 \text{ MHz}$)	MM8000	f_T	550	—	—	MHz
	MM8001		700	—	—	
	MM8002		1000	—	—	
($I_C = 50 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 200 \text{ MHz}$)	MM8000	700	—	—		
	MM8001	900	—	—		
	MM8002	1200	—	—		
($I_C = 100 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 200 \text{ MHz}$)	MM8000	700	—	—		
	MM8001	900	—	—		
	MM8002	1000	—	—		
Output Capacitance ($V_{CB} = 30 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	—	3.5	pF	
Noise Figure (Figure 1) ($I_C = 10 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 200 \text{ MHz}$)	NF	—	2.7	—	dB	

FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain (Figure 1) ($I_C = 10 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 200 \text{ MHz}$)	G_{pe}	—	11.4	—	dB
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FIGURE 1 - 200 MHz TEST CIRCUIT



MM8009

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	35	Vdc
Collector-Base Voltage	V _{CBO}	45	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Continuous	I _C	400	mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	V _{(BR)CBO}	45	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μA _{dc} , I _C = 0)	V _{(BR)EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V _{CE} = 15 Vdc, I _B = 0)	I _{CEO}	—	—	100	μA _{dc}
Collector Cutoff Current (V _{CE} = 35 Vdc, V _{BE} = 0)	I _{CES}	—	—	10	μA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 100 mA _{dc} , V _{CE} = 5.0 Vdc)	h _{FE}	20	—	—	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 50 mA _{dc} , V _{CE} = 15 Vdc, f = 100 MHz)	f _T	1000	—	—	MHz
Output Capacitance (V _{CB} = 30 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	—	2.3	3.0	pF

FUNCTIONAL TEST

Power Output (Figure 1) (P _{in} = 316 mW, V _{CE} = 28 Vdc, f = 1.0 GHz)	P _{out}	0.9	—	—	Watt
Power Output (Oscillator) (Figure 2) (V _{CE} = 20 Vdc, V _{EB} = 1.5 Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P _{out}	—	0.3	—	Watt
Collector Efficiency (P _{in} = 316 mW, V _{CE} = 28 Vdc, f = 1.0 GHz)	η	35	—	—	%

FIGURE 1 - 1.0 GHz POWER AMPLIFIER TEST CIRCUIT

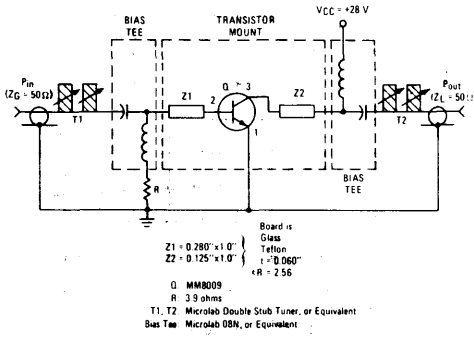


FIGURE 2 - 1.68 GHz POWER OSCILLATOR TEST CIRCUIT

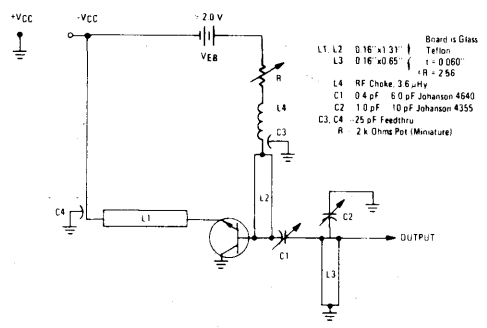


FIGURE 3 - POWER OUTPUT versus POWER INPUT

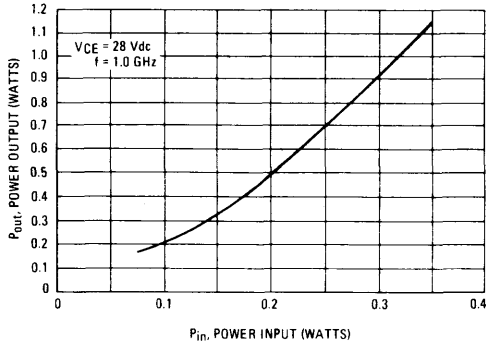


FIGURE 4 - POWER OUTPUT versus FREQUENCY

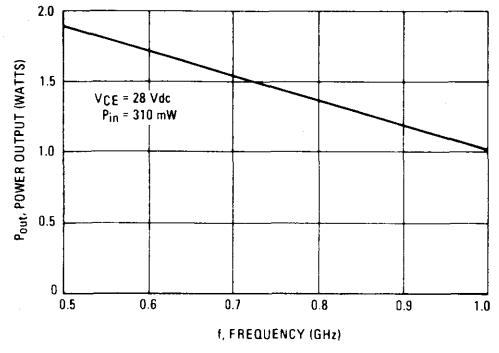


FIGURE 5 - POWER OUTPUT versus VOLTAGE

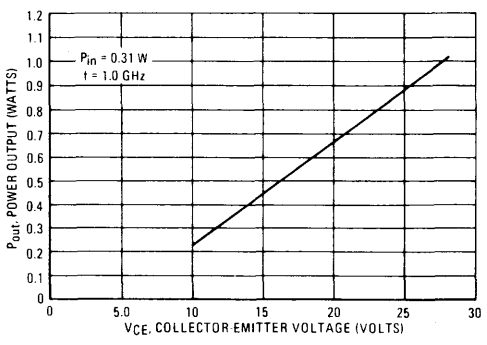
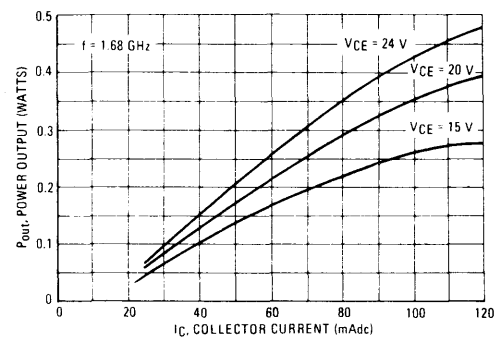


FIGURE 6 - OSCILLATOR POWER OUTPUT versus CURRENT



MM8009

FIGURE 7 – CURRENT-GAIN-BANDWIDTH PRODUCT

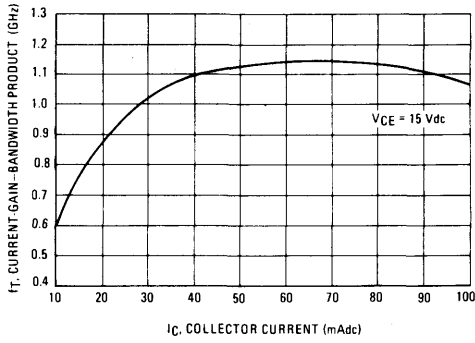
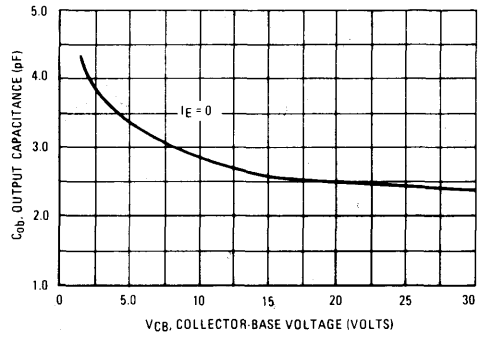


FIGURE 8 – OUTPUT CAPACITANCE versus VOLTAGE



MRF207

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ (1) Derate above 25°C	P_D	3.5 20	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

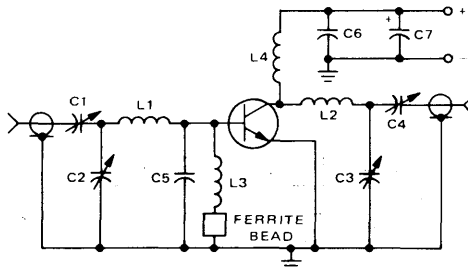
(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 2.0$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	5.0	—	—	—
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5$ Vdc, $P_{out} = 1.0$ W, $f = 220$ MHz)	G_{PE}	8.2	12.5	—	dB
Input Impedance ($P_{out} = 1.0$ W, $f = 220$ MHz)	Z_{in}	—	10 - j11.5	—	Ohms
Output Impedance ($P_{out} = 1.0$ W, $f = 220$ MHz)	Z_{out}	—	32 - j41	—	Ohms

220 MHz TEST CIRCUIT

FIGURE 1 - MRF207

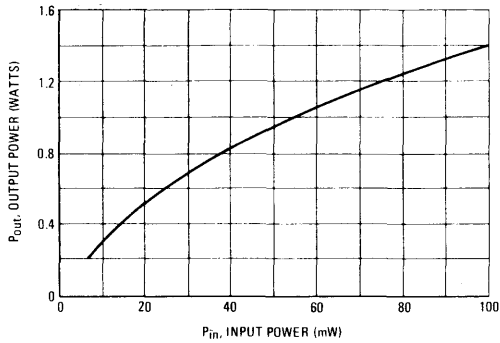


- C1 2.0 - 50 pF ARCO 461
- C2, C4 5.0 - 80 pF ARCO 462
- C3 1.5 - 15 pF ARCO 460
- C5 40 pF
- C6 1000 pF
- C7 5.0 μ F TANTALUM
- L1 1 Turn, #20 AWG, 1/4" ID
- L2 4 Turns, #20 AWG, 1/4" ID
- L3, L4 15 μ H RFC

OUTPUT POWER versus INPUT POWER

($V_{CC} = 12.5$ Vdc, $f = 220$ MHz)

FIGURE 2 - MRF207



7

MRF225

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.25	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ (1) Derate above 25°C	P_D	3.5 0.02	Watts mW/°C
Storage Temperature	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF amplifiers.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 20 \text{ mAdc}$, $I_E = 0$)	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 20 \text{ mAdc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	100	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 100 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	15	150	—
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SMALL SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 12 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	8.0	pF
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FUNCTIONAL TEST (FIGURE 1)

Common-Emitter Amplifier Power Gain ($P_{out} = 1.5 \text{ W}$, $V_{CC} = 12.5 \text{ Vdc}$, $f = 225 \text{ MHz}$)	G_{PE}	9.0	—	dB
Collector Efficiency ($P_{out} = 1.5 \text{ W}$, $V_{CC} = 12.5 \text{ Vdc}$, $f = 225 \text{ MHz}$)	η	50	—	%

FIGURE 1 - 225 MHz TEST CIRCUIT SCHEMATIC

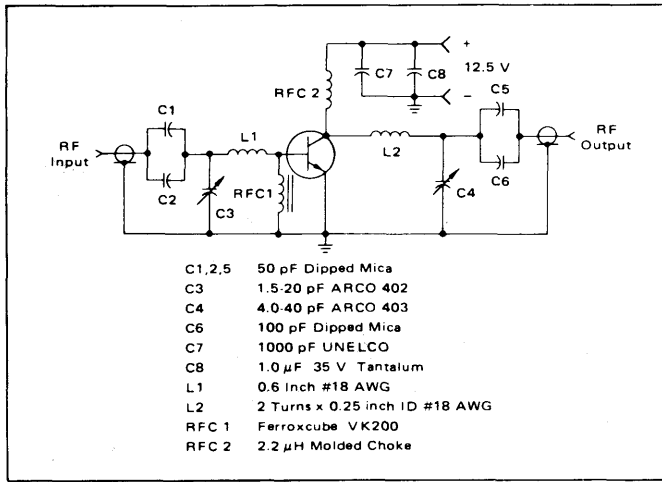


FIGURE 2 - OUTPUT POWER versus INPUT POWER

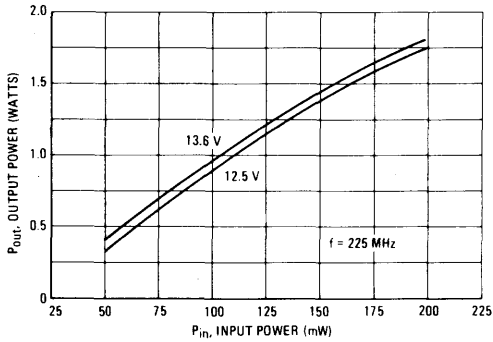
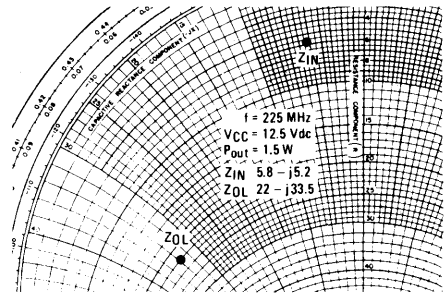


FIGURE 3 - SERIES EQUIVALENT IMPEDANCE



MRF227

CASE 79-03, STYLE 5 HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	400	mdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.5	Watts mW/°C
Storage Temperature	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 50\text{ mA}$, $I_B = 0$)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 50\text{ mA}$, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0\text{ mA}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	1.0	mA
Collector Cutoff Current ($V_{CE} = 15\text{ Vdc}$, $V_{BE} = 0$, $T_C = 55^\circ\text{C}$)	I_{CES}	—	—	10	mA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	20	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 12.5\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	—	15	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($P_{out} = 3.0\text{ W}$, $V_{CC} = 12.5\text{ Vdc}$, $f = 225\text{ MHz}$)	G_{PE}	13.5	15	—	dB
Collector Efficiency ($P_{out} = 3.0\text{ W}$, $V_{CC} = 12.5\text{ Vdc}$, $f = 225\text{ MHz}$)	η	60	—	—	%

7

FIGURE 1 – 225 MHz TEST CIRCUIT

- C1,C2,C3,C4 ARCO 420
 - C5 1000 pF, UNELCO
 - C6 0.047 pF, ERIE
 - C7 1.0 pF, TANTALUM
 - L1 #18 AWG, 1" Wire Length
 - L2 VK200-4 Ferroxcube
 - L3 1 Turn, #18 AWG, 1/4" ID x 2" Wire Length
 - L4 0.15 μH DELEVAN Molded Choke
- Board – Glass Teflon, $\epsilon_R = 2.56$, $t = 0.062"$
 Input/Output Connectors – Type N

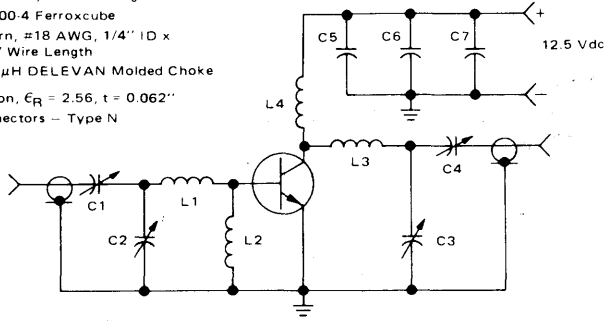


FIGURE 2 – INPUT POWER versus OUTPUT POWER – 12.5 V

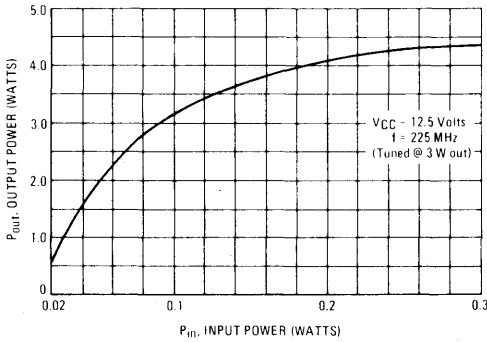


FIGURE 3 – INPUT POWER versus OUTPUT POWER – 13.6 V

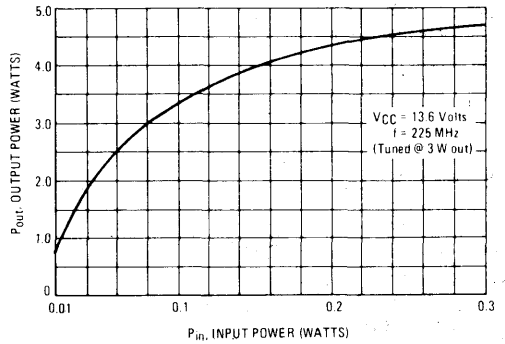


FIGURE 4 – INPUT POWER versus OUTPUT POWER – 7.5 V

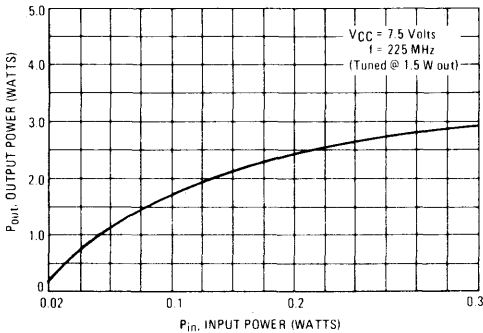


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE

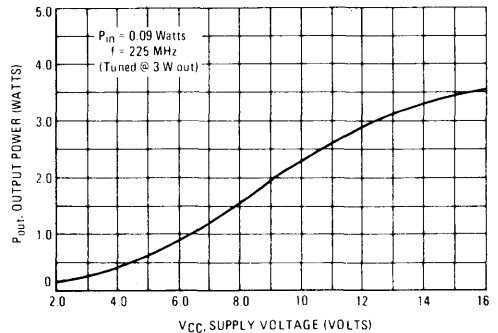
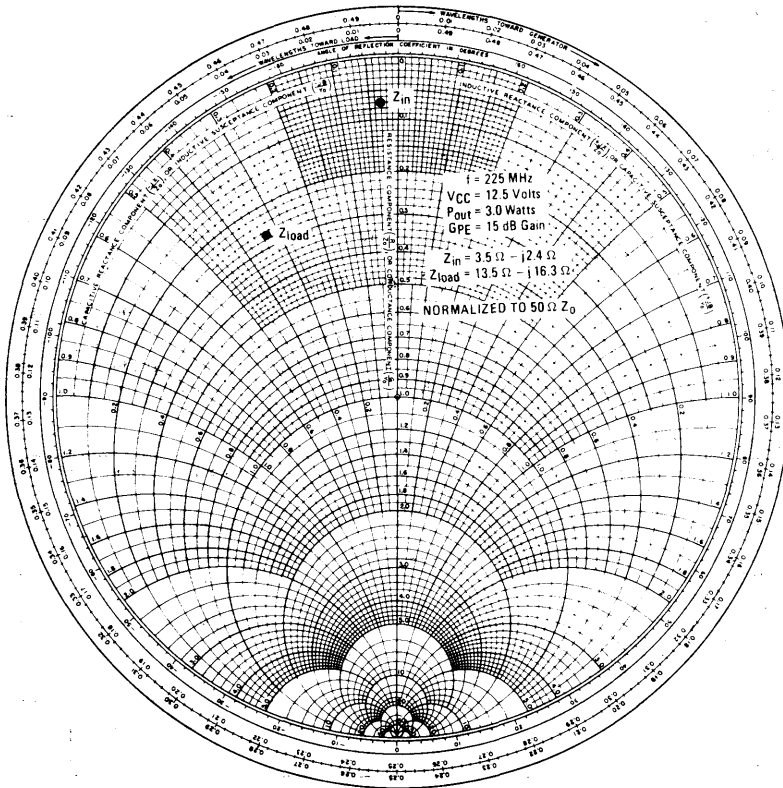


FIGURE 6 – SERIES EQUIVALENT IMPEDANCE



7

MRF229 MRF230

MRF229
CASE 79-03, STYLE 5

MRF230
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ (1) Derate above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF Amplifiers.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 25 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 25 \text{ mAdc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.25 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	0.5	mAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 250 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	5.0	—	—
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SMALL SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 12.5 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	25	pF
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FUNCTIONAL TEST (FIGURE 1)

Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 1.5 \text{ W}$, $f = 90 \text{ MHz}$)	G_{PE}	10	—	dB
Collector Efficiency ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 1.5 \text{ W}$, $f = 90 \text{ MHz}$)	η	55	—	%
Load Mismatch ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 1.5 \text{ W}$, $f = 90 \text{ MHz}$, $T_C \leq 25^\circ\text{C}$)	—	VSWR > 30:1 Through All Phase Angles in 3 Second Interval After Which Devices Will Meet G_{PE} Test Limits		

FIGURE 1 - 90 MHz TEST CIRCUIT SCHEMATIC

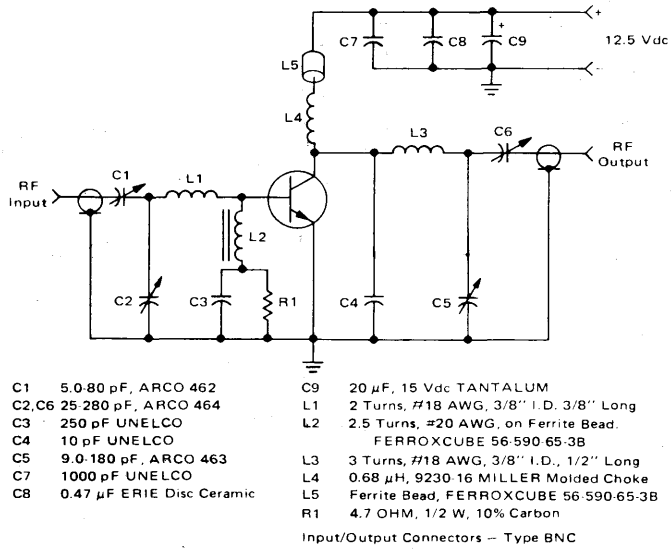


FIGURE 2 - OUTPUT POWER versus INPUT POWER

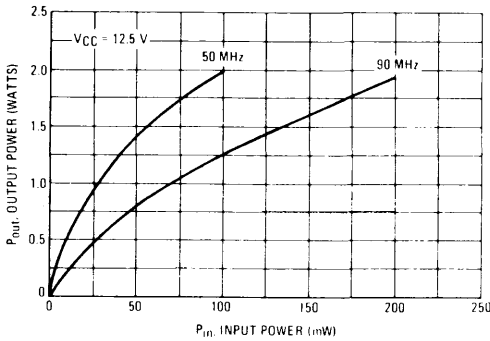


FIGURE 3 - OUTPUT POWER versus FREQUENCY

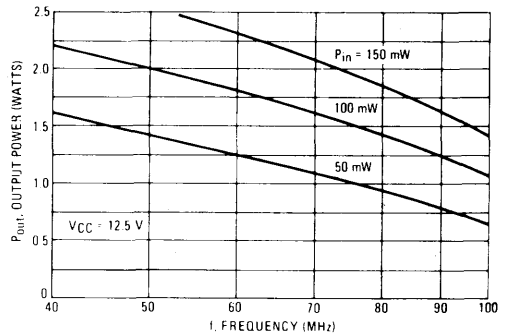


FIGURE 4 - OUTPUT POWER versus SUPPLY VOLTAGE

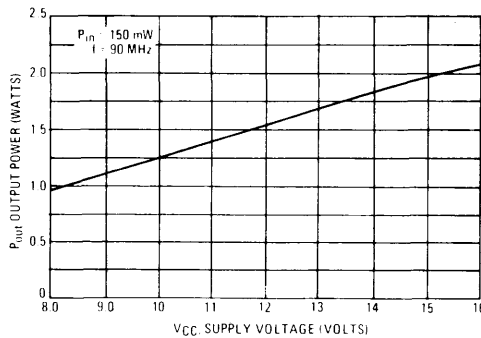
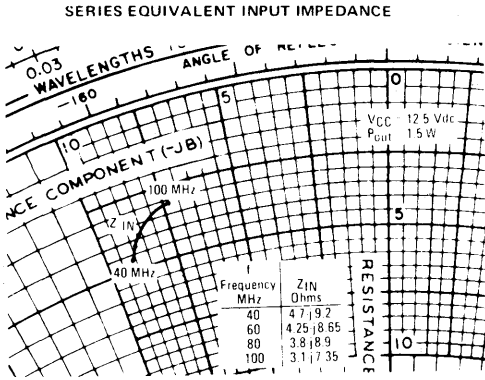


FIGURE 5



SERIES EQUIVALENT OUTPUT IMPEDANCE

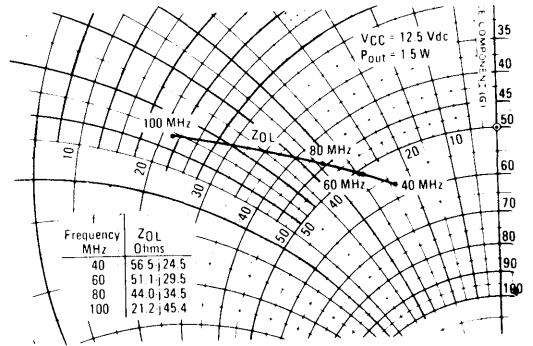


FIGURE 6 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

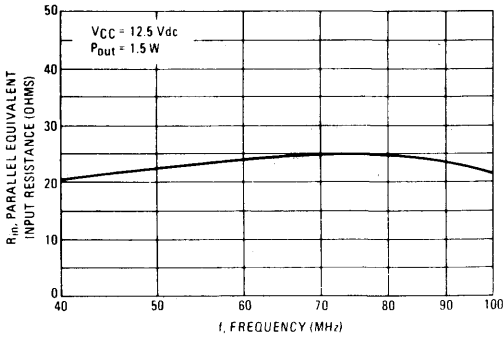


FIGURE 7 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

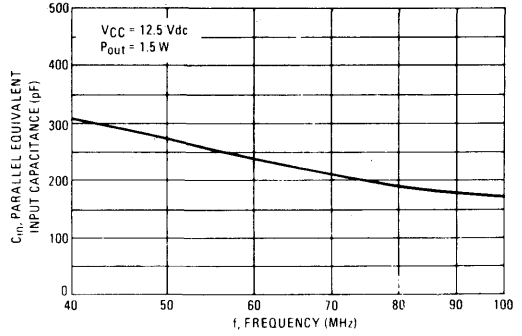


FIGURE 8 – PARALLEL EQUIVALENT OUTPUT RESISTANCE versus FREQUENCY

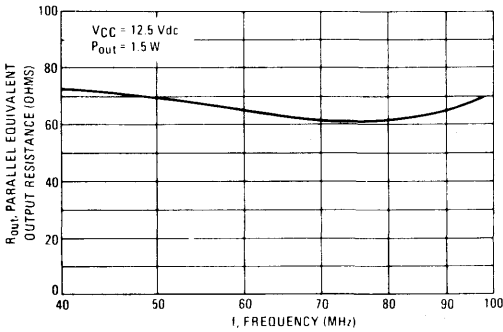
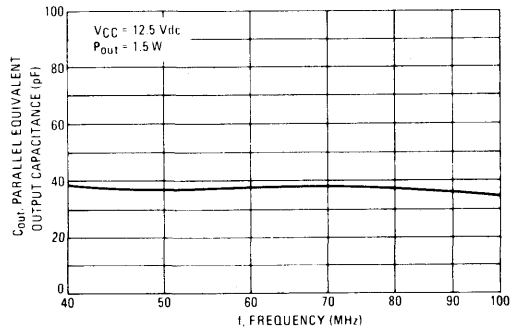


FIGURE 9 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



MRF237

CASE 79-03, STYLE 5 HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	640	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	8.0 45.7	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	- 65 to + 200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.25	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 250$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	5.0	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 15$ Vdc, $I_E = 0$, $f = 0.1$ MHz)	C_{obo}	—	15	20	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($P_{out} = 4.0$ W, $V_{CC} = 12.5$ Vdc, $I_C(\text{max}) = 640$ mAdc, $f = 175$ MHz)	G_{PE}	12	14	—	dB
Collector Efficiency ($P_{out} = 4.0$ W, $V_{CC} = 12.5$ Vdc, $I_C(\text{max}) = 640$ mAdc, $f = 175$ MHz)	η	50	62	—	%

FIGURE 1 - 175 MHz TEST CIRCUIT SCHEMATIC

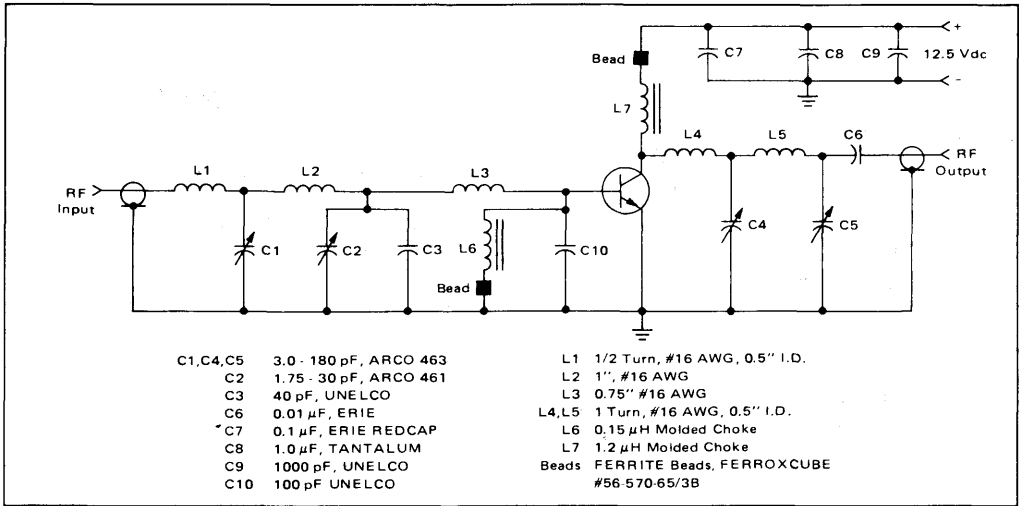


FIGURE 2 - OUTPUT POWER versus INPUT POWER

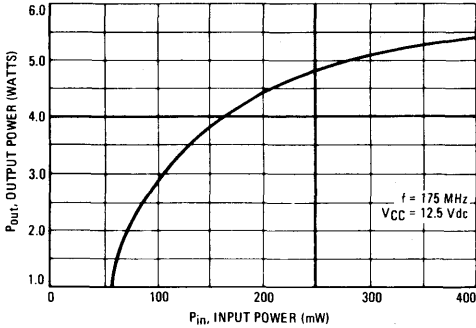


FIGURE 3 - OUTPUT POWER versus FREQUENCY

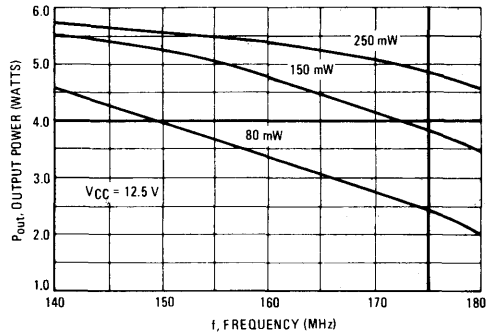


FIGURE 4 - OUTPUT POWER versus SUPPLY VOLTAGE

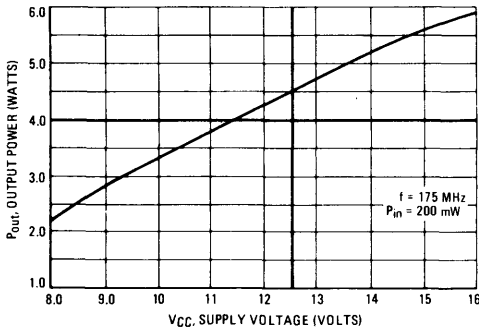
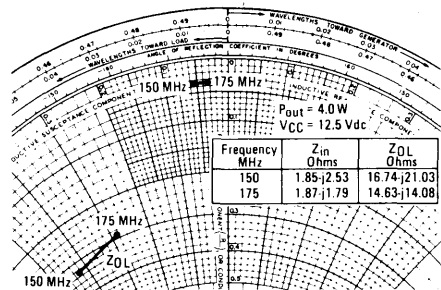


FIGURE 5 - SERIES EQUIVALENT IMPEDANCE



MRF313 MRF313A

MRF313
CASE 305A-01, STYLE 1

MRF313A
CASE 305-1, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 35	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	28.5	$^\circ\text{C/W}$

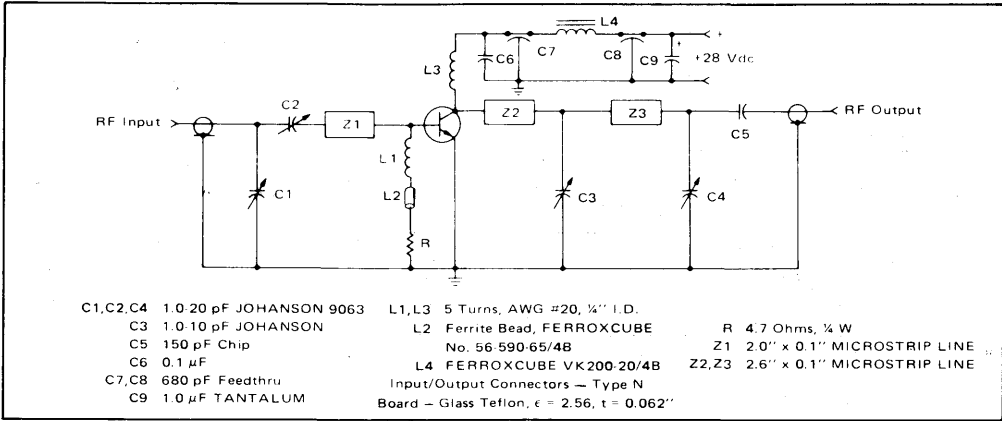
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0\text{ mAdc}, V_{BE} = 0$)	$V_{(BR)CES}$	35	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1\text{ mAdc}, I_E = 0$)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0\text{ mAdc}, I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}, I_B = 0$)	I_{CEO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	h_{FE}	20	60	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 100\text{ mAdc}, V_{CE} = 20\text{ Vdc}, f = 200\text{ MHz}$)	f_T	—	2.5	—	GHz
Output Capacitance ($V_{CB} = 28\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$)	C_{obo}	—	3.5	5.0	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain(1) ($V_{CC} = 28\text{ Vdc}, P_{out} = 1.0\text{ W}, f = 400\text{ MHz}$)	G_{pe}	15	16	—	dB
Collector Efficiency ($V_{CC} = 28\text{ Vdc}, P_{out} = 1.0\text{ W}, f = 400\text{ MHz}$)	η	—	45	—	%
Series Equivalent Input Impedance ($V_{CC} = 28\text{ Vdc}, P_{out} = 1.0\text{ W}, f = 400\text{ MHz}$)	Z_{in}	—	6.4 - j4.8	—	Ohms
Series Equivalent Output Impedance ($V_{CC} = 28\text{ Vdc}, P_{out} = 1.0\text{ W}, f = 400\text{ MHz}$)	Z_{out}	—	75 - j45	—	Ohms

(1) Class C

MRF313 • MRF313A

FIGURE 1 - 400 MHz POWER GAIN TEST CIRCUIT



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MRF402

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

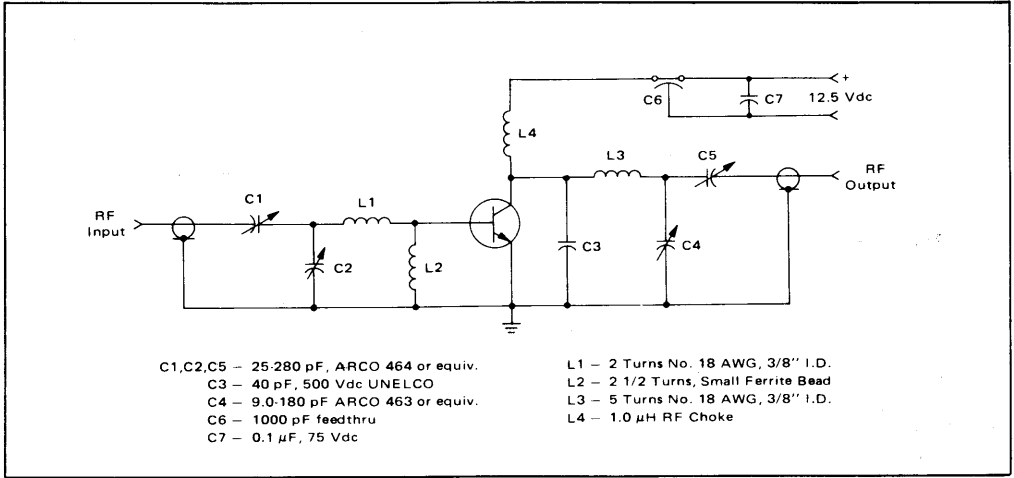
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.62	Watts $\text{mW}/^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \text{ mAdc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.25 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 250 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	5.0	—	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	25	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 1.0 \text{ W}$, $I_C(\text{max}) = 160 \text{ mAdc}$, $f = 50 \text{ MHz}$)	G_{PE}	10	—	dB
Collector Efficiency ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 1.0 \text{ W}$, $I_C(\text{max}) = 160 \text{ mAdc}$, $f = 50 \text{ MHz}$)	η	50	—	%

7

FIGURE 1 - 50 MHz TEST CIRCUIT SCHEMATIC



MRF501 MRF502

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



Refer to 2N5179 for curves

MAXIMUM RATINGS

Rating	Symbol	MRF501	MRF502	Unit
Collector-Emitter Voltage	V_{CE0}	15		Vdc
Collector-Base Voltage	V_{CB0}	25	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5		Vdc
Collector Current	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200	1.14	mW mW/°C
Storage Temperature	T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	MRF501 25 MRF502 35	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 1.0$ Vdc, $I_E = 0$)	I_{CBO}	MRF501 — MRF502 —	— —	50 20	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc)	h_{FE}	MRF501 30 MRF502 40	— —	250 170	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, $f = 100$ MHz)	f_T	MRF501 600 MRF502 800	1000 2000	— —	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 0.1$ to 1.0 MHz)	C_{cb}	—	0.6	—	pF
Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 6.0$ Vdc, $f = 31.8$ MHz)	$r_b' C_C$	—	8.0	—	ps
Noise Figure (Figure 1) ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50$ ohms, $f = 200$ MHz)	NF	MRF501 — MRF502 —	4.5 4.0	— —	dB

FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain (Figure 1) ($V_{CC} = 6.0$ Vdc, $I_C = 5.0$ mAdc, $f = 200$ MHz)	G_{pe}	MRF501 — MRF502 —	15 17	— —	dB
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MRF511

CASE 244A-01, STYLE 1
TO-117

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	250	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$
Stud Torque(1)	—	6.5	In. Lb.

(1) For Repeated Assembly use 5 In. Lb.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $I_B = 0$)	I_{CEO}	—	—	100	μ Adc

ON CHARACTERISTICS

DC Current Gain ($I_C = 80$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	50	200	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	—	0.2	0.5	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 80$ mAdc, $V_{CE} = 20$ Vdc, $f = 200$ MHz)	f_T	1.5	2.1	—	GHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	3.2	4.5	pF
Noise Figure ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, $f = 200$ MHz)	NF	—	7.3	10	dB

FUNCTIONAL TEST (FIGURE 1)

Common-Emitter Amplifier Power Gain ($V_{CE} = 20$ Vdc, $I_C = 80$ mAdc, $f = 250$ MHz)	G_{pe}	10	11	—	dB	
2nd Order Intermodulation Distortion ($V_{CE} = 20$ Vdc, $I_C = 80$ mAdc, $V_{out} = +50$ dBmV, Chn 2 + Chn 13 = 266.5 MHz)	IMD	—	-55	-50	dB	
Cross-Modulation Distortion ($V_{CE} = 20$ Vdc, $V_{out} = +50$ dBmV, $I_C = 80$ mAdc)	Chn 13	12 Chn XMD	—	-59	-57	dB
	Chn R	30 Chn XMD	—	-46	—	
Triple Beat ($V_{CE} = 20$ Vdc, $I_C = 80$ mAdc, $V_{out} = +50$ dBmV, Chn 2 + Chn 3 + Chn E = 261.75 MHz)	TB	—	-68	-65	dB	

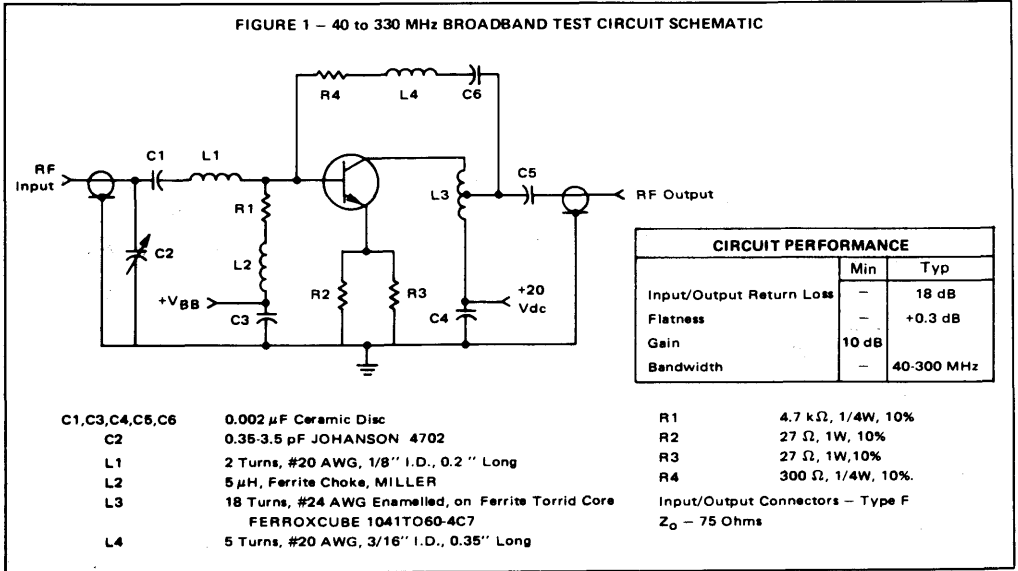


FIGURE 2 - CURRENT-GAIN-BANDWIDTH PRODUCT

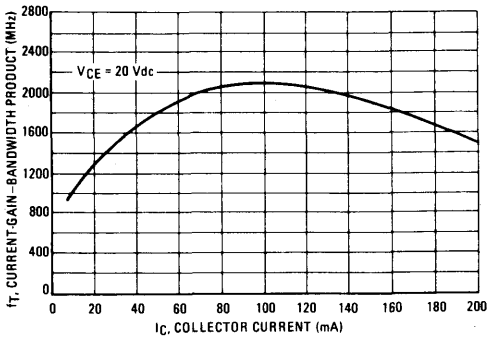


FIGURE 3 - OUTPUT CAPACITANCE

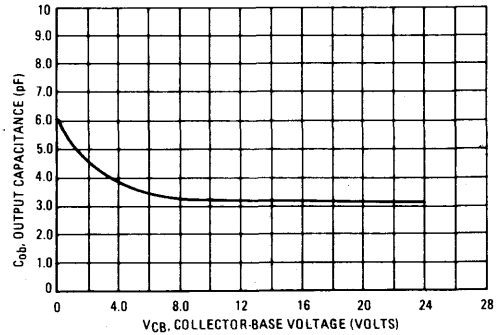


FIGURE 4 - INPUT CAPACITANCE

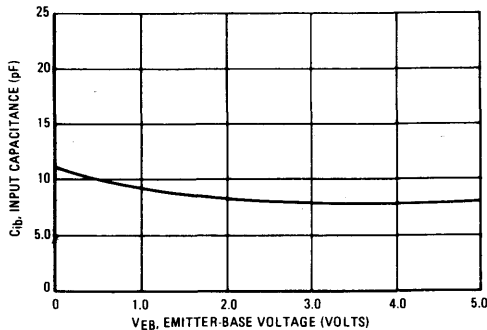


FIGURE 5 - BROADBAND NOISE FIGURE

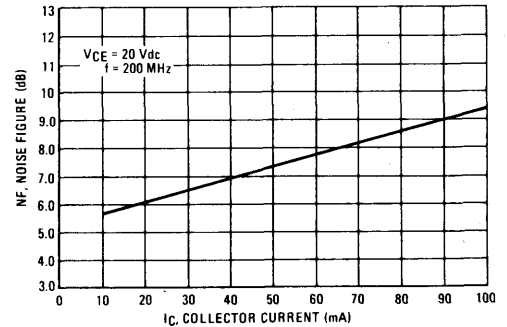


FIGURE 6 - 12 CHANNEL CROSS-MODULATION versus COLLECTOR-EMITTER VOLTAGE

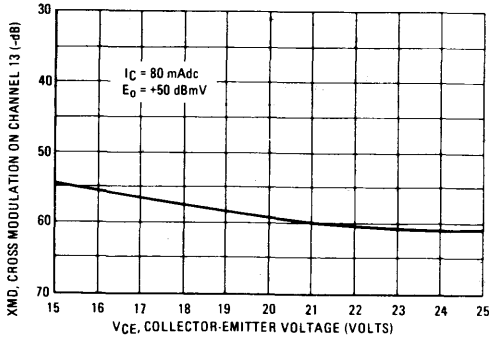


FIGURE 7 - 12 CHANNEL CROSS-MODULATION versus COLLECTOR CURRENT

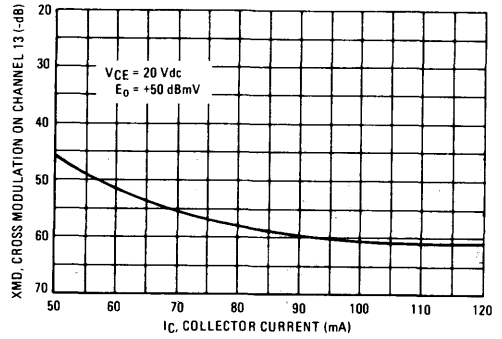


FIGURE 8 - 30 CHANNEL CROSS-MODULATION ON CHANNEL R

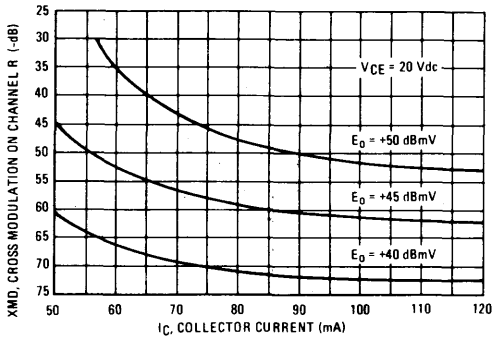


FIGURE 9 - 30 CHANNEL CROSS-MODULATION ON CHANNEL 2, 13, R

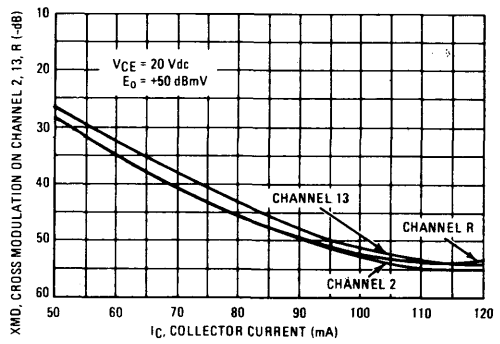


FIGURE 10 - 30-CHANNEL CROSS-MODULATION versus COLLECTOR-EMITTER VOLTAGE

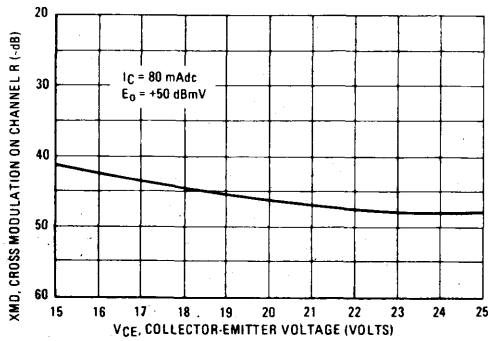


FIGURE 11 – TRIPLE BEAT versus COLLECTOR CURRENT

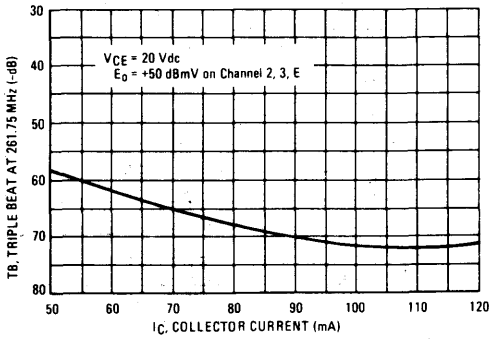


FIGURE 12 – TRIPLE BEAT versus COLLECTOR-EMITTER VOLTAGE

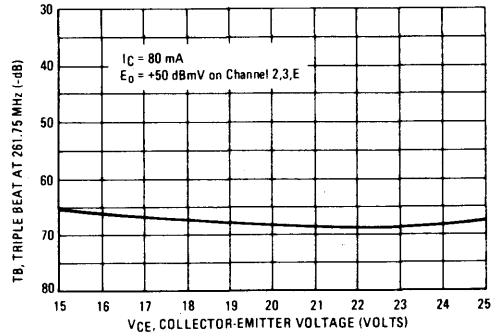


FIGURE 13 – SECOND ORDER IMD versus COLLECTOR CURRENT

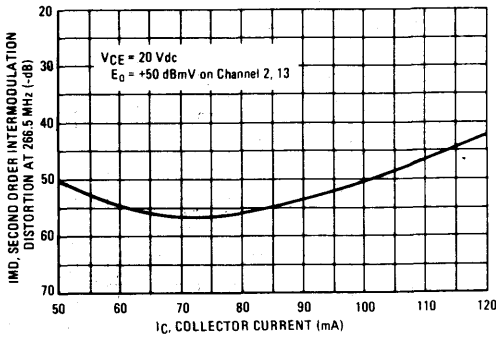


FIGURE 14 – SECOND ORDER IMD versus COLLECTOR-EMITTER VOLTAGE

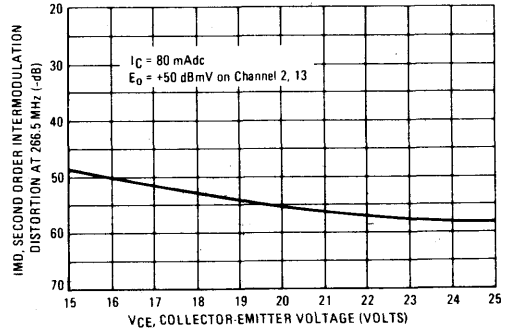
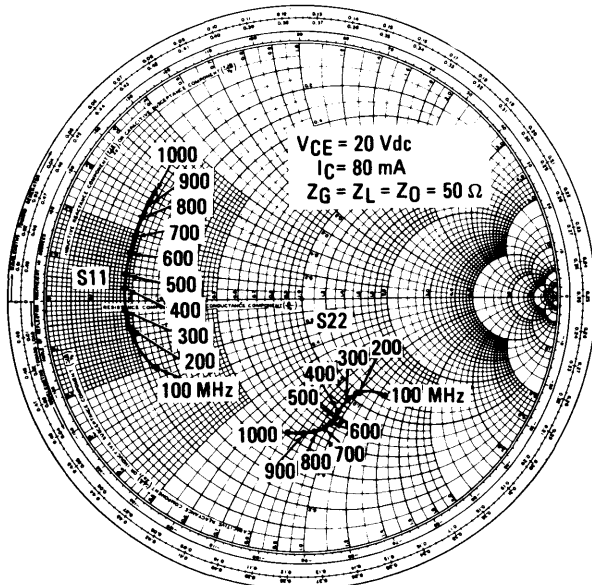


FIGURE 15 – INPUT REFLECTION COEFFICIENT (S11) AND OUTPUT REFLECTION COEFFICIENT (S22) versus FREQUENCY



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FIGURE 16 – FORWARD TRANSMISSION COEFFICIENT (S₂₁) versus FREQUENCY

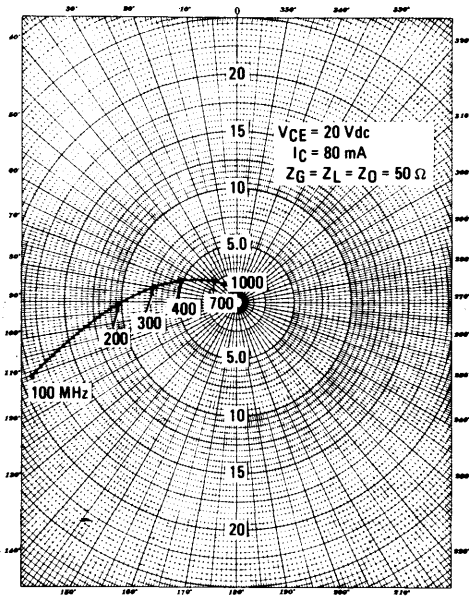
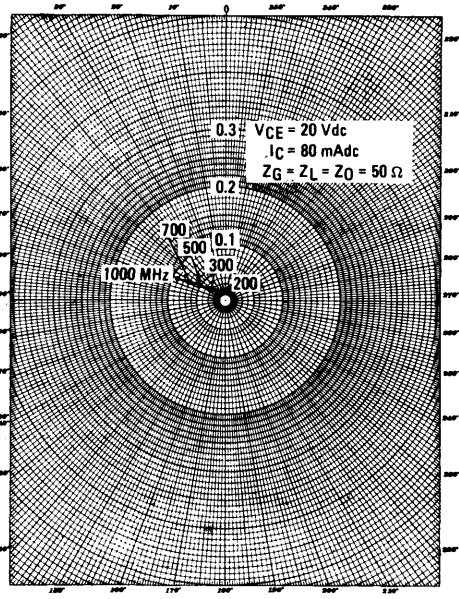


FIGURE 17 – REVERSE TRANSMISSION COEFFICIENT (S₁₂) versus FREQUENCY



MRF515

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



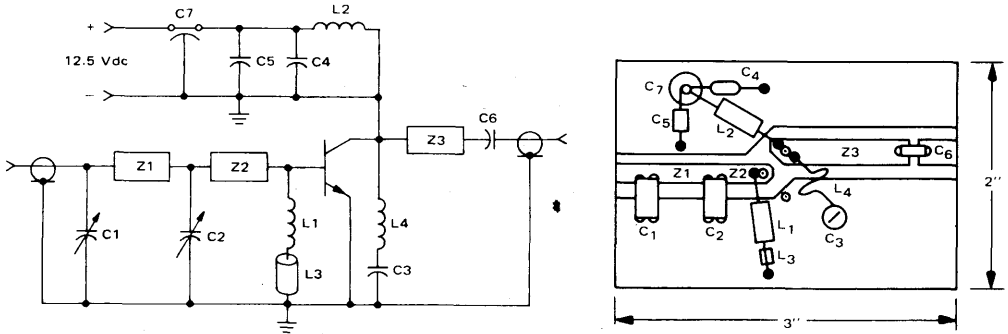
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 14.3	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $I_B = 0$)	I_{CEO}	—	—	10	μ Adc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	60	150	—
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc, $f = 200$ MHz)	f_T	1800	2000	—	MHz
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	3.5	4.0	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.75$ W, $f = 470$ MHz)	G_{PE}	8.0	8.5	—	dB
Collector Efficiency ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.75$ W, $f = 470$ MHz)	η	50	70	—	%
Series Equivalent Input Impedance ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.75$ W, $f = 470$ MHz)	Z_{in}	—	$14 + j4.0$	—	Ohms
Series Equivalent Output Impedance ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.75$ W, $f = 470$ MHz)	Z_{out}	—	$28 - j38$	—	Ohms

FIGURE 1 - 470 MHz TEST CIRCUIT



- C1, C2, C3 - 1.0-10 pF JOHANSON
 C4 - 0.1 μ F disc
 C5 - 1.0 μ F TANTULAM
 C6 - 0.018 μ F chip
 C7 - 1000 pF Feedthru
 L1, L2 - 0.15 μ F Choke
 L3 - Bead Ferrite
 Z1, Z2 - 0.09" x 0.5" LINE, $Z_0 = 100 \Omega$
 Z3 - 0.18" x 1.0" LINE, $Z_0 = 50 \Omega$
- BOARD = 0.032" TEFLON GLASS.
 $\epsilon_R = 2.5$

FIGURE 2 - OUTPUT POWER versus INPUT POWER

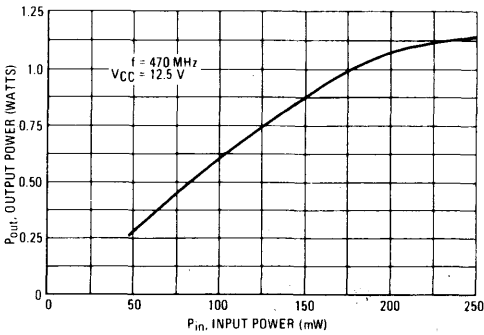


FIGURE 3 - CURRENT-GAIN - BANDWIDTH PRODUCT versus COLLECTOR CURRENT

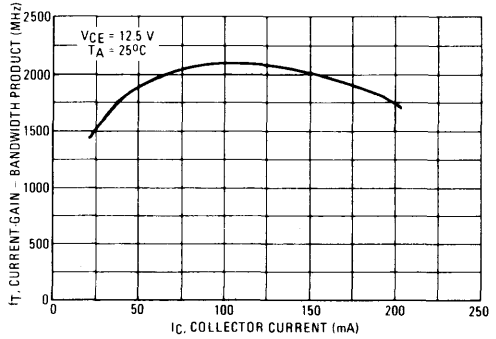


FIGURE 4 - OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE

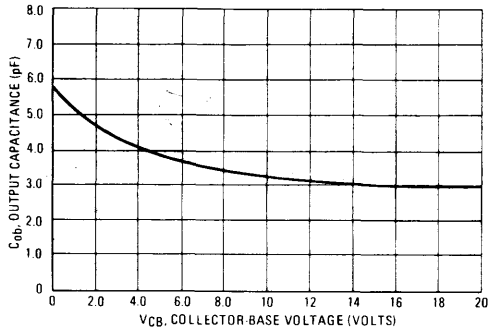


FIGURE 5 – S_{11} and S_{22} versus FREQUENCY

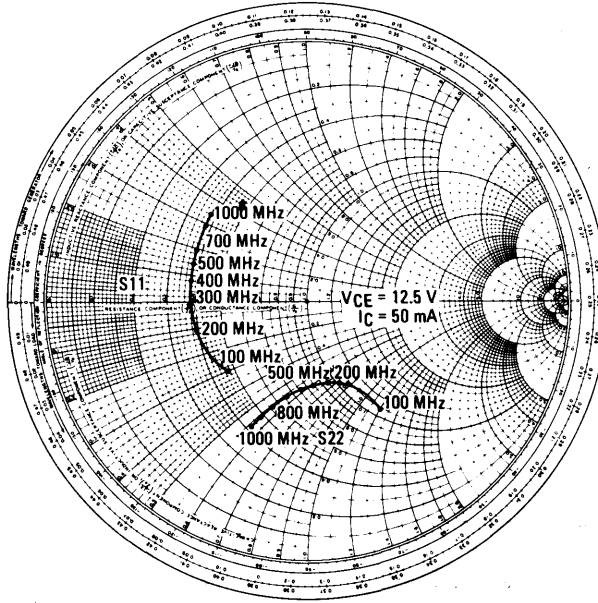


FIGURE 6 – S_{12} versus FREQUENCY

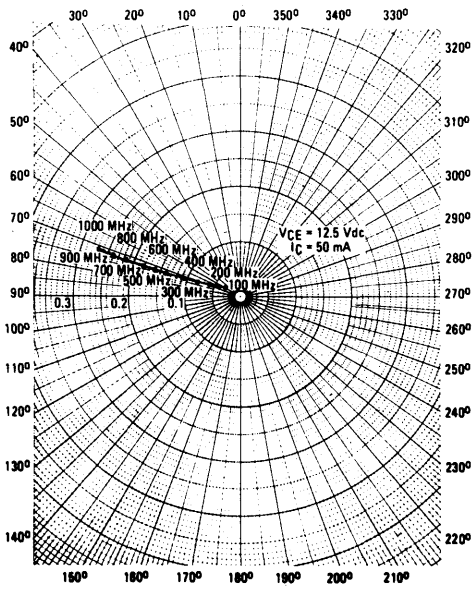
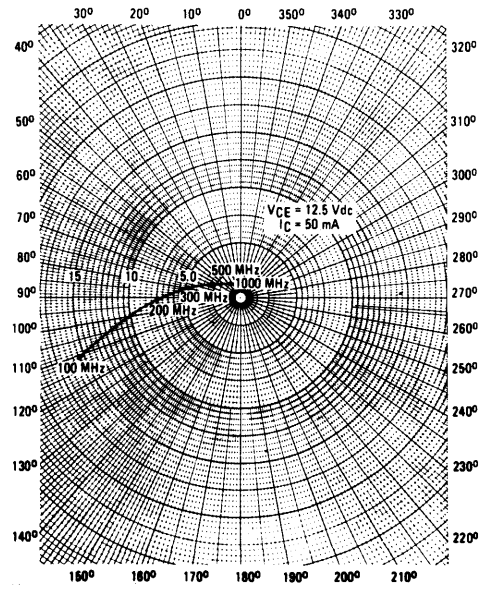


FIGURE 7 – S_{21} versus FREQUENCY



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage ($R_{BE} = 330\Omega$)	V_{CER}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ $T_C = 50^\circ\text{C}$ Derate above 50°C	P_D	2.5 20.0	Watts mW/ $^\circ\text{C}$
Junction Temperature	T_J	+175	$^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ\text{C/W}$

MRF517

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}, R_{BE} = 330 \text{ Ohms}$)	$V_{(BR)CER}$	25	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15 \text{ Vdc}, I_B = 0$)	I_{CEO}	—	—	100	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 60 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	40	—	200	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 60 \text{ mAdc}, V_{CE} = 15 \text{ Vdc}, f = 200 \text{ MHz}$)	f_T	2200	2700	—	MHz
Output Capacitance ($V_{CB} = 15 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)	C_{obo}	—	3.0	4.5	pF

FUNCTIONAL TEST (FIGURE 1)

Common-Emitter Amplifier Power Gain ($V_{CE} = 15 \text{ Vdc}, I_C = 60 \text{ mAdc}, f = 300 \text{ MHz}$)	G_{pe}	—	10	—	dB
Broadband Noise Figure ($V_{CE} = 15 \text{ Vdc}, I_C = 50 \text{ mAdc}, f = 300 \text{ MHz}$)	NF	—	—	7.5	dB
2nd Order Distortion ($V_{CE} = 15 \text{ Vdc}, I_C = 60 \text{ mAdc}, E_{out} = +45 \text{ dBmV}$, Ch 2 + Ch G = 212.5 MHz)	IMD ₂	—	—	-57	dB
NCTA Cross Modulation Distortion, 12 Ch's (2-13) ($V_{CE} = 15 \text{ Vdc}, I_C = 60 \text{ mAdc}, E_{out} = +45 \text{ dBmV}$, Measured at Ch's 2 and 13)	XMD ₁₂	—	—	-57	dB
Triple Beat Distortion, 3 Ch's ($V_{CE} = 15 \text{ Vdc}, I_C = 60 \text{ mAdc}, E_{out} = +45 \text{ dBmV}$, Ch's (4 + 5 + A) = 265 MHz)	TB ₃	—	—	-72	dB

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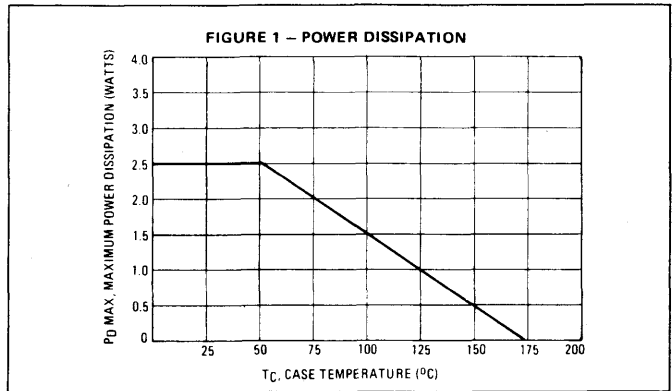
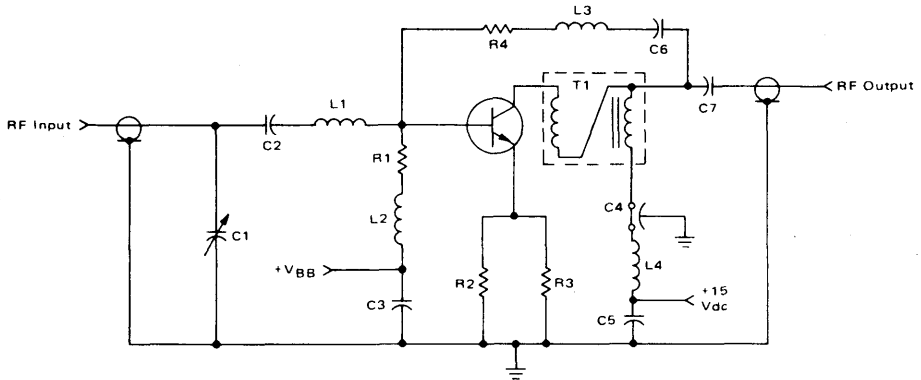


FIGURE 2 - 40 to 330 MHz BROADBAND TEST CIRCUIT SCHEMATIC



- | | | | |
|------------|-----------------------------|--------|--|
| C1 | 1.0 - 10 pF JOHANSON | L4 | VK200 |
| C2, C6, C7 | 0.002 μF Ceramic Disk | T1 | 16:1 Bifilar Wound, #20 AWG Enameled Wire, Wound on a FERROXCUBE 1041T060 4C4 Core |
| C3, C5 | 0.1 μF, 50 Vdc Tantalum | R1 | 4.7 kΩ, 1/4 Watt, 10% |
| C4 | 1000 pF Button | R2, R3 | 27 Ω, 1/4 Watt, 5% |
| L1 | 1 Turn, #20 AWG | R4 | 270 Ω, 1/4 Watt, 5% |
| L2 | 5.6 μH Molded Choke | | |
| L3 | 4 Turns, #20 AWG, 1/4" I.D. | | |

Input/Output Connectors - Type F
Z₀ = 75 Ohms

FIGURE 3 – TYPICAL RESPONSE CURVE
(See Figure 2)

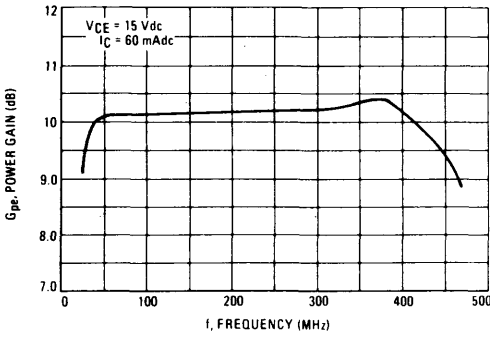


FIGURE 4 – COMMON-EMITTER POWER GAIN
versus FREQUENCY

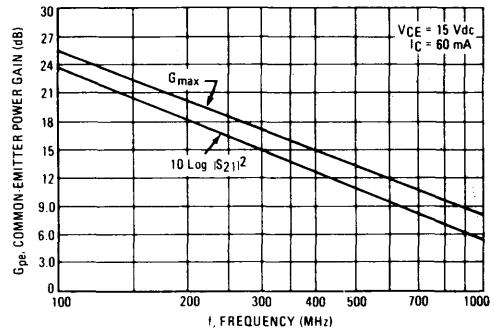


FIGURE 5 – CURRENT GAIN BANDWIDTH PRODUCT
versus COLLECTOR CURRENT

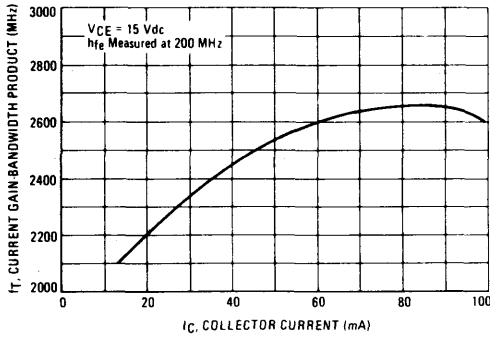


FIGURE 6 – INPUT CAPACITANCE versus
EMITTER-BASE VOLTAGE

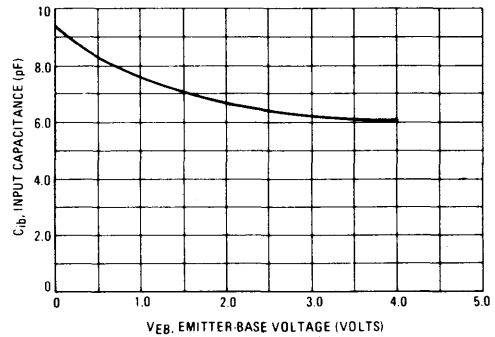


FIGURE 7 – OUTPUT CAPACITANCE versus
COLLECTOR-BASE VOLTAGE

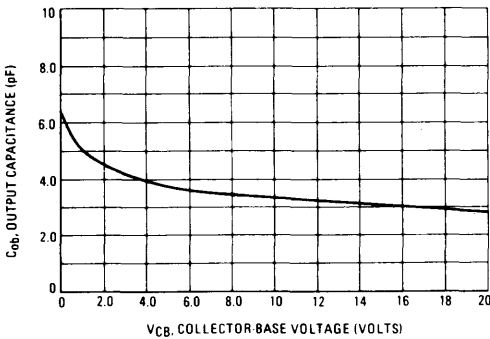


FIGURE 8 – BROADBAND NOISE FIGURE versus
COLLECTOR CURRENT

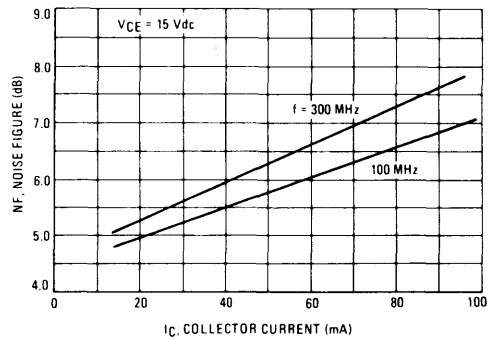


FIGURE 9 – 2nd ORDER DISTORTION ($f_1 \pm f_2$) versus COLLECTOR CURRENT

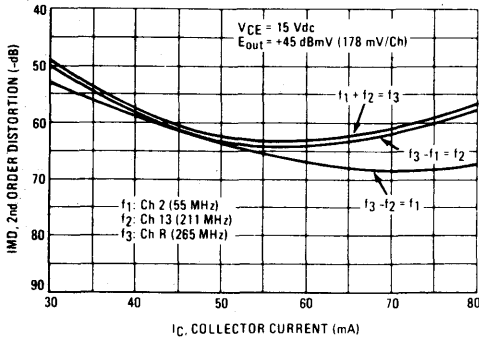


FIGURE 10 – 12-CHANNEL CROSS MODULATION DISTORTION versus COLLECTOR CURRENT

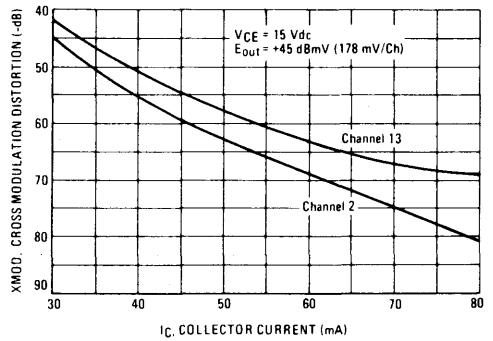


FIGURE 11 – DIN 45004 CROSS-MODULATION DISTORTION

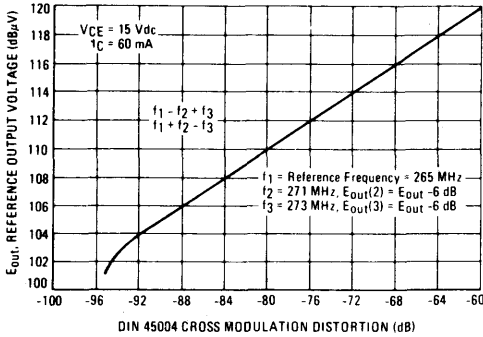


FIGURE 12 – TRIPLE BEAT DISTORTION ($f_1 + f_2 + f_3$) versus COLLECTOR CURRENT

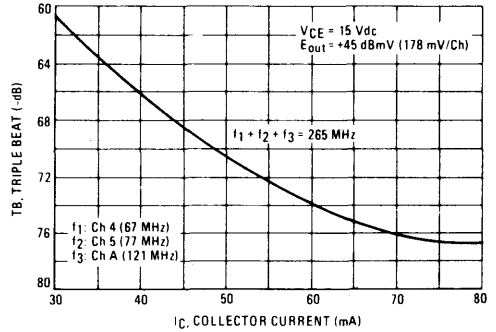
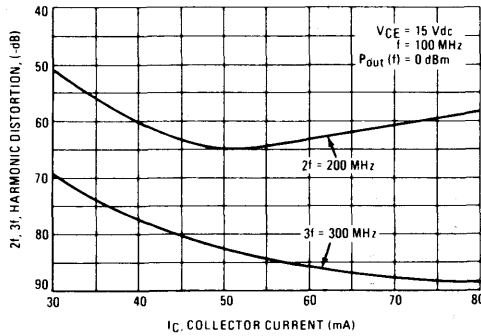


FIGURE 13 – HARMONIC DISTORTION (2f, 3f) versus COLLECTOR CURRENT



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VCE (Volts)	Ic (mA)	Frequency (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
5	30	100	0.538	-152	12.821	100	0.043	49	0.381	-102
		200	0.546	-173	6.612	86	0.064	55	0.314	-121
		400	0.557	163	3.440	71	0.105	60	0.315	-132
		600	0.602	147	2.357	59	0.144	61	0.360	-140
		800	0.625	136	1.872	46	0.181	59	0.437	-143
		1000	0.626	120	1.614	34	0.211	57	0.482	-144
	60	100	0.532	-160	13.475	98	0.040	54	0.362	-111
		200	0.542	-178	6.850	86	0.063	60	0.314	-130
		400	0.558	160	3.586	72	0.109	63	0.313	-140
		600	0.602	145	2.475	60	0.151	62	0.353	-146
		800	0.619	134	1.962	48	0.190	59	0.423	-147
		1000	0.616	118	1.706	35	0.221	57	0.464	-147
	90	100	0.532	-163	13.530	98	0.038	57	0.354	-115
		200	0.545	179	6.908	85	0.063	62	0.313	-133
		400	0.558	159	3.607	72	0.111	64	0.312	-143
		600	0.604	145	2.489	61	0.153	63	0.352	-148
		800	0.620	133	1.982	48	0.193	59	0.419	-149
		1000	0.614	117	1.721	35	0.224	57	0.455	-148
10	30	100	0.500	-145	14.176	102	0.040	50	0.386	-87
		200	0.502	-170	7.358	87	0.059	55	0.304	-105
		400	0.512	164	3.819	71	0.097	61	0.304	-118
		600	0.559	149	2.593	59	0.133	62	0.356	-128
		800	0.583	137	2.033	46	0.166	60	0.442	-134
		1000	0.584	122	1.724	34	0.194	59	0.497	-137
	60	100	0.487	-154	14.977	100	0.037	55	0.353	-96
		200	0.498	-174	7.715	86	0.059	60	0.287	-114
		400	0.506	161	4.009	72	0.101	63	0.294	-125
		600	0.553	146	2.731	60	0.139	63	0.341	-133
		800	0.572	135	2.158	47	0.174	60	0.422	-137
		1000	0.569	119	1.835	35	0.202	58	0.475	-139
	90	100	0.486	-157	15.192	99	0.036	57	0.337	-98
		200	0.493	-176	7.764	86	0.058	61	0.280	-116
		400	0.508	160	4.043	72	0.101	64	0.287	-126
		600	0.555	145	2.761	60	0.141	63	0.336	-134
		800	0.574	134	2.184	47	0.176	60	0.417	-138
		1000	0.568	118	1.861	35	0.204	58	0.469	-139
15	30	100	0.465	-153	15.774	100	0.035	56	0.337	-88
		200	0.475	-174	8.091	86	0.056	61	0.274	-105
		400	0.487	161	4.209	71	0.097	64	0.284	-116
		600	0.532	146	2.863	59	0.133	63	0.337	-126
		800	0.551	135	2.249	47	0.167	60	0.425	-132
		1000	0.547	119	1.909	34	0.193	58	0.482	-135
	60	100	0.468	-150	15.650	101	0.036	54	0.354	-87
		200	0.475	-172	8.088	87	0.057	60	0.282	-104
		400	0.486	163	4.178	72	0.096	63	0.290	-116
		600	0.530	147	2.846	60	0.133	63	0.341	-126
		800	0.549	136	2.228	47	0.166	60	0.429	-132
		1000	0.547	120	1.887	34	0.192	59	0.487	-135
	90	100	0.487	-141	14.773	103	0.039	50	0.391	-80
		200	0.486	-167	7.724	87	0.057	55	0.303	-97
		400	0.491	166	3.986	71	0.093	61	0.306	-110
		600	0.537	150	2.694	59	0.127	62	0.359	-122
		800	0.565	138	2.108	45	0.159	60	0.448	-129
		1000	0.566	123	1.779	33	0.185	60	0.507	-134

MRF525

CASE 79-03, STYLE 5
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage $R_{BE} = 330 \Omega$	V_{CER}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ $T_A = 50^\circ\text{C}$ Derate above 50°C	P_D	2.5 0.017	Watts W/ $^\circ\text{C}$
Junction Temperature	T_J	+175	$^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

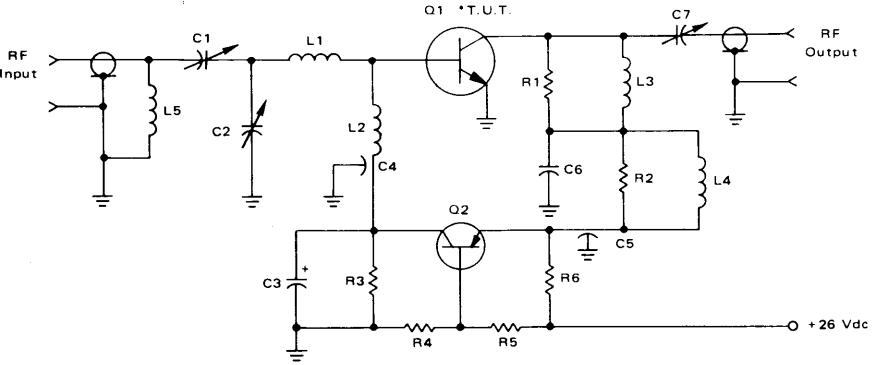
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	60	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}$, $R_{BE} = 330 \text{ Ohms}$)	$V_{(BR)CER}$	25	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mA}$, $I_E = 0$)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mA}$, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	—	100	μA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 80 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	60	—	175	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 200 \text{ MHz}$)	f_T	2.2	2.5	—	GHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	3.0	4.0	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 26 \text{ Vdc}$, $P_{in} = 0 \text{ dBm}$, $f = 400 \text{ MHz}$)	G_{PE}	13	14	—	dB
Broadband Noise Figure ($V_{CE} = 26 \text{ Vdc}$, $f = 400 \text{ MHz}$)	NF	—	—	4.0	dB

FIGURE 1 – 225 to 400 MHz BROADBAND TEST CIRCUIT SCHEMATIC



- C1, C2 – 2.5-11 pF Erie Ceramic Variable
- C3 – 47 μ F 6.0 Volt Electrolytic
- C4, C5 – 1000 pF Feedthru
- C6 – 470 pF Ceramic Chip
- C7 – 5.5-18 pF Erie Ceramic Variable
- R1 – 150 Ω 1/8 Watt Carbon
- R2 – 100 Ω 1/8 Watt Carbon
- R3, R4 – 10 k Ω 1/8 Watt Carbon
- R5 – 3.3 k Ω 1/8 Watt Carbon
- R6 – 120 Ω 1/2 Watt Carbon
- L1 – 1 Turn #24, 0.125 mil ID
- L2, L4 – 0.47 μ H Molded Choke
- L3 – 2 Turns #24, 0.125 mil ID
- L5 – 4 Turns #24, 0.125 mil ID
- Q2 – 2N2907A
- *Transistor Under Test
- I_E = 47 mA_{Dc} (Nominal)

FIGURE 2 – COMMON-EMITTER POWER GAIN (G_{max}) versus FREQUENCY

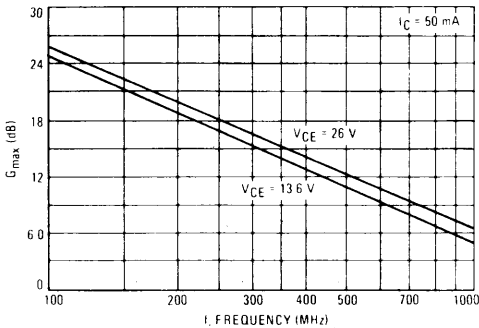


FIGURE 3 – CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT

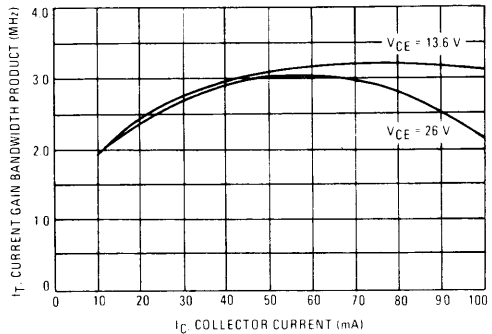


FIGURE 4 – BROADBAND AMPLIFIER RESPONSE

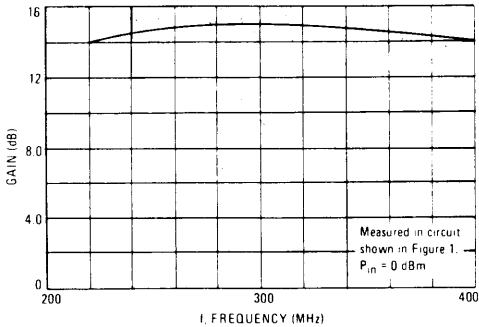


FIGURE 5 – 1.0 dB GAIN COMPRESSION OUTPUT versus FREQUENCY

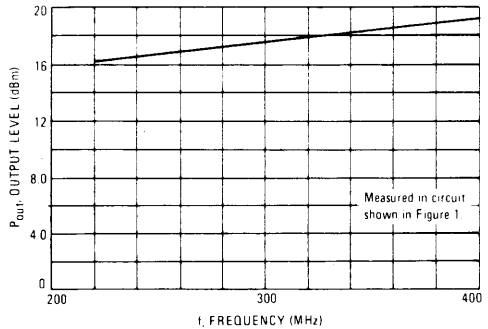
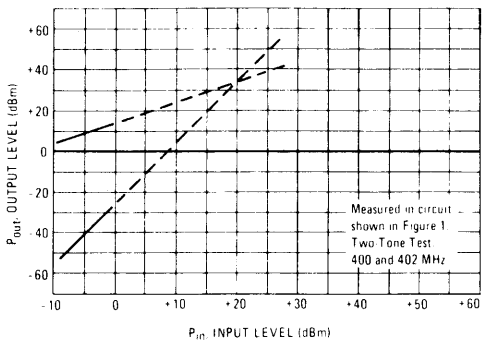


FIGURE 6 - THIRD ORDER INTERCEPT



S-PARAMETERS

VCE (Volts)	IC (mA)	Frequency (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
13.6	10	100	0.388	-111	12.318	107	0.032	61	0.597	-24
		200	0.331	-151	6.768	88	0.049	68	0.480	-25
		300	0.337	-171	4.650	77	0.072	73	0.443	-31
		400	0.344	176	3.580	68	0.096	78	0.442	-40
		500	0.349	166	2.889	59	0.125	80	0.459	-47
	20	100	0.287	-125	14.160	103	0.030	67	0.516	-24
		200	0.263	-160	7.585	86	0.053	73	0.414	-23
		300	0.275	-177	5.167	76	0.078	76	0.378	-30
		400	0.288	172	3.968	68	0.104	77	0.378	-38
		500	0.293	164	3.214	60	0.135	78	0.396	-45
	50	100	0.206	-140	15.745	99	0.029	74	0.446	-24
		200	0.208	-171	8.299	84	0.056	76	0.358	-21
		300	0.226	176	5.612	75	0.084	76	0.324	-27
		400	0.235	169	4.307	68	0.113	77	0.326	-36
		500	0.243	161	3.488	60	0.114	76	0.345	-42
	100	100	0.179	-151	15.931	98	0.029	77	0.430	-22
		200	0.187	-177	8.293	85	0.058	80	0.358	-19
		300	0.203	171	5.626	77	0.087	80	0.330	-25
		400	0.212	164	4.276	70	0.115	80	0.338	-33
		500	0.213	157	3.456	63	0.147	79	0.364	-39
26	10	100	0.454	-100	13.580	105	0.027	58	0.625	-15
		200	0.313	-138	7.339	88	0.040	67	0.552	-17
		300	0.291	-161	4.989	78	0.060	76	0.532	-23
		400	0.287	-175	3.826	70	0.080	84	0.544	-30
		500	0.287	173	3.096	63	0.106	89	0.570	-36
	20	100	0.313	-105	15.191	102	0.025	62	0.566	-14
		200	0.220	-144	8.086	87	0.044	73	0.509	-15
		300	0.213	-166	5.487	77	0.067	78	0.489	-20
		400	0.215	-178	4.204	71	0.092	83	0.498	-28
		500	0.214	170	3.404	64	0.116	86	0.523	-34
	50	100	0.165	-117	16.375	102	0.026	71	0.529	-14
		200	0.139	-157	8.695	87	0.048	78	0.471	-14
		300	0.151	-176	5.882	78	0.073	80	0.449	-20
		400	0.157	173	4.494	71	0.098	82	0.458	-27
		500	0.158	164	3.659	65	0.124	84	0.485	-32
	100	100	0.215	-147	13.156	103	0.023	72	0.602	-14
		200	0.212	-176	7.220	88	0.044	82	0.536	-17
		300	0.222	171	4.951	79	0.069	84	0.507	-24
		400	0.230	164	3.851	72	0.093	87	0.513	-31
		500	0.233	156	3.123	64	0.123	89	0.534	-36

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MRF531

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 14.3	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	70	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	100	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}$, $I_E = 0$)	$V_{(BR)CBO}$	100	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 75 \text{ Vdc}$, $V_{BE} = 0$)	I_{CES}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	25	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 25 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	500	800	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	—	4.0	pF
Input Capacitance ($V_{BE} = 3.0 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{ibo}	—	9.0	—	pF

MRF531

FIGURE 1 – CURRENT-GAIN – BANDWIDTH PRODUCT

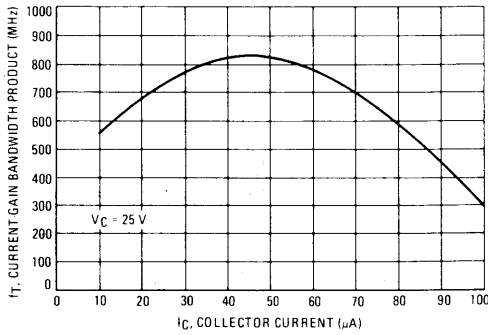


FIGURE 2 – INPUT CAPACITANCE

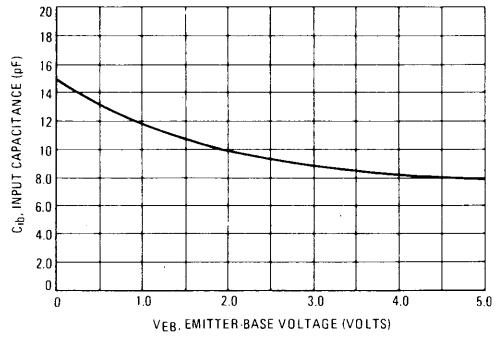


FIGURE 3 – OUTPUT CAPACITANCE

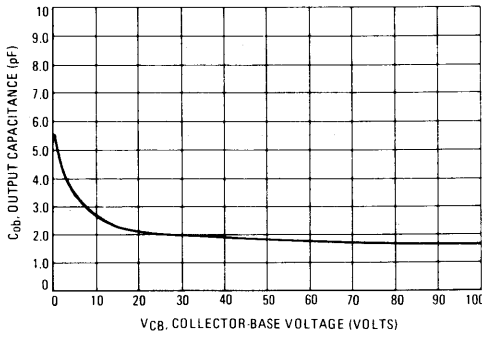
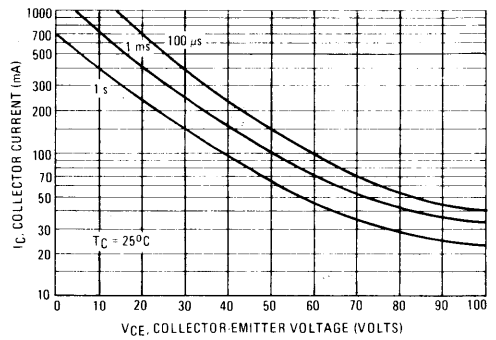


FIGURE 4 – DC SAFE OPERATING AREA



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MRF532

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	80	Volts
Collector-Base Voltage	V _{CBO}	80	Volts
Emitter-Base Voltage	V _{EBO}	3.5	Volts
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 14.3	Watts mW/°C
Storage Temperature	T _{stg}	-60 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	70	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 10 mA)	V(BR)CEO	80	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 0.1 mA)	V(BR)CBO	80	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 0.1 mA)	V(BR)EBO	3.5	—	V _{dc}
Collector Cutoff Current (V _{CE} = 75 V)	I _{CES}	—	10	μA _{dc}
ON CHARACTERISTICS				
DC Current Gain (I _C = 5.0 mA, V _{CE} = 10 V)	h _{FE}	25	—	—
Collector-Emitter Saturation Voltage (I _C = 10 mA, I _B = 1.0 mA)	V _{CE(sat)}	—	1.0	V _{dc}
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 50 mA, V _{CE} = 25 V, f = 100 MHz)	f _T	500	—	MHz
Output Capacitance (V _{CB} = 10 V, f = 1.0 MHz)	C _{obo}	—	4.0	pF

MRF534, MRF536 For Specifications, See MM4049 Data.

MRF559

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON



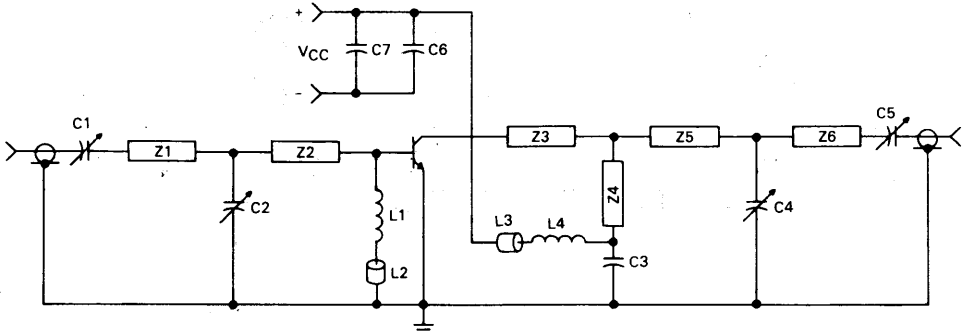
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ $T_C = 50^\circ\text{C}$ Derate above 50°C	P_D	2.0 20	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	18	—	—	Vdc	
Collector-Base Breakdown Voltage ($I_C = 100$ μ Adc, $I_E = 0$)	$V_{(BR)CBO}$	36	—	—	Vdc	
Emitter-Base Breakdown Voltage ($I_E = 100$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc	
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$)	I_{CES}	—	—	1.0	mAdc	
ON CHARACTERISTICS						
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	90	200	—	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc, $f = 200$ MHz)	f_T	—	3000	—	MHz	
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	2.0	2.5	pF	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W)	G_{PE}	$f = 870$ MHz $f = 512$ MHz	8.0 —	9.5 13	— —	dB
Collector Efficiency (Figure 1) ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W)	η	$f = 870$ MHz $f = 512$ MHz	50 —	65 60	— —	%
TYPICAL PERFORMANCE @ $V_{CC} = 7.5$ V						
Common-Emitter Amplifier Power Gain ($V_{CC} = 7.5$ Vdc, $P_{out} = 0.5$ W)	G_{PE}	$f = 870$ MHz $f = 512$ MHz	— —	6.5 10	— —	dB
Collector Efficiency ($V_{CC} = 7.5$ Vdc, $P_{out} = 0.5$ W)	η	$f = 870$ MHz $f = 512$ MHz	— —	70 65	— —	%

FIGURE 1 — 870 MHz TEST FIXTURE



- | | |
|--|-----------------------|
| C1, C2, C4, C5 — 1.0–10 pF Johanson | Z1 — 50 Ω 1.5 cm |
| C3, C6 — 0.001 μF Chip Capacitor | Z2 — 30 Ω 2.5 cm |
| C7 — 1.0 μF Tantalum | Z3 — 50 Ω 2.0 cm |
| L1, L4 — 4 Turns #26 AWG, 0.3 cm ID, 0.4 cm Long | Z4 — 50 Ω 1.2 cm |
| L2, L3 — Ferrite Bead | Z5, Z6 — 50 Ω 1.25 cm |
| Microstrip Elements — $\epsilon_r = 1.0$ | |

FIGURE 2 — OUTPUT POWER versus INPUT POWER
f = 512 MHz

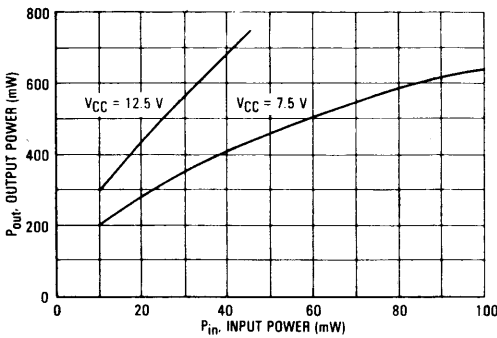


FIGURE 3 — OUTPUT POWER versus FREQUENCY
VCC = 7.5 V

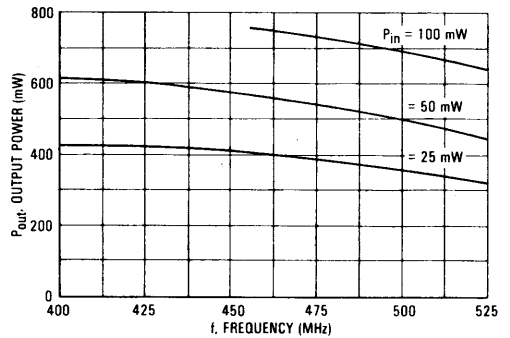


FIGURE 4 — OUTPUT POWER versus COLLECTOR VOLTAGE
f = 512 MHz

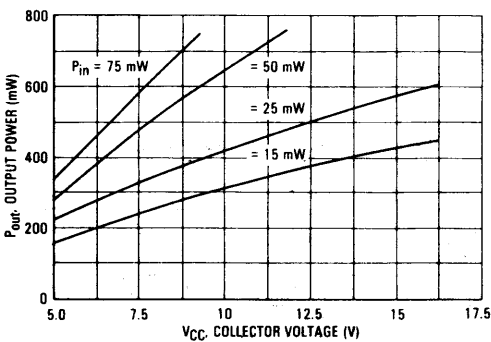


FIGURE 5 — OUTPUT POWER versus FREQUENCY
VCC = 12.5 V

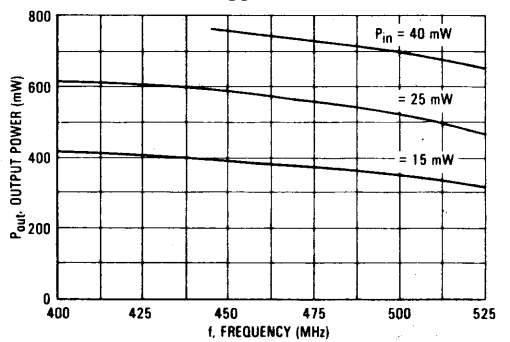


FIGURE 6 — Z_{in} AND Z_{OL}^* versus COLLECTOR VOLTAGE, INPUT POWER, AND OUTPUT POWER

f FREQUENCY MHz	Z_{in} OHMS			Z_{OL}^* OHMS					
	$V_{CC} = 7.5-12.5\text{ V}$			$V_{CC} = 7.5\text{ V}$			$V_{CC} = 12.5\text{ V}$		
	15 mW	25 mW	50 mW	0.25 W	0.50 W	0.75 W	0.25 W	0.50 W	0.75 W
400	4.3 - j13.3	4.9 - j11.0	5.7 - j8.7	31 - j49	44 - j34	42 - j4.9	20 - j68	42 - j60	52 - j54
440	3.9 - j8.8	4.5 - j8.7	5.4 - j6.9	27 - j42	39 - j30	40 - j6.9	19 - j62	37 - j54	49 - j50
480	3.5 - j4.4	4.1 - j6.5	5.0 - j4.3	24 - j36	36 - j25	39 - j9.0	18 - j56	33 - j48	47 - j46
520	3.2 - j2.2	3.8 - j4.3	4.7 - j1.7	22 - j30	34 - j20	37 - j12	17 - j52	31 - j44	47 - j42

* Z_{OL}^* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

FIGURE 7 — OUTPUT POWER versus INPUT POWER
f = 870 MHz

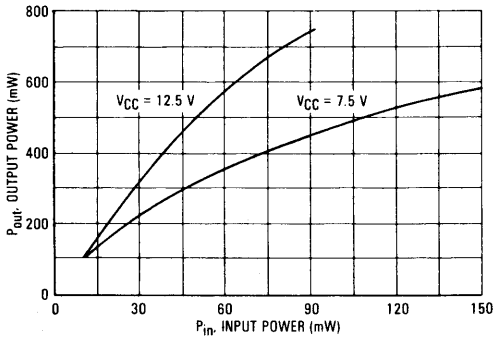


FIGURE 8 — OUTPUT POWER versus FREQUENCY
 $V_{CC} = 7.5\text{ V}$

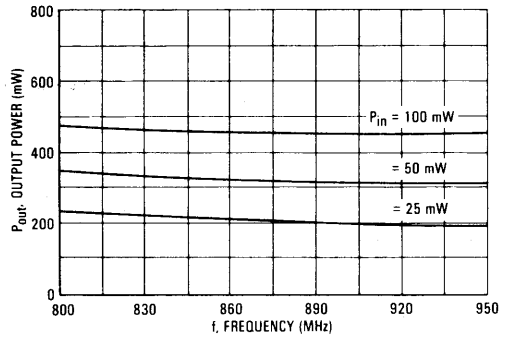


FIGURE 9 — OUTPUT POWER versus COLLECTOR VOLTAGE
f = 870 MHz

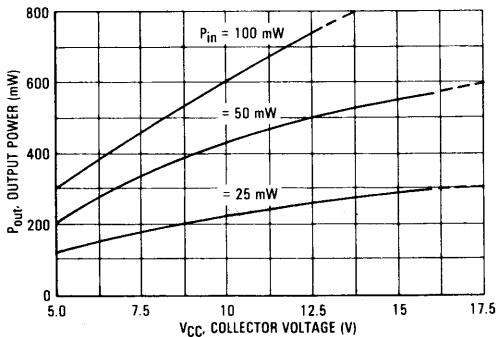


FIGURE 10 — OUTPUT POWER versus FREQUENCY
 $V_{CC} = 12.5\text{ V}$

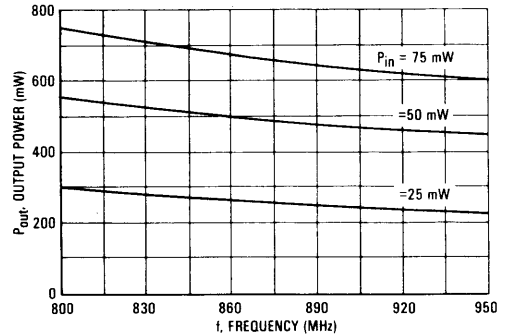
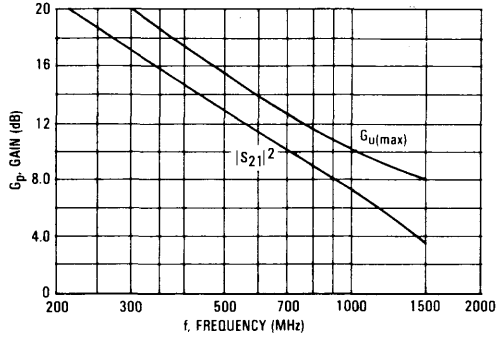


FIGURE 11 — Z_{in} AND Z_{OL} versus COLLECTOR VOLTAGE, INPUT POWER, AND OUTPUT POWER

f FREQUENCY MHz	Z_{in} OHMS			Z_{OL}^* OHMS					
	$V_{CC} = 7.5-12.5\text{ V}$			$V_{CC} = 7.5\text{ V}$			$V_{CC} = 12.5\text{ V}$		
	25 mW	50 mW	100 mW	0.25 W	0.50 W	0.75 W	0.25 W	0.50 W	0.75 W
800	2.9 + j2.2	3.8 + j4.4	4.7 + j6.5	15.0 - j36.8	22.7 - j30.6	27.1 - j22.6	14.6 - j43.6	17.2 - j39.7	23.4 - j37.7
850	3.2 + j3.5	3.8 + j5.2	4.8 + j7.4	15.7 - j35.3	23.9 - j28.7	27.3 - j21.5	16.3 - j40.8	17.8 - j39.5	23.7 - j36.8
900	3.8 + j5.7	4.4 + j7.0	5.4 + j8.7	16.4 - j33.7	25.1 - j27.0	27.5 - j20.5	17.3 - j38.2	18.3 - j39.3	23.9 - j36.0
950	4.1 + j7.4	4.5 + j8.8	5.5 + j10.1	17.0 - j32.2	26.3 - j25.2	27.6 - j19.4	17.2 - j36.1	20.1 - j38.5	24.5 - j35.6

* Z_{OL}^* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

FIGURE 12 — GAIN versus FREQUENCY
 $V_{CE} = 10 \text{ V}$, $I_C = 50\text{-}100 \text{ mA}$



$$G_{u(max)} = \frac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$$

FIGURE 13 — GAIN versus COLLECTOR CURRENT
 $V_{CE} = 10 \text{ V}$

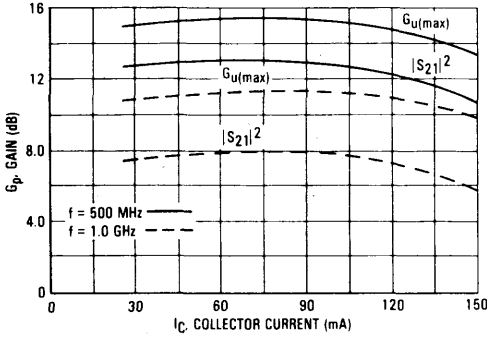


FIGURE 14 — NOISE FIGURE AND ASSOCIATED GAIN
 versus COLLECTOR CURRENT
 $V_{CE} = 10 \text{ V}$

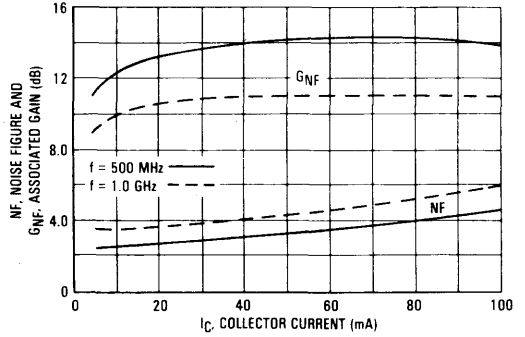


FIGURE 15 — CURRENT GAIN BANDWIDTH PRODUCT
 versus COLLECTOR CURRENT
 $V_{CE} = 10 \text{ V}$

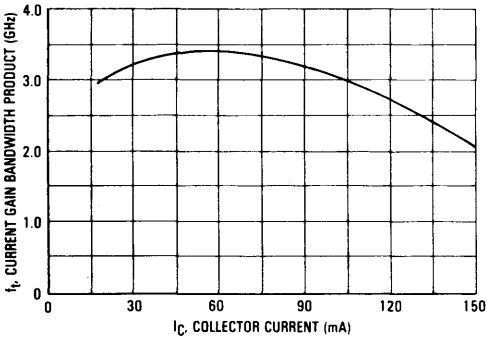


FIGURE 16 — OUTPUT CAPACITANCE versus
 COLLECTOR BASE VOLTAGE

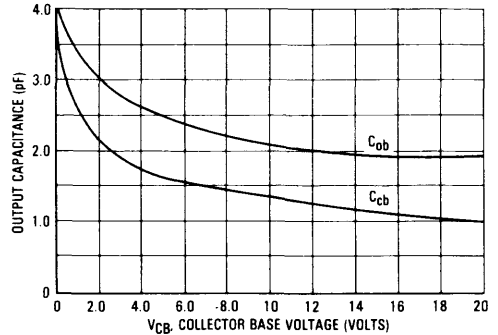


FIGURE 17 — COMMON EMITTER SCATTERING PARAMETERS

VCE (Volts)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
5.0	10	250	0.72	-161	6.20	93	0.057	30	0.30	-91
		500	0.73	179	3.16	76	0.069	43	0.27	-94
		1000	0.76	158	1.62	55	0.105	63	0.27	-119
		1500	0.82	142	1.08	41	0.155	70	0.41	-137
	25	250	0.70	-173	7.17	89	0.045	47	0.26	-123
		500	0.70	172	3.63	75	0.073	60	0.20	-128
		1000	0.74	152	1.90	54	0.134	67	0.21	-157
		1500	0.79	136	1.32	39	0.196	66	0.32	-167
	50	250	0.72	-178	7.63	89	0.038	56	0.27	-139
		500	0.72	170	3.85	77	0.068	67	0.23	-141
		1000	0.75	153	2.01	59	0.129	72	0.23	-162
		1500	0.81	137	1.40	46	0.188	70	0.32	-164
	100	250	0.73	179	7.34	88	0.036	61	0.26	-143
		500	0.74	169	3.70	77	0.067	71	0.22	-144
		1000	0.76	153	1.94	59	0.130	74	0.24	-166
		1500	0.81	138	1.36	46	0.191	71	0.32	-167
	150	250	0.78	176	5.19	92	0.033	64	0.22	-131
		500	0.78	167	2.76	78	0.065	74	0.21	-131
		1000	0.80	151	1.49	58	0.129	77	0.24	-155
		1500	0.85	135	1.05	45	0.191	73	0.35	-161
10	10	250	0.69	-157	7.03	94	0.050	33	0.34	-67
		500	0.70	-178	3.59	77	0.060	46	0.32	-69
		1000	0.74	160	1.84	55	0.094	67	0.29	-94
		1500	0.81	142	1.20	41	0.148	76	0.42	-121
	25	250	0.67	-168	8.30	91	0.039	46	0.24	-93
		500	0.68	176	4.25	77	0.060	60	0.21	-89
		1000	0.72	158	2.19	57	0.109	71	0.19	-114
		1500	0.78	142	1.47	44	0.165	74	0.31	-134
	50	250	0.68	-174	8.88	90	0.035	55	0.21	-110
		500	0.68	172	4.49	77	0.060	67	0.18	-104
		1000	0.72	155	2.31	59	0.113	74	0.17	-128
		1500	0.77	139	1.58	46	0.169	74	0.28	-140
	100	250	0.68	-178	8.49	89	0.03	61	0.19	-104
		500	0.69	170	4.32	76	0.06	71	0.17	-97
		1000	0.72	153	2.25	58	0.12	76	0.17	-123
		1500	0.78	137	1.53	44	0.18	75	0.28	-137
	150	250	0.72	178	6.53	91	0.029	64	0.22	-71
		500	0.73	169	3.37	77	0.056	75	0.24	-75
		1000	0.76	152	1.79	57	0.112	80	0.22	-105
		1500	0.83	137	1.22	43	0.175	79	0.34	-129

FIGURE 18 — TUNABLE TEST FIXTURE

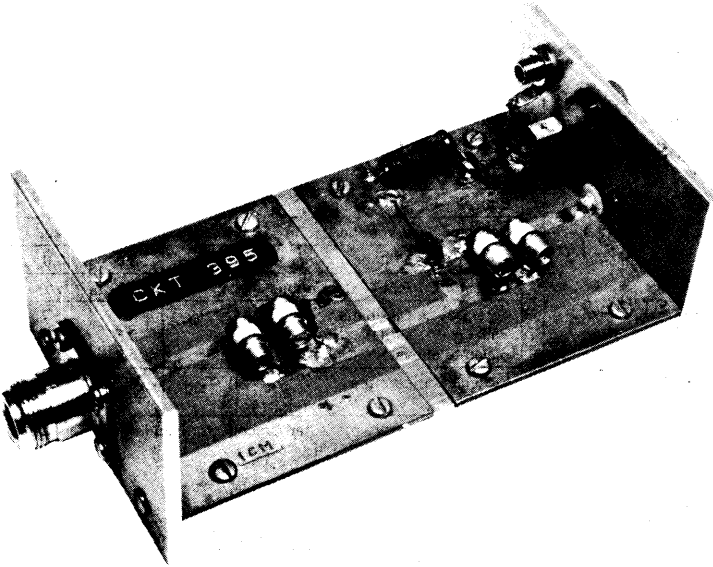
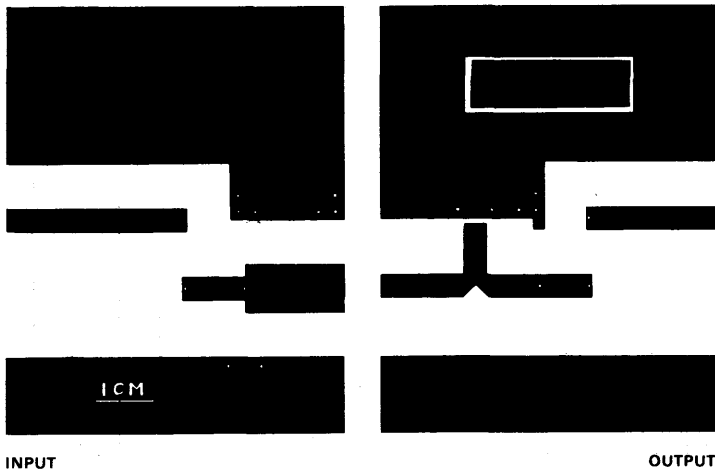


FIGURE 19 — PRINTED CIRCUIT BOARD LAYOUT



MRF571 MRF572 MRF573



MRF571
CASE 317-01, STYLE 2



MRF572
CASE 303-01, STYLE 1



MRF573
CASE 358-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MRF571	MRF572	MRF573	Unit
Collector-Emitter Voltage	V _{CEO}	10	10	10	V _{dc}
Collector-Base Voltage	V _{CBO}	20	20	20	V _{dc}
Emitter-Base Voltage	V _{EBO}	3.0	3.0	3.0	V _{dc}
Collector Current — Continuous	I _C	70	70	70	mAdc
Total Device Dissipation @ T _C = 100°C(1) Derate above 100°C	P _D	0.5 5.0	0.75 7.5	0.75 7.5	Watts mW/°C
Storage Temperature	T _{stg}	-65 to +150	-65 to +200	-65 to +200	°C

(1) Case temperature measured on collector lead immediately adjacent to body of package.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 0.1 mAdc, I _B = 0)	V _{(BR)CEO}	10	12	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 1.0 mAdc, I _E = 0)	V _{(BR)CBO}	20	—	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 50 μAdc, I _C = 0)	V _{(BR)EBO}	2.5	—	—	V _{dc}
Collector Cutoff Current (V _{CB} = 8.0 V _{dc} , I _E = 0)	I _{CBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 30 mAdc, V _{CE} = 5.0 V _{dc})	h _{FE}	50	—	300	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V _{CE} = 8.0 V _{DC} , I _C = 50 mA, f = 1.0 GHz)	f _T	—	8.0	—	GHz
Collector-Base Capacitance (V _{CB} = 6.0 V _{dc} , I _E = 0, f = 1.0 MHz)	C _{cb}	—	.7	1.0	pF
FUNCTIONAL TEST					
Noise Figure (I _C = 5.0 mAdc, V _{CE} = 6.0 V _{dc} , f = .50 GHz) (I _C = 5.0 mAdc, V _{CE} = 6.0 V _{dc} , f = 1.0 GHz) (I _C = 5.0 mAdc, V _{CE} = 6.0 V _{dc} , f = 2.0 GHz) (I _C = 5.0 mAdc, V _{CE} = 6.0 V _{dc} , f = 2.0 GHz)	NF	—	1.0 1.5 2.8 2.5	— 2.0 — —	dB
Gain @ Noise Figure (V _{CE} = 6.0 V _{dc} , I _C = 5.0 mAdc, f = .50 GHz) (V _{CE} = 6.0 V _{dc} , I _C = 5.0 mAdc, f = 1.0 GHz)	G _{NF}	— 10	16.5 12	— —	dB

MRF571 • MRF572 • MRF573

FIGURE 1 — C_{cb} , COLLECTOR-BASE CAPACITANCE versus VOLTAGE

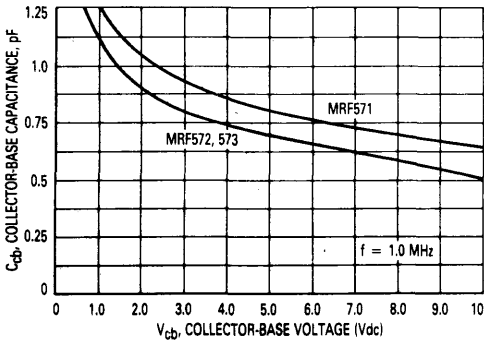


FIGURE 2 — C_{ib} , INPUT CAPACITANCE versus EMITTER BASE VOLTAGE

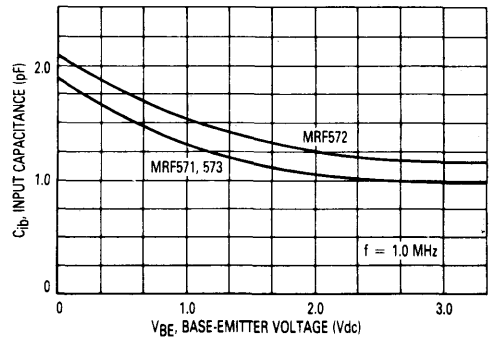


FIGURE 3 — MRF571 — GAIN AT NOISE FIGURE AND NOISE FIGURE versus FREQUENCY

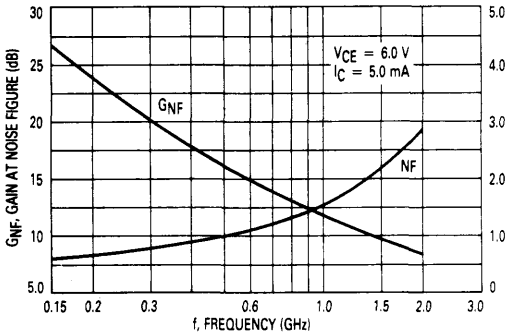


FIGURE 4 — MRF572, MRF573 — GAIN AT NOISE FIGURE AND NOISE FIGURE versus FREQUENCY

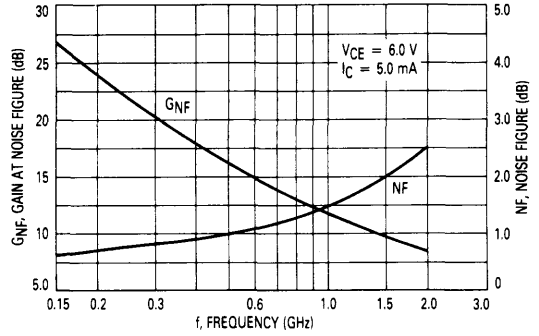


FIGURE 5 — MRF571, MRF572 and MRF573 — GAIN AT NOISE FIGURE AND NOISE FIGURE versus COLLECTOR CURRENT

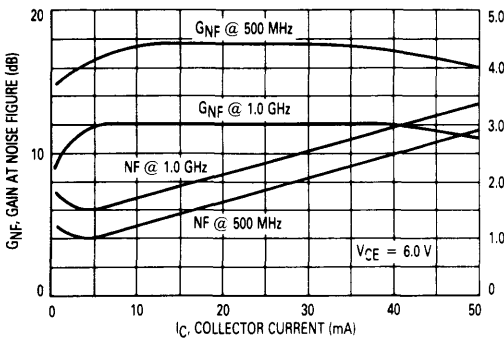
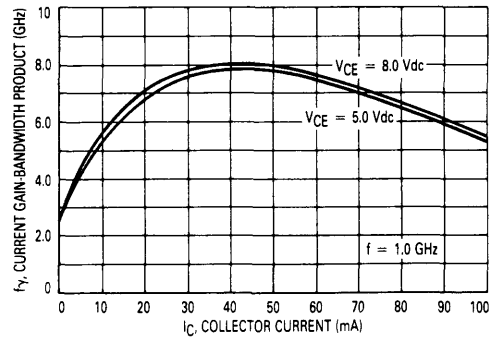


FIGURE 6 — f_T , CURRENT GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT



MRF571 • MRF572 • MRF573

FIGURE 7 — G_A MAX, MAXIMUM AVAILABLE GAIN
versus FREQUENCY

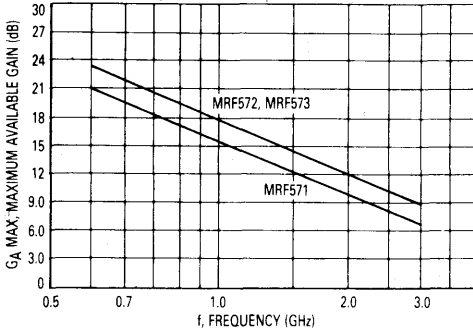


FIGURE 8 — 1.0 dB COMPRESSION PT.
AND THIRD ORDER INTERCEPT

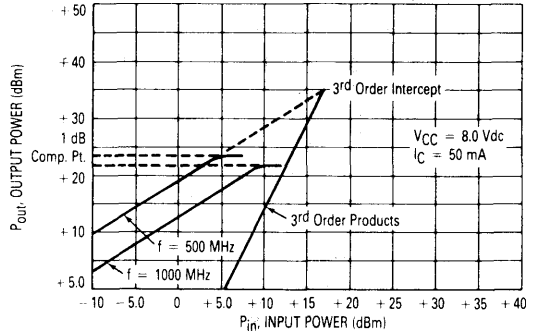


FIGURE 9 — MRF571 — G_{Umax} and $|S_{21}|^2$
versus FREQUENCY

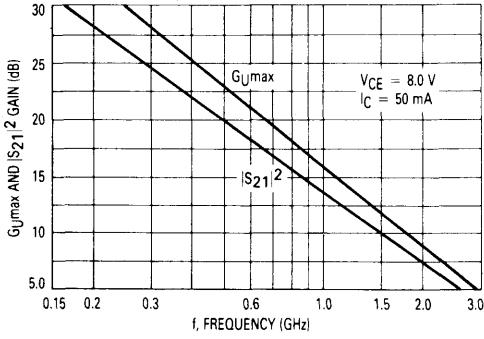
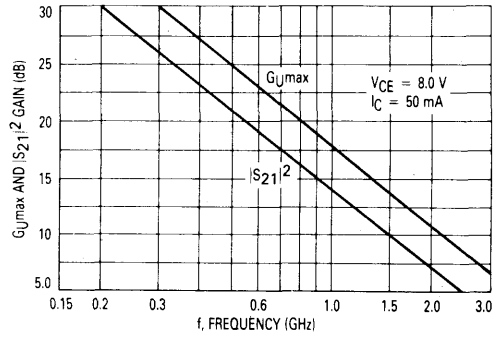
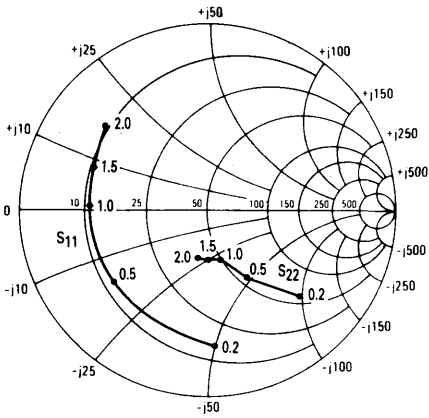


FIGURE 10 — MRF572, MRF573 — G_{Umax} and $|S_{21}|^2$
versus FREQUENCY

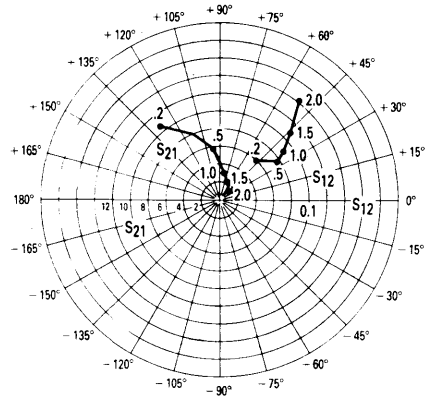


MRF571 • MRF572 • MRF573

MRF571
INPUT/OUTPUT REFLECTION COEFFICIENTS
 versus FREQUENCY (GHz)
 VCE = 6.0 V, IC = 5.0 mA



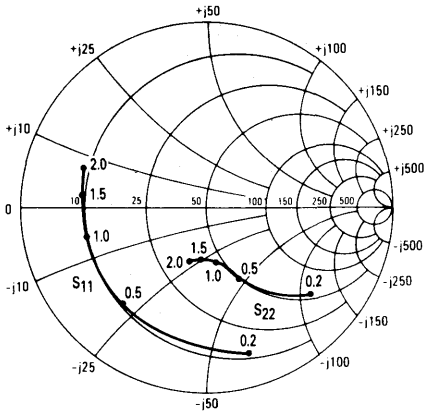
MRF571
FORWARD/REVERSE TRANSMISSION
 COEFFICIENTS versus FREQUENCY (GHz)
 VCE = 6.0 V, IC = 5.0 mA



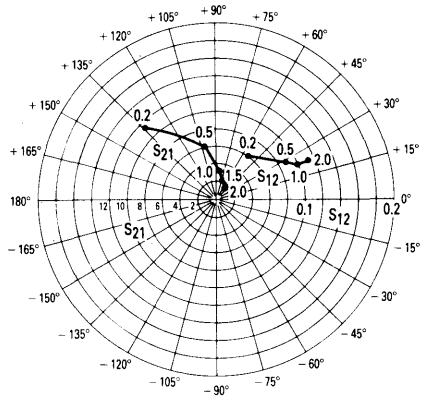
MRF571 COMMON EMITTER S-PARAMETERS

VCE (Volts)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
6.0	5.0	200	0.74	-86	10.5	129	0.06	48	0.69	-42
		500	0.62	-143	5.5	97	0.08	33	0.41	-59
		1000	0.61	178	3.0	78	0.09	37	0.28	-69
		1500	0.65	158	2.0	62	0.11	44	0.26	-88
		2000	0.70	140	1.6	51	0.14	51	0.27	-99
	10	200	0.64	-111	15	118	0.04	44	0.53	-59
		500	0.58	-160	6.9	93	0.06	42	0.27	-77
		1000	0.59	168	3.7	77	0.09	52	0.16	-91
		1500	0.63	151	2.5	64	0.12	56	0.16	-113
		2000	0.67	134	2.0	53	0.16	57	0.16	-118
	50	200	0.56	-160	20.4	102	0.02	57	0.27	-98
		500	0.57	176	8.4	86	0.05	67	0.14	-130
		1000	0.60	156	4.4	75	0.09	70	0.11	-164
		1500	0.62	152	2.9	64	0.13	68	0.13	-175
		2000	0.66	127	2.4	53	0.18	62	0.11	-178
8.0	5.0	200	0.75	-83	10.7	129	0.06	49	0.71	-39
		500	0.62	-140	5.1	98	0.08	34	0.43	-54
		1000	0.60	-179	3.7	78	0.09	38	0.31	-62
		1500	0.64	159	2.1	62	0.10	45	0.29	-80
		2000	0.69	141	1.7	52	0.13	52	0.29	-91
	10	200	0.64	-99	15.1	120	0.05	46	0.54	-60
		500	0.52	-152	7.1	94	0.07	45	0.32	-75
		1000	0.52	170	3.7	76	0.10	54	0.15	-82
		1500	0.52	150	2.5	62	0.13	56	0.16	-108
		2000	0.57	133	2.0	51	0.18	55	0.16	-107
	50	200	0.52	-153	19.6	102	0.03	56	0.28	-92
		500	0.52	178	8.1	86	0.05	67	0.16	-98
		1000	0.56	157	4.1	73	0.10	70	0.06	-130
		1500	0.54	139	2.8	62	0.13	68	0.11	-146
		2000	0.59	126	2.2	52	0.19	63	0.10	-137

MRF572
INPUT/OUTPUT REFLECTION
COEFFICIENTS versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



MRF572
FORWARD/REVERSE COEFFICIENTS
versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA

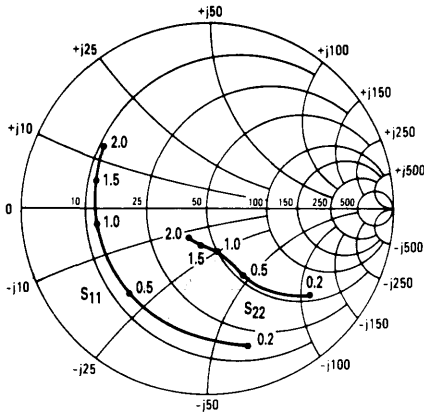


MRF572 COMMON EMITTER S-PARAMETERS

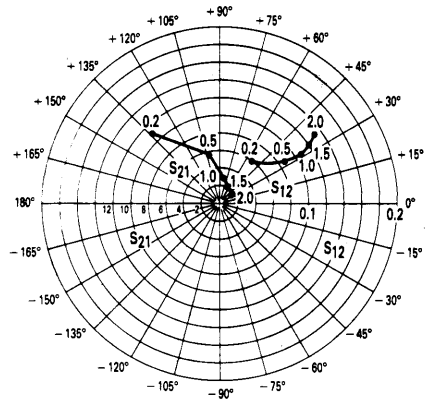
V _{CE} (Volts)	I _C (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂		
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ	
6.0	5.0	200	0.81	-73	10.9	134	0.06	50	0.74	-40	
		500	0.68	-130	6.1	102	0.09	29	0.43	-64	
		1000	0.66	-167	3.3	79	0.10	22	0.29	-77	
		1500	0.66	174	2.3	63	0.10	22	0.27	-94	
		2000	0.68	161	1.8	49	0.11	23	0.29	-104	
		10	200	0.72	-101	15.9	123	0.05	43	0.57	-58
	500	0.66	-150	7.7	95	0.06	30	0.29	-86		
	1000	0.66	-178	4.0	77	0.08	33	0.19	-103		
	1500	0.67	166	2.7	63	0.09	36	0.19	-122		
	2000	0.69	155	2.1	51	0.10	37	0.20	-129		
	50	200	0.67	-154	21.8	104	0.02	43	0.30	-94	
	500	0.68	-177	9.0	87	0.03	52	0.17	-129		
	1000	0.70	167	4.5	74	0.06	58	0.14	-151		
	1500	0.71	157	3.0	62	0.08	59	0.16	-160		
	2000	0.73	148	2.3	51	0.10	55	0.17	-161		
	8.0	5.0	200	0.83	-69	10.9	136	0.06	52	0.75	-36
			500	0.71	-125	6.3	103	0.08	30	0.46	-57
			1000	0.64	-164	3.5	80	0.09	24	0.31	-68
1500			0.65	176	2.4	63	0.10	23	0.29	-84	
2000			0.66	163	1.8	49	0.11	24	0.30	-94	
10			200	0.74	-94	16.2	125	0.05	45	0.60	-51
500		0.65	-146	7.9	96	0.06	32	0.31	-74		
1000		0.64	-176	4.2	77	0.07	33	0.20	-87		
1500		0.65	168	2.8	63	0.09	36	0.19	-104		
2000		0.67	156	2.2	50	0.10	37	0.20	-111		
50		200	0.62	-150	22.7	104	0.02	43	0.30	-81	
500		0.64	-174	9.4	86	0.03	51	0.15	-107		
1000		0.68	167	4.8	74	0.05	58	0.10	-126		
1500		0.69	160	3.2	61	0.07	58	0.13	-140		
2000		0.70	147	2.4	50	0.09	55	0.15	-140		

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MRF573
INPUT/OUTPUT REFLECTION
COEFFICIENTS versus FREQUENCY (GHz)
V_CE = 6.0 V, I_C = 5.0 mA



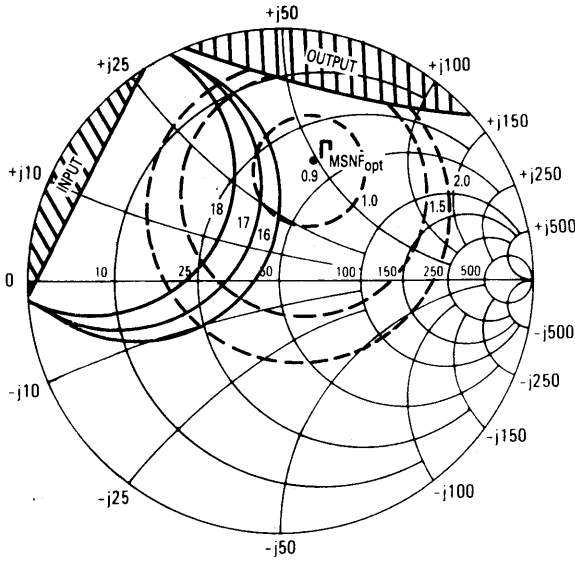
MRF573
FORWARD/REVERSE COEFFICIENTS
versus FREQUENCY (GHz)
V_CE = 8.0 V, I_C = 5.0 mA



MRF573 COMMON EMITTER S-PARAMETERS

V _C E (Volts)	I _C (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ
6.0	5.0	200	0.76	-73	10.6	134	0.06	52	0.72	-40
		500	0.61	-132	6.0	100	0.09	35	0.41	-63
		1000	0.59	-173	3.2	77	0.11	33	0.24	-76
		1500	0.61	165	2.2	59	0.12	35	0.19	-99
		2000	0.64	149	1.8	45	0.13	36	0.18	-117
		5000	0.64	144	2.0	46	0.13	45	0.13	-155
	10	200	0.64	-99	15.1	122	0.05	48	0.56	-55
		500	0.58	-152	7.2	94	0.07	41	0.27	-81
		1000	0.58	175	3.8	74	0.09	45	0.14	-102
		1500	0.60	158	2.6	60	0.12	47	0.13	-135
		2000	0.64	144	2.0	46	0.13	45	0.13	-155
		5000	0.64	144	2.0	46	0.13	45	0.13	-155
	50	200	0.54	-153	19.6	104	0.03	55	0.29	-83
		500	0.56	-179	8.1	85	0.05	62	0.13	-115
		1000	0.59	162	4.1	71	0.09	63	0.08	-157
		1500	0.61	150	2.8	58	0.12	60	0.12	179
		2000	0.65	138	2.1	46	0.13	54	0.14	165
		5000	0.65	138	2.1	46	0.13	54	0.14	165
8.0	5.0	200	0.78	-67	10.6	136	0.06	54	0.75	-36
		500	0.61	-125	6.1	102	0.09	36	0.44	-56
		1000	0.57	-169	3.4	78	0.10	33	0.27	-66
		1500	0.59	168	2.3	60	0.12	35	0.21	-84
		2000	0.62	151	1.8	46	0.14	36	0.19	-100
		5000	0.62	151	1.8	46	0.14	36	0.19	-100
	10	200	0.66	-92	15.3	125	0.05	49	0.60	-49
		500	0.55	-147	7.5	95	0.07	41	0.30	-70
		1000	0.55	178	3.9	75	0.09	45	0.16	-81
		1500	0.57	160	2.7	60	0.12	47	0.12	-109
		2000	0.62	146	2.1	47	0.13	45	0.11	-130
		5000	0.62	146	2.1	47	0.13	45	0.11	-130
	50	200	0.53	-147	20.8	105	0.02	47	0.31	-73
		500	0.53	-176	9.0	87	0.04	57	0.16	-90
		1000	0.57	166	4.5	72	0.07	61	0.06	-110
		1500	0.59	151	3.1	61	0.11	59	0.07	-154
		2000	0.63	143	2.3	49	0.13	55	0.09	-172
		5000	0.63	143	2.3	49	0.13	55	0.09	-172

MRF571 — CONSTANT GAIN and NOISE FIGURE CONTOURS

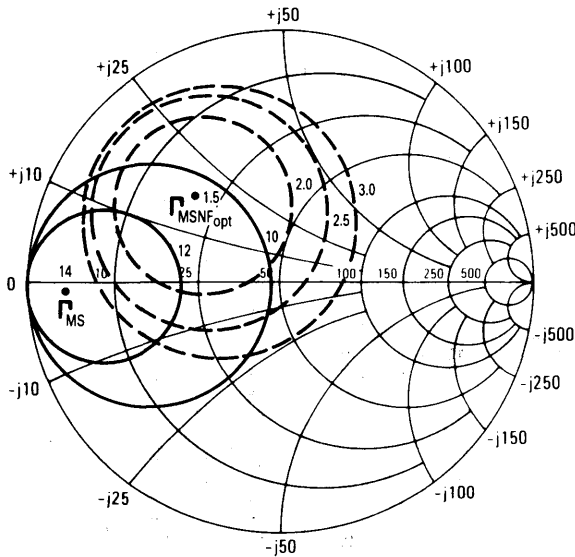


VCE = 6.0 V, IC = 5.0 mA
 f = 500 MHz
 ▨ — REGION OF INSTABILITY

f(GHz)	NFOPT(dB)	Rn (Ω)	NF50 Ω (dB)
0.5	0.9	9.3	1.3

ΓmsNFOPT	K
0.49 ∠74°	0.58

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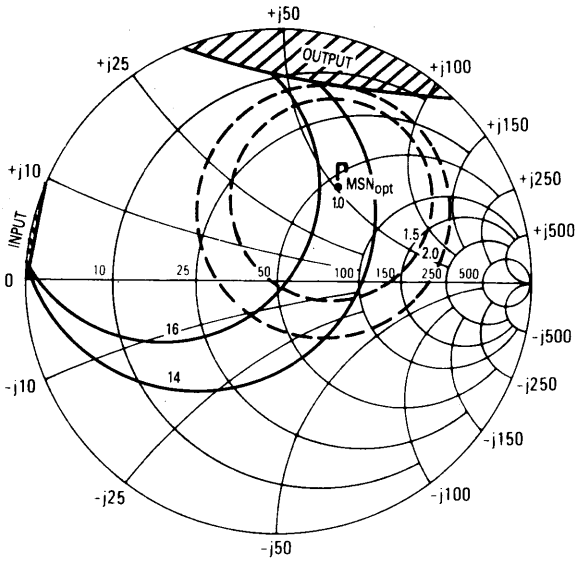


VCE = 6.0 V, IC = 5.0 mA
 f = 1.0 GHz

f(GHz)	NFOPT(dB)	Rn (Ω)	NF50 Ω (dB)	ΓmsNFOPT
1.0	1.5	7.5	2.2	0.48 ∠134°

Γms	ΓmL
0.89 ∠-179°	0.81 ∠66°

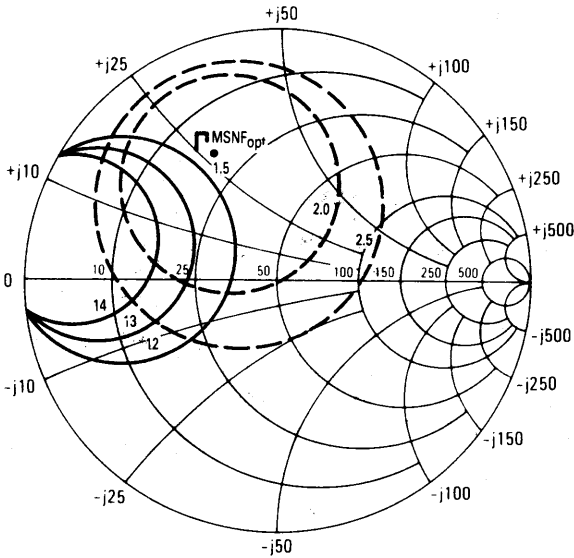
MRF572, MRF573 — CONSTANT GAIN and NOISE FIGURE CONTOURS



$V_{CE} = 6.0 \text{ V}, I = 5.0 \text{ mA}$
 $f = 500 \text{ MHz}$
 ▨ — REGION OF INSTABILITY

f(GHz)	R _n (Ω)	NF (50Ω)	Γ _{msNF_{OPT}}
0.5	17.1	1.5	0.43 ∠ 57°

K	NF _{OPT}
0.55	1.0

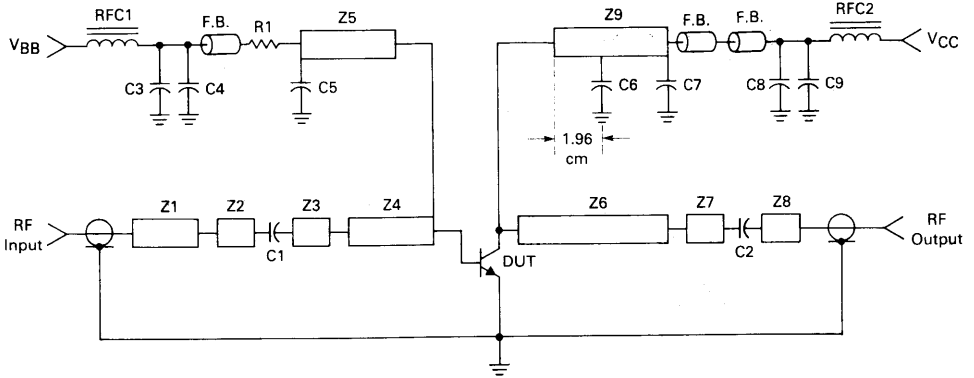


$V_{CE} = 6.0 \text{ V}, I_C = 5.0 \text{ mA}$
 $f = 1.0 \text{ GHz}$

f(GHz)	NF _{OPT}	R _n (Ω)	NF50 (Ω) (dB)
1.0	1.5	6.0	2.0

Γ _{msNF_{OPT}}	K
0.56 ∠ 116°	0.93

MRF571 1.0 GHz TEST CIRCUIT

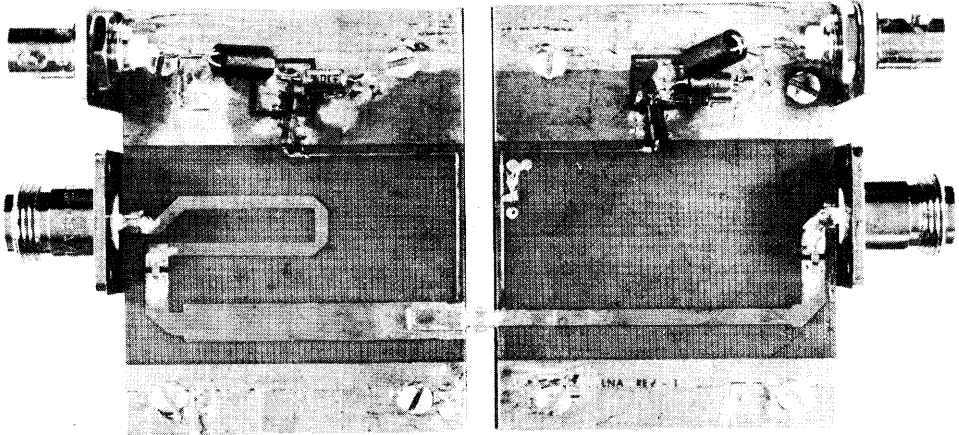


- C1, C2, C6 560 pF Chip Capacitor
- C5, C7 0.018 μ F Chip Capacitor
- C3, C8 0.1 μ F Mylar Capacitor
- C4, C9 1.0 μ F Electrolytic Capacitor
- R1 2.7 k Ω

- RFC1, RFC2 VK-200, Ferroxcube
- Z1-Z9 Microstrip, See Photomaster
- Bead Ferrite Bead, Ferroxcube 56-590-65/3B
- Board Material 0.0625" Teflon Fiberglass $\epsilon_r = 2.5 \pm 0.05$

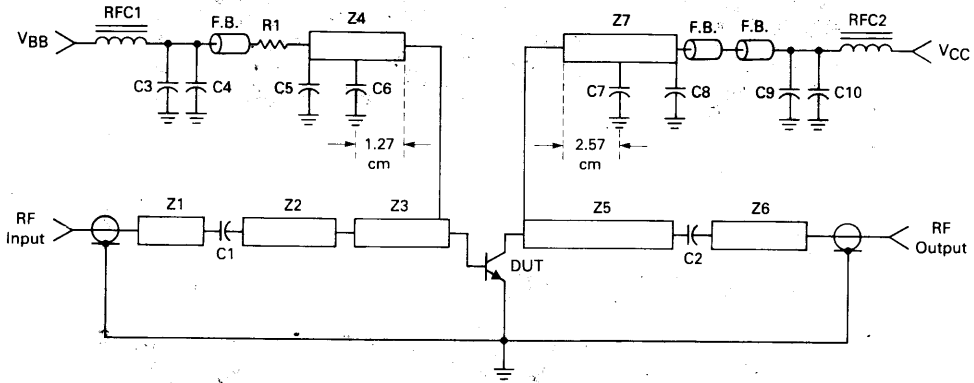
7

MRF571 TEST CIRCUIT



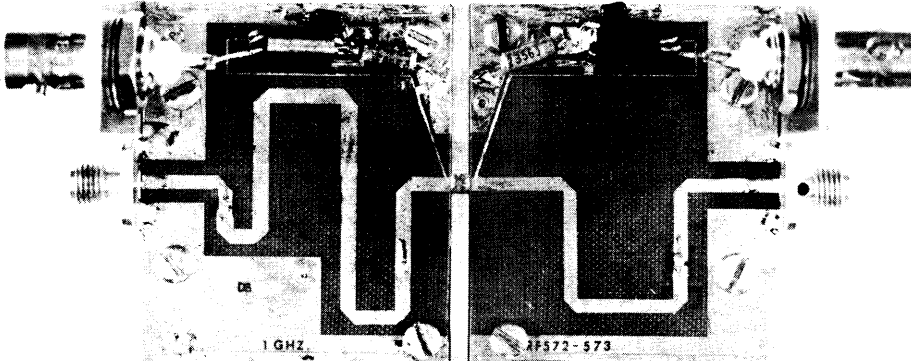
MRF571 • MRF572 • MRF573

MRF572, 573 1.0 GHz TEST FIXTURE

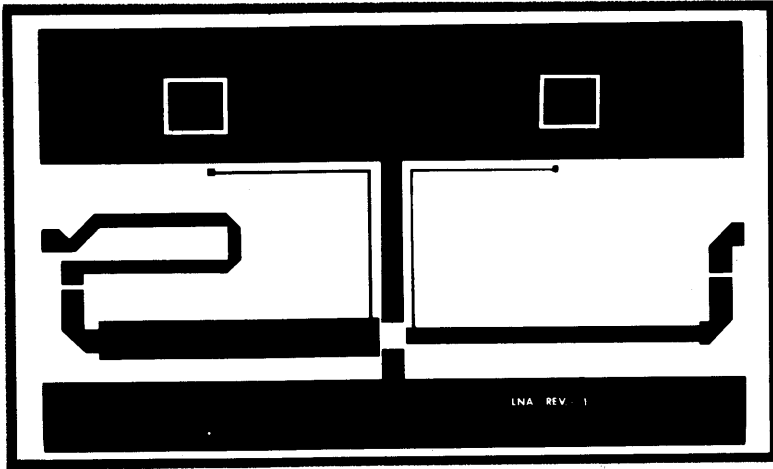


- | | | | |
|----------------|------------------------------------|----------------|--|
| C1, C2, C6, C7 | 560 pF Chip Capacitor | RFC1, RFC2 | VK-200, Ferroxcube |
| C5, C8 | 0.018 μ F Chip Capacitor | Z1-Z7 | Microstrip, See Photomaster |
| C3, C9 | 0.1 μ F Mylar Capacitor | Bead | Ferrite Bead, Ferroxcube 56-590-65/3B |
| C4, C10 | 1.0 μ F Electrolytic Capacitor | Board Material | 0.031" Teflon Fiberglass $\epsilon_r = 2.5 \pm 0.05$ |
| R1 | 2.7 k Ω | | |

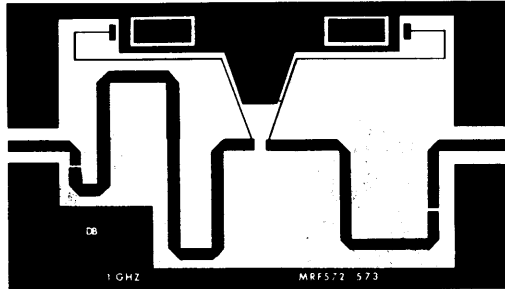
MRF572, 573 TEST CIRCUIT



PHOTOMASTER OF MRF571 CIRCUIT LAYOUT



PHOTOMASTER OF MRF572, 573 CIRCUIT LAYOUT



7

MRF580

CASE 317A-01, STYLE 2
HIGH FREQUENCY TRANSISTOR

NPN SILICON



MRF581

CASE 317-01, STYLE 2
HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	MRF581	MRF581	Unit
Collector-Emitter Voltage	V _{CEO}	18	18	V _{dc}
Collector-Base Voltage	V _{CBO}	36	36	V _{dc}
Emitter-Base Voltage	V _{EBO}	2.5	2.5	V _{dc}
Collector Current — Continuous	I _C	200	200	mAdc
Total Device Dissipation @ T _C = 50°C(1) Derate above T _C = 50°C	P _D	2.5 25	2.5 25	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +150	-65 to +150	°C

(1) Case temperature measured on collector lead immediately adjacent to body of package.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	18	—	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 1.0 mAdc, I _E = 0)	V _{(BR)CBO}	36	—	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 0.10 mAdc, I _C = 0)	V _{(BR)EBO}	2.5	—	—	V _{dc}
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	—	100	μAdc
Emitter Cutoff Current (V _{CE} = 2.0 Vdc, V _{BE} = 0)	I _{EBO}	—	—	100	μAdc

ON CHARACTERISTICS

DC Current Gain(1) (I _C = 50 mAdc, V _{CE} = 5.0 Vdc)	h _{FE}	50	—	200	—
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SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 75 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz)	f _T	—	5.0	—	GHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	1.4	2.0	pF

FUNCTIONAL TESTS

Noise Figure MRF580/581 (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz)	Figure 18	NF	—	2.0	3.0	dB
Power Gain at Optimum Noise Figure MRF580 (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz)	Figure 18	G _{NF}	11	14	—	dB
Power Gain at Optimum Noise Figure MRF581 (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz)	Figure 18	G _{NF}	13	15.5	—	dB
Maximum Available Power Gain MRF580(2) (I _C = 75 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz)		G _{max}	—	15	—	dB
Maximum Available Power Gain MRF581(2) (I _C = 75 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz)		G _{max}	—	17.5	—	dB
Intermodulation Distortion MRF581(3) (V _{CE} = 10 V, I _C = 75 mA, V _{out} = +50 dBmV)	Figure 16	IMD(d3)	—	-65	—	dB

(1) 300 μs pulse on Tektronix 576 or equivalent.

(2) Characterized on HP8542 Automatic Network Analyzer.

(3) 2 Tones, f₁ = 497 MHz, f₂ = 503 MHz, 3rd Order Single Tone reference.

FIGURE 1 — C_{ib} INPUT CAPACITANCE versus VOLTAGE

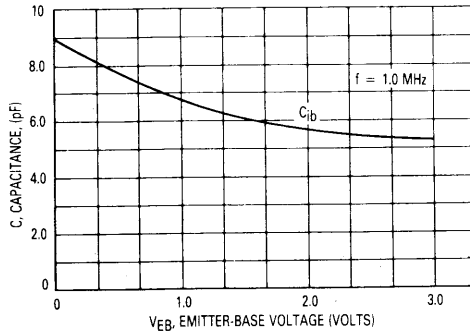


FIGURE 2 — C_{cb} , C_{ob} COLLECTOR-BASE CAPACITANCE versus VOLTAGE

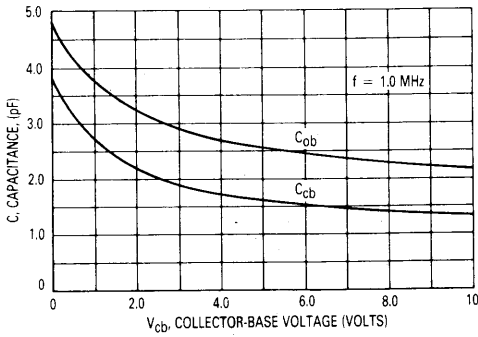


FIGURE 3 — GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

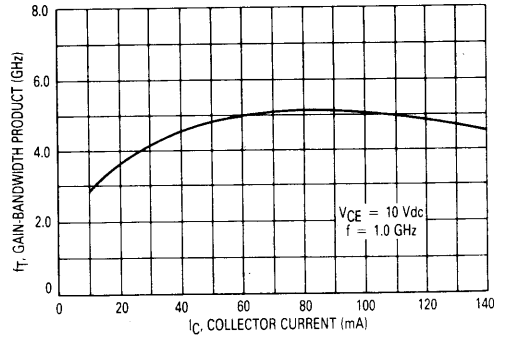
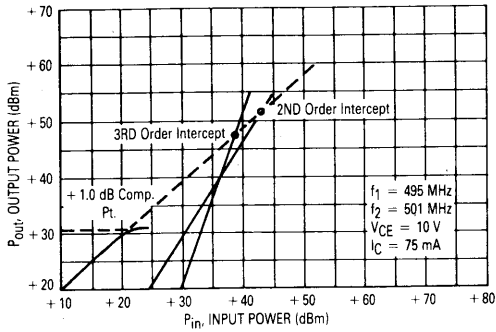


FIGURE 4 — 2ND AND 3RD ORDER INTERCEPT POINTS



MRF580 TYPICAL PERFORMANCE

FIGURE 5 — $G_{U \max}$ MAXIMUM UNILATERAL GAIN, $|S_{21}|^2$ versus FREQUENCY

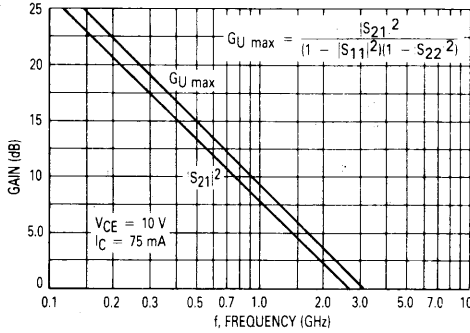


FIGURE 6 — $G_{A \max}$ MAXIMUM AVAILABLE GAIN versus FREQUENCY

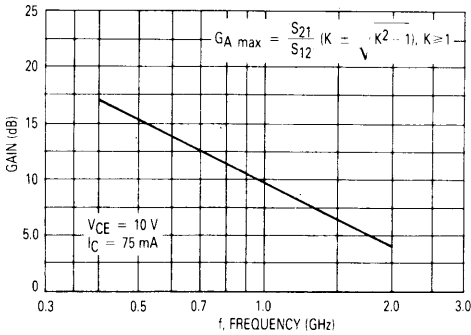


FIGURE 7 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus FREQUENCY

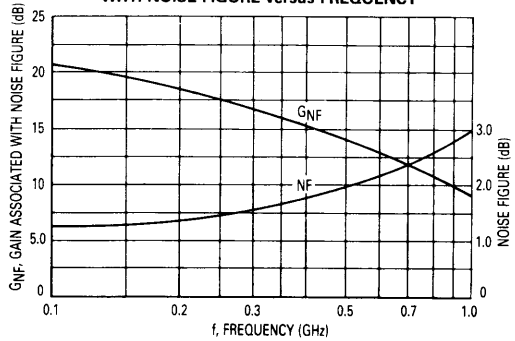


FIGURE 8 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus COLLECTOR CURRENT

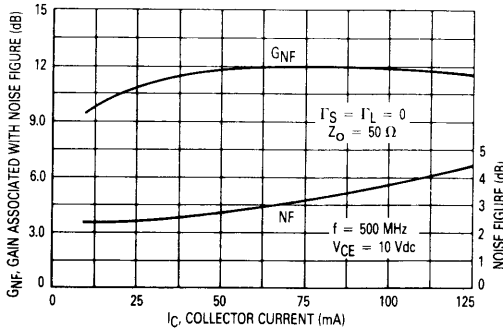
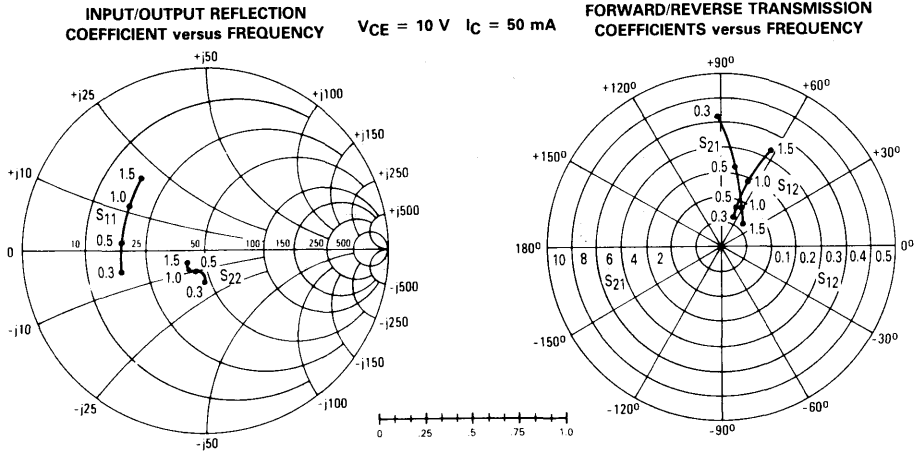


FIGURE 9 — MRF580 COMMON EMITTER S-PARAMETERS



VCE (Volts)	IC (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂		
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ	
5.0	25	300	0.49	-170	5.97	91	0.083	60	0.24	-108	
		500	0.52	171	3.63	78	0.127	64	0.18	-117	
		1000	0.53	149	1.98	58	0.24	66	0.13	-154	
		1500	0.56	125	1.46	44	0.35	60	0.19	-172	
	50	300	0.48	-175	6.35	90	0.08	64	0.24	-126	
		500	0.51	168	3.85	79	0.13	67	0.18	-139	
		1000	0.51	148	2.10	59	0.25	66	0.16	-178	
		1500	0.54	123	1.56	46	0.36	58	0.20	169	
	75	300	0.48	-177	6.42	90	0.08	65	0.24	-132	
		500	0.51	167	3.88	79	0.13	67	0.19	-145	
		1000	0.50	147	2.12	59	0.26	65	0.17	175	
		1500	0.53	123	1.57	46	0.36	58	0.21	164	
	100	300	0.48	-177	6.41	89	0.08	66	0.24	-134	
		500	0.51	167	3.87	78	0.13	68	0.19	-148	
		1000	0.51	146	2.114	59	0.26	65	0.17	172	
		1500	0.53	123	1.58	46	0.36	58	0.21	162	
	10	25	300	0.44	-164	6.67	92	0.07	61	0.25	-76
			500	0.47	175	4.08	79	0.11	66	0.19	-75
			1000	0.48	152	2.2	60	0.21	68	0.12	-91
			1500	0.52	126	1.56	45	0.32	64	0.15	-129
		50	300	0.47	-167	7.40	91	0.07	65	0.17	-89
			500	0.47	174	4.53	79	0.11	68	0.12	-112
			1000	0.50	149	2.38	62	0.20	67	0.13	-126
			1500	0.53	131	1.71	47	0.31	63	0.11	-147
75		300	0.41	-171	7.24	91	0.07	66	0.20	-96	
		500	0.45	171	4.39	79	0.12	69	0.13	-99	
		1000	0.45	150	2.36	61	0.23	67	0.07	-130	
		1500	0.48	125	1.72	47	0.33	61	0.12	-157	
100		300	0.42	-172	7.22	90	0.07	67	0.19	-97	
		500	0.45	170	4.38	78	0.12	69	0.14	-98	
		1000	0.45	149	2.35	60	0.23	67	0.07	-129	
		1500	0.49	125	1.71	46	0.33	62	0.11	-158	
15		25	300	0.48	-159	7.28	93	0.06	60	0.24	-55
			500	0.48	-179	4.44	80	0.09	66	0.17	-62
			1000	0.51	153	2.33	62	0.18	68	0.19	-82
			1500	0.54	133	1.67	46	0.27	68	0.17	-97
		50	300	0.39	-165	7.49	0.92	0.07	65	0.23	-71
			500	0.42	174	4.57	80	0.11	69	0.18	-67
			1000	0.43	152	2.44	61	0.21	68	0.11	-74
			1500	0.46	126	1.76	47	0.31	64	0.12	-115
	75	300	0.39	-167	7.57	91	0.07	66	0.21	-74	
		500	0.42	173	4.57	79	0.11	70	0.17	-69	
		1000	0.42	151	2.45	61	0.21	68	0.09	-75	
		1500	0.46	126	1.76	46	0.31	64	0.11	-118	
	100	300	0.39	-168	7.46	90	0.07	67	0.20	-72	
		500	0.43	172	4.53	78	0.11	70	0.17	-66	
		1000	0.43	151	2.41	60	0.21	69	0.10	-71	
		1500	0.47	126	1.74	46	0.31	64	0.12	-113	

MRF581 TYPICAL PERFORMANCE

FIGURE 10 — $G_{U \max}$ — MAXIMUM UNILATERAL GAIN, $|S_{21}|^2$ versus FREQUENCY

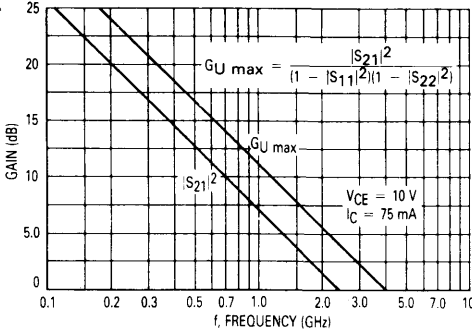


FIGURE 11 — $G_{A \max}$ — MAXIMUM AVAILABLE GAIN versus FREQUENCY

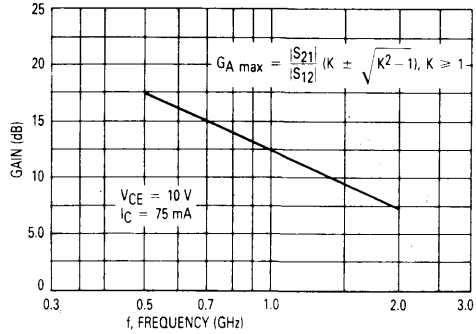


FIGURE 12 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus FREQUENCY

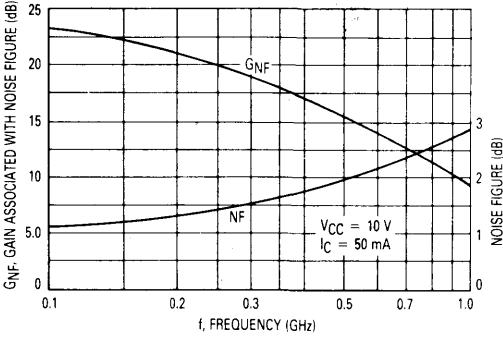


FIGURE 13 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus COLLECTOR CURRENT

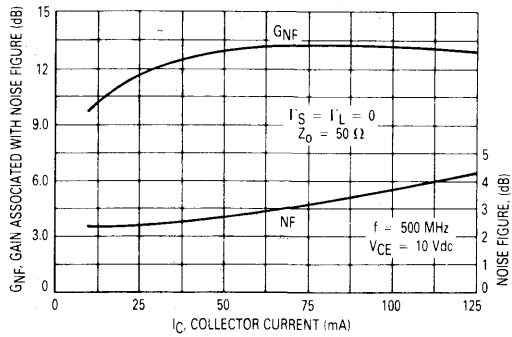


FIGURE 14 — OUTPUT POWER versus INPUT POWER $f = 470 \text{ MHz}$

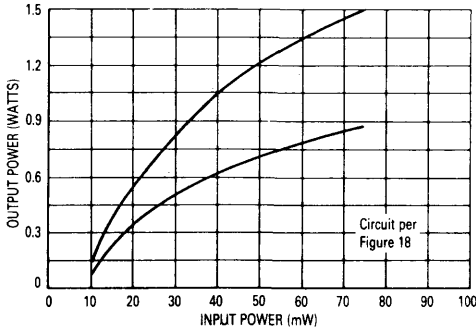


FIGURE 15 — OUTPUT POWER versus INPUT POWER $f = 870 \text{ MHz}$

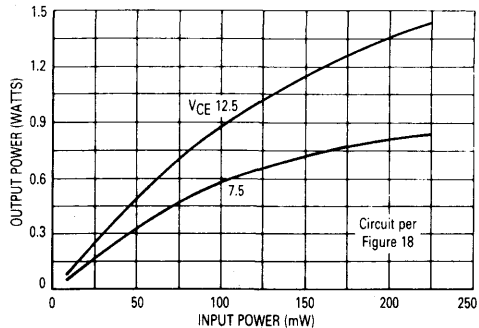
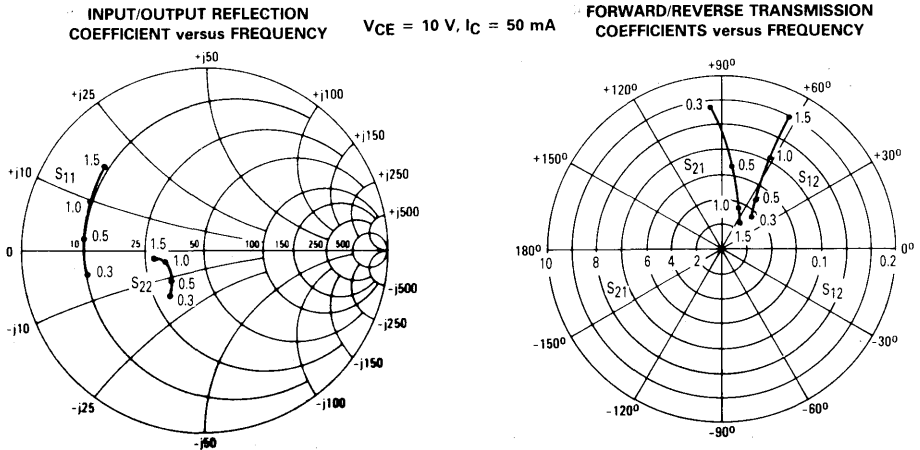
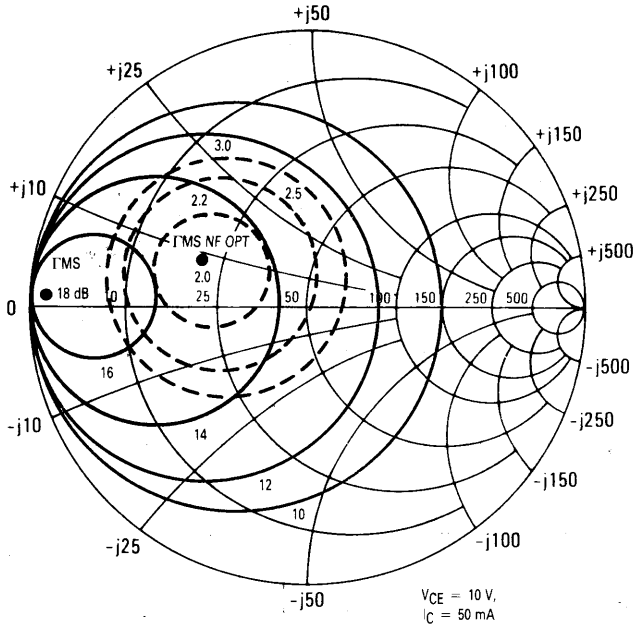


FIGURE 16 — MRF581 COMMON EMITTER S-PARAMETERS



VCE (Volts)	IC (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ
5.0	25	300	0.69	-169	6.57	93	0.06	39	0.34	-129
		500	0.72	176	3.95	82	0.07	47	0.29	-142
		1000	0.73	157	2.10	62	0.12	60	0.27	-165
		1500	0.76	139	1.47	50	0.17	61	0.33	172
	50	300	0.70	-173	7.14	93	0.05	45	0.38	-144
		500	0.72	173	4.27	82	0.07	53	0.34	-157
		1000	0.72	157	2.24	65	0.13	62	0.33	179
		1500	0.76	138	1.61	53	0.18	61	0.37	173
	75	300	0.70	-175	7.26	92	0.05	48	0.40	-148
		500	0.72	172	4.33	82	0.07	55	0.36	-161
		1000	0.72	155	2.28	65	0.13	63	0.35	176
		1500	0.76	138	1.64	53	0.19	61	0.39	170
100	300	0.70	-176	7.30	92	0.05	48	0.40	-151	
	500	0.72	172	4.34	82	0.07	56	0.37	-163	
	1000	0.72	155	2.28	65	0.13	63	0.362	175	
	1500	0.75	137	1.64	53	0.19	61	0.39	168	
10	25	300	0.66	-165	7.58	95	0.05	40	0.29	-106
		500	0.69	178	4.56	82	0.07	48	0.23	-116
		1000	0.70	159	2.39	64	0.11	61	0.19	-141
		1500	0.74	141	1.65	50	0.16	64	0.26	-153
	50	300	0.65	-169	8.25	94	0.05	46	0.30	-126
		500	0.68	175	4.96	82	0.07	54	0.24	-138
		1000	0.69	157	2.60	65	0.12	63	0.22	-164
		1500	0.72	139	1.82	52	0.17	63	0.27	-171
	75	300	0.66	-171	8.49	93	0.05	48	0.30	-132
		500	0.68	175	5.06	82	0.07	55	0.25	-145
		1000	0.69	157	2.64	65	0.12	64	0.23	-170
		1500	0.72	139	1.86	53	0.17	63	0.27	-176
100	300	0.66	-172	8.46	93	0.05	49	0.30	-134	
	500	0.68	174	5.06	82	0.07	56	0.25	-147	
	1000	0.68	157	2.64	65	0.12	64	0.23	-172	
	1500	0.72	139	1.86	52	0.17	63	0.27	-177	
15	25	300	0.65	-163	7.96	95	0.05	40	0.28	-92
		500	0.67	179	4.82	82	0.06	48	0.21	-98
		1000	0.68	160	2.51	63	0.10	62	0.17	-119
		1500	0.72	141	1.73	49	0.16	65	0.24	-137
	50	300	0.64	-167	8.76	94	0.0	46	0.26	-112
		500	0.66	177	5.37	82	0.06	54	0.20	-122
		1000	0.67	159	2.75	65	0.11	64	0.16	-148
		1500	0.71	141	1.91	51	0.16	64	0.22	-157
	75	300	0.64	-168	8.93	93	0.05	47	0.25	-117
		500	0.66	176	5.34	82	0.06	55	0.20	-128
		1000	0.69	158	2.78	65	0.11	65	0.16	-154
		1500	0.70	140	1.93	51	0.16	64	0.22	-162
100	300	0.64	-169	8.91	93	0.05	48	0.25	-117	
	500	0.66	176	5.33	82	0.6	56	0.19	-129	
	1000	0.67	158	2.78	64	0.11	65	0.16	-154	
	1500	0.70	140	1.93	51	0.16	64	0.21	-160	

FIGURE 17 — MRF581 CONSTANT GAIN CONTOURS NOISE FIGURE CONTOURS



f(MHz)	Γ_{MS}	Γ_{ML}	Γ_{MS} NF OPT	$G_{A\text{MAX}}$ (dB)	R_n (Ω)	NF OPT (50 Ω)	NF (50 Ω)
500	0.91/ $\angle 176^\circ$	0.78/ $\angle 77^\circ$	0.39/ $\angle 159^\circ$	18	10.5	2.0	2.5

Circuit Per Figure 20

FIGURE 18 — FUNCTIONAL CIRCUIT SCHEMATIC

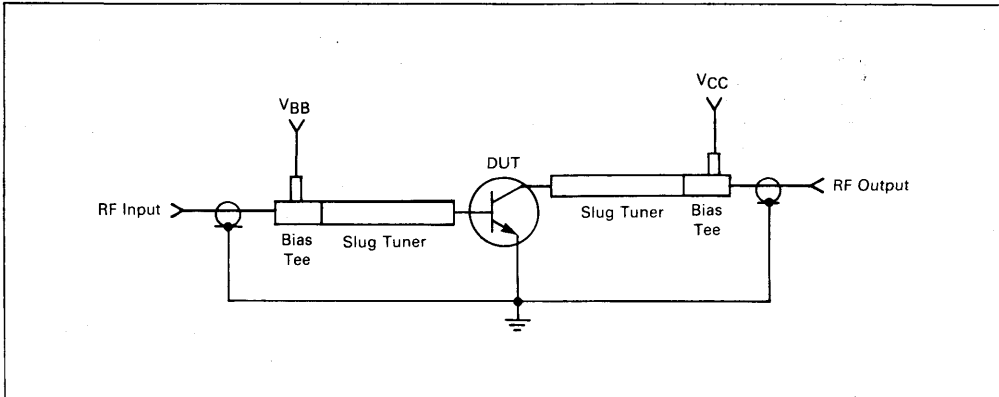


FIGURE 19 — Z_{in} AND Z_{OL} versus COLLECTOR VOLTAGE, INPUT POWER AND FREQUENCY

P_{in} (mW)	f MHz	Z_{in} Ohms		Z_{OL}^* Ohms	
		7.5 V	12.5 V	7.5 V	12.5 V
50	420	9.8 - j12.0	10.3 - j11.1	27.5 - j2.7	54.5 + j5.7
	470	14.2 - j11.1	10.2 - j10.2	28.6 - j2.9	30.8 - j26.3
	520	13.6 - j8.6	8.2 - j7.7	27.0 - j5.0	30.4 - j26.0
75	806	7.6 + j1.3	7.7 + j0.8	16.4 - j22.7	22.3 - j34.0
	870	7.7 - j1.7	7.7 - j2.1	18.4 - j19.2	25.1 - j28.1
	960	6.0 + j4.3	5.9 + j2.5	21 - j17.1	24.5 - j20.4

* Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

FIGURE 20 — MRF580/581 TEST FIXTURE SCHEMATIC
500 MHz

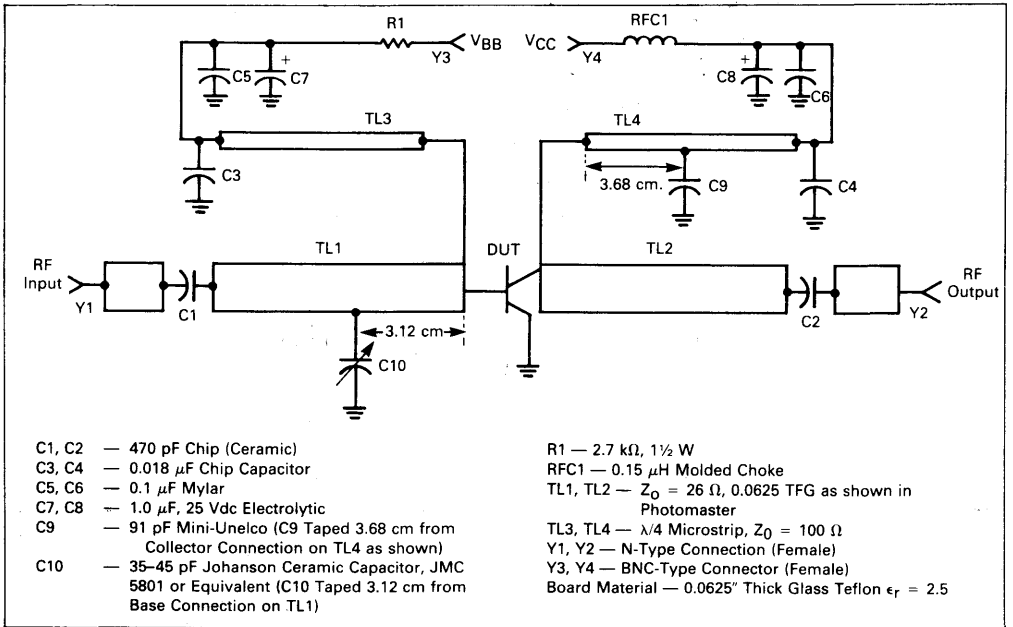
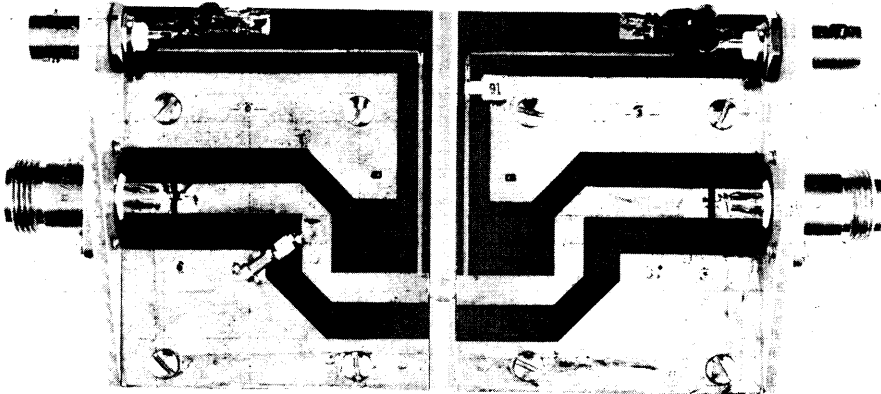
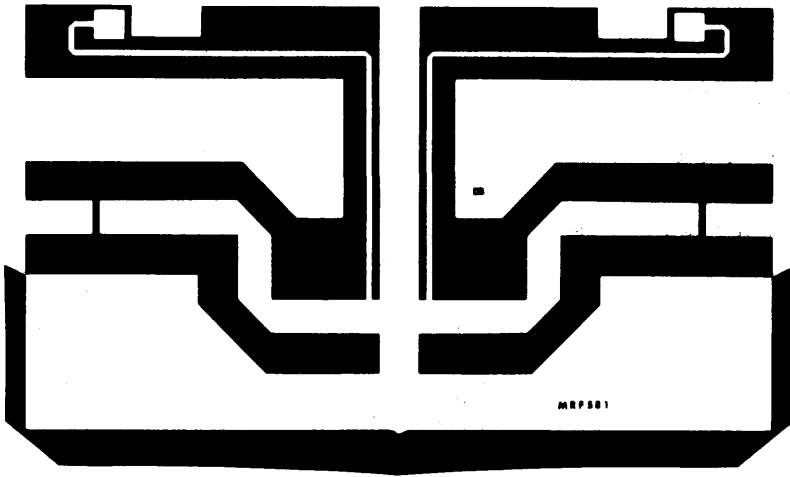


FIGURE 21 — PC BOARD PHOTOMASTER



7

MRF604

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 0.04	Watts $\text{W}/^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}$, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 12 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	20	80	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 200 \text{ MHz}$)	f_T	800	—	—	MHz
Output Capacitance ($V_{CB} = 12.5 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	—	3.5	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 1.0 \text{ W}$, $f = 175 \text{ MHz}$)	G_{PE}	10	—	—	dB
Collector Efficiency ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 1.0 \text{ W}$, $f = 175 \text{ MHz}$)	η	50	—	—	%
Series Equivalent Input Impedance ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 1.0 \text{ W}$, $f = 175 \text{ MHz}$)	Z_{in}	—	$7.5 - j14$	—	Ohms
Series Equivalent Output Impedance ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 1.0 \text{ W}$, $f = 175 \text{ MHz}$)	Z_{out}	—	$47 - j60$	—	Ohms

FIGURE 1 - 175 MHz TEST CIRCUIT SCHEMATIC

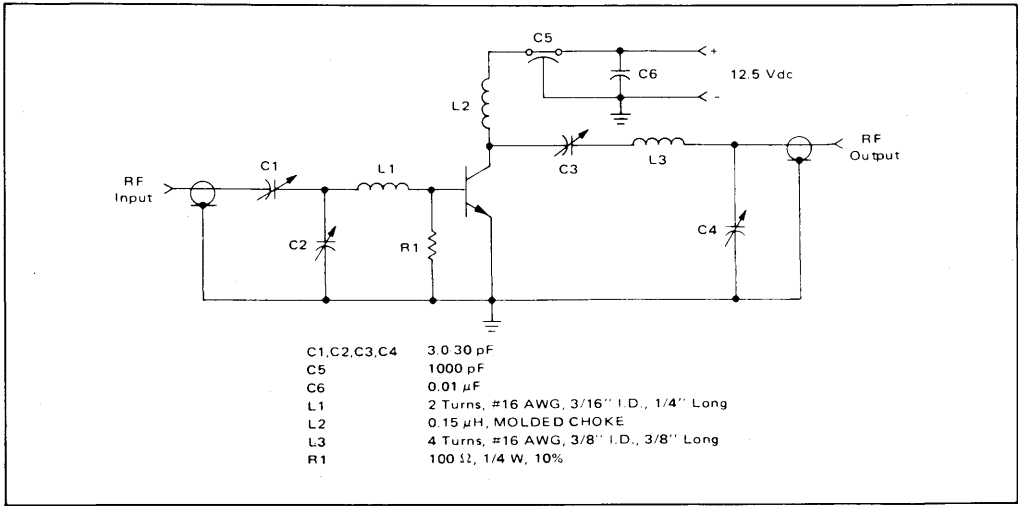


FIGURE 2 - OUTPUT POWER versus INPUT POWER

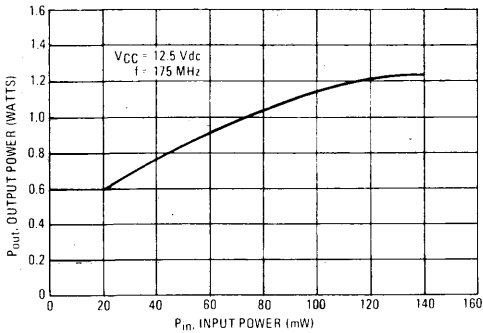


FIGURE 3 - CURRENT GAIN BANDWIDTH PRODUCT

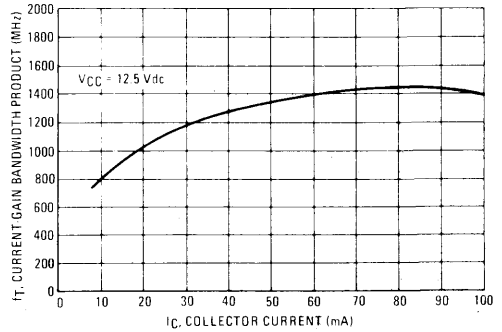
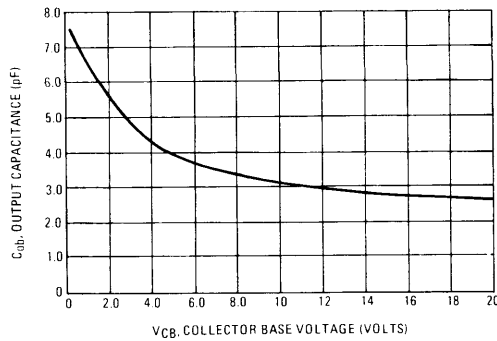


FIGURE 4 - OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE



MRF607

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

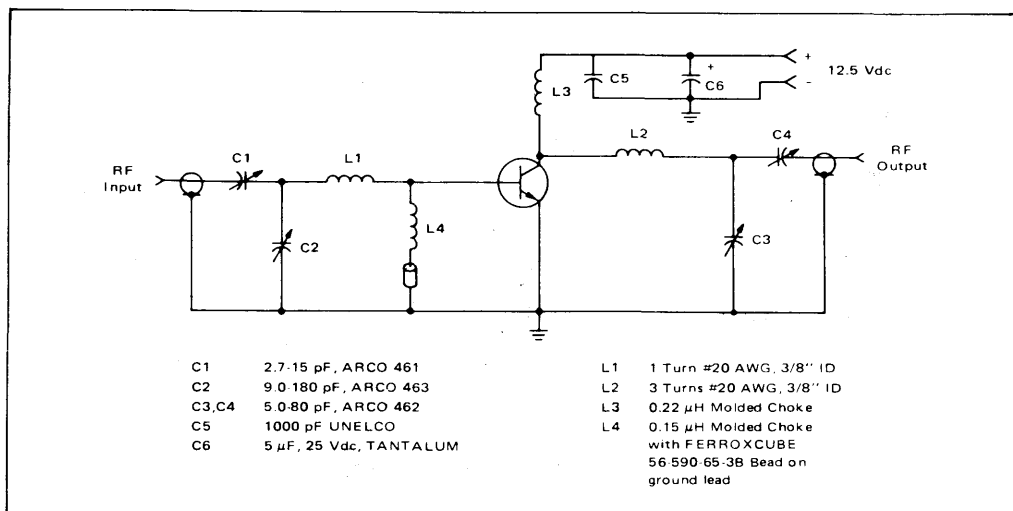
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.33	Adc
Total Device Dissipation @ $T_C = 75^\circ\text{C}$ (1) Derate above 75°C	P_D	3.5 28	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 25 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	16	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 25 \text{ mAdc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.5 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 10 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	0.3	mAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 50 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	20	150	—
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 12 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	15	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain ($P_{out} = 1.75 \text{ W}$, $V_{CC} = 12.5 \text{ Vdc}$, $f = 175 \text{ MHz}$)	G_{PE}	11.5	—	dB
Collector Efficiency ($P_{out} = 1.75 \text{ W}$, $V_{CC} = 12.5 \text{ Vdc}$, $f = 175 \text{ MHz}$)	η	50	—	%

FIGURE 1 - 175 MHz TEST CIRCUIT SCHEMATIC



TYPICAL PERFORMANCE DATA

FIGURE 2 - OUTPUT POWER versus FREQUENCY

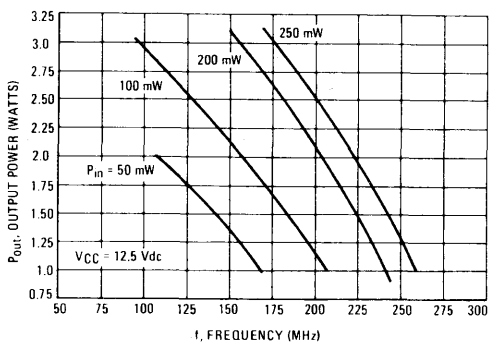


FIGURE 3 - OUTPUT POWER versus INPUT POWER

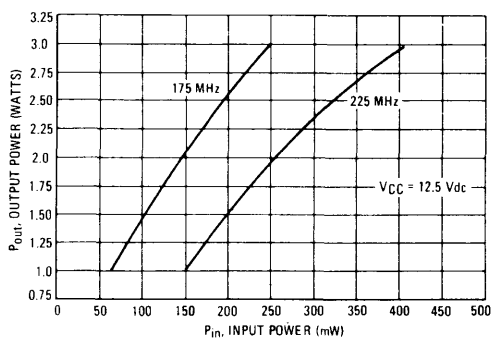


FIGURE 4 - OUTPUT POWER versus SUPPLY VOLTAGE

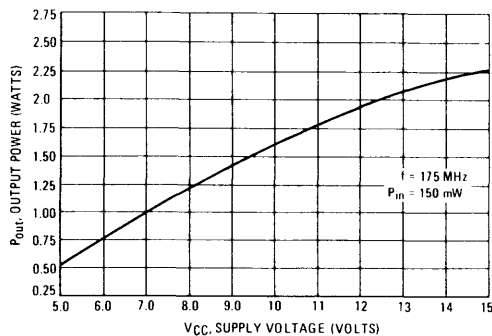
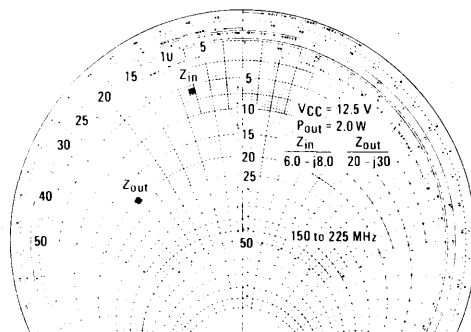


FIGURE 5 - SERIES EQUIVALENT IMPEDANCE PARAMETERS



MRF626 MRF627

MRF626
CASE 305-01, STYLE 1

MRF627
CASE 305A-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 35	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200 $^\circ\text{C}$	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	28.5	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 12$ Vdc, $I_B = 0$)	I_{CEO}	—	—	1.0	mAdc
Emitter Cutoff Current ($V_{BE} = 3.5$ Vdc, $I_C = 0$)	I_{EBO}	—	—	1.0	mAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	15	—	150	—
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SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 12.5$ Vdc, $f = 200$ MHz) ($I_C = 100$ mAdc, $V_{CE} = 12.5$ Vdc, $f = 200$ MHz) ($I_C = 150$ mAdc, $V_{CE} = 12.5$ Vdc, $f = 200$ MHz)	f_T	—	2.5 2.7 2.6	—	GHz
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	3.0	3.5	pF
Input Capacitance ($V_{BE} = 1.0$ Vdc, $I_C = 0$, $f = 1.0$ MHz)	C_{ibo}	—	8.8	—	pF

FUNCTIONAL TEST (FIGURE 1)

Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, $f = 470$ MHz)	G_{PE}	10	12	—	dB
Collector Efficiency ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, $f = 470$ MHz)	η	—	60	—	%
Series Equivalent Input Impedance ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, $f = 470$ MHz)	Z_{in}	—	6.0 - j4.0	—	Ohms
Series Equivalent Output Impedance ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, $f = 470$ MHz)	Z_{out}	—	45 - j28	—	Ohms

FIGURE 1 – OUTPUT POWER versus INPUT POWER

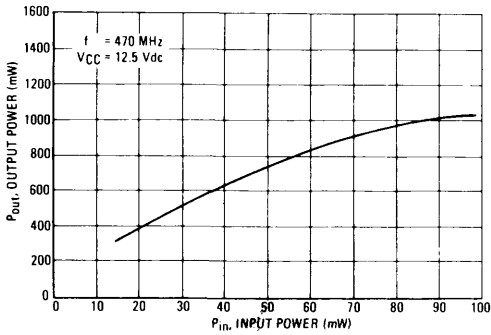


FIGURE 2 – OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE

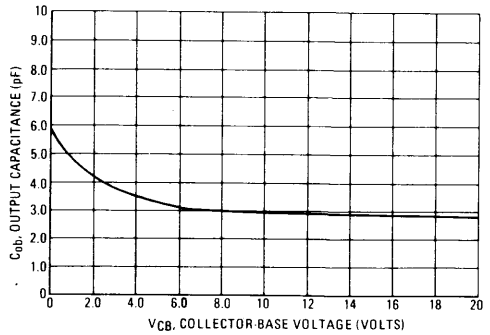
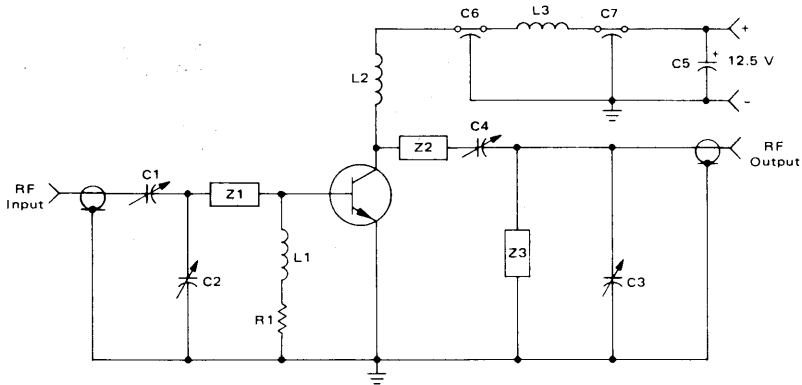


FIGURE 3 – 470 MHz TEST CIRCUIT SCHEMATIC



- | | | |
|--------------------------------------|---|---|
| C1, C2 – 1.0-25 pF ARCO 421 | L3 – Choke FERROXCUBE VK 200-20-4B | Z3 – Microstrip Line, 0.50" W x 1.00" L |
| C3, C4 – 1.0-25 pF ARCO 421 | R1 – 1 Ohm, 1/2 W Carbon | Board-Glass Teflon, 3" x 5" x 0.060" |
| C5 – 1.0 μF, 35 V Capacitor | Z1 – Microstrip Line, 0.25" W x 1.75" L | Mounting Plate is 3" x 5" x 0.75" |
| C6, C7 – 1000 pF Feedthru | Z2 – Microstrip Line, 0.25" W x 2.00" L | Input/Output Connectors – Type N |
| L1, L2 – 7 Turns, #22 AWG, 0.2" I.D. | | |

FIGURE 4 – 470 MHz TEST CIRCUIT LAYOUT

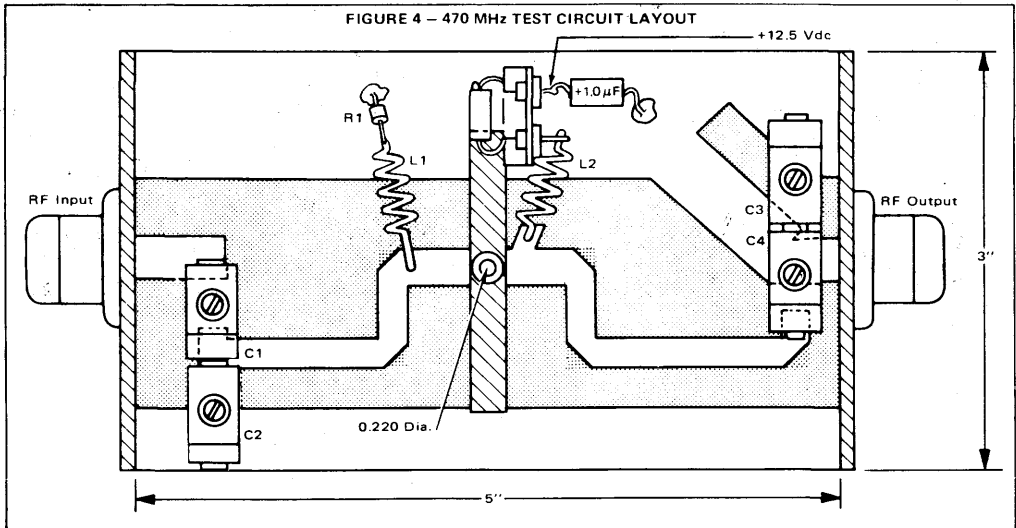


FIGURE 5 – TYPICAL S_{11} and S_{22} versus FREQUENCY

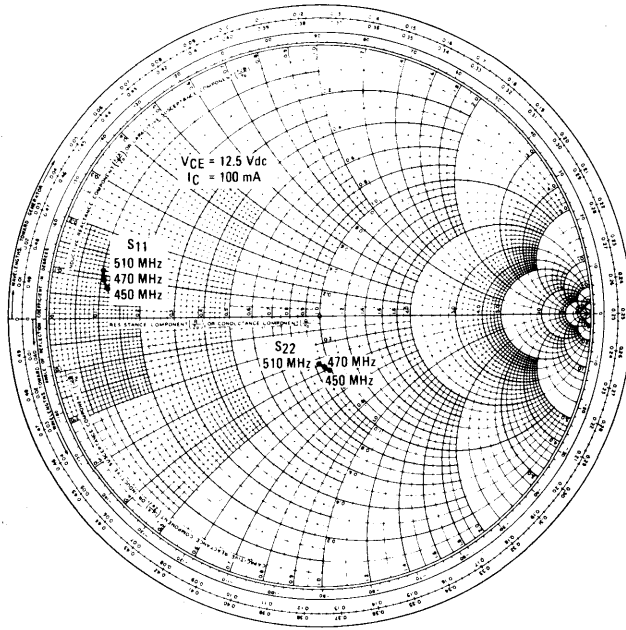


FIGURE 6 – TYPICAL S_{12} versus FREQUENCY

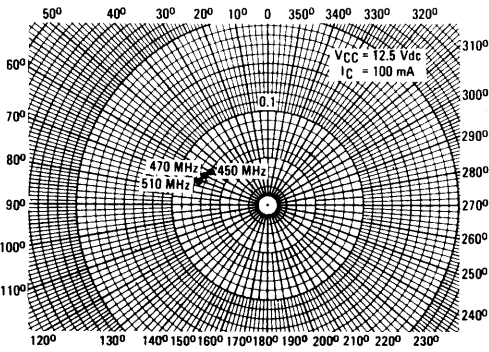
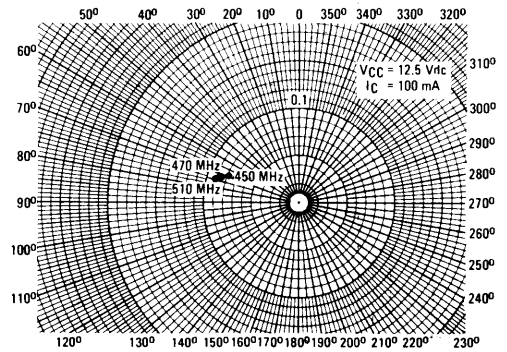


FIGURE 7 – TYPICAL S_{21} versus FREQUENCY



MRF628

CASE 249-05, STYLE 1

UHF AMPLIFIER TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.2	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 20$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage(1) ($I_C = 20$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 20$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 5.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_C = 0$)	I_{CBO}	—	—	0.5	mAdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$, $T_C = 25^\circ\text{C}$)	I_{CES}	—	—	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 12$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	6.0	10	pF
FUNCTIONAL TEST (FIGURES 5 AND 6)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, $I_C(\text{max}) = 80$ mAdc, $f = 470$ MHz)	G_{PE}	10	—	—	dB
Collector Efficiency ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, $I_C(\text{max}) = 80$ mAdc, $f = 470$ MHz)	η	50	—	—	%

(1) Pulsed thru 25 mH inductor.

FIGURE 1 – SERIES EQUIVALENT IMPEDANCE PARAMETERS

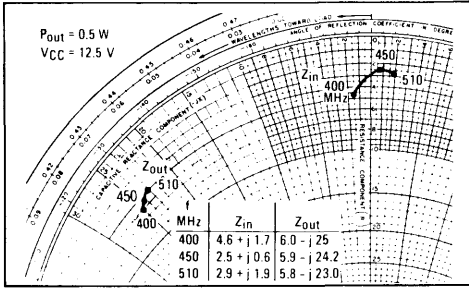


FIGURE 2 – OUTPUT POWER versus INPUT POWER

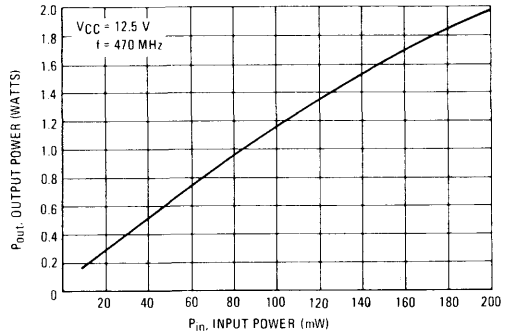


FIGURE 3 – OUTPUT POWER versus FREQUENCY

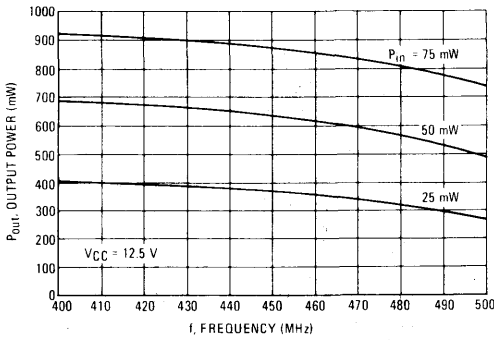


FIGURE 4 – OUTPUT POWER versus VOLTAGE

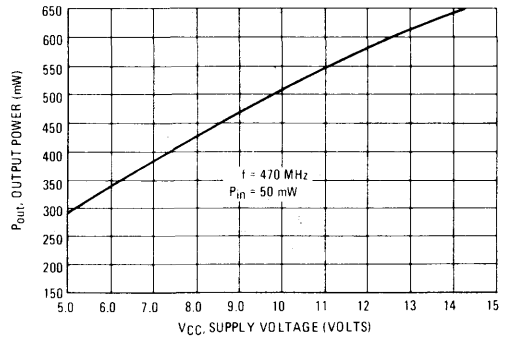


FIGURE 5 – 470 MHz TEST CIRCUIT

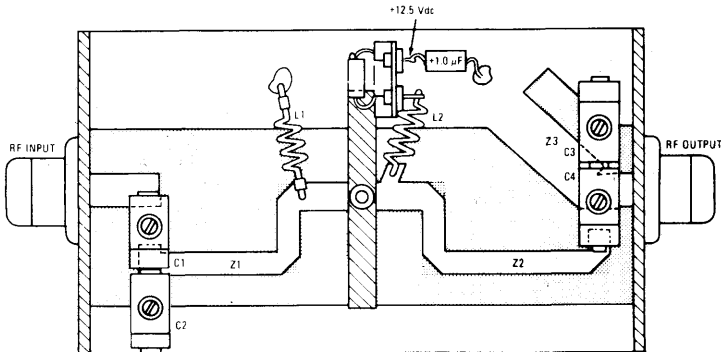
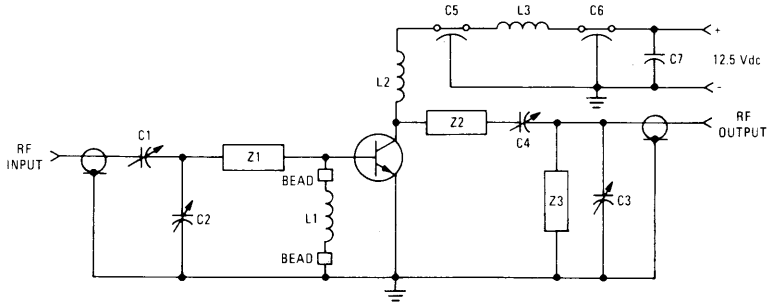


FIGURE 6 - 470 MHz TEST CIRCUIT SCHEMATIC



- | | | |
|----------|---|---|
| C1,2,3,4 | 1.0-25 pF ARCO 421 OR EQUIVALENT | BOARD GLASS TEFLON, $\epsilon_r = 2.56$, $t = 0.062$ |
| C5,6 | 1000 pF FEEDTHRU CAPACITOR | MOUNTING PLATE - 3" x 5" x 0.060" |
| C7 | 1.0 μ F, 35 V CAPACITOR | INPUT OUTPUT CONNECTORS - TYPE N |
| L1,2 | 7 TURNS =22 AWG, 0.2" I.D.
FERRITE BEADS FERROXCUBE
56-590 65-3B AS SHOWN ON L1 | |
| L3 | 1-CHOKE FERROXCUBE VK-200-20-4B | |

MRF629

CASE 79-03, STYLE 5

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 50	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 50\text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	16	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 50\text{ mAdc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0\text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 100\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	20	200	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 12.5\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{obo}	—	15	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5\text{ Vdc}$, $P_{out} = 2.0\text{ W}$, $f = 470\text{ MHz}$)	G_{PE}	8.0	—	dB
Collector Efficiency ($V_{CC} = 12.5\text{ Vdc}$, $P_{out} = 2.0\text{ W}$, $f = 470\text{ MHz}$)	η	50	—	%

FIGURE 1 - 470 MHz TEST CIRCUIT SCHEMATIC

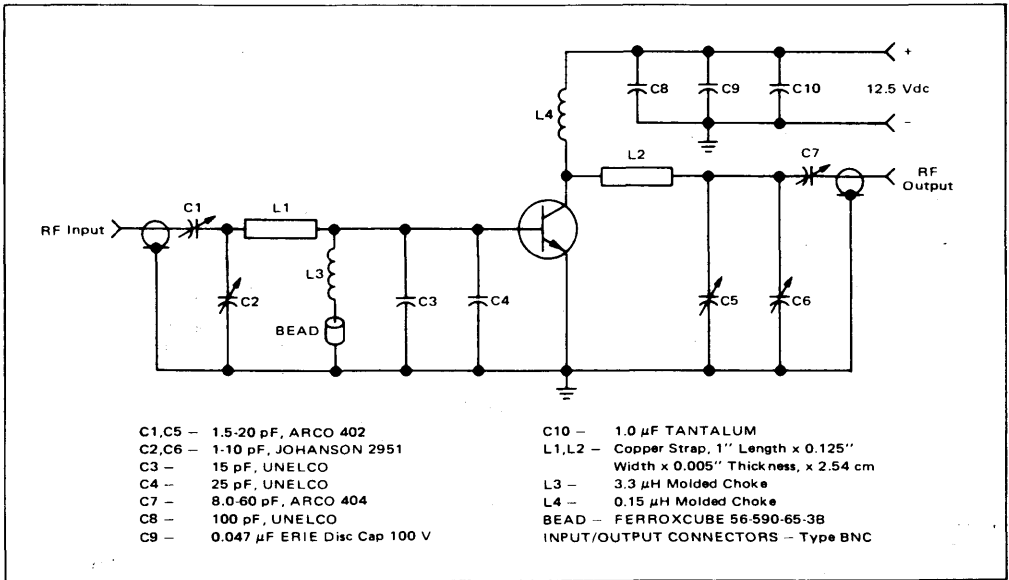


FIGURE 2 - OUTPUT POWER versus INPUT POWER

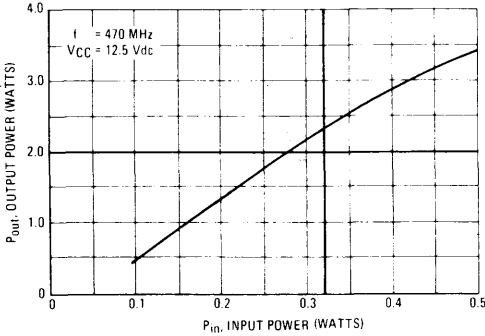


FIGURE 3 - OUTPUT POWER versus FREQUENCY

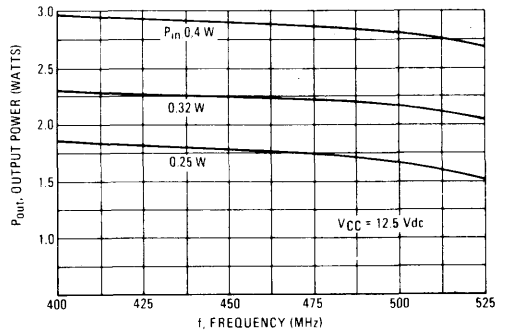


FIGURE 4 - OUTPUT POWER versus SUPPLY VOLTAGE

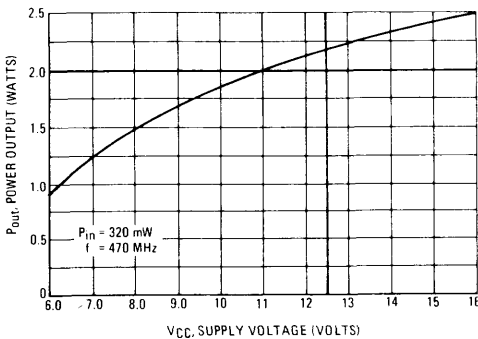
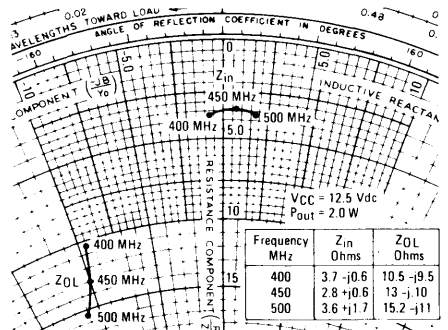


FIGURE 5 - SERIES EQUIVALENT IMPEDANCE



MRF630

CASE 79-03, STYLE 5

UHF AMPLIFIER TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CES}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	8.75 50	Watts mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 50 \text{ mAdc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 12.5 \text{ Vdc}$, $V_{BE} = 0$, $T_C = 25^\circ\text{C}$)	I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	20	60	—	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 12.5 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	8.0	12	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 3.0 \text{ W}$, $f = 470 \text{ MHz}$)	G_{PE}	9.5	10	—	dB
Collector Efficiency ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 3.0 \text{ W}$, $f = 470 \text{ MHz}$)	η	—	55	—	%

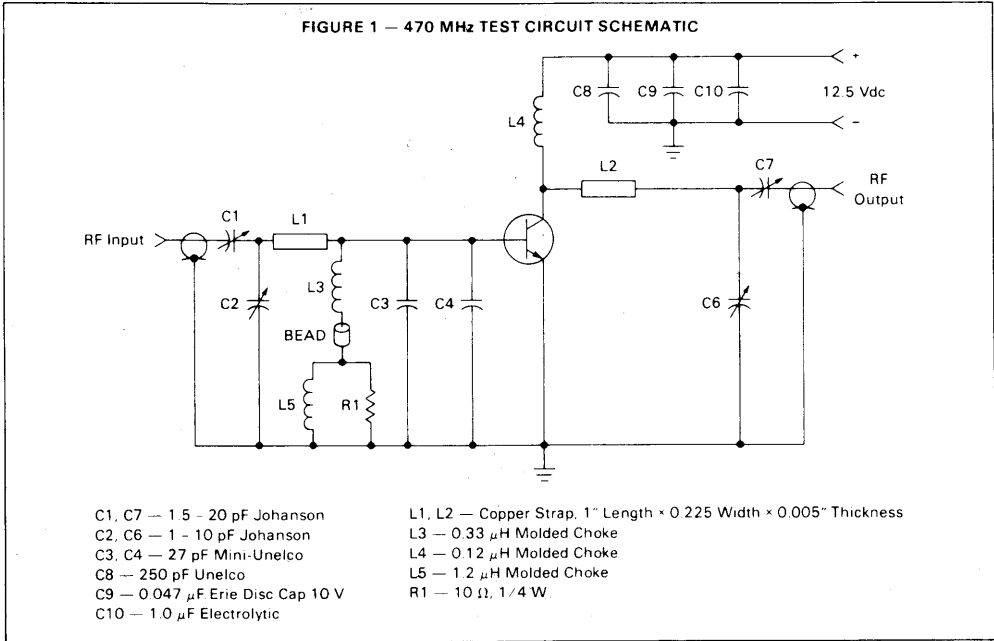


FIGURE 2 — OUTPUT POWER versus INPUT POWER

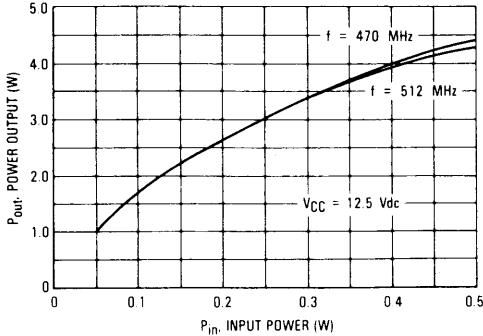


FIGURE 3 — OUTPUT POWER versus FREQUENCY

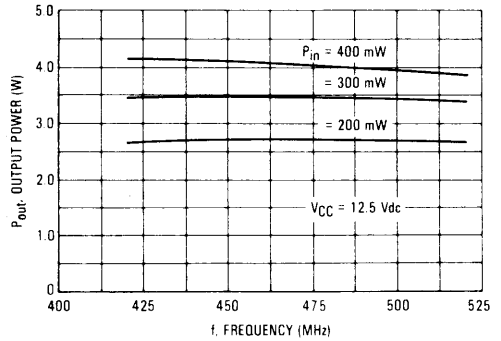


FIGURE 4 — POWER OUT versus SUPPLY VOLTAGE

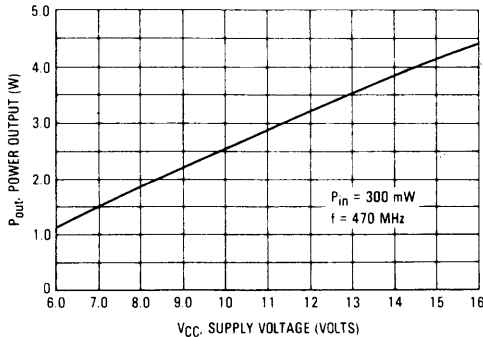


FIGURE 5 — SERIES EQUIVALENT IMPEDANCE

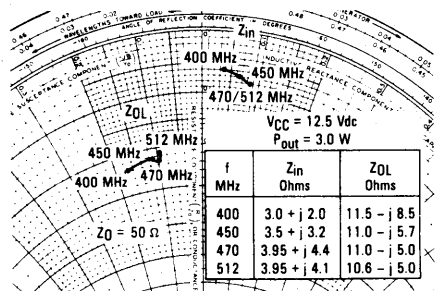


FIGURE 6 — OUTPUT POWER versus FREQUENCY, BROADBAND CIRCUIT

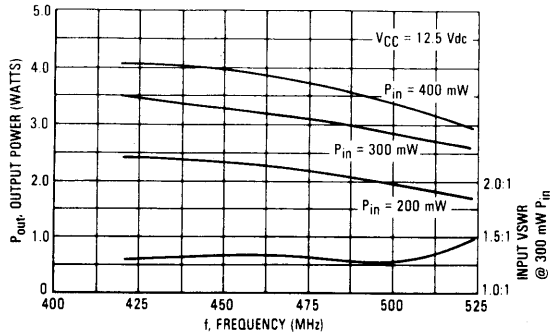
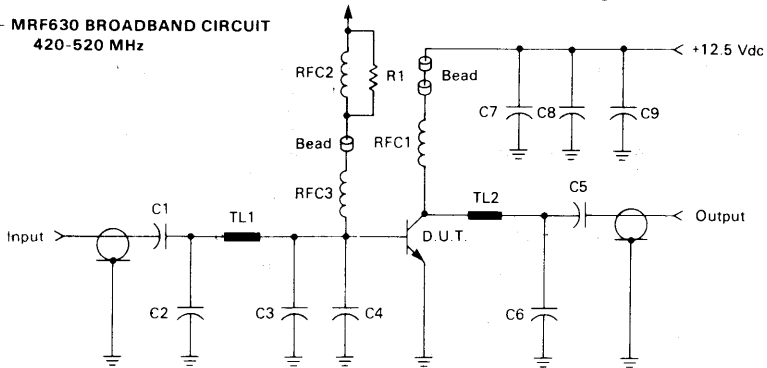


FIGURE 7 — MRF630 BROADBAND CIRCUIT
420-520 MHz

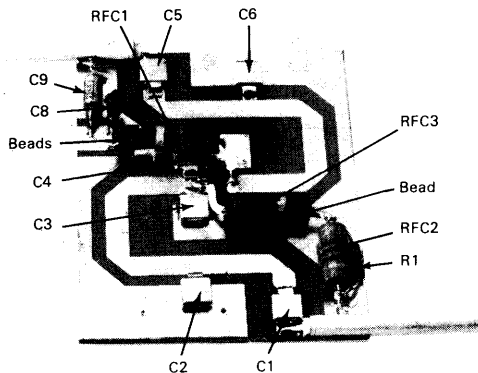


- C1, C5 — 43 pF Mini-Unelco
- C2 — 10 pF Mini-Unelco
- C3 — 18 pF Mini-Unelco
- C4 — 27 pF Mini-Unelco
- C6 — 6.8 pF Mini-Unelco

- C7 — 220 pF Ceramic Chip
- C8 — 0.1 mF
- C9 — 1.0 mF Tantalum
- RFC1 — 0.47 μ H Molded Choke
- RFC2 — 1.0 μ H Molded Choke

- RFC3 — 0.3 μ H Molded Choke
- R1 — 12 Ω / 1/4 W
- TL1 — Transmission Line 0.166" \times 1.85" (WXL)
- TL2 — Transmission Line 0.166" \times 1.77" (WXL)
- Board Material — 2 oz. 0.0625" TFG

FIGURE 8 — BROADBAND CIRCUIT



MRF901

CASE 317-01, STYLE 2 HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	0.375 3.3	Watt mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	300	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_E = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	30	80	200	—
--	----------	----	----	-----	---

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 15$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	0.4	1.0	pF
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, $f = 1.0$ GHz)	NF	—	2.0	2.5	dB

FUNCTIONAL TEST (FIGURE 1)

Common-Emitter Amplifier Power Gain ($V_{CC} = 6.0$ Vdc, $I_C = 5.0$ mA, $f = 1.0$ GHz)	G_{pe}	10	12	—	dB
Third Order Intercept ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, $f = 0.9$ GHz)	—	—	+23	—	dBm

FIGURE 1 – 1.0 GHz TEST CIRCUIT SCHEMATIC

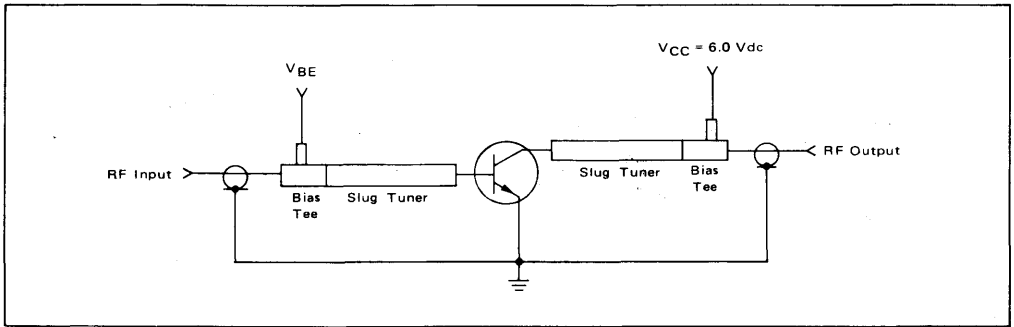


FIGURE 2 – MAXIMUM UNILATERAL GAIN versus FREQUENCY

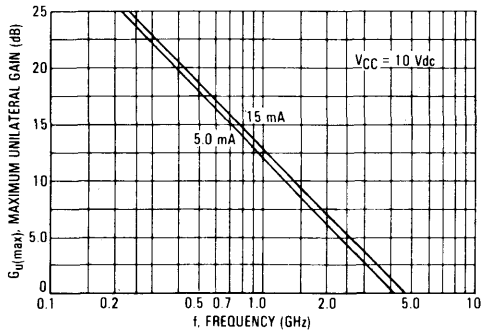


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT versus COLLECTOR CURRENT

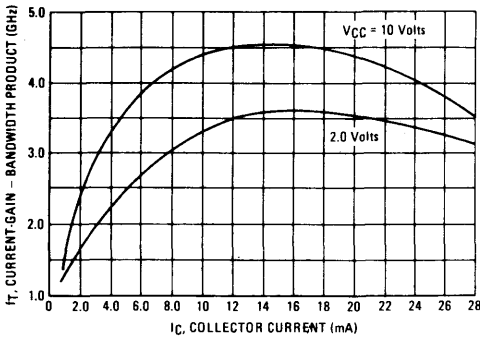
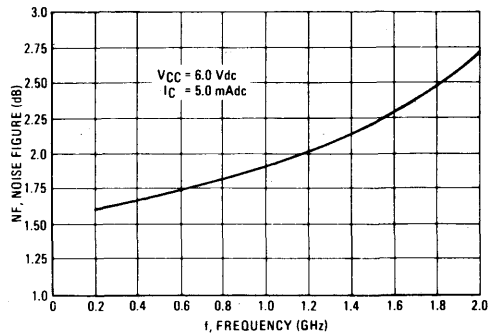


FIGURE 4 – NOISE FIGURE versus FREQUENCY



7

FIGURE 5 – NOISE FIGURE versus COLLECTOR CURRENT

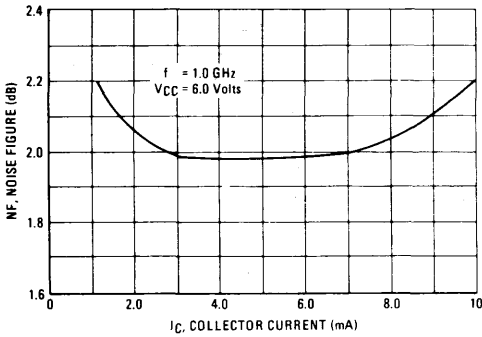


FIGURE 6 – OUTPUT POWER versus INPUT POWER

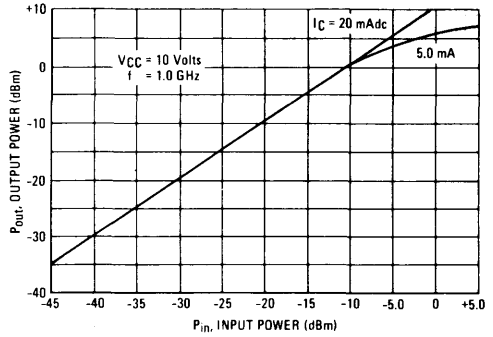


FIGURE 7 – G_{max} versus FREQUENCY

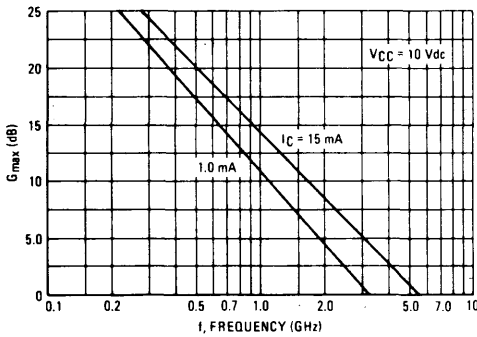


FIGURE 8 – COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

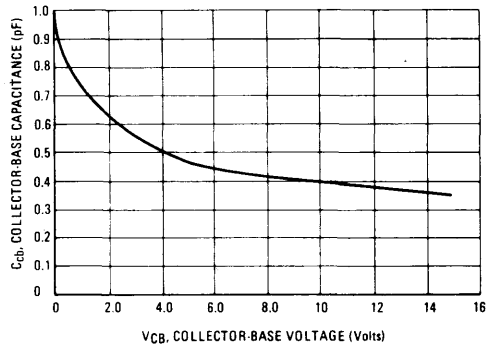


TABLE I – S_{11}

FREQUENCY (MHz)		200		500		1000		1500		2000	
V_{CC}	I_C	$ S_{11} $	$\angle\phi$	$ S_{11} $	$\angle\phi$	$ S_{11} $	$\angle\phi$	$ S_{11} $	$\angle\phi$	$ S_{11} $	$\angle\phi$
1 Volt	1.0mA	.83	-54	.65	-110	.61	-153	.62	+177	.65	+157
	2.5	.72	-74	.57	-132	.56	-171	.58	+165	.61	+148
	5.0	.63	-98	.55	-151	.55	+174	.58	+154	.60	+140
	10	.55	-130	.55	-170	.56	+164	.59	+148	.61	+135
	15	.55	-147	.56	-178	.58	+160	.62	+145	.63	+133
20	.58	-165	.60	+174	.62	+158	.65	+144	.67	+132	
3 Volts	1.0	.85	-48	.68	-100	.61	-149	.62	+178	.65	+156
	2.5	.75	-63	.58	-121	.53	-169	.56	+164	.59	+146
	5.0	.64	-82	.52	-139	.51	+177	.54	+156	.57	+139
	10	.53	-112	.48	-160	.51	+167	.54	+149	.56	+134
	15	.49	-126	.48	-168	.52	+162	.55	+145	.57	+132
20	.48	-137	.49	-173	.53	+160	.56	+145	.58	+131	
6 Volts	1.0	.87	-45	.71	-94	.60	-148	.60	+179	.63	+156
	2.5	.77	-58	.60	-114	.52	-164	.55	+168	.57	+148
	5.0	.66	-75	.52	-132	.48	-177	.52	+159	.54	+142
	10	.53	-101	.46	-151	.47	+171	.50	+152	.53	+137
	15	.47	-115	.45	-162	.47	+166	.51	+148	.53	+135
20	.46	-125	.45	-167	.48	+163	.52	+147	.54	+134	
10 Volts	1.0	.88	-43	.72	-91	.60	-145	.60	-178	.63	+158
	2.5	.79	-55	.60	-109	.52	-160	.54	+170	.57	+150
	5.0	.68	-70	.50	-130	.47	-175	.50	+160	.53	+143
	10	.55	-93	.45	-147	.45	+173	.48	+154	.52	+138
	15	.50	-107	.43	-158	.44	+168	.49	+151	.52	+136
20	.47	-116	.43	-163	.45	+166	.49	+150	.52	+136	

TABLE II - S₂₁

FREQUENCY (MHz)		200		500		1000		1500		2000	
V _{CC}	I _C	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ
1 Volt	1.0mA	4.2	+140	2.7	+104	1.4	+73	.96	+52	.77	+39
	2.5	7.2	+130	3.9	+98	2.1	+73	1.4	+55	1.1	+42
	5.0	9.9	+121	4.8	+92	2.6	+72	1.8	+57	1.4	+44
	10	12.0	+109	5.2	+87	2.8	+70	1.9	+57	1.5	+44
	15	11.4	+103	4.9	+84	2.7	+68	1.8	+55	1.4	+42
	20	6.3	+96	2.6	+81	1.9	+65	1.3	+52	1.0	+41
3 Volts	1.0	4.5	+144	3.0	+110	1.5	+78	1.0	+56	.82	+43
	2.5	7.8	+136	4.5	+103	2.5	+76	1.7	+58	1.3	+45
	5.0	11.2	+127	5.7	+97	3.0	+74	2.0	+58	1.6	+45
	10	14.9	+116	6.8	+91	3.4	+72	2.3	+58	1.8	+45
	15	16	+111	7.0	+88	3.6	+70	2.4	+57	1.8	+45
	20	16.4	+108	7.0	+87	3.5	+69	2.4	+56	1.8	+44
6 Volts	1.0	4.5	+146	3.1	+113	1.8	+81	1.2	+60	.96	+46
	2.5	7.8	+139	4.8	+106	2.7	+78	1.8	+60	1.4	+46
	5.0	11.6	+130	6.2	+99	3.3	+75	2.2	+60	1.7	+47
	10	15.9	+120	7.5	+92	3.8	+73	2.5	+59	1.9	+47
	15	17.2	+114	7.7	+90	4.0	+71	2.6	+58	2.0	+46
	20	17.7	+110	7.8	+88	4.0	+70	2.6	+57	2.0	+45
10 Volts	1.0	4.5	+147	3.2	+114	1.8	+82	1.2	+61	.96	+47
	2.5	7.8	+140	4.9	+107	2.7	+79	1.8	+61	1.4	+47
	5.0	11.7	+132	6.4	+100	3.5	+75	2.3	+60	1.8	+48
	10	15.9	+121	7.6	+93	4.0	+73	2.6	+58	2.0	+47
	15	17.4	+115	8.0	+90	4.0	+71	2.7	+57	2.0	+46
	20	17.8	+112	8.0	+88	4.0	+70	2.6	+56	2.0	+45

TABLE III - S₁₂

FREQUENCY (MHz)		200		500		1000		1500		2000	
V _{CC}	I _C	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ
1 Volt	1.0mA	.09	+57	.14	+32	.15	+17	.15	+13	.13	+21
	2.5	.08	+49	.10	+32	.12	+27	.13	+32	.14	+40
	5.0	.06	+43	.08	+35	.10	+42	.13	+48	.16	+51
	10	.05	+42	.06	+45	.09	+54	.13	+57	.17	+57
	15	.04	+43	.06	+50	.09	+60	.13	+60	.18	+60
	20	.03	+41	.05	+55	.09	+63	.14	+64	.18	+62
3 Volts	1.0	.06	+61	.10	+37	.13	+21	.12	+20	.10	+31
	2.5	.06	+57	.08	+36	.09	+33	.10	+40	.12	+49
	5.0	.05	+51	.07	+39	.08	+45	.11	+52	.14	+56
	10	.04	+49	.05	+49	.08	+56	.11	+61	.15	+61
	15	.03	+49	.05	+55	.08	+62	.12	+64	.15	+64
	20	.03	+52	.04	+59	.08	+65	.12	+65	.15	+65
6 Volts	1.0	.05	+63	.09	+40	.10	+26	.09	+29	.09	+43
	2.5	.05	+59	.07	+39	.08	+37	.09	+45	.11	+55
	5.0	.04	+55	.05	+42	.07	+48	.09	+56	.12	+62
	10	.03	+50	.04	+51	.07	+58	.10	+64	.13	+66
	15	.02	+53	.04	+55	.07	+64	.10	+67	.13	+68
	20	.03	+54	.04	+60	.07	+66	.10	+69	.13	+69
10 Volts	1.0	.05	+65	.08	+41	.09	+28	.08	+32	.08	+48
	2.5	.04	+59	.06	+42	.07	+38	.08	+48	.09	+59
	5.0	.03	+57	.05	+44	.07	+51	.08	+60	.11	+65
	10	.03	+54	.04	+51	.06	+60	.09	+66	.12	+69
	15	.03	+52	.04	+55	.06	+64	.09	+68	.12	+70
	20	.02	+54	.03	+59	.06	+66	.09	+69	.12	+71

TABLE IV - S₂₂

FREQUENCY (MHz)		200		500		1000		1500		2000	
V _{CC}	I _C	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ
1 Volt	1.0mA	.88	-23	.66	-41	.57	-56	.54	-76	.53	-96
	2.5	.76	-34	.48	-50	.40	-61	.37	-78	.37	-98
	5.0	.61	-45	.34	-58	.25	-67	.23	-84	.24	-103
	10	.42	-60	.20	-70	.15	-75	.14	-95	.16	-115
	15	.31	-67	.15	-77	.11	-83	.11	-105	.14	-125
	20	.16	-72	.09	-82	.10	-92	.12	-119	.16	-140
3 Volts	1.0	.91	-18	.75	-32	.66	-47	.62	-65	.60	-82
	2.5	.83	-25	.60	-38	.47	-50	.44	-64	.43	-81
	5.0	.72	-32	.47	-41	.36	-50	.34	-64	.33	-80
	10	.56	-40	.34	-42	.27	-49	.25	-62	.25	-78
	15	.48	-43	.30	-41	.23	-46	.21	-60	.22	-76
	20	.43	-43	.27	-39	.22	-44	.21	-58	.22	-75
6 Volts	1.0	.93	-15	.79	-27	.68	-42	.65	-57	.63	-74
	2.5	.87	-20	.67	-31	.55	-42	.52	-56	.51	-71
	5.0	.77	-26	.55	-34	.45	-41	.43	-53	.42	-68
	10	.63	-32	.43	-33	.37	-38	.36	-50	.35	-64
	15	.57	-33	.40	-31	.35	-35	.34	-47	.33	-62
	20	.53	-33	.38	-29	.34	-34	.33	-46	.33	-61
10 Volts	1.0	.94	-13	.82	-25	.73	-38	.69	-53	.67	-69
	2.5	.89	-18	.70	-28	.60	-38	.57	-51	.56	-66
	5.0	.81	-23	.60	-29	.50	-37	.48	-48	.47	-61
	10	.68	-27	.50	-28	.44	-34	.43	-45	.42	-58
	15	.62	-28	.47	-26	.43	-30	.42	-42	.42	-56
	20	.59	-27	.46	-24	.43	-30	.42	-42	.42	-56

MRF904

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.2 1.14	Watt mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_E = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 15$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ GHz)	f_T	—	4.0	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	—	1.0	pF
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, $f = 450$ MHz) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, $f = 1.0$ GHz)	NF	—	1.5 2.5	—	dB
FUNCTIONAL TEST					
Maximum Available Power(1) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, $f = 450$ MHz) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, $f = 1.0$ GHz)	G_{max}	—	16 10	—	dB

$$(1) G_{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$$

FIGURE 1 – NOISE FIGURE versus FREQUENCY

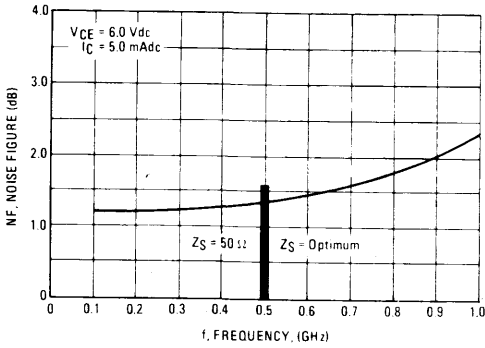


FIGURE 2 – NOISE FIGURE versus COLLECTOR CURRENT

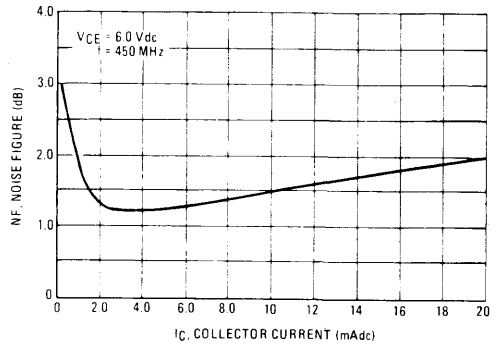


FIGURE 3 – COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

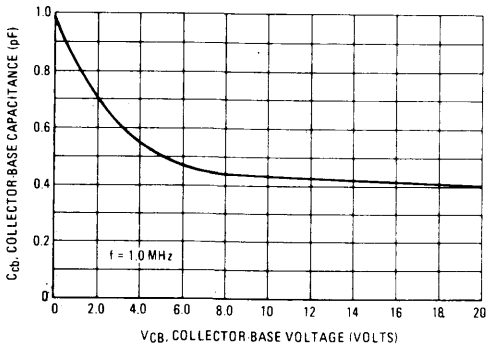


FIGURE 4 – UNILATERALIZED GAIN (G_{max}) versus FREQUENCY

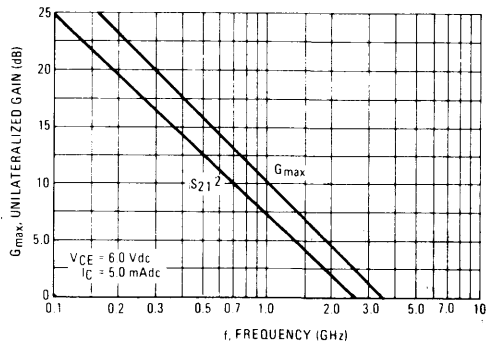


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT versus COLLECTOR CURRENT

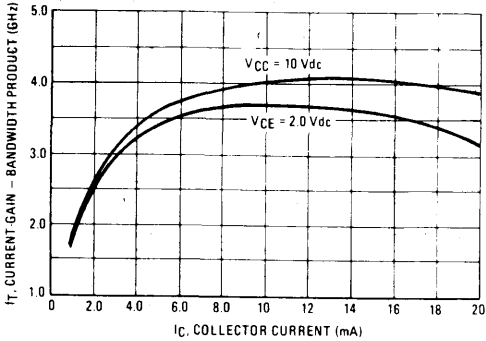


FIGURE 6 – INTERMODULATION DISTORTION versus COLLECTOR CURRENT

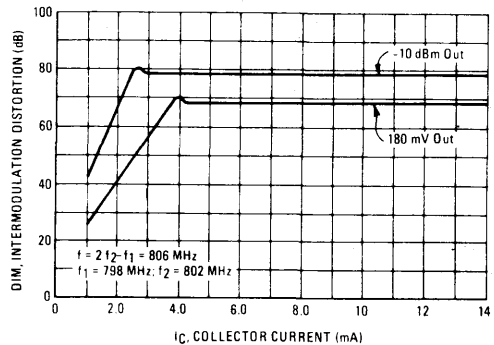


TABLE 1 - S₁₁ PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V _{CC} (Volts)	I _C (mA)	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ
1.0	1.0	0.941	-22	0.85	-43	0.57	-91	0.37	-128	0.30	-151
	2.5	0.85	-31	0.67	-57	0.35	-102	0.20	-136	0.14	-157
	5.0	0.69	-44	0.46	-71	0.21	-109	0.10	-144	0.069	-166
	10	0.45	-67	0.28	-94	0.13	-136	0.087	172	0.075	145
	15	0.37	-110	0.31	-145	0.26	170	0.27	139	0.27	122
	30	0.71	-178	0.71	169	0.68	144	0.68	121	0.65	107
3.0	1.0	0.94	-19	0.87	-37	0.61	-80	0.39	-114	0.30	-134
	2.5	0.87	-26	0.71	-47	0.39	-84	0.21	-106	0.15	-115
	5.0	0.74	-34	0.52	-55	0.25	-77	0.13	-82	0.109	-79
	10	0.55	-42	0.35	-58	0.18	-66	0.11	-60	0.105	-55
	15	0.46	-46	0.28	-59	0.15	-64	0.096	-55	0.092	-49
	30	0.28	-95	0.21	-134	0.16	175	0.17	135	0.17	116
6.0	1.0	0.95	-18	0.88	-35	0.63	-76	0.40	-108	0.30	-126
	2.5	0.89	-23	0.74	-43	0.42	-77	0.23	-94	0.17	-100
	5.0	0.77	-31	0.56	-49	0.29	-67	0.18	-69	0.15	-66
	10	0.61	-37	0.40	-50	0.23	-55	0.16	-51	0.16	-50
	15	0.52	-40	0.34	-51	0.20	-52	0.15	-47	0.15	-47
	30	0.36	-55	0.21	-70	0.098	-77	0.037	-59	0.033	-27
10	1.0	0.96	-17	0.89	-33	0.65	-73	0.41	-103	0.31	-121
	2.5	0.89	-22	0.76	-41	0.44	-73	0.25	-88	0.18	-93
	5.0	0.79	-28	0.59	-46	0.32	-63	0.20	-65	0.18	-63
	10	0.64	-34	0.44	-47	0.26	-52	0.19	-49	0.18	-49
	15	0.57	-37	0.38	-48	0.23	-49	0.18	-46	0.17	-46
	30	0.41	-51	0.24	-64	0.12	-67	0.061	-52	0.055	-36

TABLE 2 - S₂₁ PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V _{CC} (Volts)	I _C (mA)	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ
1.0	1.0	5.32	156	3.06	137	2.22	97	1.65	70	1.44	56
	2.5	6.79	146	5.57	124	3.15	86	2.14	64	1.81	52
	5.0	10.97	133	7.60	110	3.62	79	2.38	61	2.00	49
	10	13.16	118	8.07	99	3.60	74	2.35	57	1.96	46
	15	9.84	108	5.66	91	2.44	67	1.63	49	1.38	38
	30	1.65	83	0.88	69	0.47	46	0.43	37	0.45	31
3.0	1.0	3.33	159	3.11	142	2.36	103	1.79	76	1.55	62
	2.5	6.89	150	5.85	129	3.48	92	2.38	70	2.00	58
	5.0	11.49	138	8.34	115	4.12	84	2.70	66	2.25	55
	10	15.71	125	9.82	104	4.39	79	2.85	63	2.34	53
	15	16.97	119	10.05	100	4.39	77	2.83	61	2.34	52
	30	12.66	108	7.02	92	2.98	70	1.94	54	1.61	44
6.0	1.0	3.31	160	3.10	144	2.41	106	1.83	79	1.60	65
	2.5	6.80	151	5.85	131	3.60	94	2.46	77	2.07	60
	5.0	11.44	140	8.54	117	4.28	86	2.83	68	2.33	57
	10	15.85	127	10.14	107	4.61	81	2.96	65	2.46	55
	15	17.20	122	10.47	102	4.60	79	2.96	63	2.45	54
	30	16.37	113	9.38	96	4.00	75	2.58	59	2.14	49
10	1.0	3.25	160	3.08	145	2.40	108	1.83	81	1.61	67
	2.5	6.73	152	5.85	132	3.63	96	2.50	74	2.10	62
	5.0	11.19	142	8.49	119	4.34	88	2.85	69	2.37	59
	10	15.59	129	10.16	108	4.66	82	3.00	66	2.47	56
	15	17.04	124	10.49	104	4.65	80	2.99	64	2.47	55
	30	16.18	115	9.38	98	4.03	96	2.60	60	2.14	50

TABLE 3 – S₁₂ PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V _{CC} (Volts)	I _C (mA)	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ
1.0	1.0	0.054	73	0.097	61	0.159	41	0.184	36	0.194	37
	2.5	0.051	69	0.084	58	0.140	50	0.189	48	0.220	46
	5.0	0.046	65	0.072	60	0.137	58	0.201	53	0.239	50
	10	0.041	64	0.067	64	0.142	62	0.215	56	0.256	51
	15	0.043	61	0.070	63	0.152	62	0.230	55	0.277	50
	30	0.058	50	0.093	58	0.209	57	0.311	46	0.372	39
3.0	1.0	0.039	75	0.072	65	0.123	46	0.143	42	0.151	44
	2.5	0.037	72	0.063	62	0.110	54	0.150	53	0.174	52
	5.0	0.033	70	0.055	64	0.108	62	0.160	58	0.190	55
	10	0.030	70	0.050	68	0.109	67	0.165	61	0.199	57
	15	0.028	70	0.049	70	0.109	68	0.167	62	0.200	57
	30	0.026	68	0.046	70	0.105	69	0.165	64	0.200	61
6.0	1.0	0.032	76	0.060	66	0.106	49	0.123	45	0.131	48
	2.5	0.031	73	0.054	64	0.095	57	0.130	56	0.151	55
	5.0	0.028	71	0.048	66	0.094	64	0.139	61	0.165	58
	10	0.026	71	0.043	69	0.094	68	0.144	63	0.172	59
	15	0.024	71	0.042	71	0.093	69	0.144	64	0.172	60
	30	0.021	71	0.037	72	0.086	71	0.134	67	0.162	63
10	1.0	0.028	77	0.053	68	0.095	50	0.109	47	0.116	50
	2.5	0.027	74	0.048	65	0.085	58	0.116	57	0.134	57
	5.0	0.025	73	0.043	67	0.084	64	0.125	62	0.148	60
	10	0.023	72	0.037	69	0.084	69	0.128	64	0.153	61
	15	0.022	73	0.037	70	0.084	69	0.128	65	0.152	62
	30	0.019	72	0.033	72	0.076	72	0.119	68	0.143	66

TABLE 4 – S₂₂ PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V _{CC} (Volts)	I _C (mA)	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ
1.0	1.0	0.966	-12	0.893	-23	0.693	-41	0.612	-53	0.594	-59
	2.5	0.901	-18	0.760	-29	0.548	-42	0.498	-51	0.494	-56
	5.0	0.793	-24	0.619	-32	0.456	-39	0.429	-49	0.439	-54
	10	0.635	-29	0.486	-32	0.390	-36	0.377	-47	0.389	-53
	15	0.453	-29	0.364	-29	0.313	-34	0.309	-48	0.321	-14
	30	0.048	-78	0.035	-88	0.032	-135	0.031	-162	0.007	-167
3.0	1.0	0.976	-9.0	0.926	-18	0.770	-35	0.702	-46	0.683	-51
	2.5	0.935	-13	0.828	-23	0.648	-35	0.608	-43	0.608	-48
	5.0	0.853	-18	0.712	-25	0.577	-32	0.555	-41	0.565	-46
	10	0.758	-20	0.629	-23	0.539	-29	0.529	-39	0.544	-44
	15	0.711	-20	0.601	-22	0.533	-27	0.526	-38	0.540	-44
	30	0.631	-15	0.576	-16	0.548	-25	0.546	-38	0.558	-45
6.0	1.0	0.982	-8.0	0.939	-16	0.803	-31	0.742	42	0.734	-47
	2.5	0.947	-11	0.861	-20	0.699	-31	0.662	-40	0.660	-45
	5.0	0.882	-15	0.759	-21	0.633	-29	0.617	-31	0.627	-43
	10	0.801	-17	0.684	-20	0.607	-26	0.601	-35	0.610	-41
	15	0.769	-17	0.667	-19	0.602	-25	0.601	-35	0.607	-40
	30	0.737	-14	0.672	-15	0.640	-22	0.641	-33	0.655	-40
10	1.0	0.983	-7.0	0.949	-14	0.830	-29	0.774	-39	0.765	-40
	2.5	0.954	-10	0.880	-18	0.733	-29	0.698	-37	0.702	-42
	5.0	0.901	-13	0.793	-19	0.676	-27	0.659	-35	0.668	-41
	10	0.834	-15	0.725	-18	0.646	-24	0.646	-33	0.658	-39
	15	0.802	-15	0.706	-17	0.645	-23	0.648	-33	0.661	-39
	30	0.776	-13	0.712	-14	0.678	-22	0.686	-32	0.699	-38

MRF905

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

RF OSCILLATOR TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	20	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ $T_C = 100^\circ\text{C}$ Derate above 100°C	P_D	2.5 40	Watts mW/°C
Storage Temperature	T_{stg}	-65 to +200	°C

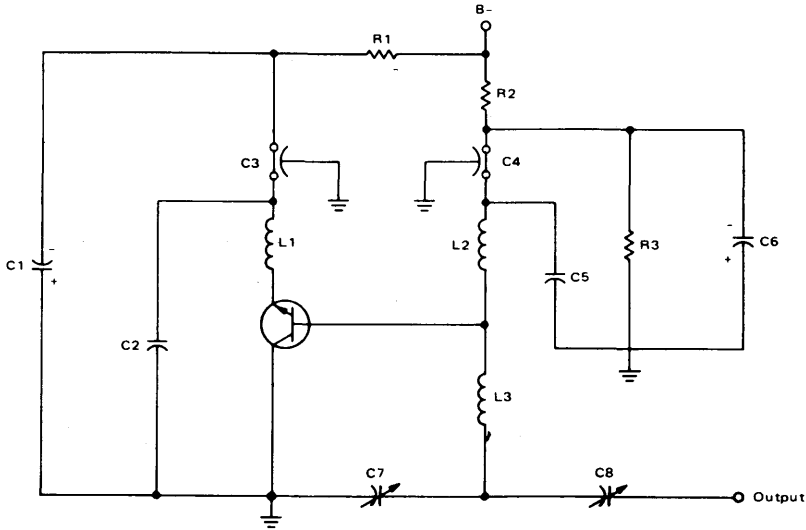
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	60	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc, $f = 200$ MHz)	f_T	—	2500	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	3.0	5.0	pF
FUNCTIONAL TEST					
Common-Collector Oscillator Output Power (Figure 1) ($V_E = -20$ Vdc, $I_E \cong 110$ mAdc, $f \cong 1.68$ GHz)	P_{out}	400	500	—	mW

FIGURE 1 - 1.68 GHz OSCILLATOR TEST CIRCUIT SCHEMATIC



C1,C6 1.0 μ F, 35 Vdc TANTALUM
 C2,C5 0.1 μ F Ceramic Disk
 C3,C4 680 pF Feedthru
 C7,C8 0.4-6.0 pF JOHANSON

R1 47 Ohms, 1/4 Watt
 R2 510 Ohms, 1/4 Watt
 R3 1.5 k Ω , 1/4 Watt
 L1,L2 5 Turns, #22 AWG, 0.125" I.D.
 L3 #20 AWG, 0.4" Length.

MRF911

CASE 317-01, STYLE 2 HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	12	Vdc
Collector-Base Voltage	V _{CBO}	20	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Peak	I _C	40	mAdc
Total Device Dissipation @ T _L = 50°C Derate above 50°C	P _D	400 4.0	mW mW/°C
Storage Temperature	T _{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Lead	R _{θJL}	250	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	12	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0)	V _{(BR)CBO}	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 30 mAdc, V _{CE} = 10 Vdc)	h _{FE}	30	—	200	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 30 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz)	f _T	—	5.0	—	GHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	0.6	1.0	pF

FUNCTIONAL TEST

Noise Figure (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz) (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 2.0 GHz)	NF	—	2.5 4.0	—	dB
Power Gain at Optimum Noise Figure (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz) (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 2.0 GHz)	G _{NF}	—	10 6.0	—	dB
Maximum Available Power Gain(1) (I _C = 30 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz) (I _C = 30 mAdc, V _{CE} = 10 Vdc, f = 2.0 GHz)	G _{max}	—	12.5 7.5	—	dB

$$(1) G_{\max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$$

FIGURE 1 – POWER DERATING

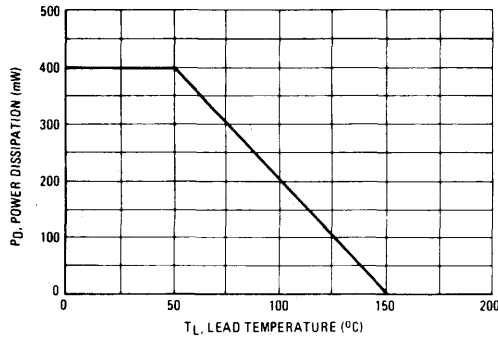


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

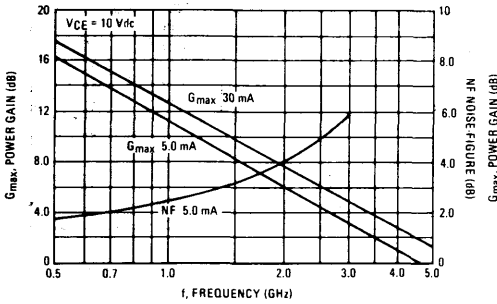


FIGURE 3 – POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

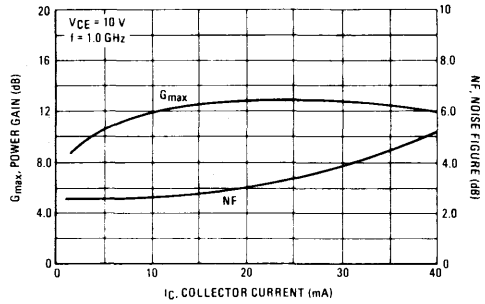


FIGURE 4 – S₁₁ PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V _{CE} (Volts)	I _C (mA)	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ
5.0	2.0	0.66	-125	0.64	-175	0.68	160	0.73	140
	5.0	0.57	-150	0.58	170	0.62	150	0.66	135
	10	0.54	-165	0.57	160	0.60	145	0.64	130
	20	0.54	-180	0.57	155	0.60	140	0.64	125
	30	0.54	175	0.57	155	0.61	140	0.65	125
10	2.0	0.66	-120	0.63	-170	0.67	160	0.71	140
	5.0	0.56	-145	0.56	175	0.60	150	0.64	135
	10	0.51	-160	0.53	165	0.57	145	0.61	130
	20	0.49	-175	0.52	160	0.57	145	0.60	130
	30	0.49	-175	0.53	160	0.57	145	0.61	130

FIGURE 5 - S₂₂ PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V _{CE} (Volts)	I _C (mA)	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ
5.0	2.0	0.61	-45	0.50	-60	0.48	-80	0.50	-100
	5.0	0.40	-55	0.31	-65	0.30	-85	0.32	-100
	10	0.27	-60	0.20	-70	0.20	-90	0.23	-105
	20	0.19	-70	0.13	-75	0.14	-95	0.17	-110
	30	0.16	-70	0.11	-75	0.13	-95	0.16	-110
10	2.0	0.66	-35	0.55	-50	0.53	-70	0.54	-90
	5.0	0.47	-45	0.38	-50	0.37	-70	0.38	-75
	10	0.35	-45	0.28	-50	0.27	-65	0.29	-85
	20	0.26	-45	0.22	-50	0.22	-65	0.24	-80
	30	0.25	-40	0.21	-45	0.22	-60	0.24	-80

FIGURE 6 - S₂₁ PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V _{CE} (Volts)	I _C (mA)	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ
5.0	2.0	3.24	100	1.84	70	1.23	50	0.96	35
	5.0	4.85	90	2.60	70	1.76	50	1.38	40
	10	5.78	85	3.04	70	2.05	50	1.61	40
	20	6.40	85	3.30	65	2.23	50	1.24	40
	30	6.47	80	3.35	65	2.26	50	1.76	40
10	2.0	3.42	100	1.95	70	1.31	50	1.01	35
	5.0	5.20	95	2.80	70	1.89	50	1.45	40
	10	6.22	90	3.28	70	2.20	55	1.71	40
	20	6.82	85	3.55	65	2.37	55	1.84	40
	30	6.90	85	3.55	65	2.36	50	1.81	40

FIGURE 7 - S₁₂ PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V _{CE} (Volts)	I _C (mA)	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ
5.0	2.0	0.11	30	0.12	25	0.11	35	0.13	50
	5.0	0.08	40	0.10	45	0.13	55	0.17	55
	10	0.07	50	0.10	55	0.14	60	0.19	60
	20	0.06	60	0.11	65	0.15	65	0.20	60
	30	0.06	65	0.11	65	0.15	65	0.20	60
10	2.0	0.10	35	0.10	30	0.10	40	0.12	55
	5.0	0.07	40	0.09	45	0.12	55	0.15	60
	10	0.06	50	0.09	55	0.13	60	0.17	60
	20	0.06	60	0.10	65	0.13	65	0.18	60
	30	0.06	60	0.10	65	0.14	65	0.18	65

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MRF912

CASE 303-01, STYLE 1 HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	12	Vdc
Collector-Base Voltage	V _{CBO}	20	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Peak	I _C	50	mAdc
Total Device Dissipation (at T _C = 75°C Derate above 75°C)	P _D	500 4.0	mW mW/°C
Storage Temperature	T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	250	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	12	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0)	V _{(BR)CBO}	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 30 mAdc, V _{CE} = 10 Vdc)	h _{FE}	30	—	200	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 30 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz)	f _T	—	5.0	—	GHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	0.6	1.0	pF

FUNCTIONAL TEST

Noise Figure (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz) (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 2.0 GHz)	NF	— —	2.5 4.0	3.0 —	dB
Power Gain at Optimum Noise Figure (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz) (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 2.0 GHz)	G _{NF}	— —	12 7.0	— —	dB
Maximum Available Power Gain(1) (I _C = 30 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz) (I _C = 30 mAdc, V _{CE} = 10 Vdc, f = 2.0 GHz)	G _{max}	14 —	16.5 11.0	— —	dB

$$(1) G_{\max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$$

FIGURE 1 – POWER DERATING

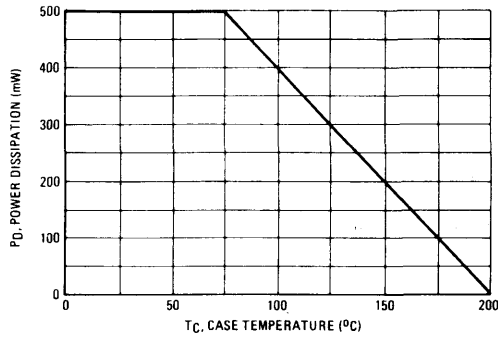


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

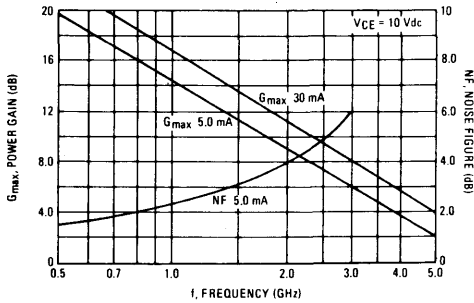


FIGURE 3 – POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

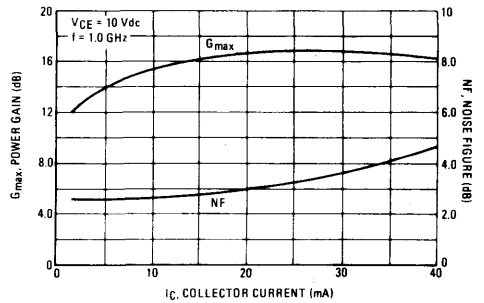


FIGURE 4 – S₁₁ PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
VCE (Volts)	I _C (mA)	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ
5.0	2.0	0.76	-120	0.74	-160	0.76	-175	0.79	175
	5.0	0.72	-145	0.73	-170	0.75	175	0.77	165
	10	0.71	-160	0.74	180	0.75	170	0.77	160
	20	0.73	-170	0.75	175	0.77	165	0.79	155
	30	0.74	-175	0.76	170	0.78	165	0.81	155
	40	0.74	-180	0.76	165	0.79	155	0.81	145
	50	0.74	180	0.77	165	0.79	155	0.82	145
10	2.0	0.77	-115	0.74	-155	0.76	-170	0.78	175
	5.0	0.71	-140	0.72	-170	0.73	175	0.75	165
	10	0.69	-155	0.71	-175	0.73	170	0.75	165
	20	0.69	-165	0.72	175	0.74	165	0.76	160
	30	0.70	-170	0.73	175	0.75	165	0.77	160
	40	0.69	-175	0.72	165	0.75	155	0.78	145
	50	0.70	-175	0.73	165	0.76	155	0.80	145

FIGURE 5 – S₂₂ PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V _{CE} (Volts)	I _C (mA)	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ
5.0	2.0	0.66	-50	0.57	-70	0.57	-95	0.61	-115
	5.0	0.45	-65	0.37	-85	0.39	-105	0.44	-120
	10	0.33	-80	0.27	-100	0.30	-115	0.35	-130
	20	0.24	-95	0.21	-115	0.24	-125	0.29	-135
	30	0.21	-100	0.18	-120	0.22	-125	0.28	-135
	40	0.18	-100	0.16	-115	0.20	-125	0.27	-135
	50	0.17	-95	0.16	-110	0.21	-120	0.28	-135
	10	2.0	0.71	-45	0.62	-65	0.62	-85	0.64
5.0		0.51	-55	0.43	-70	0.44	-90	0.48	-105
10		0.37	-60	0.31	-75	0.33	-95	0.38	-110
20		0.27	-70	0.23	-80	0.26	-95	0.32	-115
30		0.23	-65	0.21	-80	0.25	-95	0.31	-110
40		0.23	-60	0.22	-70	0.25	-90	0.32	-110
50		0.24	-50	0.24	-65	0.28	-90	0.34	-105

FIGURE 6 – S₂₁ PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V _{CE} (Volts)	I _C (mA)	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ
5.0	2.0	3.52	102	1.97	70	1.33	50	0.99	35
	5.0	5.61	95	2.96	70	1.98	50	1.50	35
	10	6.84	90	3.55	70	2.35	55	1.78	40
	20	7.65	85	3.94	65	2.59	50	1.96	40
	30	7.93	85	4.02	65	2.63	50	1.98	40
	40	7.87	80	3.95	65	2.57	45	1.92	30
	50	7.65	80	3.86	60	2.48	45	1.86	30
	10	2.0	3.70	105	2.12	75	-1.43	50	1.07
5.0		6.09	95	3.24	70	2.17	50	1.62	35
10		7.53	90	3.91	70	2.58	55	1.96	40
20		8.54	85	4.38	70	2.86	55	2.17	40
30		8.79	85	4.45	65	2.92	50	2.17	40
40		8.58	80	4.32	65	2.80	45	2.08	30
50		8.30	80	4.15	60	2.69	45	1.98	30

FIGURE 7 – S₁₂ PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V _{CE} (Volts)	I _C (mA)	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ
5.0	2.0	0.11	25	0.11	5.0	0.10	-5	0.09	-5
	5.0	0.07	25	0.08	15	0.08	15	0.08	15
	10	0.05	25	0.06	25	0.07	30	0.08	30
	20	0.04	35	0.05	40	0.07	40	0.08	40
	30	0.03	45	0.05	45	0.06	50	0.08	45
	40	0.03	50	0.05	50	0.07	50	0.08	50
	50	0.03	55	0.05	55	0.06	50	0.08	50
	10	2.0	0.09	25	0.10	5.0	0.09	0	0.08
5.0		0.06	25	0.07	15	0.07	20	0.07	20
10		0.05	30	0.06	30	0.06	30	0.07	35
20		0.03	40	0.05	40	0.06	45	0.07	40
30		0.03	40	0.05	45	0.06	47	0.07	45
40		0.03	45	0.05	50	0.06	50	0.07	45
50		0.03	50	0.04	50	0.06	50	0.07	50

MRF914

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	12	Vdc
Collector-Base Voltage	V _{CBO}	20	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Peak	I _C	40	mAdc
Total Device Dissipation @ T _A = 75°C Derate above 75°C	P _D	200 1.6	mW mW/°C
Storage Temperature	T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	625	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 1.0 mAdc, I _B = 0)	V _{(BR)CEO}	12	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0)	V _{(BR)CBO}	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	V _{(BR)EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V _{CB} = 15 Vdc, I _E = 0)	I _{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 20 mAdc, V _{CE} = 10 Vdc)	h _{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz)	f _T	—	4.5	—	GHz
Collector-Base Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{cb}	—	0.7	1.0	pF
FUNCTIONAL TEST					
Noise Figure (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz) (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz)	NF	—	2.0 2.5	—	dB
Power Gain at Optimum Noise Figure (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz) (I _C = 5.0 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz)	G _{NF}	—	12 7.0	—	dB
Maximum Available Power Gain(1) (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 0.5 GHz) (I _C = 20 mAdc, V _{CE} = 10 Vdc, f = 1.0 GHz)	G _{max}	—	15 10	—	dB

$$(1) G_{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$$

FIGURE 1 – POWER DERATING

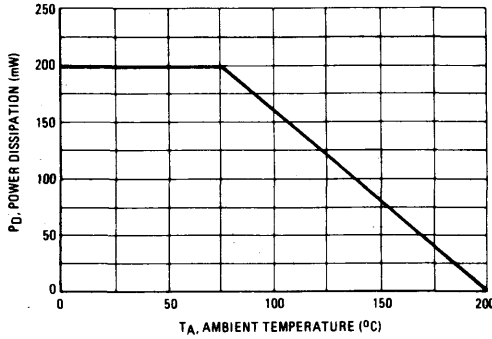


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

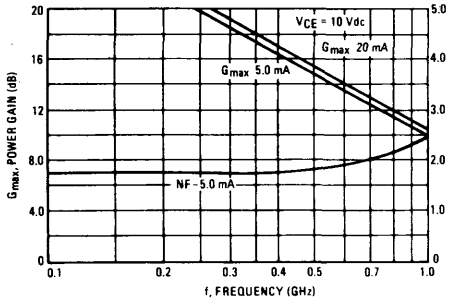


FIGURE 3 – POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

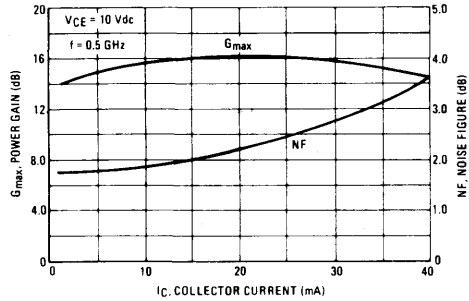


FIGURE 4 – S₁₁ PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
VCE (Volts)	IC (mA)	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ	S ₁₁	∠φ
5.0	2.0	0.84	-35	0.57	-80	0.42	-115	0.34	-140	0.27	-166
	5.0	0.65	-45	0.34	-85	0.23	-115	0.18	-130	0.16	-150
	10	0.48	-50	0.32	-85	0.14	-105	0.12	-115	0.09	-120
	20	0.33	-50	0.15	-75	0.10	-90	0.09	-100	0.09	-101
	30	0.27	-50	0.13	-70	0.09	-85	0.09	-100	0.09	-101
10	2.0	0.86	-30	0.59	-75	0.42	-105	0.34	-130	0.25	-155
	5.0	0.70	-40	0.37	-75	0.24	-95	0.18	-110	0.13	-125
	10	0.55	-45	0.26	-70	0.17	-80	0.14	-90	0.13	-90
	20	0.41	-45	0.21	-60	0.15	-65	0.13	-75	0.14	-80
	30	0.36	-45	0.19	-55	0.14	-65	0.13	-75	0.13	-80

FIGURE 5 – S₂₂ PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
V _{CE} (Volts)	I _C (mA)	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ	S ₂₂	∠φ
5.0	2.0	0.94	-15	0.77	-25	0.68	-30	0.66	-35	0.64	-45
	5.0	0.85	-20	0.63	-30	0.57	-30	0.55	-35	0.55	-45
	10	0.75	-25	0.55	-25	0.51	-30	0.50	-35	0.50	-40
	20	0.66	-25	0.50	-25	0.47	-30	0.47	-35	0.48	-40
	30	0.62	-25	0.49	-25	0.46	-25	0.46	-30	0.47	-40
10	2.0	0.95	-10	0.81	-20	0.74	-30	0.72	-35	0.71	-40
	5.0	0.87	-15	0.69	-25	0.64	-25	0.63	-30	0.63	-40
	10	0.80	-20	0.63	-20	0.59	-25	0.59	-30	0.60	-40
	20	0.72	-20	0.59	-20	0.57	-23	0.57	-30	0.58	-35
	30	0.70	-20	0.59	-20	0.57	-20	0.57	-30	0.58	-35

FIGURE 6 – S₂₁ PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
V _{CE} (Volts)	I _C (mA)	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ	S ₂₁	∠φ
5.0	2.0	5.99	150	4.06	110	2.90	90	2.27	75	1.71	55
	5.0	11.38	135	5.91	100	3.90	80	2.93	70	2.17	55
	10	15.21	125	6.78	95	4.34	80	3.23	70	2.38	55
	20	17.98	115	7.27	90	4.58	75	3.40	65	2.50	50
	30	18.78	110	7.37	85	4.64	75	3.42	65	2.50	50
10	2.0	6.05	150	4.20	115	3.04	90	2.37	75	1.75	55
	5.0	11.46	135	6.17	100	4.06	85	3.08	70	2.26	55
	10	15.45	127	7.08	95	4.56	80	3.41	70	2.50	55
	20	18.35	120	7.57	90	4.80	75	3.58	65	2.61	55
	30	19.12	115	7.63	90	4.79	75	3.56	65	2.60	55

FIGURE 7 – S₁₂ PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
V _{CE} (Volts)	I _C (mA)	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ	S ₁₂	∠φ
5.0	2.0	0.04	70	0.09	50	0.11	50	0.12	50	0.16	50
	5.0	0.04	70	0.07	60	0.11	60	0.14	60	0.19	55
	10	0.03	70	0.07	70	0.11	65	0.15	65	0.20	55
	20	0.03	75	0.07	70	0.12	70	0.15	65	0.21	55
	30	0.03	75	0.07	70	0.12	70	0.16	65	0.21	57
10	2.0	0.03	70	0.07	55	0.09	50	0.10	50	0.13	55
	5.0	0.03	70	0.06	60	0.09	65	0.12	60	0.15	60
	10	0.03	70	0.06	65	0.09	65	0.12	65	0.17	60
	20	0.03	75	0.06	70	0.09	70	0.13	65	0.18	60
	30	0.03	75	0.06	70	0.10	70	0.13	65	0.17	60

MRF931

CASE 317-01, STYLE 2 HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	5.0	Vdc
Collector-Base Voltage	V_{CB0}	10	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Peak	I_C	5.0	mAdc
Total Device Dissipation @ $T_A = 100^\circ\text{C}$ Derate above 100°C	P_D	50 1.0	mW mW/°C
Junction Temperature	T_J	+150	°C
Storage Temperature	T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 0.1$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	5.0	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	10	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 5.0$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	30	—	150	—
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SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_E = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc, $f = 1.0$ GHz)	f_T	—	3.0	—	GHz
Collector-Base Capacitance ($V_{CB} = 1.0$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{cb}	—	0.35	0.5	pF

FUNCTIONAL TEST

Noise Figure ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, $f = 0.5$ GHz) ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, $f = 1.0$ GHz)	NF	— —	3.8 4.3	— —	dB
Power Gain at Optimum Noise Figure ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, $f = 0.5$ GHz) ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, $f = 1.0$ GHz)	G _{NF}	— —	16 10	— —	dB
Transducer Power Gain ($I_E = 0.5$ mAdc, $V_{CE} = 1.0$ Vdc, $f = 0.5$ GHz) ($I_E = 0.5$ mAdc, $V_{CE} = 1.0$ Vdc, $f = 1.0$ GHz)	G _T	— —	18 12	— —	dB

FIGURE 1 – POWER DERATING

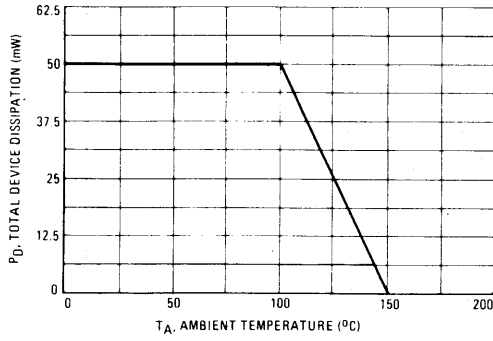


FIGURE 2 – TRANSDUCER POWER GAIN AND NOISE FIGURE versus FREQUENCY

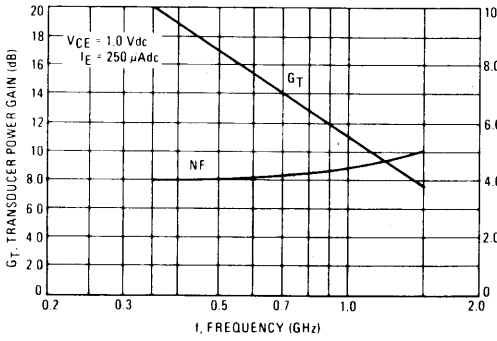
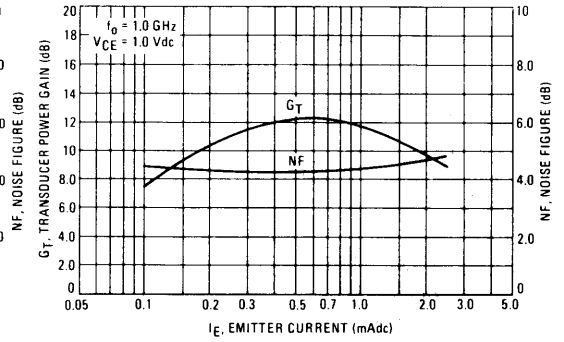


FIGURE 3 – TRANSDUCER POWER GAIN AND NOISE FIGURE versus EMITTER CURRENT



MRF966



CASE 317-01, STYLE 1

DUAL GATE
GaAs FET

N-CHANNEL

MRF967



CASE 358-01, STYLE 2

DUAL GATE
GaAs FET

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	MRF966	MRF967	Unit
Drain-Source Voltage	V_{DS}	10	10	Vdc
Gate-Source Voltage — Reverse	V_{G1S}	-8.0 -8.0	-8.0 -8.0	Vdc
Gate-Source Voltage — Forward	V_{G1S} V_{G2S}	+1.0 +1.0	+1.0 +1.0	Vdc
Drain Current	I_D	60	60	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 3.5	350 3.5	mW mW/°C
Junction Temperature Range	T_J	-65 to +125	-65 to +125	°C
Storage Channel Temperature Range	T_{stg}	-65 to +125	-65 to +125	°C

Handling and Packaging — MES devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MES devices should be observed.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($V_{G1S} = V_{G2S} = -4.0$ Vdc, $I_D = 100$ μA)	$V_{(BR)DSX}$	10	—	—	Vdc
Gate 1 Leakage Current ($V_{G1S} = -5.0$ Vdc, $V_{G2S} = V_{DS} = 0$)	I_{G1SS}	—	—	10	μAdc
Gate 2 Leakage Current ($V_{G2S} = -5.0$ Vdc, $V_{G1S} = V_{DS} = 0$)	I_{G2SS}	—	—	10	μAdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0$)	$V_{G1S(off)}$	-2.0	—	-4.5	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 5.0$ Vdc, $V_{G1S} = 0$)	$V_{G2S(off)}$	-2.0	—	-4.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain ($V_{DS} = 5.0$ Vdc, $V_{G1S} = V_{G2S} = 0$)	I_{DSS}	30	50	80	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0$, $I_D = 10$ mA, $f = 1.0$ kHz)	$ Y_{fs} $	14	20	—	mmhos
Input Capacitance ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0$, $I_D = 10$ mA, $f = 1.0$ MHz)	C_{iss}	—	0.45	—	pF
Reverse Transfer Capacitance ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0$, $I_D = 10$ mA, $f = 1.0$ MHz)	C_{rss}	—	0.04	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0(1)$, $I_{DS} = 10$ mA, $f = 1.0$ GHz)	NF	—	1.2	1.5	dB
Common Source Power Gain ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0(1)$, $I_{DS} = 10$ mA, $f = 1.0$ GHz)	G_{ps}	MRF967 13 MRF966 15	15 18	—	dB
Intermodulation Distortion ($V_{DS} = 5.0$ Vdc, $I_{DS} = 10$ mA, $f_1 = 995$ MHz, $f_2 = 1001$ MHz, $V_{G2} = 0$, $P_{in} = -40$ dBm)	IMD ₃	—	-65	—	dB

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ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Linear Power Point(2) ($V_{DS} = 5.0\text{ Vdc}$, $I_{DS} = 10\text{ mA}$, $f_1 = 995\text{ MHz}$, $f_2 = 1001\text{ MHz}$, $V_{G2} = 0$)	P_L	—	+1.0	—	dBm
Output Power at 1 dB Compression Point ($V_{DS} = 5.0\text{ Vdc}$, $I_{DS} = 10\text{ mA}$, $f = 1.0\text{ GHz}$)	P_{out}	—	10	—	dBm

- (1) Data taken using a HP11608A 50 Ω test fixture, Microlab slug tuners, HP11590A bias networks and the HP8970A noise figure meter.
Note: $V_{G2S} = 0$. Refer to Figure 16.
- (2) The linear power point is the output power level at which either the signal $2f_1 \pm f_2$ or $2f_2 \pm f_1$ are 30 dB below f_1 or f_2 .

TYPICAL CHARACTERISTICS
MRF966

FIGURE 1 — DRAIN CURRENT versus DRAIN-TO-SOURCE VOLTAGE

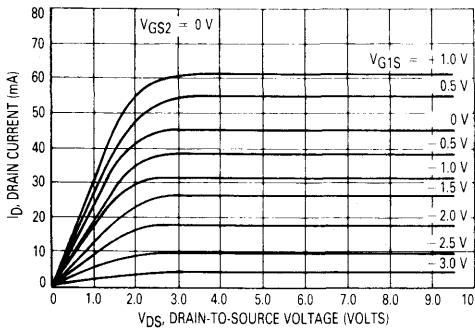


FIGURE 2 — DRAIN CURRENT versus GATE ONE-TO-SOURCE VOLTAGE

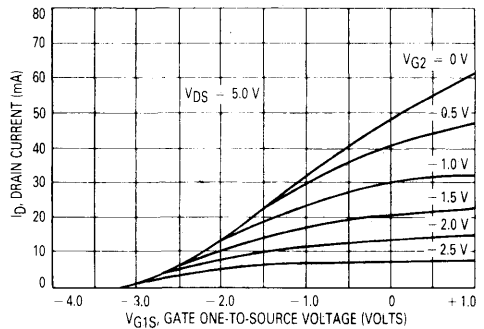


FIGURE 3 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus DRAIN-TO-SOURCE VOLTAGE

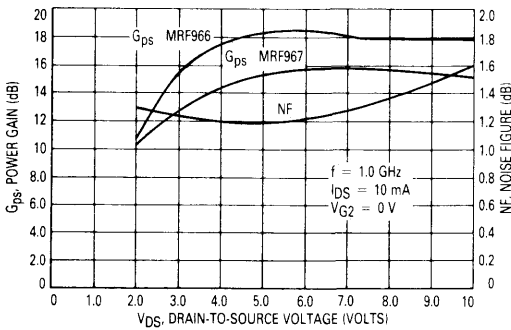


FIGURE 4 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus PERCENT-OF-DRAIN CURRENT

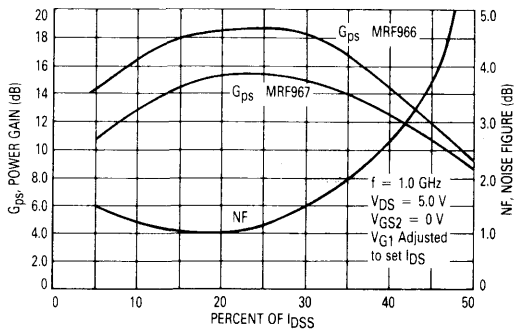


FIGURE 5 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus GATE ONE-TO-SOURCE VOLTAGE

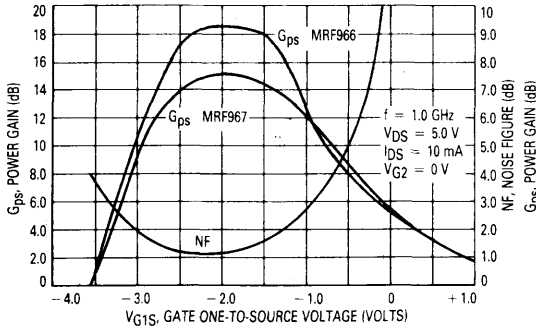


FIGURE 6 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus GATE CONTROL SUPPLY VOLTAGE

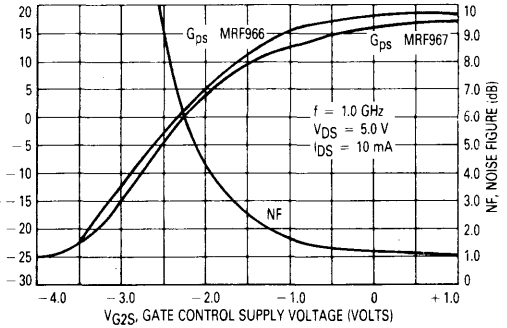


FIGURE 7 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus FREQUENCY

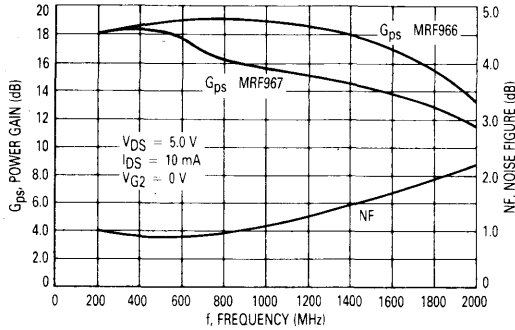


FIGURE 8 — MAXIMUM AVAILABLE GAIN AND STABILITY FACTOR versus FREQUENCY

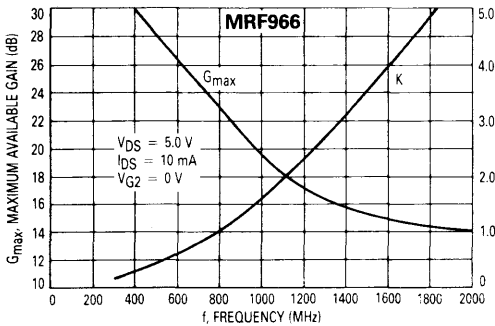


FIGURE 9 — MAXIMUM AVAILABLE GAIN AND STABILITY FACTOR versus FREQUENCY

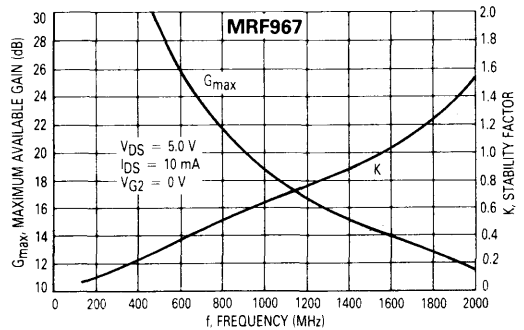


FIGURE 10 — OUTPUT POWER versus INPUT POWER @ 500 MHz

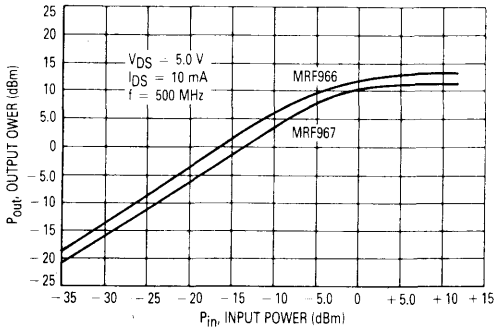
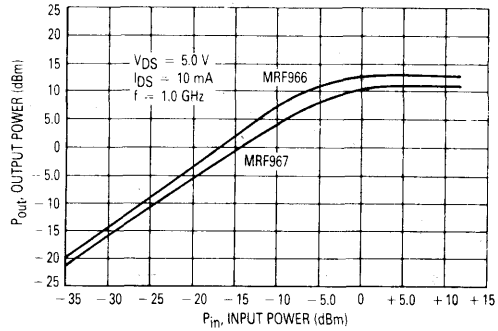


FIGURE 11 — OUTPUT POWER versus INPUT POWER @ 1.0 GHz



TYPICAL CHARACTERISTICS

MRF967

FIGURE 12 — THIRD ORDER INTERMODULATION DISTORTION @ 500 MHz

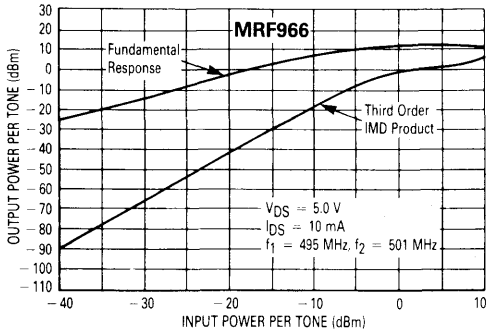


FIGURE 13 — THIRD ORDER INTERMODULATION DISTORTION @ 500 MHz

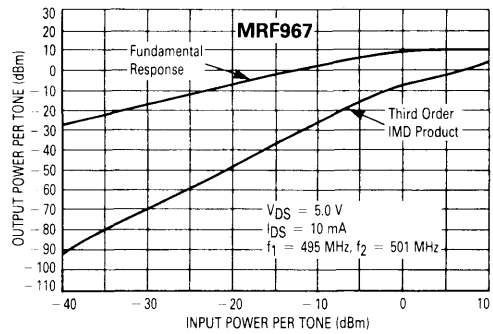


FIGURE 14 — THIRD ORDER INTERMODULATION DISTORTION @ 1.0 GHz

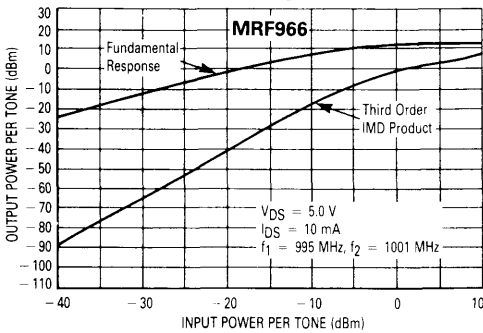


FIGURE 15 — THIRD ORDER INTERMODULATION DISTORTION @ 1.0 GHz

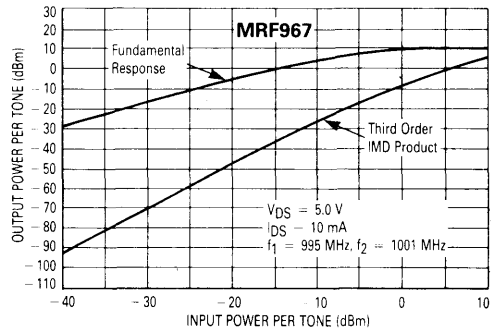
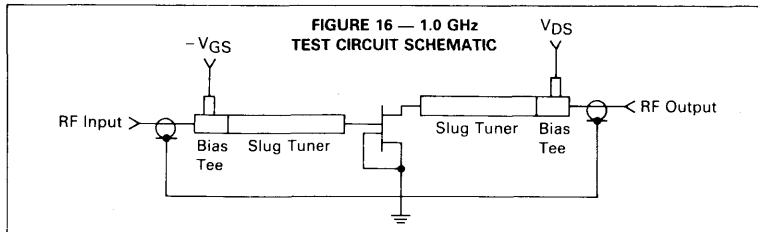
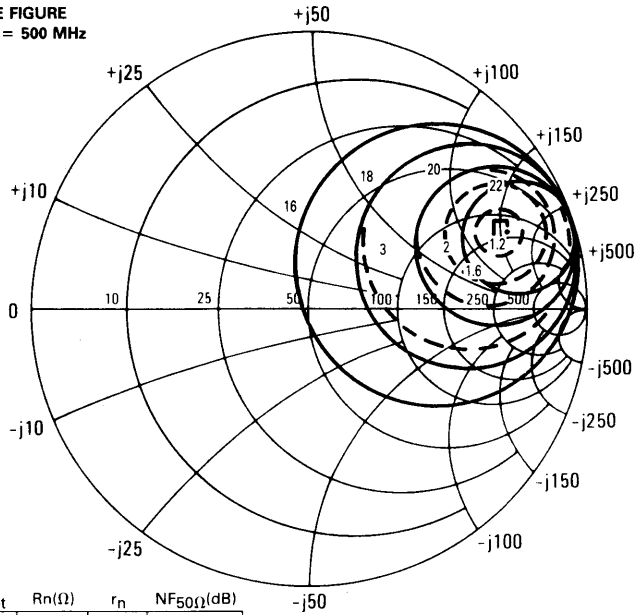


FIGURE 16 — 1.0 GHz TEST CIRCUIT SCHEMATIC



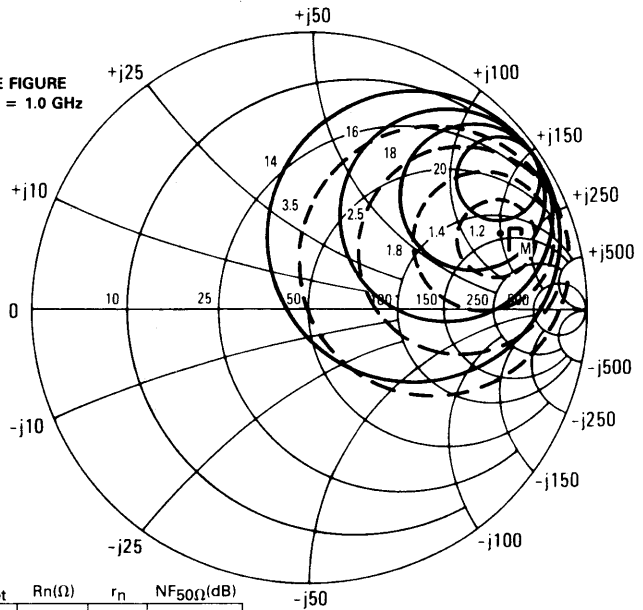
MRF966

FIGURE 17 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT $V_{DS} = 5.0$ V, $I_{DS} = 10$ mA, $f = 500$ MHz (MATCHED OUTPUT)



f(MHz)	NF _{opt} (dB)	Γ_{MS} NF _{opt}	Γ_{ML} NF _{opt}	Rn(Ω)	r _n	NF _{50Ω} (dB)
500	1.0	0.76/22°	0.75/14°	101.5	2.03	4.5

FIGURE 18 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT $V_{DS} = 5.0$ V, $I_{DS} = 10$ mA, $f = 1.0$ GHz (MATCHED OUTPUT)



f(MHz)	NF _{opt} (dB)	Γ_{MS} NF _{opt}	Γ_{ML} NF _{opt}	Rn(Ω)	r _n	NF _{50Ω} (dB)
1000	1.2	0.74/21°	0.77/12°	63	1.26	3.5

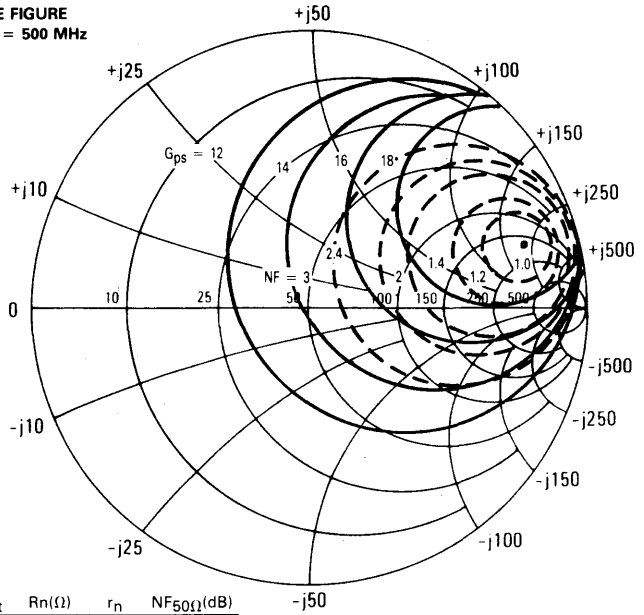
MRF966 COMMON-SOURCE S-PARAMETERS

V _{DS} (Volts)	I _{DS} (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ
3.0	5.0	200	0.99	-4.0	1.10	171	0.002	94	0.96	-3.0
		500	0.96	-12	1.07	155	0.004	79	0.95	-8.0
		1000	0.92	-24	1.06	134	0.008	71	0.93	-17
		1500	0.84	-38	1.00	112	0.008	70	0.90	-26
		2000	0.71	-49	0.96	90	0.006	100	0.86	-34
	10	200	0.99	-5.0	1.31	171	0.002	82	0.95	-3.0
		500	0.96	-13	1.28	155	0.005	78	0.94	-8.0
		1000	0.90	-26	1.25	134	0.008	73	0.91	-17
		1500	0.81	-40	1.19	112	0.009	72	0.88	-27
		2000	0.67	-51	1.08	90	0.008	100	0.84	-35
	15	200	0.99	-5.0	1.34	170	0.002	92	0.93	-3.0
		500	0.96	-14	1.30	155	0.005	78	0.93	-8.0
		1000	0.90	-27	1.29	133	0.009	73	0.91	-17
		1500	0.79	-42	1.23	111	0.009	74	0.87	-26
		2000	0.65	-53	1.12	88	0.009	98	0.83	-34
	20	200	0.99	-5.0	1.24	170	0.002	95	0.91	-3.0
		500	0.96	-15	1.21	154	0.006	80	0.90	-8.0
		1000	0.89	-29	1.20	131	0.010	74	0.88	-17
		1500	0.79	-45	1.17	108	0.011	74	0.85	-26
		2000	0.64	-57	1.08	84	0.012	94	0.83	-33
5.0	5.0	200	0.99	-5.0	1.33	170	0.001	84	0.97	-3.0
		500	0.98	-13	1.29	156	0.004	70	0.97	-9.0
		1000	0.90	-27	1.25	132	0.006	78	0.95	-17
		1500	0.81	-40	1.19	112	0.005	73	0.91	-25
		2000	0.68	-51	1.00	94	0.006	115	0.88	-35
	10	200	0.99	-5.0	1.66	170	0.001	75	0.97	-3.0
		500	0.97	-14	1.63	156	0.004	76	0.96	-9.0
		1000	0.89	-28	1.56	132	0.006	79	0.94	-17
		1500	0.78	-41	1.47	112	0.005	80	0.90	-25
		2000	0.65	-52	1.23	94	0.007	121	0.87	-35
	15	200	0.99	-5.0	1.84	170	0.001	78	0.96	-3.0
		500	0.97	-14	1.80	155	0.004	72	0.95	-8.0
		1000	0.89	-29	1.71	131	0.006	79	0.94	-17
		1500	0.77	-42	1.61	110	0.005	83	0.90	-25
		2000	0.63	-52	1.34	93	0.007	119	0.87	-34
	20	200	0.99	-5.0	1.89	170	0.001	71	0.96	-3.0
		500	0.97	-15	1.84	155	0.004	78	0.95	-9.0
		1000	0.87	-30	1.75	130	0.006	80	0.93	-17
		1500	0.75	-43	1.64	109	0.006	84	0.90	-24
		2000	0.61	-54	1.37	91	0.008	123	0.87	-34

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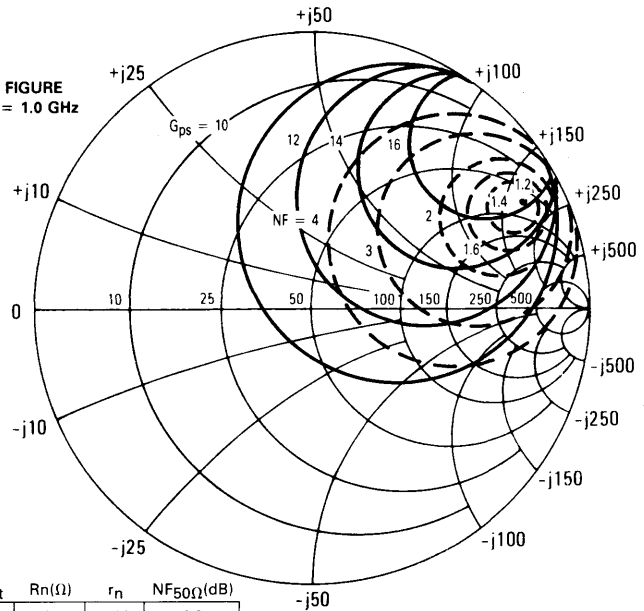
MRF967

FIGURE 19 — CONSTANT GAIN AND NOISE FIGURE
CONTOURS AT $V_{DS} = 5.0$ V, $I_{DS} = 10$ mA, $f = 500$ MHz
(MATCHED OUTPUT)



f(MHz)	NF _{opt} (dB)	Γ_{MS} NF _{opt}	Γ_{ML} NF _{opt}	R _n (Ω)	r _n	NF _{50Ω} (dB)
500	1.0	0.81/16°	0.76/21°	63	1.26	3.6

FIGURE 20 — CONSTANT GAIN AND NOISE FIGURE
CONTOURS AT $V_{DS} = 5.0$ V, $I_{DS} = 10$ mA, $f = 1.0$ GHz
(MATCHED OUTPUT)



f(MHz)	NF _{opt} (dB)	Γ_{MS} NF _{opt}	Γ_{ML} NF _{opt}	R _n (Ω)	r _n	NF _{50Ω} (dB)
1000	1.2	0.84/26°	0.82/17°	88.5	1.77	4.6

MRF967 COMMON-SOURCE S-PARAMETERS

V _{DS} (Volts)	I _{DS} (mA)	f (MHz)	S ₁₁		S ₂₁		S ₁₂		S ₂₂	
			S ₁₁	∠φ	S ₂₁	∠φ	S ₁₂	∠φ	S ₂₂	∠φ
3.0	5.0	200	0.99	-5	1.19	170	0.005	77	0.96	-4
		500	0.97	-14	1.16	155	0.016	73	0.94	-11
		1000	0.92	-27	1.11	131	0.030	65	0.93	-21
		1500	0.86	-40	1.03	111	0.040	54	0.87	-31
		2000	0.78	-52	0.96	91	0.048	45	0.83	-43
	10	200	0.99	-5	1.47	170	0.006	81	0.95	-4
		500	0.97	-15	1.43	155	0.016	73	0.93	-11
		1000	0.91	-29	1.39	131	0.031	65	0.92	-21
		1500	0.84	-43	1.29	111	0.040	54	0.86	-31
		2000	0.75	-56	1.19	90	0.047	45	0.81	-44
	15	200	1.00	-6	1.50	170	0.006	82	0.93	-4
		500	0.97	-16	1.46	155	0.016	74	0.91	-11
		1000	0.89	-31	1.42	131	0.031	64	0.90	-21
		1500	0.83	-46	1.33	110	0.040	53	0.84	-31
		2000	0.73	-59	1.24	89	0.048	45	0.79	-43
	20	200	1.00	-6	1.33	170	0.007	78	0.90	-3
		500	0.97	-17	1.30	154	0.017	73	0.88	-10
		1000	0.89	-33	1.27	129	0.033	64	0.88	-21
		1500	0.82	-49	1.21	108	0.043	53	0.82	-30
		2000	0.73	-63	1.14	86	0.050	44	0.78	-42
5.0	5.0	200	0.99	-5	1.17	170	0.006	84	0.97	-3
		500	0.97	-14	1.16	155	0.014	76	0.97	-9
		1000	0.93	-27	1.11	131	0.027	65	0.94	-18
		1500	0.87	-28	1.07	110	0.039	57	0.93	-28
		2000	0.79	-53	0.97	91	0.045	50	0.88	-37
	10	200	0.99	-5	1.47	170	0.006	84	0.97	-3
		500	0.97	-15	1.43	156	0.014	76	0.96	-9
		1000	0.92	-29	1.35	132	0.027	65	0.93	-18
		1500	0.85	-44	1.32	111	0.038	57	0.90	-29
		2000	0.77	-56	1.19	91	0.044	49	0.86	-37
	15	200	1.00	-6	1.53	170	0.006	85	0.96	-3
		500	0.98	-15	1.48	156	0.014	77	0.95	-9
		1000	0.91	-29	1.41	131	0.027	64	0.93	-18
		1500	0.85	-46	1.37	110	0.038	57	0.90	-28
		2000	0.75	-58	1.24	90	0.043	49	0.86	-36
	20	200	1.00	-6	1.32	170	0.006	85	0.95	-3
		500	0.98	-16	1.29	155	0.015	76	0.95	-8
		1000	0.91	-32	1.23	129	0.027	64	0.92	-17
		1500	0.88	-49	1.21	107	0.038	55	0.90	-27
		2000	0.75	-62	1.11	87	0.043	48	0.86	-36

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MRF8003

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

RF AMPLIFIER TRANSISTOR

NPN SILICON



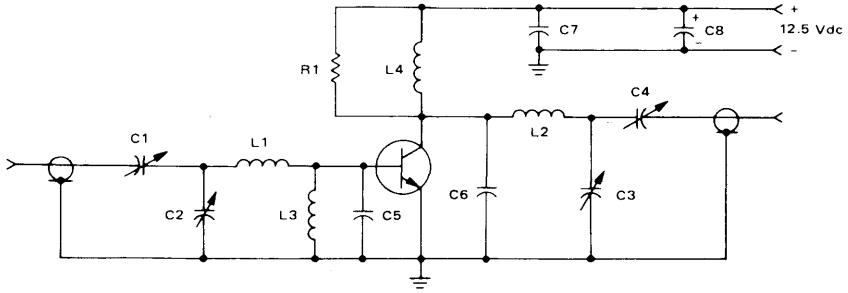
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.7	Watt mW/ $^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 0.1 \text{ mAdc}$, $V_{BE} = 0$)	$V_{(BR)CES}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.5 \text{ mAdc}$, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 12 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 12.5 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{obo}	—	—	15	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 0.5 \text{ W}$, $f = 27 \text{ MHz}$)	G_{PE}	10	—	—	dB
Collector Efficiency ($V_{CC} = 12.5 \text{ Vdc}$, $P_{out} = 0.5 \text{ W}$, $f = 27 \text{ MHz}$)	η		50		%

FIGURE 1 - 27 MHz TEST CIRCUIT SCHEMATIC



- C1, C2, C3, C4 9.0-180 pF ARCO 463 or equivalent
- C5 25 pF UNDERWOOD
- C6 100 pF UNDERWOOD
- C7 1000 pF UNDERWOOD
- C8 10 μF ELECTROLYTIC
- L1, L2 0.47 μH Molded Coil
- L3 VK 200-20/4B RFC
- L4 16 Turns No. 26 Wire Closewound on R1
- R1 390 Ω, 2 W

MRF8004

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

RF AMPLIFIER TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ (1) Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	-65 to +200	°C

(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
----------------	--------	-----	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 50$ mA dc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 200$ mA dc, $V_{BE} = 0$)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mA dc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.01	mA dc

ON CHARACTERISTICS

DC Current Gain ($I_C = 400$ mA dc, $V_{CE} = 2.0$ Vdc)	h_{FE}	10	—	—	—
---	----------	----	---	---	---

SMALL SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{obo}	—	35	70	pF
---	-----------	---	----	----	----

FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain (See Figure 1) ($P_{out} = 3.5$ W, $V_{CC} = 12.5$ Vdc, $f = 27$ MHz)	G_{PE}	10	—	—	dB
Collector Efficiency(2) (See Figure 1) ($P_{out} = 3.5$ W, $V_{CC} = 12.5$ Vdc, $f = 27$ MHz)	η	62.5	70	—	%
Percentage Up-Modulation(1) (See Figure 1) ($f = 27$ MHz)	—	—	85	—	%
Parallel Equivalent Input Resistance ($P_{out} = 3.5$ W, $V_{CC} = 12.5$ Vdc, $f = 27$ MHz)	R_{in}	—	21	—	Ohms
Parallel Equivalent Input Capacitance ($P_{out} = 3.5$ W, $V_{CC} = 12.5$ Vdc, $f = 27$ MHz)	C_{in}	—	900	—	pF
Parallel Equivalent Output Capacitance ($P_{out} = 3.5$ W, $V_{CC} = 12.5$ Vdc, $f = 27$ MHz)	C_{out}	—	200	—	pF

(1) Percentage Up-Modulation is measured in the test circuit (Figure 1) by setting the Carrier Power (P_C) to 3.5 Watts with $V_{CC} = 12.5$ Vdc and noting the power input. Then the Peak Envelope Power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the V_{CC} to 25 Vdc (to simulate the modulating voltage). Percentage Up-Modulation is then determined by the relation:

$$\text{Percentage Up-Modulation} = \left[\left(\frac{PEP}{P_C} \right)^{1/2} - 1 \right] \cdot 100$$

$$(2) \eta = \frac{RF P_{out}}{(V_{CC})(I_C)} \cdot 100$$

FIGURE 1 – 27 MHz TEST CIRCUIT

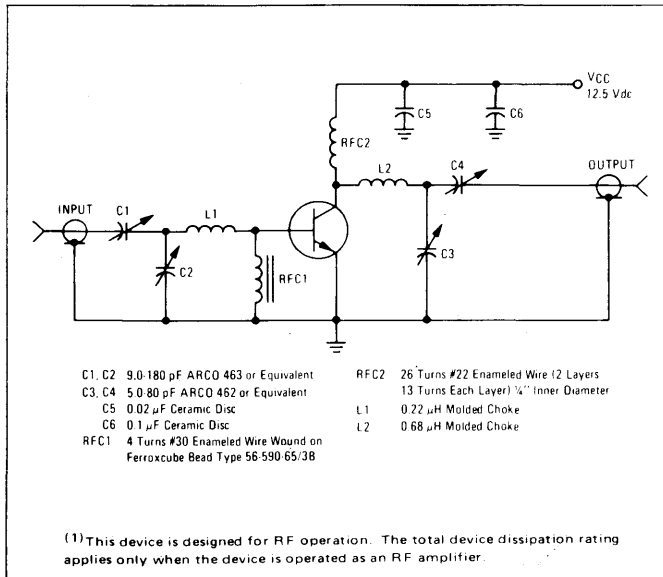


FIGURE 2 – CIRCUIT TUNED AT 25 V, 25% DUTY CYCLE. $P_{out} = 15$ W PEAK

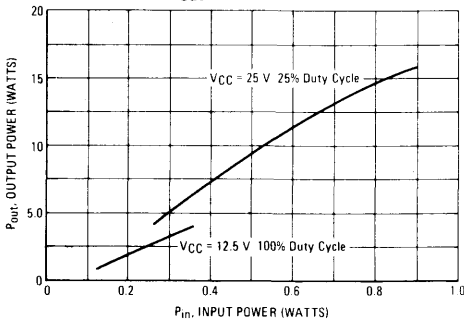
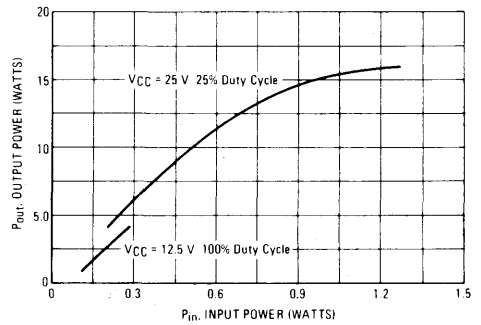


FIGURE 3 – CIRCUIT TUNED AT 12.5 V, $P_{out} = 4$ W



MWA110 MWA120 MWA130

CASE 31A-01, STYLE 2
GENERAL PURPOSE HYBRID
AMPLIFIERS

9.2

MAXIMUM RATINGS

Rating	Symbol	Value			Unit
		MWA110	MWA120	MWA130	
RF Input Power	P_{in}	100			mW
DC Supply Current	I_D	25	55	100	mA
Maximum Case Temperature	T_C	125			$^{\circ}C$
Storage Temperature Range	T_{stg}	-65 to +200			$^{\circ}C$

OPERATING CONDITIONS

Device Voltage	V_D	2.9	5.0	5.5	Vdc
Device Current	I_D	10	25	60	mAdc
Decoupling Impedance	Z_D	1000	1000	330	Ω

ELECTRICAL CHARACTERISTICS ($T_C = -25$ to $+125^{\circ}C$, 50 Ω system and specified operating conditions.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	0.1	—	400	MHz
Power Gain	G_p	13	14	—	dB
Response Flatness	F	—	0	± 1.0	dB
Input VSWR	MWA110/120	—	—	2.5:1	—
	MWA130	—	—	3:1	—
Output VSWR	MWA110/120/130	—	—	2.5:1	—
Output @ 1.0 dB Gain Compression	MWA110	—	-2.5	—	dBm
	MWA120	—	+8.2	—	
	MWA130	—	+18	—	
Noise Figure	MWA110	—	4.0	—	dB
	MWA120	—	5.5	—	
	MWA130	—	7.0	—	
Reverse Isolation	MWA110	—	18.8	—	dB
	MWA120	—	19.2	—	
	MWA130	—	16.8	—	
Harmonic Output	MWA110 ($P_{out} = -9.0$ dBm)	—	-24	—	dB
	MWA120 ($P_{out} = 0$ dBm)	—	-34	—	
	MWA130 ($P_{out} = +10$ dBm)	—	-35	—	

FIGURE 1 – DEVICE VOLTAGE versus DEVICE CURRENT

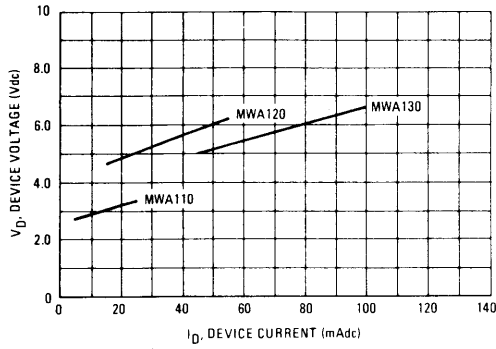


FIGURE 2 – DEVICE CURRENT versus CASE TEMPERATURE

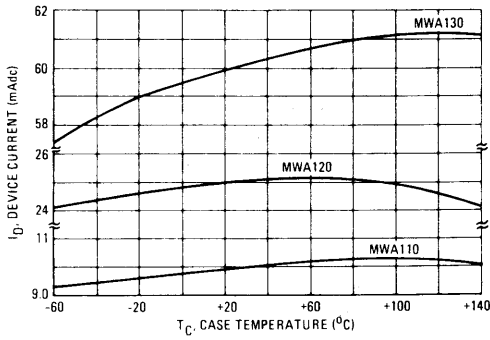


FIGURE 3 – POWER GAIN versus FREQUENCY

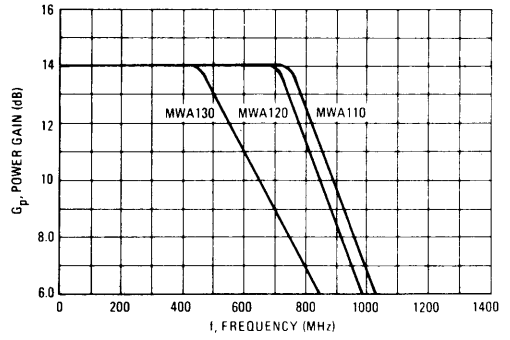
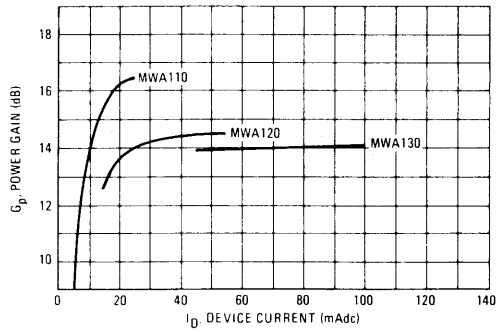


FIGURE 4 – POWER GAIN versus DEVICE CURRENT
f = 400 MHz



7

MWA110 • MWA120 • MWA130

FIGURE 5 – POWER GAIN versus CASE TEMPERATURE
f = 100 MHz

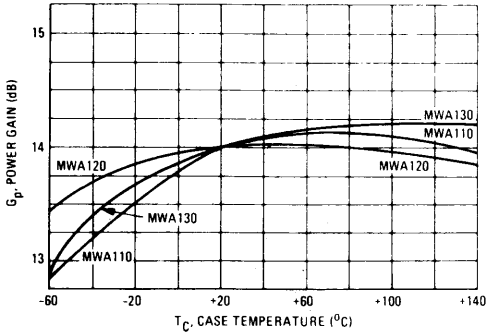


FIGURE 6 – POWER GAIN versus CASE TEMPERATURE
f = 400 MHz

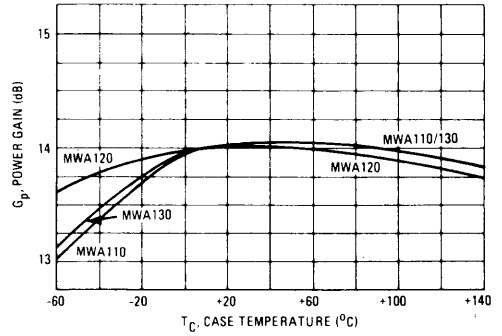


FIGURE 7 – VSWR versus FREQUENCY
MWA110

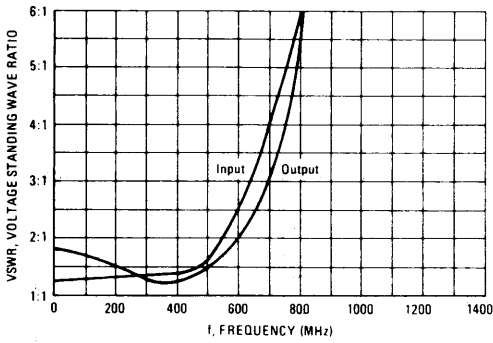


FIGURE 8 – VSWR versus FREQUENCY
MWA120

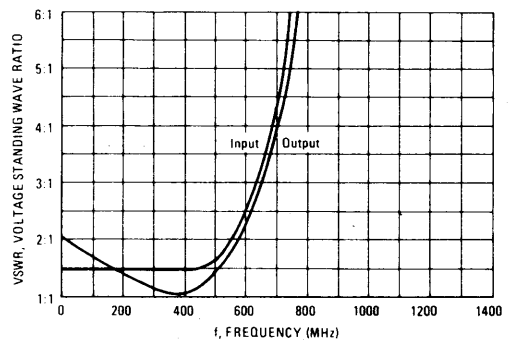
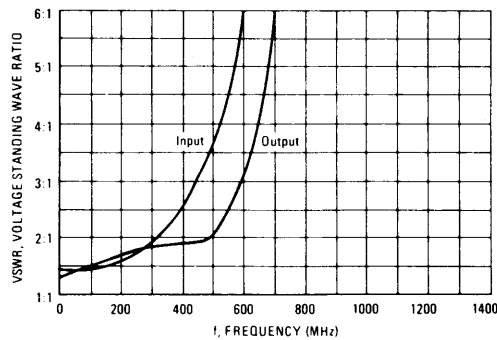


FIGURE 9 – VSWR versus FREQUENCY
MWA130



MWA110 • MWA120 • MWA130

FIGURE 10 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY
MWA110

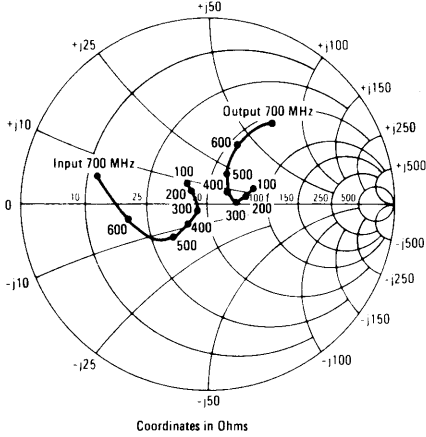


FIGURE 11 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY
MWA120

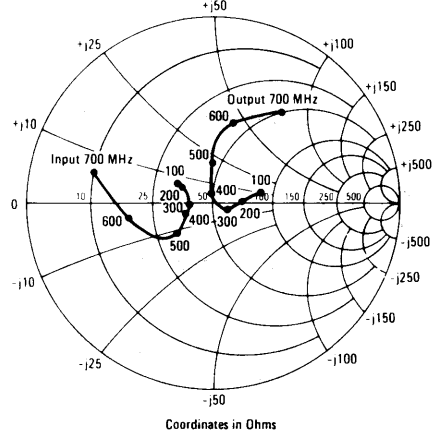


FIGURE 12 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY
MWA130

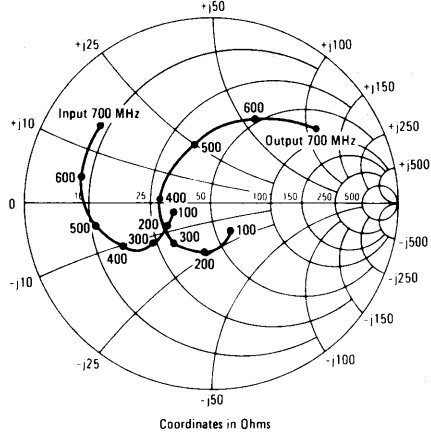
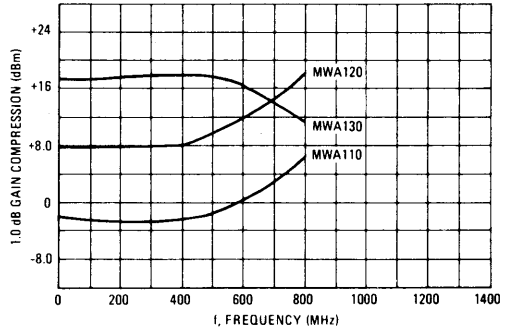


FIGURE 13 – 1.0 dB GAIN COMPRESSION versus FREQUENCY



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MWA110 • MWA120 • MWA130

FIGURE 14 – 1.0 dB GAIN COMPRESSION versus DEVICE CURRENT
 versus DEVICE CURRENT
 $f = 400 \text{ MHz}$

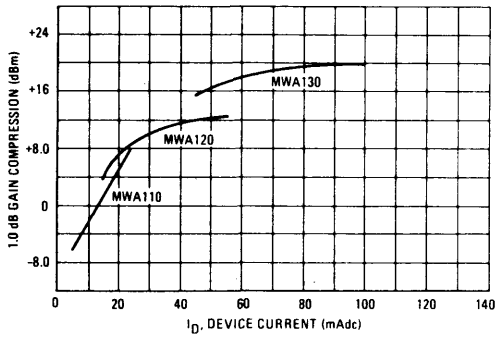


FIGURE 15 – 1.0 dB GAIN COMPRESSION versus CASE TEMPERATURE
 versus CASE TEMPERATURE
 $f = 400 \text{ MHz}$

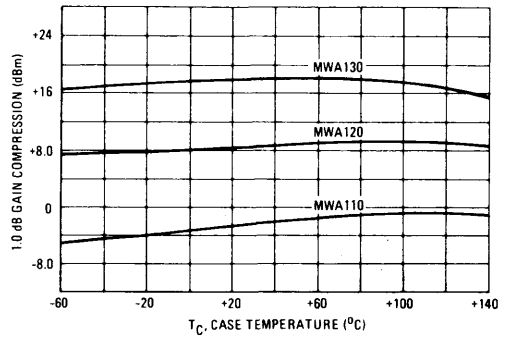


FIGURE 16 – NOISE FIGURE versus FREQUENCY

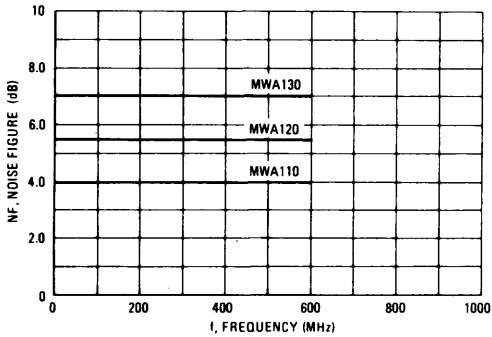


FIGURE 17 – REVERSE ISOLATION versus FREQUENCY

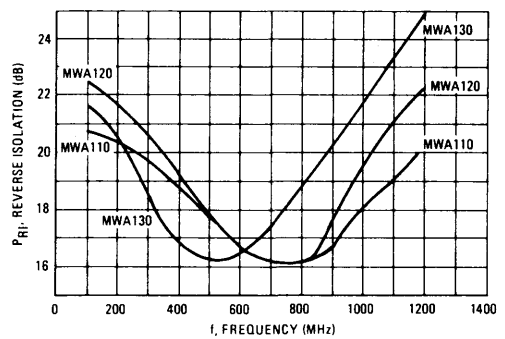


FIGURE 18 – SECOND HARMONIC OUTPUT versus FREQUENCY

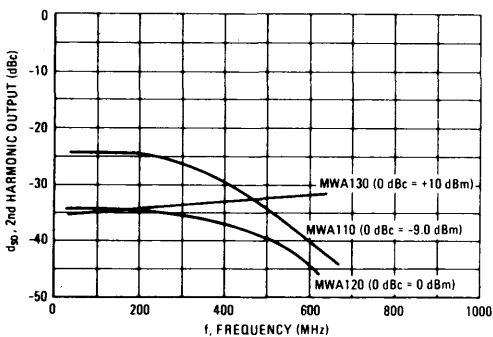


FIGURE 19 – SECOND AND THIRD ORDER INTERCEPT
 MWA110

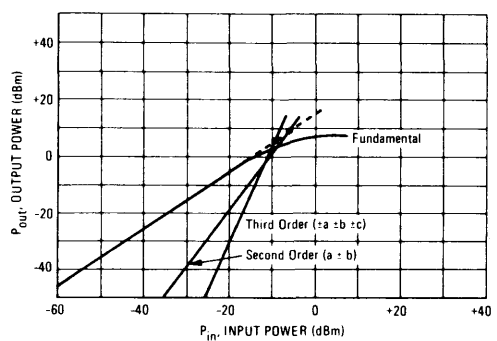


FIGURE 20 – SECOND AND THIRD ORDER INTERCEPT
MWA120

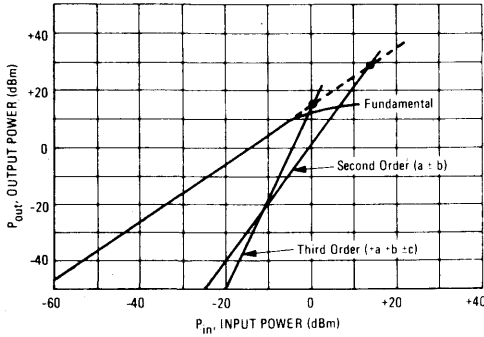


FIGURE 21 – SECOND AND THIRD ORDER INTERCEPT
MWA130

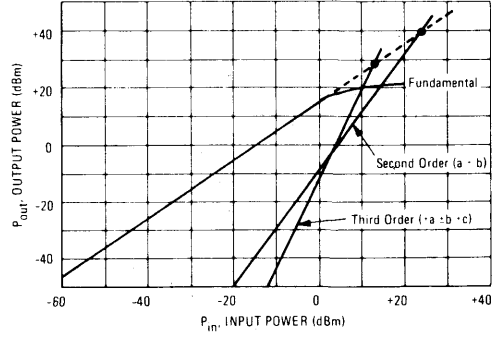


FIGURE 22 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA110

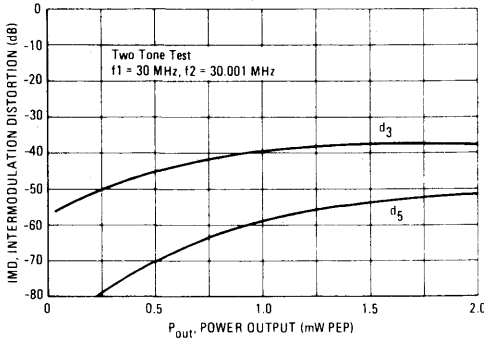


FIGURE 23 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA120

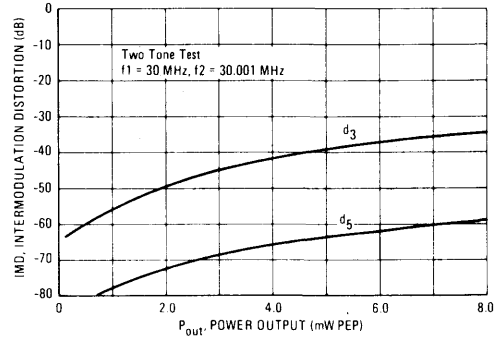


FIGURE 24 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA130

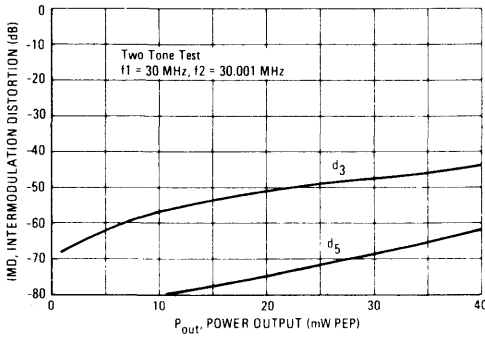
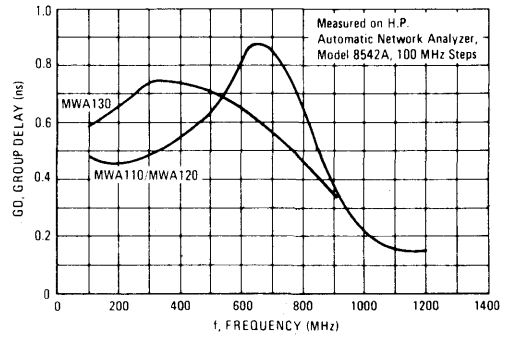


FIGURE 25 – GROUP DELAY versus FREQUENCY



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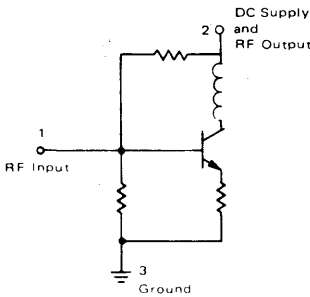
MWA SERIES HYBRID AMPLIFIER APPLICATIONS INFORMATION

The MWA series hybrid amplifiers are designed for wideband general purpose applications in 50 Ω systems. Fully cascadable for any gain combination, operable at voltages as low as 3 Vdc, and external control of the low frequency corner make the MWA amplifiers extremely versatile gain blocks.

Basic Circuit Configuration

Figure 26 shows the basic internal circuit. It is important to note that the specified operating conditions of voltage, current, and external decoupling impedance must be applied to the units in order to achieve the published electrical characteristics.

FIGURE 26 – INTERNAL CIRCUIT



Amplifier Application

The circuit schematic for a simple amplifier design is shown in Figure 27. External to the MWA hybrid amplifier the only components required are:

- Decoupling elements – Bypass Capacitor
Decoupling Impedance
(resistor/inductor)
- DC Blocking Capacitors at the RF input and output.

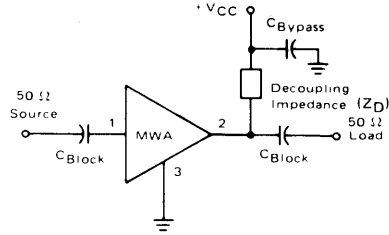
External Decoupling Impedance

In all cases the external bias (decoupling elements) must present an impedance which is large compared to the 50 Ω load impedance to minimize RF gain reduction. The loss in gain due to the decoupling impedance is given by the equation:

$$\text{Loss} = 20 \text{ Log } \frac{Z_D}{Z_D + 25} \text{ dB}$$

where Z_D = decoupling impedance in ohms. For example, if $Z_D = 1 \text{ k}\Omega$, Loss = 0.214 dB.

FIGURE 27 – AMPLIFIER SCHEMATIC DIAGRAM



Supply Voltage

The value of the external decoupling resistive impedance (R_D) determines the supply voltage ($+V_{CC}$) and is determined by the following equation:

$$V_{CC} = R_D \times I_D + V_D$$

where I_D and V_D are the device current and voltage stated in the data sheet. For example, for MWA110,

$$I_D = 10 \text{ mA}$$

$$V_D = 2.9 \text{ V}$$

and, if $R_D = 330 \Omega$, then

$$V_{CC} = 6.2 \text{ V}$$

More commonly V_{CC} is predetermined and R_D may be calculated from:

$$R_D = \frac{V_{CC} - V_D}{I_D}$$

If an RF choke is used for decoupling, then the supply voltage (V_{CC}) required is equal to the device voltage (V_D).

Low Frequency Response

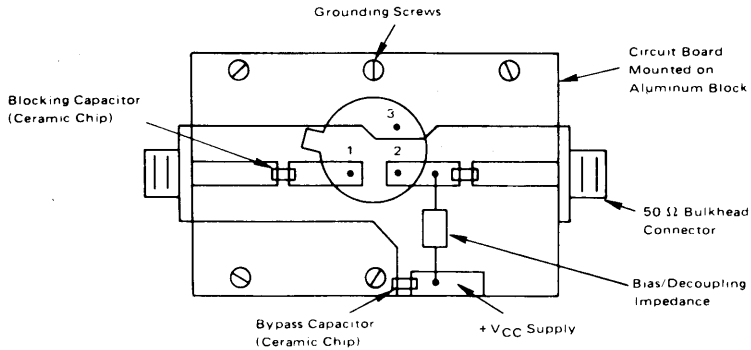
The value of the blocking capacitors determines the low frequency response of the amplifier. The following expression is used to determine the blocking capacitor value to yield a desired 3 dB low frequency corner (f_{LFC}).

$$C_{Block}(\text{Farads}) = \frac{1}{100 \pi f_{LFC}(\text{Hz})}$$

Bypass Capacitor

The reactive impedance of the bypass capacitor should be small compared to the impedance of the decoupling element at the lowest frequency of operation.

FIGURE 28 – TEST FIXTURE



Note: The circuitry indicated is on the underside of the printed circuit board with sockets for the amplifier pins. The case of the amplifier should contact the printed circuit board top surface to ensure effective RF grounding.

Text Fixture

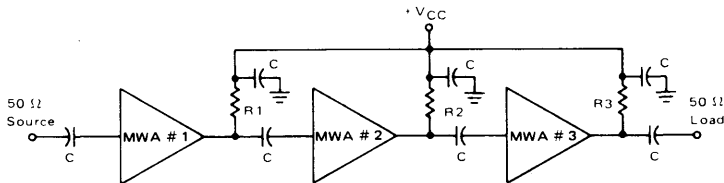
The 50 Ω input/output impedance levels of the MWA hybrids are most easily preserved on a circuit board by using 50 Ω microstrip transmission lines. Figure 28 is an example of a circuit board layout which utilizes microstrip transmission lines in conjunction with other sound RF construction techniques.

The characteristic impedance and corresponding line width of the microstrip are a function of the circuit board dielectric constant and thickness. The table lists appropriate line widths for 50 Ω microstrip lines on commonly used circuit board materials.

MATERIAL TYPE	DIELECTRIC CONSTANT	DIELECTRIC THICKNESS INCHES	LINE WIDTH INCHES
Teflon-Fiberglass	2.5	0.03125	0.090
Fiberglass Epoxy	5.0	0.0625	0.100

As in all good RF circuit designs, care should be taken to minimize parasitic lead inductances and to provide adequate grounding.

FIGURE 29 – TYPICAL CASCADE



All Capacitors (C) are 0.018 μF Chip Capacitors

Cascading

The inherent stability of the MWA hybrid modules makes possible the cascading of two or more units with no oscillatory problems. Figure 29 shows a typical 3 hybrid cascade with measured data for 400 MHz and 1000 MHz hybrids.

	Cascade 1	Cascade 2
Frequency Range	0.25 to 400 MHz	0.25 to 1000 MHz
Gain	43.5 dB	20.5 dB
Gain Flatness	± 1.0 dB	± 0.75 dB
Input VSWR	2.0:1	2.4:1
Output VSWR	1.2:1	2.1:1
VCC Supply	12 Vdc	33 Vdc
I Supply	44 mAdc	150 mAdc
MWA #1	MWA110	MWA320
MWA #2	MWA110	MWA330
MWA #3	MWA120	MWA330
R1	1000 Ω	1000 Ω
R2	1000 Ω	500 Ω
R3	300 Ω	500 Ω

MWA210 MWA220 MWA230

CASE 31A-01, STYLE 2
GENERAL PURPOSE HYBRID
AMPLIFIERS

MAXIMUM RATINGS

Rating	Symbol	Value			Unit
		MWA210	MWA220	MWA230	
RF Input Power	P_{in}	100			mW
DC Supply Current	I_D	25	55	100	mA
Maximum Case Temperature	T_C	125			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C

OPERATING CONDITIONS

Device Voltage	V_D	1.75	3.2	4.4	Vdc
Device Current	I_D	10	25	60	mAdc
Decoupling Impedance	Z_D	1000	1000	330	Ω

ELECTRICAL CHARACTERISTICS ($T_C = -25$ to $+100^\circ\text{C}$, $50\ \Omega$ system and specified operating conditions.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	0.1	—	600	MHz
Power Gain	G_D	9.0	10	—	dB
Response Flatness	F	—	0	± 1.0	dB
Input VSWR					
	MWA210/220	—	—	2.5:1	—
	MWA230	—	—	3:1	—
Output VSWR	MWA210/220/230	—	—	2.5:1	—
Output @ 1.0 dB Gain Compression					dBm
	MWA210	—	+1.5	—	
	MWA220	—	+10.5	—	
	MWA230	—	+18.5	—	
Noise Figure					dB
	MWA210	—	6.0	—	
	MWA220	—	6.5	—	
	MWA230	—	7.5	—	
Reverse Isolation					dB
	MWA210	—	13.5	—	
	MWA220	—	14.5	—	
	MWA230	—	12.9	—	
Harmonic Output					dB
	MWA210 ($P_{out} = -9.0$ dBm)	—	-29	—	
	MWA220 ($P_{out} = 0$ dBm)	—	-36	—	
	MWA230 ($P_{out} = +10$ dBm)	—	-36	—	

7

FIGURE 1 – DEVICE VOLTAGE versus DEVICE CURRENT

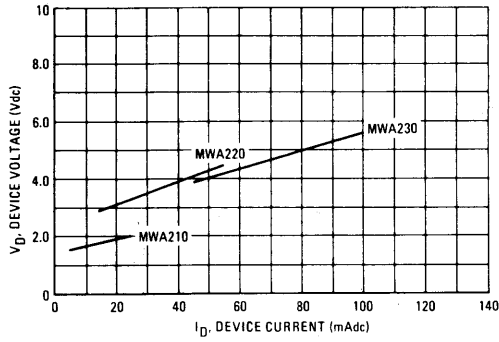


FIGURE 2 – DEVICE CURRENT versus CASE TEMPERATURE

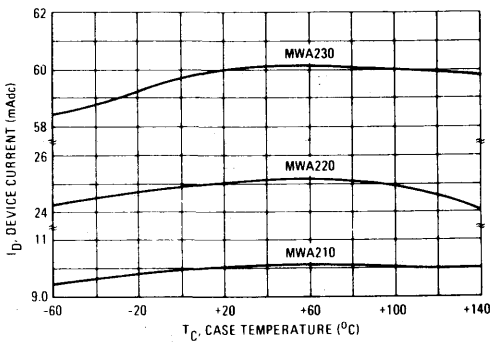


FIGURE 3 – POWER GAIN versus FREQUENCY

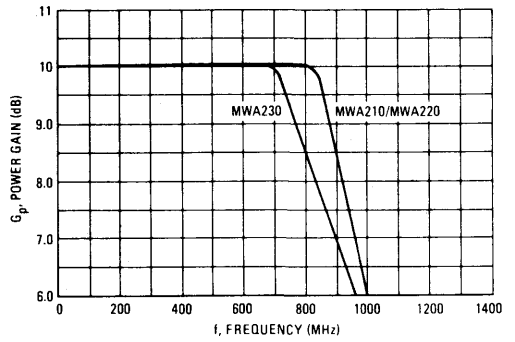
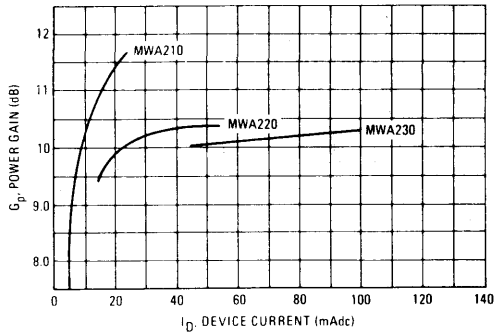


FIGURE 4 – POWER GAIN versus DEVICE CURRENT
f = 600 MHz



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FIGURE 5 – POWER GAIN versus CASE TEMPERATURE
f = 100 MHz

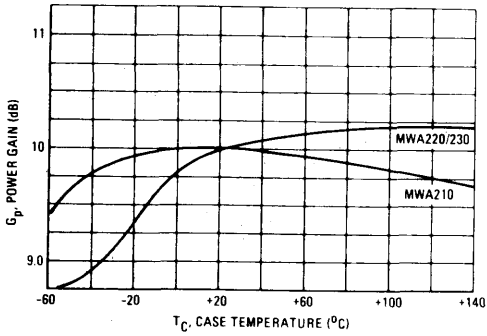


FIGURE 6 – POWER GAIN versus CASE TEMPERATURE
f = 600 MHz

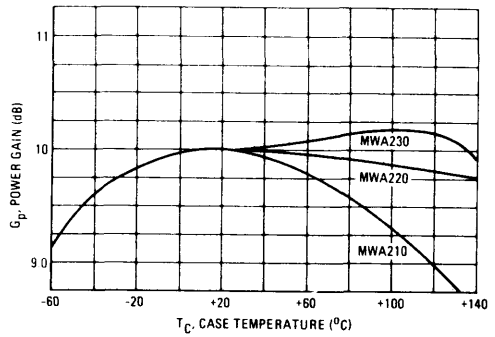


FIGURE 7 – VSWR versus FREQUENCY
MWA210

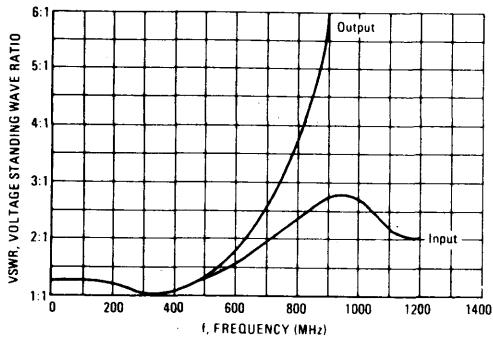


FIGURE 8 – VSWR versus FREQUENCY
MWA220

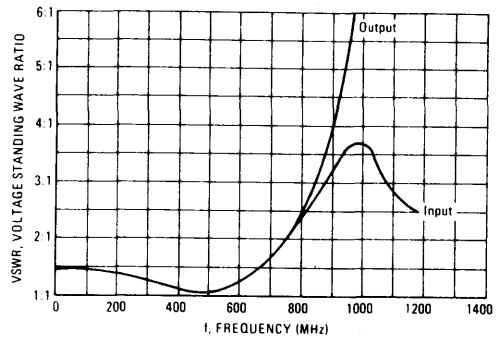
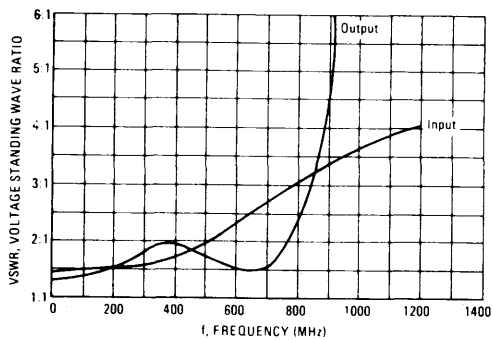


FIGURE 9 – VSWR versus FREQUENCY
MWA230



MWA210 • MWA220 • MWA230

FIGURE 10 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA210

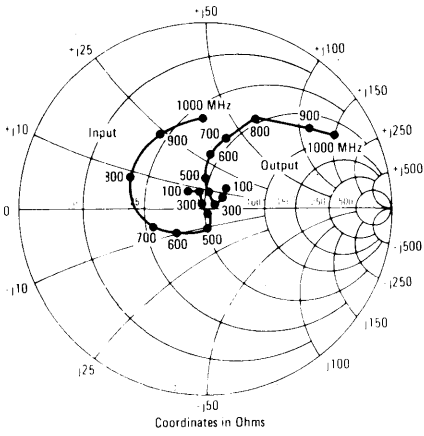


FIGURE 11 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA220

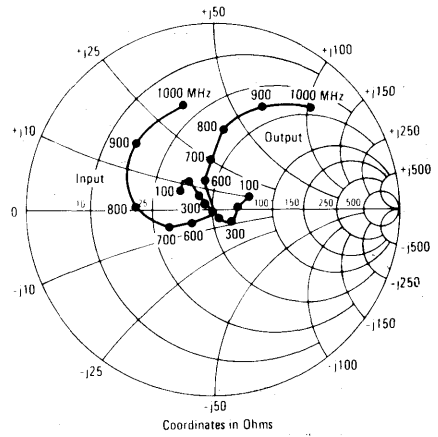


FIGURE 12 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA230

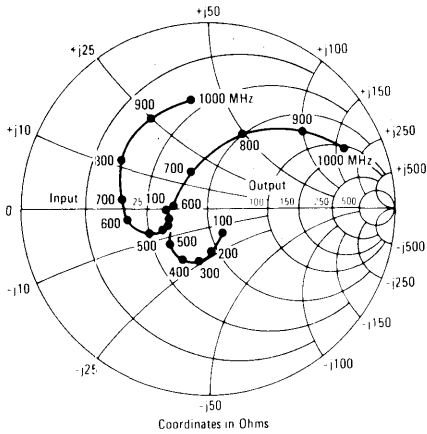
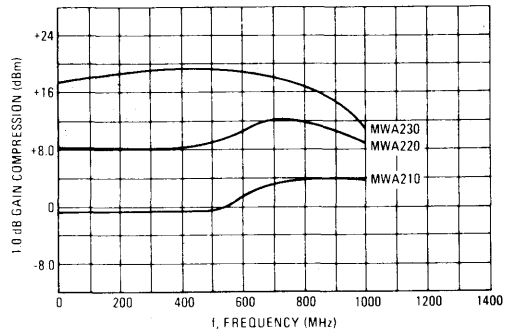


FIGURE 13 – 1.0 dB GAIN COMPRESSION versus FREQUENCY



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MWA210 • MWA220 • MWA230

FIGURE 14 – 1.0 dB GAIN COMPRESSION versus DEVICE CURRENT $f = 600$ MHz

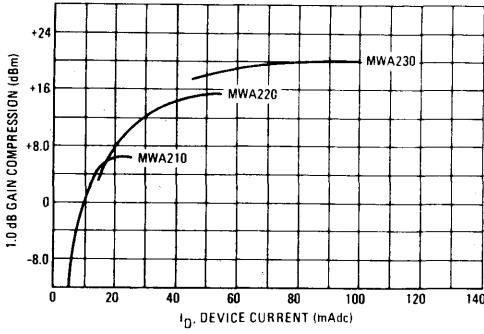


FIGURE 15 – 1.0 dB GAIN COMPRESSION versus CASE TEMPERATURE $f = 600$ MHz

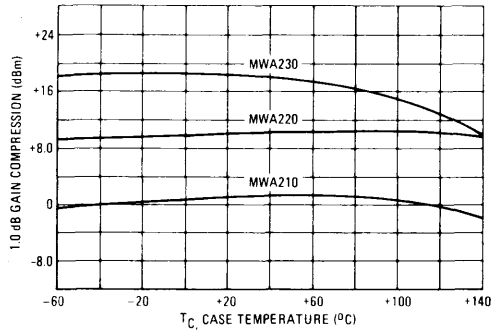


FIGURE 16 – NOISE FIGURE versus FREQUENCY

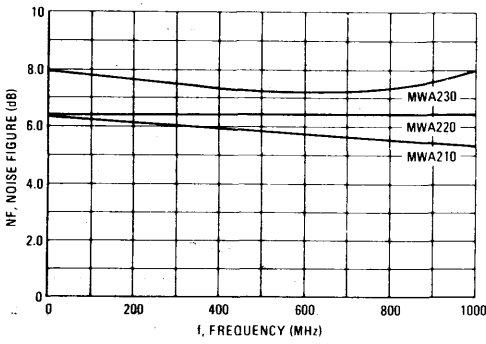


FIGURE 17 – REVERSE ISOLATION versus FREQUENCY

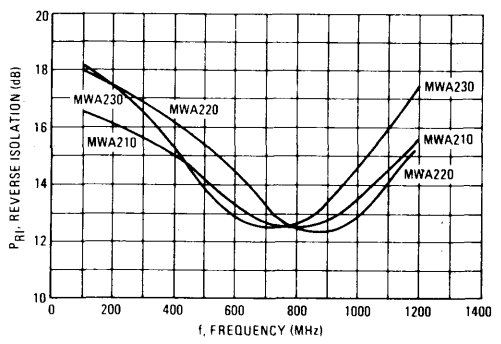


FIGURE 18 – SECOND HARMONIC OUTPUT versus FREQUENCY

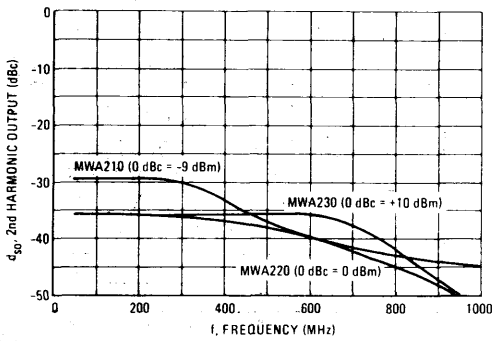
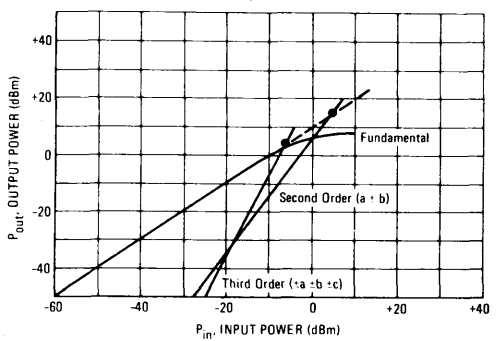


FIGURE 19 – SECOND AND THIRD ORDER INTERCEPT MWA210



MWA210 • MWA220 • MWA230

FIGURE 20 – SECOND AND THIRD ORDER INTERCEPT
MWA220

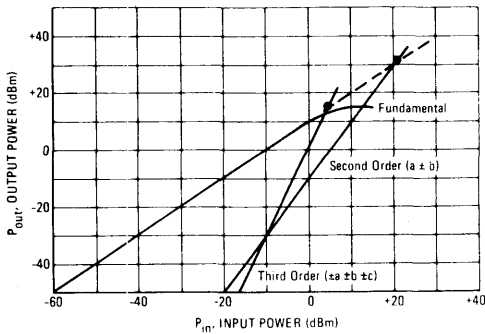


FIGURE 21 – SECOND AND THIRD ORDER INTERCEPT
MWA230

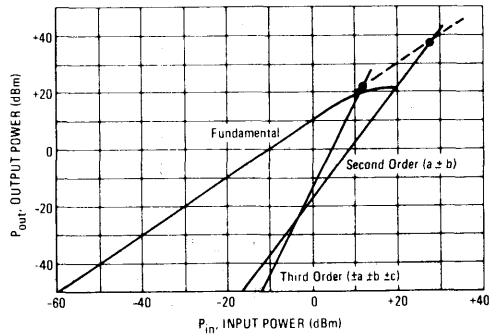


FIGURE 22 – INTERMODULATION DISTORTION versus
POWER OUTPUT MWA210

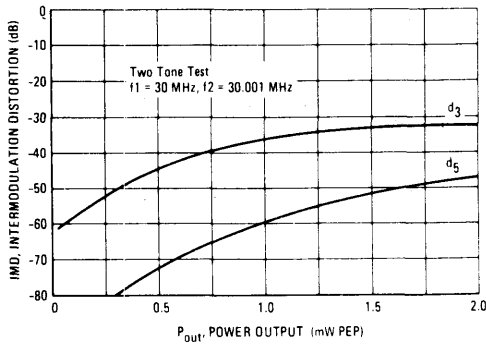


FIGURE 23 – INTERMODULATION DISTORTION versus
POWER OUTPUT MWA220

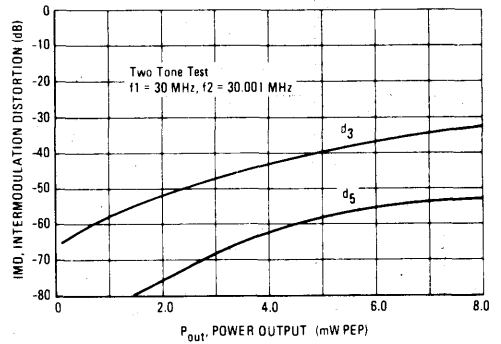


FIGURE 24 – INTERMODULATION DISTORTION versus
POWER OUTPUT MWA230

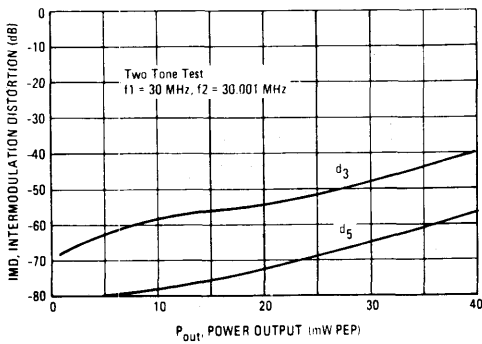
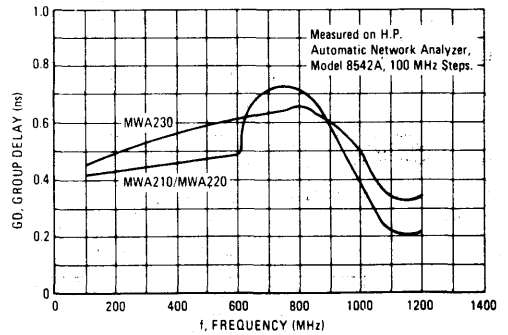


FIGURE 25 – GROUP DELAY versus FREQUENCY



7

MWA310 MWA320 MWA330

CASE 31A-01, STYLE 2
GENERAL PURPOSE HYBRID
AMPLIFIERS

MAXIMUM RATINGS

Rating	Symbol	Value			Unit
		MWA310	MWA320	MWA330	
RF Input Power	P_{in}	100			mW
DC Supply Current	I_D	25	55	100	mA
Maximum Case Temperature	T_C	125			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C

OPERATING CONDITIONS

Device Voltage	V_D	1.6	2.9	4.0	Vdc
Device Current	I_D	10	25	60	mAdc
Decoupling Impedance	Z_D	1000	1000	330	Ω

ELECTRICAL CHARACTERISTICS ($T_C = -25$ to $+80^\circ\text{C}$, 50 Ω system and specified operating conditions.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	0.1	—	1000	MHz
Power Gain	G_p	7.0	8.0	—	dB
	MWA310/320 MWA330	—	6.2	—	
Response Flatness	F	—	0	± 1.0	dB
Input VSWR	—	—	—	3:1	—
Output VSWR	—	—	—	3:1	—
Output @ 1.0 dB Gain Compression		—	+3.5	—	dBm
	MWA310	—	+11.5	—	
	MWA320 MWA330	—	+15.2	—	
Noise Figure	NF	—	6.5	—	dB
	MWA310	—	6.7	—	
	MWA320 MWA330	—	9.0	—	
Reverse Isolation	P_{RI}	—	10.4	—	dB
	MWA310	—	10.4	—	
	MWA320 MWA330	—	9.0	—	
Harmonic Output	d_{60}	—	-30	—	dB
	MWA310 ($P_{out} = -9.0$ dBm)	—	-38	—	
	MWA320 ($P_{out} = 0$ dBm) MWA330 ($P_{out} = +10$ dBm)	—	-35	—	

7

FIGURE 1 – DEVICE VOLTAGE versus DEVICE CURRENT

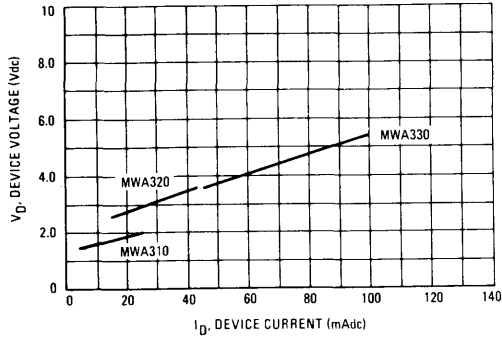


FIGURE 2 -- DEVICE CURRENT versus CASE TEMPERATURE

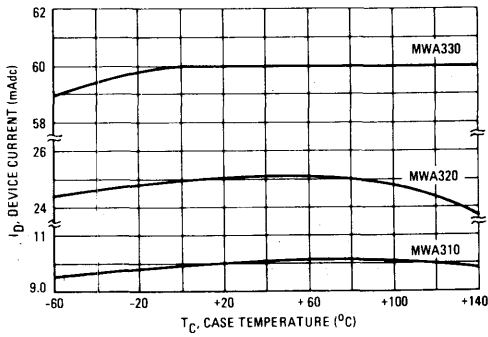


FIGURE 3 – POWER GAIN versus FREQUENCY

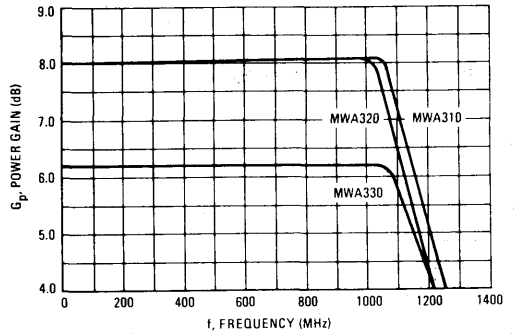
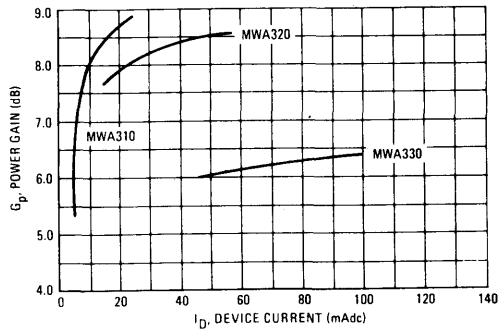


FIGURE 4 – POWER GAIN versus DEVICE CURRENT
f = 1000 MHz



MWA310 • MWA320 • MWA330

FIGURE 5 – POWER GAIN versus CASE TEMPERATURE
f = 100 MHz

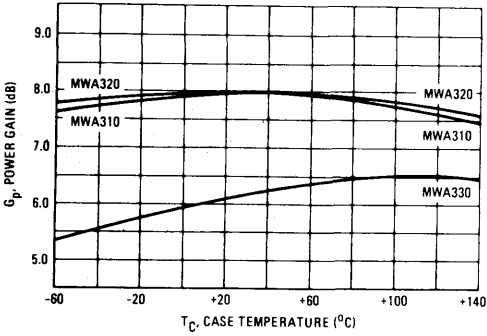


FIGURE 6 – POWER GAIN versus CASE TEMPERATURE.
f = 1000 MHz

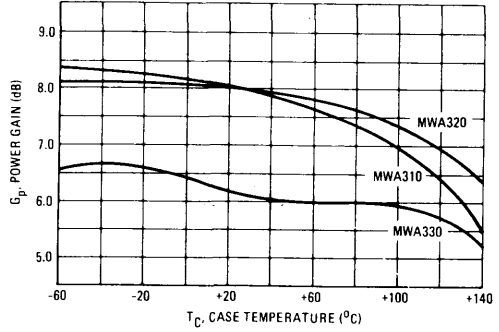


FIGURE 7 – VSWR versus FREQUENCY
MWA310

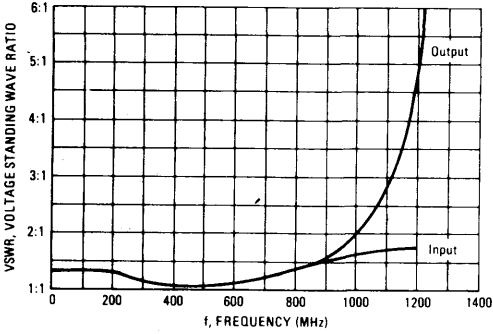


FIGURE 8 – VSWR versus FREQUENCY
MWA320

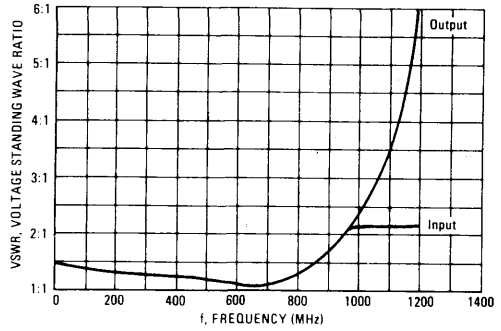


FIGURE 9 – VSWR versus FREQUENCY
MWA330

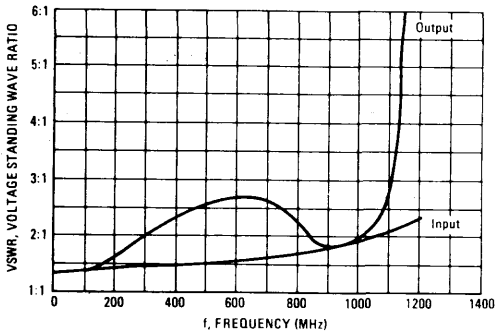
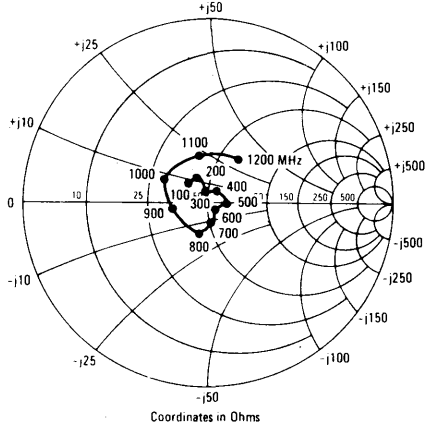


FIGURE 10 – INPUT IMPEDANCE versus FREQUENCY
MWA310



MWA310 • MWA320 • MWA330

FIGURE 11 – OUTPUT IMPEDANCE versus FREQUENCY
MWA310

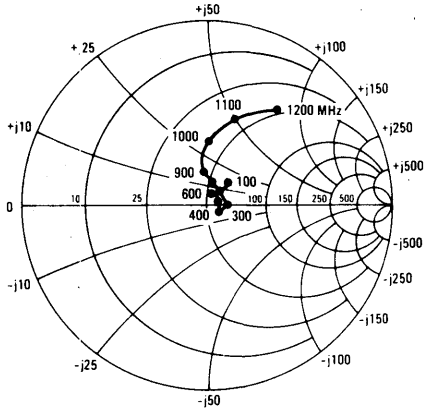


FIGURE 12 – INPUT IMPEDANCE versus FREQUENCY
MWA320

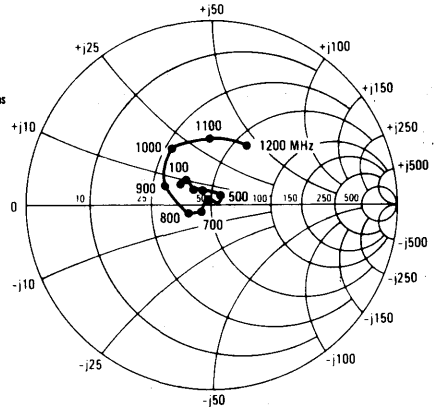


FIGURE 13 – OUTPUT IMPEDANCE versus FREQUENCY
MWA320

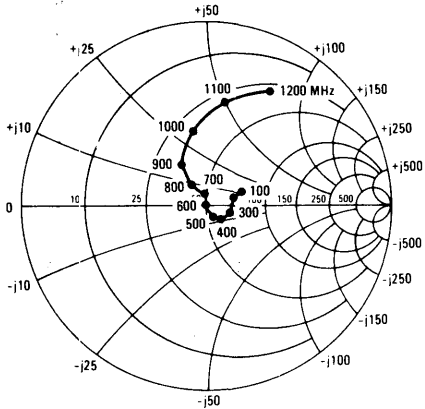


FIGURE 14 – INPUT IMPEDANCE versus FREQUENCY
MWA330

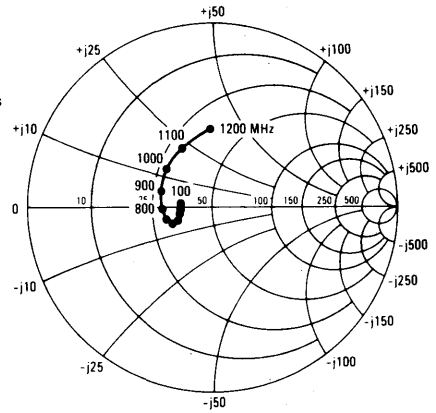


FIGURE 15 – OUTPUT IMPEDANCE versus FREQUENCY
MWA330

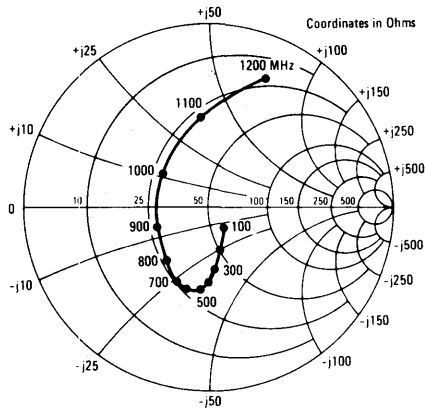
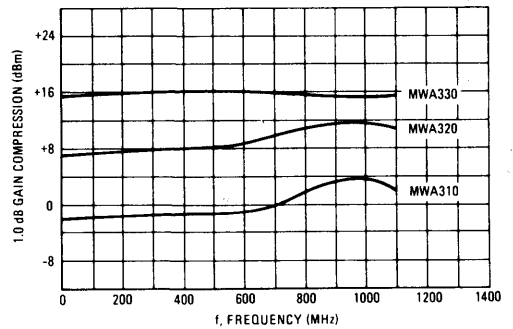


FIGURE 16 – 1.0 dB GAIN COMPRESSION versus FREQUENCY



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MWA310 • MWA320 • MWA330

FIGURE 17 – 1.0 dB GAIN COMPRESSION versus DEVICE CURRENT
f = 1000 MHz

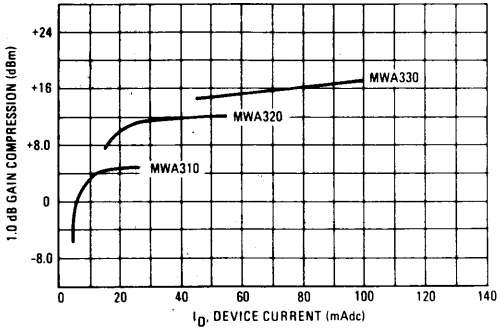


FIGURE 18 – 1.0 dB GAIN COMPRESSION versus CASE TEMPERATURE
f = 1000 MHz

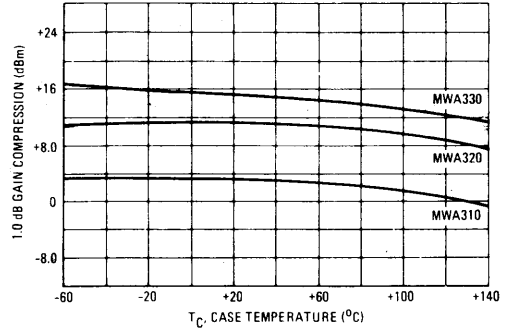


FIGURE 19 – NOISE FIGURE versus FREQUENCY

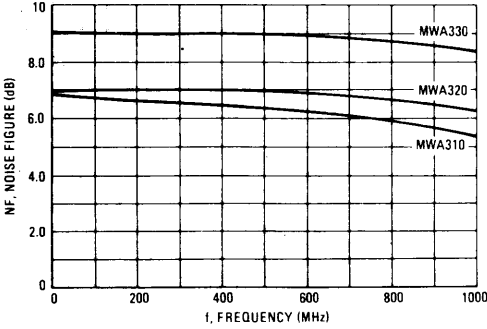


FIGURE 20 – REVERSE ISOLATION versus FREQUENCY

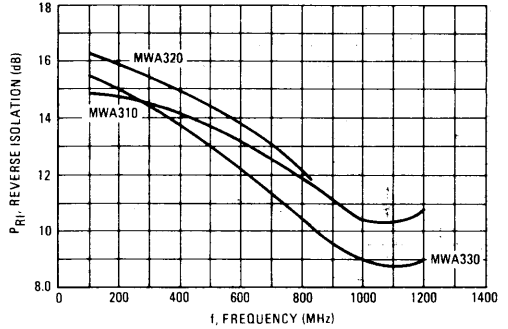


FIGURE 21 – SECOND HARMONIC OUTPUT versus FREQUENCY

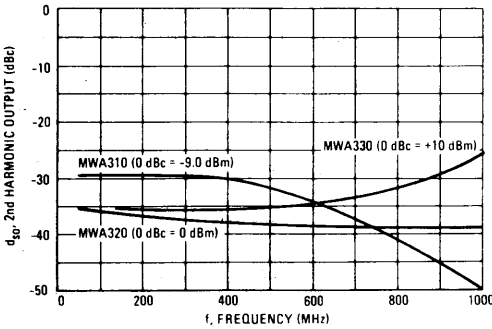
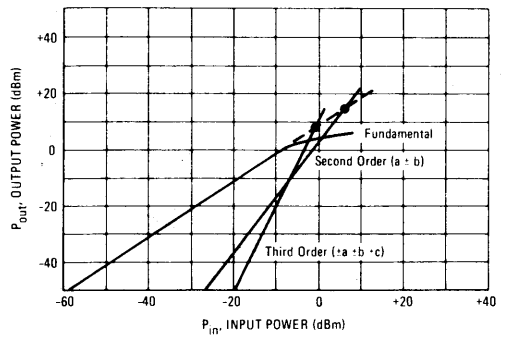


FIGURE 22 – SECOND AND THIRD ORDER INTERCEPT MWA310



7

FIGURE 23 – SECOND AND THIRD ORDER INTERCEPT
MWA320

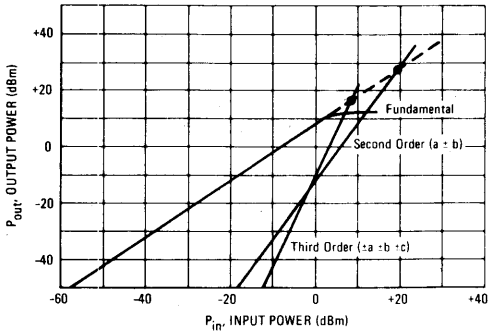


FIGURE 24 – SECOND AND THIRD ORDER INTERCEPT
MWA330

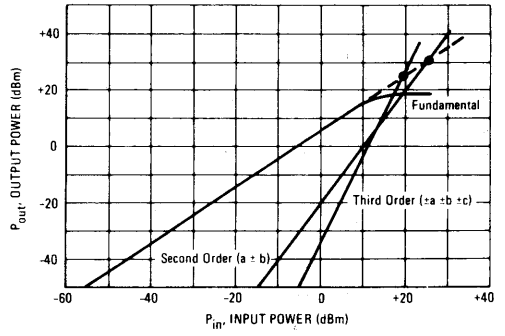


FIGURE 25 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA310

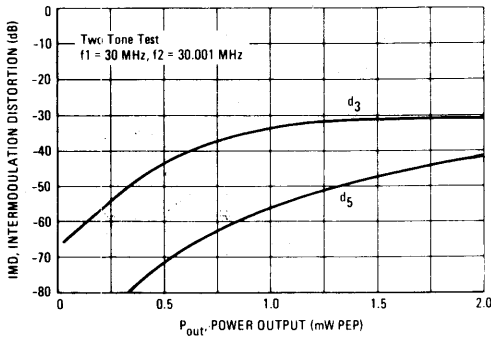


FIGURE 26 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA320

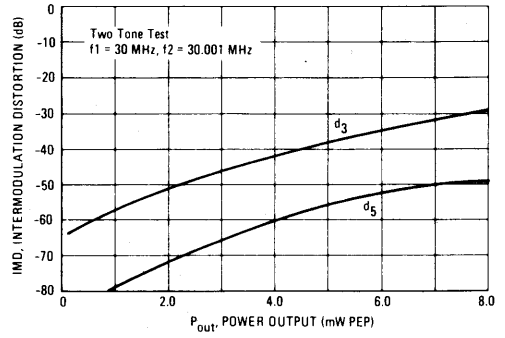


FIGURE 27 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA330

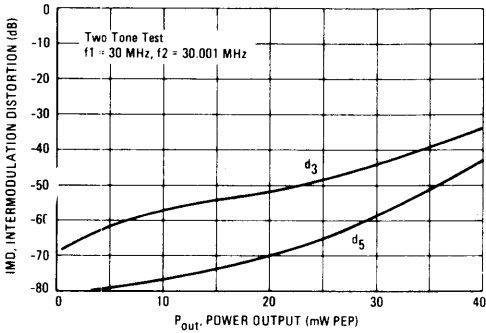
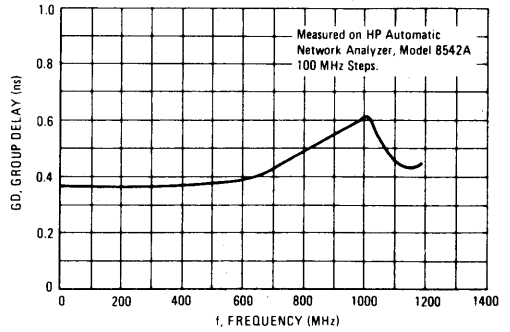


FIGURE 28 – GROUP DELAY versus FREQUENCY
MWA310/MWA320/MWA330



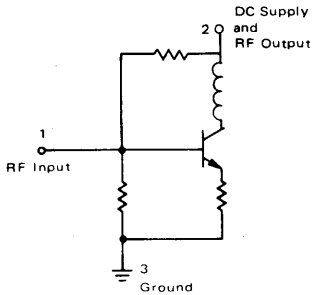
MWA SERIES HYBRID AMPLIFIER APPLICATIONS INFORMATION

The MWA series hybrid amplifiers are designed for wideband general purpose applications in 50 Ω systems. Fully cascadable for any gain combination, operable at voltages as low as 3 Vdc, and external control of the low frequency corner make the MWA amplifiers extremely versatile gain blocks.

Basic Circuit Configuration

Figure 29 shows the basic internal circuit. It is important to note that the specified operating conditions of voltage, current, and external decoupling impedance must be applied to the units in order to achieve the published electrical characteristics.

FIGURE 29 – INTERNAL CIRCUIT



Amplifier Application

The circuit schematic for a simple amplifier design is shown in Figure 30. External to the MWA hybrid amplifier the only components required are:

- Decoupling elements – Bypass Capacitor
Decoupling Impedance (resistor/inductor)
- DC Blocking Capacitors at the RF input and output.

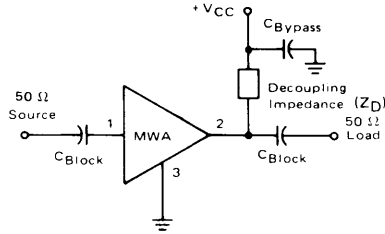
External Decoupling Impedance

In all cases the external bias (decoupling elements) must present an impedance which is large compared to the 50 Ω load impedance to minimize RF gain reduction. The loss in gain due to the decoupling impedance is given by the equation:

$$\text{Loss} = 20 \text{ Log } \frac{Z_D}{Z_D + 25} \text{ dB}$$

where Z_D = decoupling impedance in ohms. For example, if $Z_D = 1 \text{ k}\Omega$, Loss = 0.214 dB.

FIGURE 30 – AMPLIFIER SCHEMATIC DIAGRAM



Supply Voltage

The value of the external decoupling resistive impedance (R_D) determines the supply voltage ($+V_{CC}$) and is determined by the following equation:

$$V_{CC} = R_D \times I_D + V_D$$

where I_D and V_D are the device current and voltage stated in the data sheet. For example, for MWA110,

$$I_D = 10 \text{ mA}$$

$$V_D = 2.9 \text{ V}$$

and, if $R_D = 330 \Omega$, then

$$V_{CC} = 6.2 \text{ V}$$

More commonly V_{CC} is predetermined and R_D may be calculated from:

$$R_D = \frac{V_{CC} - V_D}{I_D}$$

If an RF choke is used for decoupling, then the supply voltage (V_{CC}) required is equal to the device voltage (V_D).

Low Frequency Response

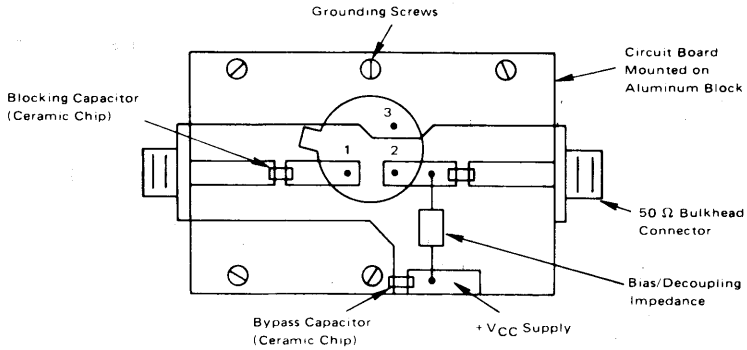
The value of the blocking capacitors determines the low frequency response of the amplifier. The following expression is used to determine the blocking capacitor value to yield a desired 3 dB low frequency corner (f_{LFC}).

$$C_{Block}(\text{Farads}) = \frac{1}{100 \pi f_{LFC}(\text{Hz})}$$

Bypass Capacitor

The reactive impedance of the bypass capacitor should be small compared to the impedance of the decoupling element at the lowest frequency of operation.

FIGURE 31 – TEST FIXTURE



Note: The circuitry indicated is on the underside of the printed circuit board with sockets for the amplifier pins. The case of the amplifier should contact the printed circuit board top surface to ensure effective RF grounding.

Text Fixture

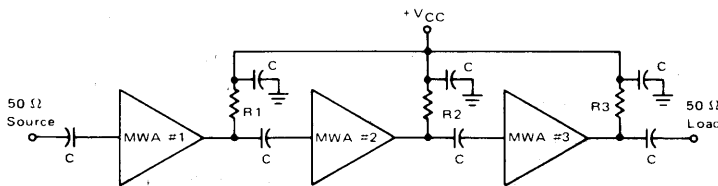
The 50 Ω input/output impedance levels of the MWA hybrids are most easily preserved on a circuit board by using 50 Ω microstrip transmission lines. Figure 31 is an example of a circuit board layout which utilizes microstrip transmission lines in conjunction with other sound RF construction techniques.

The characteristic impedance and corresponding line width of the microstrip are a function of the circuit board dielectric constant and thickness. The table lists appropriate line widths for 50 Ω microstrip lines on commonly used circuit board materials.

MATERIAL TYPE	DIELECTRIC CONSTANT	DIELECTRIC THICKNESS INCHES	LINE WIDTH INCHES
Teflon-Fiberglass	2.5	0.03125	0.090
Fiberglass-Epoxy	5.0	0.0625	0.180

As in all good RF circuit designs, care should be taken to minimize parasitic lead inductances and to provide adequate grounding.

FIGURE 32 – TYPICAL CASCADE



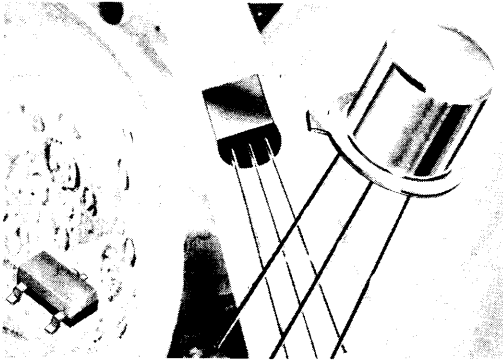
All Capacitors (C) are 0.018 μF Chip Capacitors

Cascading

The inherent stability of the MWA hybrid modules makes possible the cascading of two or more units with no oscillatory problems. Figure 32 shows a typical 3 hybrid cascade with measured data for 400 MHz and 1000 MHz hybrids.

	Cascade 1	Cascade 2
Frequency Range	0.25 to 400 MHz	0.25 to 1000 MHz
Gain	43.5 dB	20.5 dB
Gain Flatness	± 1.0 dB	± 0.75 dB
Input VSWR	2.0 : 1	2.4 : 1
Output VSWR	1.2 : 1	2.1 : 1
VCC Supply	12 Vdc	33 Vdc
I Supply	44 mA dc	150 mA dc
MWA #1	MWA110	MWA320
MWA #2	MWA110	MWA330
MWA #3	MWA120	MWA330
R1	1000 Ω	1000 Ω
R2	1000 Ω	500 Ω
R3	300 Ω	500 Ω

7



The following pages contain information on the various packages referenced on the individual data sheets. Information includes: a picture of the package, dimensions in both millimeters and inches, the various pinout configurations (styles), a cross reference for Case numbers, "old" JEDEC "TO" numbers, and the new JEDEC "TO" designation.

An information on Tape and Reel packaging capabilities is also given.

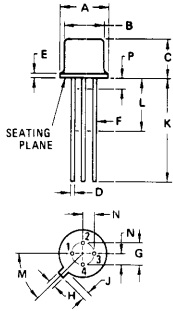
Package Outline Dimensions

8

Package Outline Dimensions

Dimensions are in inches unless otherwise noted.

CASE 20-03 TO-72 (TO-206AF)



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	-	0.76	-	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC	0.100 BSC		
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	-	0.500	-
L	6.35	-	0.250	-
M	45° BSC	45° BSC		
N	1.27 BSC	0.050 BSC		
P	-	1.27	-	0.050

All JEDEC dimensions and notes apply



CASE 20 STYLES



STYLE 1
PIN 1. SOURCE
2. DRAIN
3. GATE
4. CASE LEAD

STYLE 5
PIN 1. SOURCE
2. GATE 1
3. DRAIN
4. CASE

STYLE 9
PIN 1. DRAIN
2. GATE 2
3. GATE 1
4. SOURCE
SUBSTRATE
AND CASE

STYLE 2
PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND
CASE LEAD

STYLE 6
PIN 1. DRAIN
2. SOURCE AND
SUBSTRATE
3. GATE
4. SOURCE AND
SUBSTRATE

STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

STYLE 3
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE LEAD

STYLE 7
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE AND
SUBSTRATE

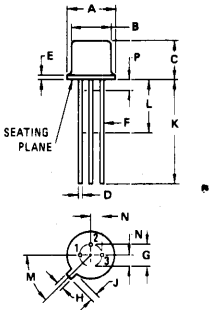
STYLE 11
PIN 1. EMITTER
2. CATHODE
3. COLLECTOR
4. ANODE

STYLE 4
PIN 1. SOURCE
2. GATE
3. DRAIN
4. GATE 2
SUBSTRATE AND
CASE

STYLE 8
PIN 1. EMITTER 2
2. BASE 1
3. COLLECTOR
4. EMITTER 1
BASE 2

NOTE
1. ALL RULES AND
NOTES WITH
TO 72 OUTLINE
SHALL APPLY

CASE 22-03 TO-18 (TO-206AA)



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	-	0.762	-	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	0.100 BSC		
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	-	0.500	-
L	6.35	-	0.250	-
M	45° BSC	45° BSC		
N	1.27 BSC	0.050 BSC		
P	-	1.27	-	0.050

All JEDEC notes and dimensions apply.



CASE 22 STYLES



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 7
PIN 1. ANODE
2. BASE
3. CATHODE

STYLE 2
PIN 1. SOURCE SUBSTRATE
AND CASE
2. GATE
3. DRAIN

STYLE 8
PIN 1. GATE
2. ANODE 1
3. ANODE 2

STYLE 3
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 9
PIN 1. ANODE 2
2. ANODE 1
3. GATE
(CONNECTED TO
CASE)

STYLE 4
PIN 1. SOURCE
2. DRAIN
3. GATE & CASE

STYLE 10
PIN 1. BASE
2. EMITTER
3. BASE

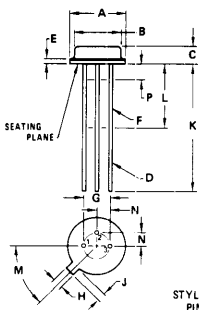
STYLE 5
PIN 1. EMITTER
2. BASE 1
3. BASE 2

STYLE 11
PIN 1. DRAIN
2. GATE
3. SOURCE SUBSTRATE

STYLE 6
PIN 1. CATHODE
2. GATE
3. ANODE

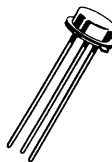
STYLE 12
PIN 1. SOURCE
2. GATE
3. DRAIN (CASE)

CASE 26-03 TO-46 (TO-206AB)



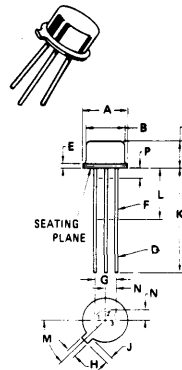
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	-	1.02	-	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC	0.100 BSC		
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	-	0.500	-
L	6.35	-	0.250	-
M	45° BSC	45° BSC		
N	1.27 BSC	0.050 BSC		
P	-	1.27	-	0.050

All JEDEC dimensions and notes apply



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 27-02 TO-52 (TO-206AC)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 3:
PIN 1. EMITTER
2. BASE
3. BASE 2

STYLE 2:
PIN 1. DRAIN
2. SOURCE
3. GATE & CASE

STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE & CASE

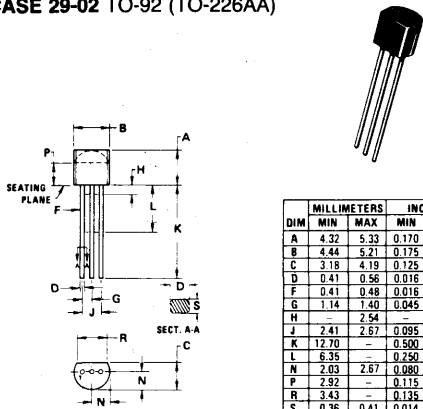
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	2.92	3.81	0.115	0.150
D	-	0.533	-	0.021
E	-	0.762	-	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	0.100 BSC		
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	-	0.500	-
L	6.35	-	0.250	-
M	45° BSC	45° BSC		
N	1.27 BSC	0.050 BSC		
P	-	1.27	-	0.050

All JEDEC dimensions and notes apply



PACKAGE OUTLINE DIMENSIONS (continued)

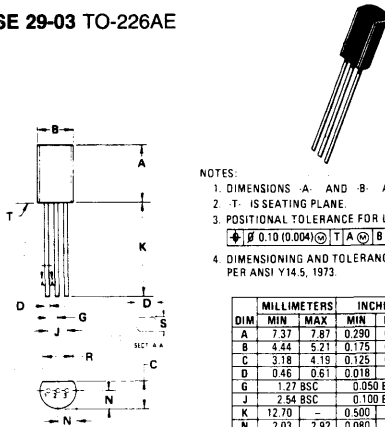
CASE 29-02 TO-92 (TO-226AA)



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.44	5.21	0.175	0.205
C	3.19	4.19	0.125	0.165
D	0.41	0.56	0.016	0.022
F	0.41	0.48	0.016	0.019
G	1.14	1.40	0.045	0.055
H	—	2.54	—	0.100
J	2.41	2.67	0.095	0.105
K	12.70	—	0.500	—
L	6.35	—	0.250	—
N	2.03	2.67	0.080	0.105
P	2.92	—	0.115	—
R	3.43	—	0.135	—
S	0.36	0.41	0.014	0.016

All JEDEC dimensions and notes apply.

CASE 29-03 TO-226AE



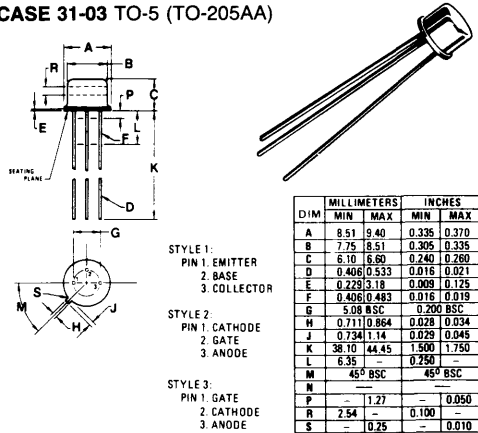
- NOTES:
 1. DIMENSIONS A AND B ARE DATUMS.
 2. T: SEATING PLANE.
 3. POSITIONAL TOLERANCE FOR LEADS
 $\pm \sqrt{0.10(0.004) \oplus T} \text{ A } \oplus \text{ B } \oplus \text{ C}$
 4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.37	7.87	0.290	0.310
B	4.44	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.46	0.61	0.018	0.024
G	1.27 BSC	0.050 BSC	—	—
J	2.54 BSC	0.100 BSC	—	—
K	12.70	—	0.500	—
N	2.03	2.92	0.080	0.115
R	3.43	—	0.135	—
S	0.46	0.61	0.018	0.024

CASE 29 STYLES

- | | | | |
|---|---|--|--|
| STYLE 1
PIN 1: EMITTER
2: BASE
3: COLLECTOR | STYLE 9
PIN 1: BASE 1
2: EMITTER
3: BASE 2 | STYLE 16
PIN 1: ANODE
2: GATE
3: CATHODE | STYLE 24
1: EMITTER
2: COLLECTOR ANODE
3: CATHODE |
| STYLE 2
PIN 1: BASE
2: EMITTER
3: COLLECTOR | STYLE 10
PIN 1: CATHODE
2: GATE
3: ANODE | STYLE 17
PIN 1: COLLECTOR
2: BASE
3: EMITTER | STYLE 25
1: MT
2: GATE
3: WT 2 |
| STYLE 3
PIN 1: ANODE
2: ANODE
3: CATHODE | STYLE 11
PIN 1: ANODE
2: CATHODE & ANODE
3: CATHODE | STYLE 18
PIN 1: ANODE
2: CATHODE
3: NOT CONNECTED | STYLE 26
PIN 1: V _{CC}
2: GROUND 2
3: OUTPUT |
| STYLE 4
PIN 1: CATHODE
2: CATHODE
3: ANODE | STYLE 12
PIN 1: MAIN TERMINAL 1
2: GATE
3: MAIN TERMINAL 2 | STYLE 19
PIN 1: GATE
2: ANODE
3: CATHODE | STYLE 27
PIN 1: MT
2: SUBSTRATE
3: MT |
| STYLE 5
PIN 1: DRAIN
2: SOURCE
3: GATE | STYLE 13
PIN 1: ANODE 1
2: GATE
3: CATHODE 2 | STYLE 20
PIN 1: NOT CONNECTED
2: CATHODE
3: ANODE | STYLE 28
PIN 1: CATHODE
2: ANODE
3: GATE |
| STYLE 6
PIN 1: GATE
2: SOURCE & SUBSTRATE
3: DRAIN | STYLE 14
PIN 1: EMITTER
2: COLLECTOR
3: BASE | STYLE 21
PIN 1: COLLECTOR
2: EMITTER
3: BASE | STYLE 29
PIN 1: NOT CONNECTED
2: ANODE
3: CATHODE |
| STYLE 7
PIN 1: SOURCE
2: DRAIN
3: GATE | STYLE 15
PIN 1: ANODE 1
2: CATHODE
3: ANODE 2 | STYLE 22
PIN 1: SOURCE
2: GATE
3: DRAIN | STYLE 30
PIN 1: DRAIN
2: GATE
3: SOURCE |
| STYLE 8
PIN 1: DRAIN
2: GATE
3: SOURCE & SUBSTRATE | | STYLE 23
PIN 1: GATE
2: SOURCE
3: DRAIN | |

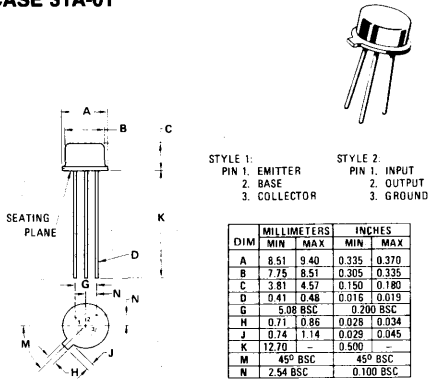
CASE 31-03 TO-5 (TO-205AA)



- STYLE 1:
 PIN 1: EMITTER
 2: BASE
 3: COLLECTOR
- STYLE 2:
 PIN 1: CATHODE
 2: GATE
 3: ANODE
- STYLE 3:
 PIN 1: GATE
 2: CATHODE
 3: ANODE

D/M	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.80	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC	—	0.200 BSC	—
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	44.45	1.500	1.750
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
P	—	1.27	—	0.050
R	—	2.54	—	0.100
S	—	0.25	—	0.010

CASE 31A-01

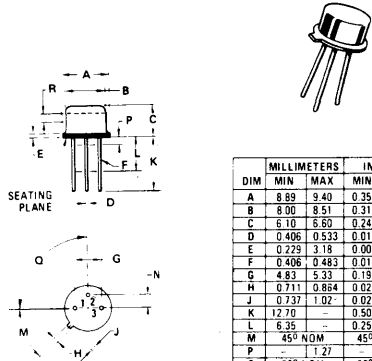


- STYLE 1:
 PIN 1: EMITTER
 2: BASE
 3: COLLECTOR
- STYLE 2:
 PIN 1: INPUT
 2: OUTPUT
 3: GROUND

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.57	0.150	0.180
D	0.41	0.48	0.016	0.019
G	5.08 BSC	—	0.200 BSC	—
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC	—	45° BSC	—
N	2.54 BSC	—	0.100 BSC	—

- NOTE:
 1. LEADS WITHIN 0.36 mm (0.014) DIA OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

CASE 79-02 TO-39 (TO-205AD)

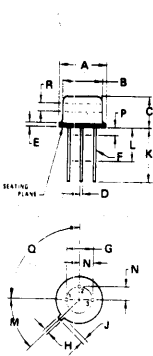


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.80	0.240	0.260
D	0.405	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.27	—	0.050
Q	—	90° NOM	—	90° NOM
R	—	2.54	—	0.100

All JEDEC dimensions and notes apply.

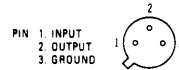
PACKAGE OUTLINE DIMENSIONS (continued)

CASE 79-03



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.02	9.30	0.315	0.366
B	8.00	8.51	0.315	0.335
C	4.19	4.57	0.165	0.180
D	0.43	0.53	0.017	0.021
E	0.43	0.89	0.017	0.035
F	0.41	0.48	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.71	0.86	0.028	0.034
J	0.74	1.02	0.029	0.040
K	12.70	-	0.500	-
M	45° NOM	-	45° NOM	-
N	2.54 TYP	-	0.100 TYP	-
Q	90° NOM	-	90° NOM	-

CASE 79 STYLES



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 4:
PIN 1. MAIN TERM. 1
2. GATE
3. MAIN TERM. 2

STYLE 2:
PIN 1. DRAIN
2. SOURCE
3. GATE

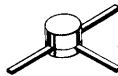
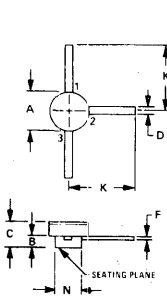
STYLE 5:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

STYLE 3:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 6:
PIN 1. SOURCE
2. GATE
3. DRAIN
(CASE)

NOTES:
1. ALL RULES AND NOTES ASSOCIATED WITH TO 39 OUTLINE SHALL APPLY.

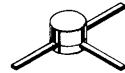
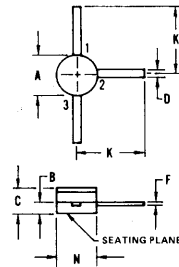
CASE 176-02



NOTE:
A Tolerance of .25 mm (0.010) must be allowed at point leads protrude from package for glass run over.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.03	2.67	0.080	0.105
B	0.38	0.76	0.015	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180
N	1.47	1.78	0.058	0.070

CASE 176B-01



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.03	2.67	0.080	0.105
B	0.38	0.76	0.015	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180
N	2.03	2.67	0.080	0.105

CASE 176 STYLES

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 2:
PIN 1. SOURCE
2. GATE
3. DRAIN

STYLE 3:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 4:
PIN 1. ANODE 2
2. ANODE 1
3. CATHODE

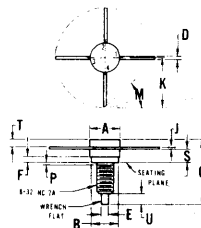
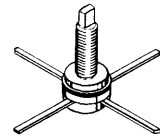
STYLE 5:
PIN 1. CATHODE
2. NOT CONNECTED
3. ANODE

STYLE 6:
PIN 1. CATHODE
2. ANODE
3. ANODE

STYLE 7:
PIN 1. ANODE
2. BASE
3. COLLECTOR

STYLE 8:
PIN 1. ANODE
2. NC
3. CATHODE

CASE 244A-01



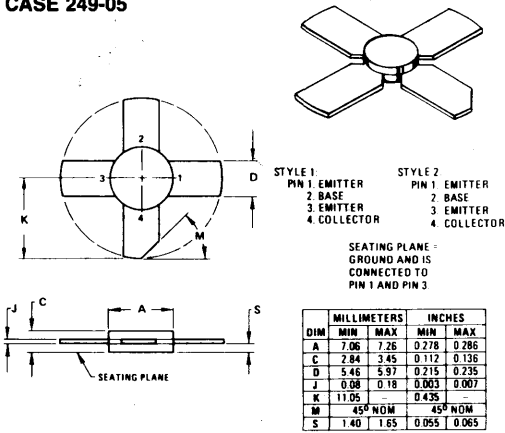
STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

STYLE 2:
PIN 1. COMMON
2. OUTPUT
3. COMMON
4. INPUT

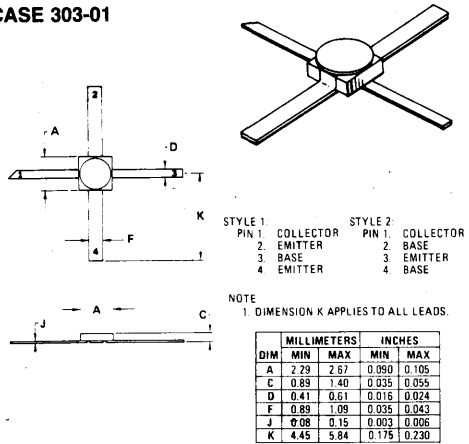
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
B	6.20	6.50	0.244	0.256
C	15.24	16.51	0.600	0.650
D	0.66	0.66	0.026	0.034
E	1.40	1.65	0.055	0.065
F	1.52	-	0.060	-
J	0.10	0.15	0.004	0.006
K	11.17	-	0.440	-
M	-	1.27	-	0.050
P	45° NOM	-	45° NOM	-
S	2.74	3.35	0.108	0.132
T	1.40	1.78	0.055	0.070
U	2.92	3.68	0.115	0.145

PACKAGE OUTLINE DIMENSIONS (continued)

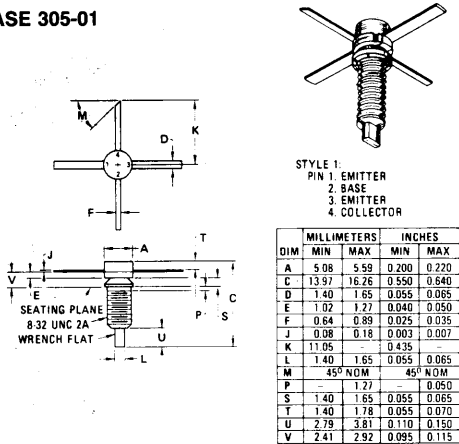
CASE 249-05



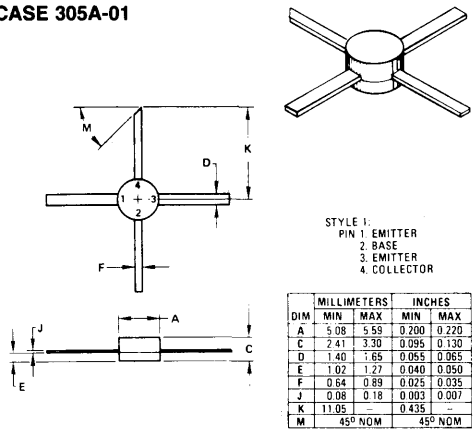
CASE 303-01



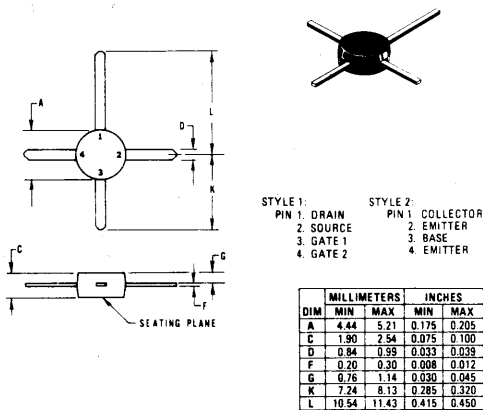
CASE 305-01



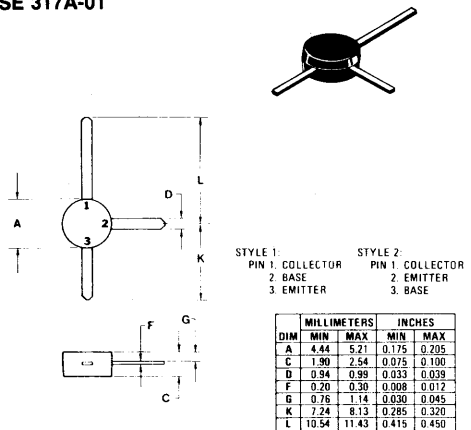
CASE 305A-01



CASE 317-01

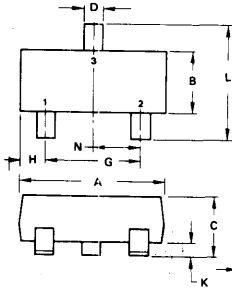
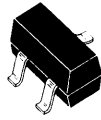


CASE 317A-01



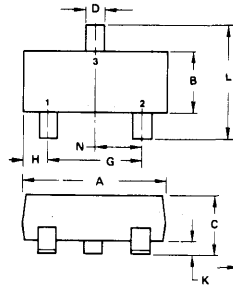
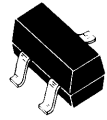
PACKAGE OUTLINE DIMENSIONS (continued)

CASE 318 TO-236AA



DIM	MIN	MAX	MILLIMETERS	MIN	MAX	INCHES
A	2.80	3.04	0.1102	0.1197		
B	1.20	1.40	0.0472	0.0551		
C	0.85	1.20	0.033	0.0472		
D	0.37	0.46	0.015	0.0177		
F	0.085	0.13	0.0034	0.0051		
G	1.78	2.04	0.0701	0.0807		
H	0.51	0.60	0.020	0.0236		
K	0.10	0.25	0.004	0.0098		
L	2.10	2.50	0.083	0.0984		
M	0.45	0.60	0.018	0.0236		
N	0.89	1.02	0.035	0.0401		

CASE 318 TO-236AB (Low Profile)



DIM	MIN	MAX	MILLIMETERS	MIN	MAX	INCHES
A	2.80	3.04	0.1102	0.1197		
B	1.20	1.40	0.0472	0.0551		
C	0.89	1.04	0.035	0.0412		
D	0.37	0.46	0.015	0.0177		
F	0.085	0.13	0.0034	0.0051		
G	1.78	2.04	0.0701	0.0807		
H	0.51	0.60	0.020	0.0236		
K	0.012	0.10	0.0005	0.0040		
L	2.10	2.50	0.083	0.0984		
M	0.45	0.60	0.018	0.0236		
N	0.89	1.02	0.035	0.0401		

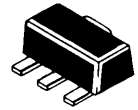
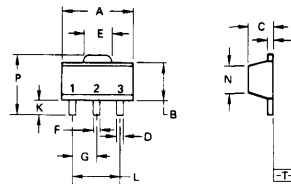
CASE 318 STYLES

- STYLE 6:
PIN 1. BASE
2. EMITTER
3. COLLECTOR
- STYLE 7:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
- STYLE 8:
PIN 1. ANODE
2. NO CONNECTION
3. CATHODE
- STYLE 9:
PIN 1. ANODE
2. ANODE
3. CATHODE
- STYLE 10:
PIN 1. DRAIN
2. SOURCE
3. GATE
- STYLE 11:
PIN 1. ANODE
2. CATHODE
3. CATHODE
ANODE
- STYLE 12:
PIN 1. CATHODE
2. CATHODE
3. ANODE
- STYLE 13:
PIN 1. SOURCE
2. DRAIN
3. GATE
- STYLE 14:
PIN 1. CATHODE
2. GATE
3. ANODE
- STYLE 15:
PIN 1. GATE
2. CATHODE
3. ANODE
- STYLE 16:
PIN 1. ANODE
2. CATHODE
3. CATHODE
- STYLE 17:
PIN 1. NO CONNECTION
2. ANODE
3. CATHODE

STYLES 1 THRU 5 ARE OBSOLETE.

NOTES
1. 318 - 02 MEETS ALL JEDEC DIMENSIONAL REQUIREMENTS FOR TO - 236 AA.

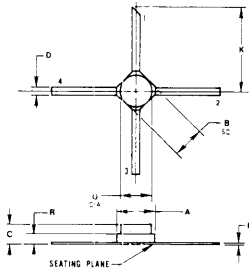
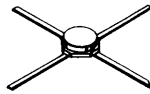
CASE 345-01



- STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
- STYLE 2:
PIN 1. ANODE
2. CATHODE
3. NO CONNECTION
- STYLE 3:
PIN 1. GATE
2. ANODE
3. CATHODE
- STYLE 4:
PIN 1. DRAIN
2. GATE
3. SOURCE

DIM	MIN	MAX	MILLIMETERS	MIN	MAX	INCHES
A	4.40	4.60	0.174	0.181		
B	2.29	2.50	0.091	0.102		
C	1.40	1.60	0.056	0.062		
D	0.36	0.48	0.015	0.018		
E	1.62	1.80	0.064	0.070		
F	0.44	0.53	0.018	0.020		
G	1.50 BSC		0.059 BSC			
J	0.35	0.44	0.014	0.017		
K	0.80	1.04	0.032	0.040		
L	3.00 BSC		0.118 BSC			
N	2.04	2.28	0.081	0.089		
P	3.94	4.25	0.156	0.167		

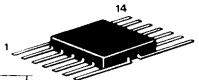
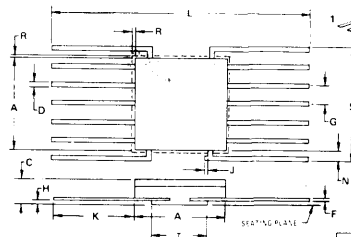
CASE 358-01



- STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR
4. EMITTER
- STYLE 2:
PIN 1. DRAIN
2. SOURCE
3. GATE 1
4. GATE 2

DIM	MIN	MAX	MILLIMETERS	MIN	MAX	INCHES
A	2.41	2.92	0.095	0.115		
B	1.95	2.36	0.077	0.093		
C	1.09	1.60	0.043	0.063		
D	0.43	0.58	0.017	0.023		
F	0.07	0.15	0.003	0.006		
K	4.82	6.60	0.190	0.260		
R	0.53	0.96	0.021	0.038		
U	1.98	2.18	0.078	0.086		

CASE 607-04 CERAMIC

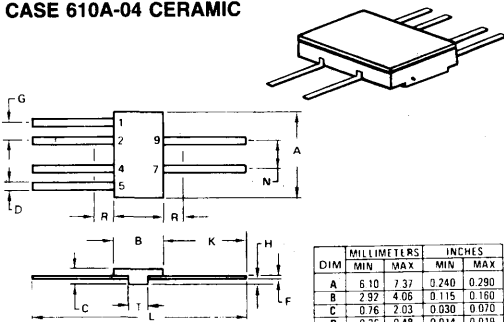


- STYLE 1
BASE 2, 6, 9, 13
EMITTER 3, 5, 10, 12
COLLECTOR 1, 7, 8, 14
FOR COMPLEMENTARY QUADS
NPN PINS 1 THRU 3, 12 THRU 14
PNP PINS 5 THRU 7, 8 THRU 10
(REFER TO STYLE 1
FOR PIN IDENTIFICATION)

DIM	MIN	MAX	MILLIMETERS	MIN	MAX	INCHES
A	6.10	6.99	0.240	0.275		
C	0.76	2.03	0.030	0.070		
D	0.25	0.48	0.010	0.019		
F	0.08	0.15	0.003	0.006		
G	1.27 BSC		0.050 BSC			
H	0.13	0.89	0.005	0.035		
J		0.38		0.015		
K	6.35		0.250			
L	18.80		0.740			
N	0.25		0.010			
R		0.38		0.015		
S	7.62	8.38	0.300	0.330		
T	4.45	4.95	0.175	0.195		

PACKAGE OUTLINE DIMENSIONS (continued)

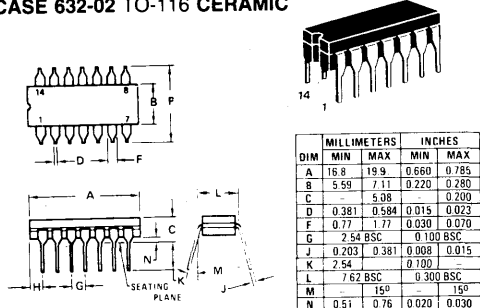
CASE 610A-04 CERAMIC



STYLE 1
 BASE 1, 5
 EMITTER 2, 4
 COLLECTOR 9, 7
 FOR COMPLEMENTARY PAIRS
 NPN PINS 1, 2, 9
 PNP PINS 4, 5, 7
 (REFER TO STYLE 1 FOR PIN IDENTIFICATION)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.37	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.070
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.77	BSC	0.050	BSC
H	0.13	0.89	0.005	0.035
K	3.81	-	0.150	-
L	10.54	-	0.415	-
N	2.54	BSC	0.100	BSC
R	-	1.27	-	0.050
T	1.65	2.03	0.065	0.080

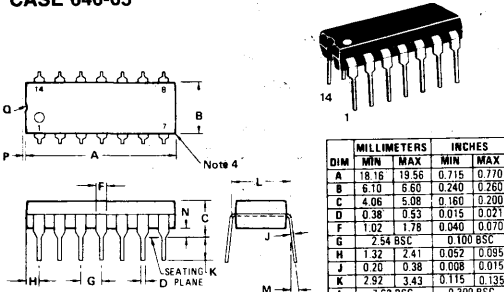
CASE 632-02 TO-116 CERAMIC



STYLE 1
 COLLECTOR 1, 7, 8, 14
 BASE 2, 6, 9, 13
 EMITTER 3, 5, 10, 12
 COMPLEMENTARY PAIRS
 TYPE 1
 NPN 1 THRU 3, 5 THRU 7
 PNP 8 THRU 10, 12 THRU 14
 (REFER TO STYLE 1 FOR PIN IDENTIFICATION)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.8	19.5	0.660	0.765
B	5.59	7.11	0.220	0.280
C	-	5.08	-	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54	BSC	0.100	BSC
J	0.203	0.381	0.008	0.015
K	2.54	-	0.100	-
L	7.62	BSC	0.300	BSC
M	-	15°	-	15°
N	0.51	0.76	0.020	0.030
P	-	8.25	-	0.325

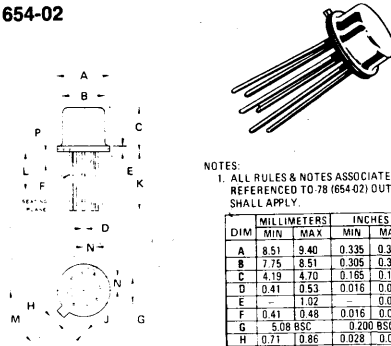
CASE 646-05



STYLE 1
 BASE 2, 6, 9, 13
 EMITTER 3, 5, 10, 12
 COLLECTOR 1, 7, 8, 14
 COMPLEMENTARY PAIRS
 TYPE 1
 NPN 1 THRU 3, 5 THRU 7
 PNP 8 THRU 10, 12 THRU 14
 (REFER TO STYLE 1 FOR PIN IDENTIFICATION)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.16	19.56	0.715	0.770
B	6.10	6.60	0.240	0.260
C	4.06	5.08	0.160	0.200
D	0.38	0.53	0.015	0.021
F	1.02	1.78	0.040	0.070
G	2.54	BSC	0.100	BSC
H	1.32	2.41	0.052	0.095
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	7.62	BSC	0.300	BSC
M	0°	16°	0°	16°
N	0.51	1.02	0.020	0.040

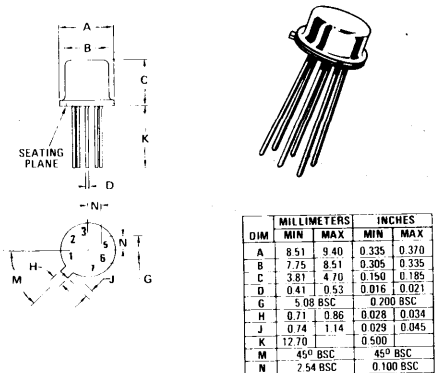
CASE 654-02



NOTES:
 1. ALL RULES & NOTES ASSOCIATED WITH REFERENCED TO 78 (654-02) OUTLINE SHALL APPLY.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	4.19	4.70	0.165	0.185
D	0.41	0.53	0.016	0.021
E	-	1.02	-	0.040
F	0.41	0.48	0.016	0.019
G	5.08	BSC	0.200	BSC
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	-	0.500	-
L	6.35	-	0.250	-
M	45°	BSC	45°	BSC
N	2.54	-	0.100	BSC
P	-	1.27	-	0.050

CASE 654-07



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08	BSC	0.200	BSC
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	-	0.500	-
M	45°	BSC	45°	BSC
N	2.54	BSC	0.100	BSC

CASE 654 STYLES

STYLE 1:
 PIN 1. COLLECTOR
 2. BASE
 3. EMITTER
 4. OMITTED

STYLE 2:
 PIN 1. COLLECTOR
 2. BASE
 3. EMITTER
 4. OMITTED

STYLE 3:
 PIN 1. EMITTER
 2. BASE
 3. COLLECTOR
 4. OMITTED
 5. ANODE
 6. NO CONNECTION
 7. CATHODE
 8. OMITTED

STYLE 4:
 PIN 1. GATE
 2. SOURCE
 3. DRAIN
 4. OMITTED

STYLE 5:
 SIDE 1 (NPN)
 PIN 1. COLLECTOR
 2. BASE
 3. EMITTER
 4. OMITTED

STYLE 6:
 PIN 1. SOURCE
 2. DRAIN
 3. GATE
 4. OMITTED

5. EMITTER
 6. BASE
 7. COLLECTOR
 8. OMITTED

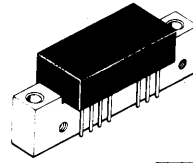
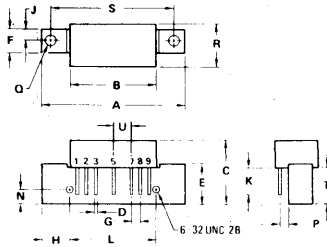
5. DRAIN
 6. SOURCE
 7. GATE
 8. OMITTED

5. SOURCE
 6. DRAIN
 7. GATE
 8. OMITTED

5. DRAIN
 6. SOURCE
 7. GATE
 8. OMITTED

PACKAGE OUTLINE DIMENSIONS (continued)

CASE 714-02



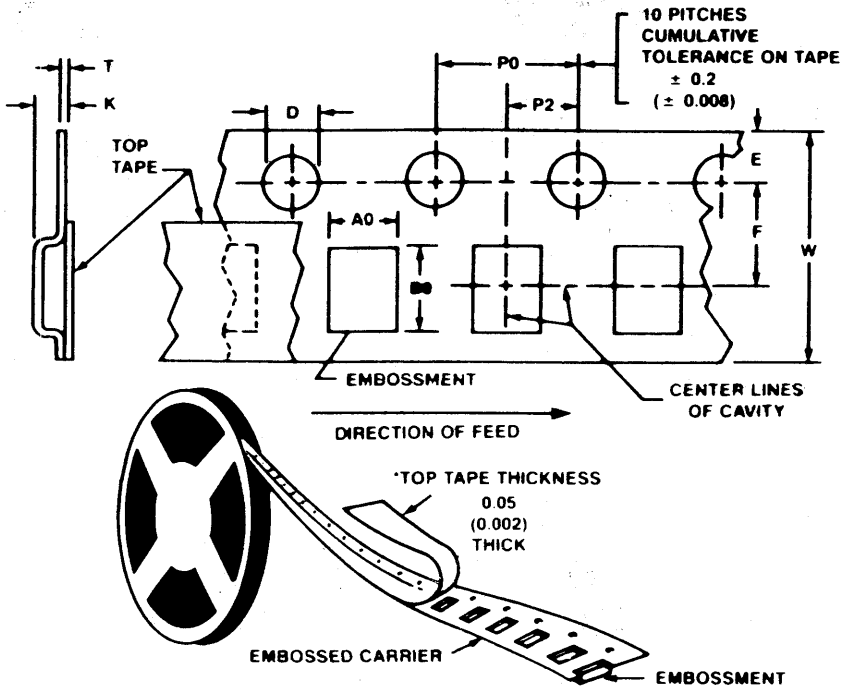
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	45.08		1.775	
B	26.42	26.92	1.040	1.060
C	20.57	21.34	0.810	0.840
D	0.46	0.56	0.018	0.022
E	11.81	12.95	0.465	0.510
F	7.62	8.13	0.300	0.320
G	2.41	2.67	0.095	0.105
H	9.65	9.78	0.380	0.385
J	3.96 BSC		0.156 BSC	
K	6.98	7.37	0.270	0.290
L	25.40 BSC		1.000 BSC	
N	4.06	4.32	0.160	0.170
P	2.16	2.92	0.085	0.115
Q	3.76	4.27	0.148	0.168
R	15.11		0.595	
S	38.10 BSC		1.500 BSC	
T	11.05	11.43	0.435	0.450
U	4.95	5.21	0.195	0.205

FIRST STAGE: PIN 1, RF IN
4, RF OUT
SECOND STAGE: PIN 6, RF IN
9, RF OUT

Vcc: PIN 5
DC AND RF GROUND: PINS 2, 3, 7, 8

NOTE:
1. MOUNTING HOLES WITHIN
0.25 mm (0.010) DIA OF TRUE
POSITION AT MAXIMUM
MATERIAL CONDITION

8 mm TAPE CARRIER (EIA STANDARD RS-481) Dimensions in mm (in.)



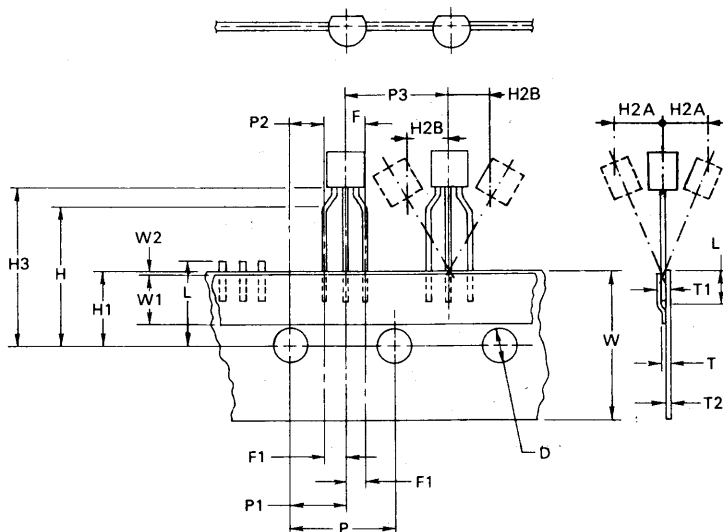
8

W	F	E	P2	P0	D	T	K	A0, B0
8.0 ± 0.2 (0.315 ± 0.008)	3.5 ± 0.05 (0.138 ± 0.002)	1.75 ± 0.05 (0.069 ± 0.002)	2.0 ± 0.05 (0.079 ± 0.002)	4.0 ± 0.1 (0.157 ± 0.004)	1.5 ± 0.1 0.0 (0.059 ± 0.004 0.000)	0.3 MAX. (0.012)	2.0 MAX (0.079)	PACKAGE MAX. DIMENSIONS PLUS 0.4 ± 0.2 (0.016 ± 0.008)

PACKAGE OUTLINE DIMENSIONS (continued)

TO-92 RADIAL TAPE AND REEL (Dimensions in mm)

FIGURE 1 — TAPING PROCEDURE



SYMBOL	ITEM	SPECIFICATION		REMARKS
		Min mm	Max mm	
D	Tape Feed Hole Diameter	3.7	4.3	
F	Overall Component Lead Pitch	4.8	5.8	
F1	Component Lead Pitch	2.4	2.9	
H	Height of Seating Plane	15.5	16.5	Note 2
H1	Feed Hole Location	8.5	9.75	Notes 9 & 10
H2A,B	Deflection Front or Rear, Left or Right	0	1.0	Note 1
H3	Feed Hole to Bottom of Component	18.0	19.0	
L	Lead Length After Component Removal	0	11.0	Notes 3 & 8
L1	Lead Wire Enclosure	2.5	—	Note 4
P	Feed Hole Pitch	12.4	13.0	Note 5
P1	Feed Hole — Component Center Distance	5.95	6.75	
P2	Feed Hole — First Lead Distance	3.02	4.35	
P3	Component Center Pitch	11.7	13.7	
T	Total Tape Thickness	0.5	0.9	
T1	Overall Taped Package Thickness	—	1.44	Note 6
T2	Carrier Tape Thickness	0.38	0.68	Note 6
W	Overall Tape Width	17.5	19.0	Note 7
W1	Holddown Tape Width	5.7	6.3	Note 7
W2	Holddown Tape Position	0	0.5	Note 7

NOTES:

- Maximum alignment deviation between leads not to be greater than 0.2 mm.
- As illustrated, the clearance to the lead standoff form shall be defined to the point of radius for the standoff form.
- Defective components shall be clipped from the carrier tape such that the remaining protrusion (L) does not exceed a maximum of 11 mm.
- Component lead to tape adhesion must meet the pull test requirements established in Figures 4, 5, and 6.
- Maximum non-cumulative variation between tape feed holes shall not exceed 1.0 mm in 20 pitches.
- Overall taped package thickness, including component leads and tape splices shall not exceed 1.44 mm.
- Holddown tape not to extend beyond the edge(s) of carrier tape and there shall be no exposure of adhesive.
- No more than 3 consecutive missing components is permitted.
- A tape trailer, having at least three feed holes is required after the last component
- Splices shall not interfere with the sprocket feed holes.

PACKAGE OUTLINE DIMENSIONS (continued)

TO-92 RADIAL TAPE AND REEL

FIGURE 2 — REEL Pack Dimensions

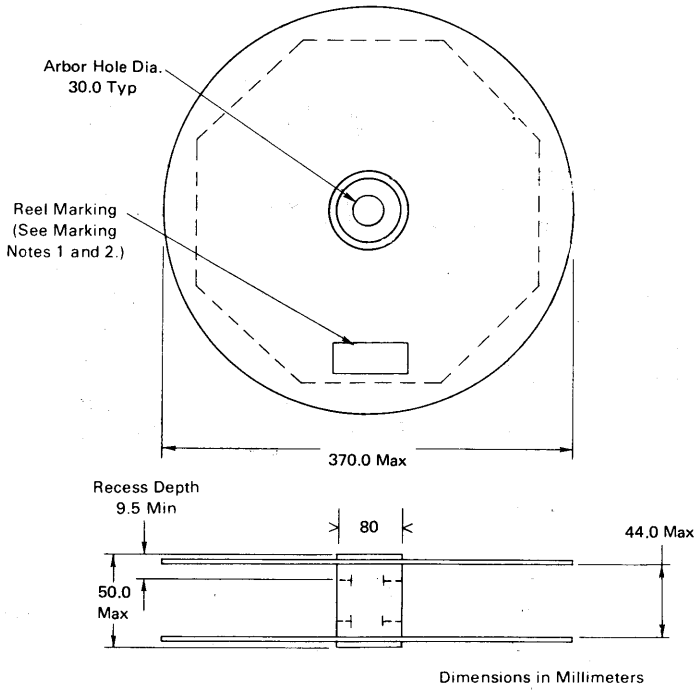
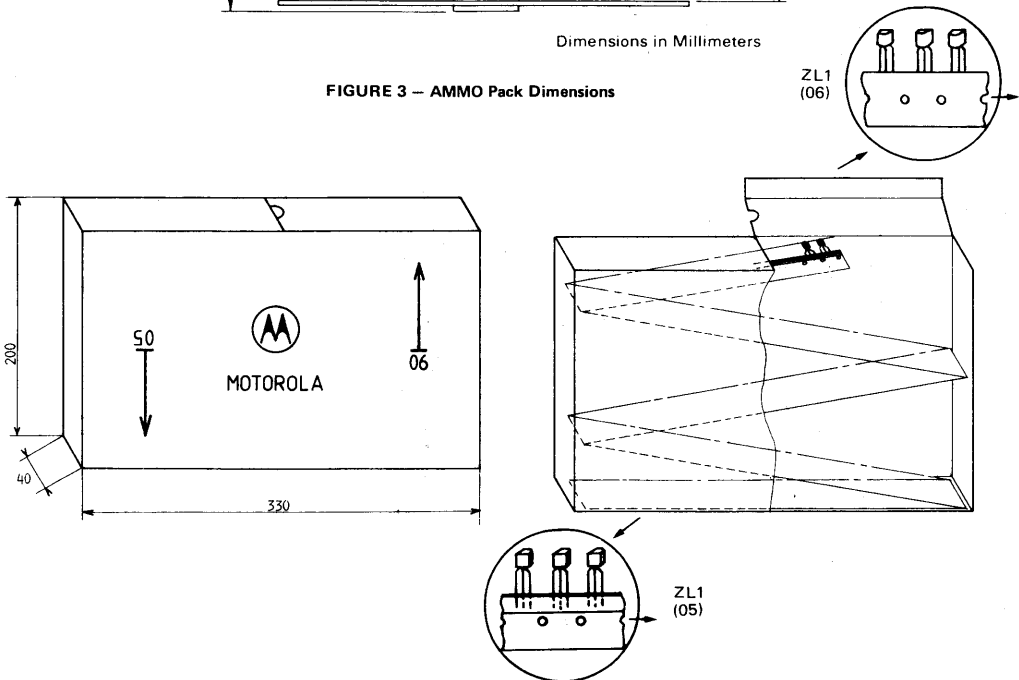


FIGURE 3 — AMMO Pack Dimensions



8

PACKAGE OUTLINE DIMENSIONS (continued)

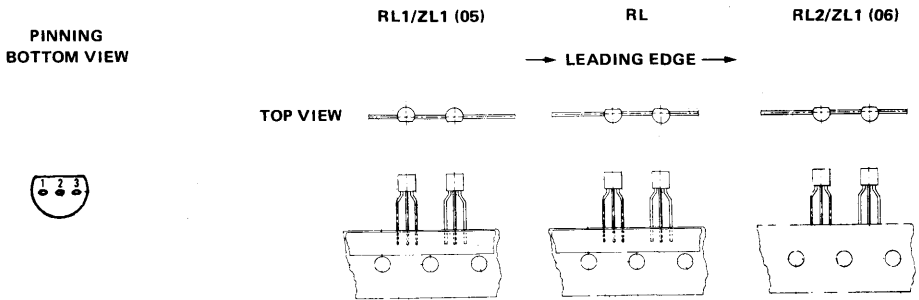
TO-92 RADIAL TAPE AND REEL

FIGURE 4 – ORDERING NOTES

1. Each package (AMMO and REEL) contains two thousand pieces; orders have to be a multiple of 2K.
2. How to choose a style of Reel Winding ?

It depends on the leading edge one needs to see first, on the TO92 pinning.

See below for guidance for your specified needs.



TRANSISTORS

1	2	3	First Lead Seen	First Lead Seen	First Lead Seen
E	B	C	Collector	Emitter	Emitter
C	B	E	Emitter	Collector	Collector
B	E	C	Collector	Base	Base
E	C	B	Base	Emitter	Emitter
C	E	B	Base	Collector	Collector

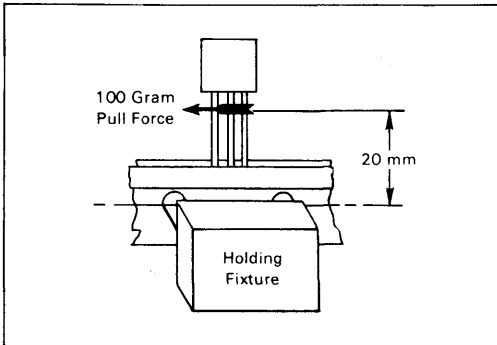
FETS

1	2	3	Drain	Gate	Gate
G	S	D	Drain	Gate	Gate
D	S	G	Gate	Drain	Drain
S	G	D	Drain	Source	Source

PACKAGE OUTLINE DIMENSIONS (continued)

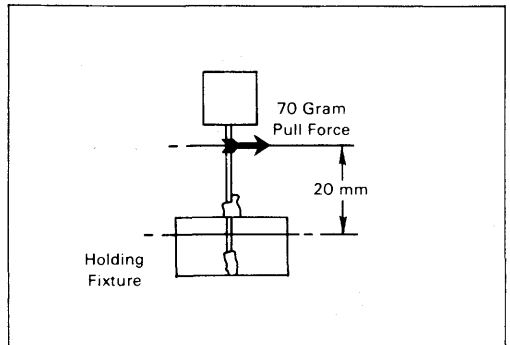
TO-92 RADIAL TAPE AND REEL

FIGURE 5 — ADHESION PULL TEST #1



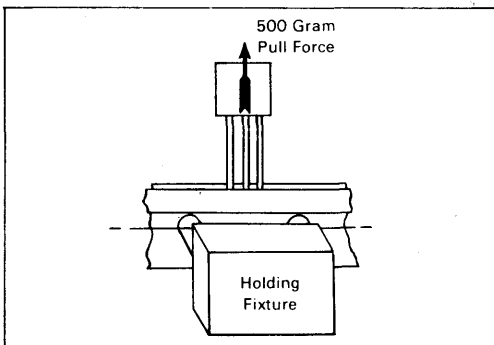
The component shall not pull free with a 100 gram load applied to the leads for 3.0 ± 1 second.

FIGURE 6 — ADHESION PULL TEST #2



The component shall not pull free with a 70 gram load applied to the leads for 3.0 ± 1 second.

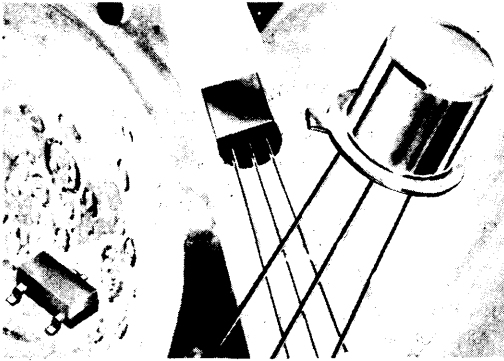
FIGURE 7 — ADHESION PULL TEST #3



There shall be no deviation in the leads and no component leads shall be pulled free of the tape with a 500 gram load applied to the component body for 3.0 ± 1 second.

MARKING NOTES:

1. Minimum container and reel marking shall consist of the following items:
 - a. Motorola
 - b. Customer Purchase Order Number
 - c. Quantity
 - d. Date of Reeling
 - e. Motorola Part Number
2. Where applicable, the following items will be included:
 - a. Customer Part Number
 - b. Device Date Code



Small-Signal Discrete products are available from Motorola in four quality and reliability classes: Industrial/Commercial grade, High Reliability Military grade, High Reliability Space grade, and Customer Specials.

This Reliability and Quality Assurance section contains information on final test and quality assurance processing. Included is a listing of Q.A. test and the applicable CECC methods relating to the above noted quality and screening levels.

A comparison table between US MIL-STD qualified product levels (JAN, JANTX, JANTXV, JANS) and CECC assessment and screening levels is given.

A glossary of Reliability and Quality terms is also included.

**Reliability and
Quality Assurance**

9

Reliability and Quality Assurance

Quality Levels

Most Small-Signal Discrete products are available from Motorola in four quality and reliability levels:

1. **INDUSTRIAL/COMMERCIAL GRADE** — Identified by a part number prefix such as 2N, BC, MM, or MPS and tested to a published Motorola, Pro-Electron or JEDEC specification.
2. **Assessed Quality and Reliability products qualified or processed per CECC 50 000** according levels and classes as follow:
CECC F — Controlled lot with sample environmental and life testing
CECC F — with screening class B: Same as CECC F plus 100% processing
CECC F — with screening class A: Same as CECC F plus 100% processing and 100% internal visual inspection.
3. **Products for Space Level Usage** qualified or processed per E.S.A./SCC specifications.
4. **CUSTOMER SPECIAL** — Screening, testing and marking as determined by the customer to meet his particular requirement. This may range from a custom-marked industrial/commercial grade product to a Hi-Rel product which is subjected to a series of stringent inspections and tests to meet aerospace or special military requirements.

Final Test Processing

Device lots are subjected to 100% processing in Final Test. This processing may be as simple as electrical testing to data sheet specifications or as complex as a series of mechanical, environmental and burn-in screening tests preceded and followed by electrical readouts. All lots, whether industrial/commercial, assessed quality or Hi-Rel space, are subjected to a minimum 24-hours storage bake at 150° C or 200° C.

Quality Assurance Processing

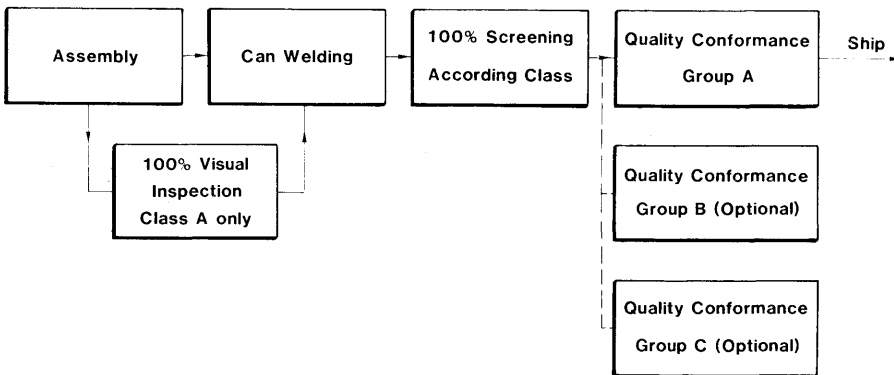
All products are transferred to QA where they are subjected to Group A electrical testing, to the customer's specification, usually the same as the one used by final test.

QA is presently performing sample testing. However, Motorola quality improvement program is planning that all Small-Signal Transistors will be subjected to 100% QA electrical testing.

High Reliability Processing of Transistors

In Europe Motorola has qualified to CECC standard the most popular Small Signal Transistors, and new types are added as market demands.

MIL-STD-750 OR CECC 50 000 PROCESSING FLOW CHART



Devices not yet qualified to CECC which must be supplied to a qualified standard can be supplied in most cases as qualified to MIL-STD-19 500 (JAN, JANTX, JANTXV or JANS). However, this solution is non preferred in Europe because these products are non standard, being imported from US factories.

Motorola Europe recommends therefore whenever possible to use parts processed in Europe.

Two programs are proposed. One is based on US MIL-STD-750 test methods and offer two classes of screening levels, "A" which is similar to JANTXV level and screening level "B" which is similar to JANTX level of MIL-STD-19 500.

The other Hi-Rel screening program is per CECC 50 000 appendix 6. Motorola offers as standard the levels A and B. Levels C and D can be obtained on special request.

Both standards MIL and CECC are similar in their philosophy and implementation. Both do guarantee on a lot by lot basis and eventually on 100% screening the reliability, the hermeticity and the solderability of transistors with comparable defect limits.

In figure 1, a flow chart of the main processing steps in both systems is described.

Figure 2 gives the comparison between Hi-Rel screening classes and assessment levels in both standards.

Figure 3 and 4 show the details of the various group A screening steps in each standard and for each class.

The list of today's Small-Signal Transistors qualified to CECC 50 000 is presented in section 1.

For more information concerning Motorola's High-Reliability capability consult the latest edition of the Hi-Rel brochure.

TABLE 1 — HIGH RELIABILITY SCREENING LEVELS FOR DISCRETE PRODUCTS

QUALIFIED(1)		PROCESSED(2)		
US Source Mandatory	European Source Mandatory	Europe		US
MIL-M-19500 to MIL-STD-750	CECC 50000	CECC 50000	MIL-STD-750	
JAN	CECC 50000 E, F	—	—	Does not exist
JANTX	CECC 50000 E, F + Screening Level B	Class B	Class B	Does not exist
JANTXV	CECC 50000 E, F + Screening Level A	Class A	Class A	Does not exist
JANS	SCC 5000 Level B	—	—	Does not exist

(1) Applicable only to qualified products with existing slash (detail) specifications. Gov. source inspection required for all qualified products.

(2) Applicable for all specifications either industry standard or MOTOROLA data sheets. No gov. source inspection mandatory but possible on request as well as customer source inspection.

TABLE 2 — PROCESSED ACCORDING TO CECC 50000

Test No.	Screen	CECC 50000 Test method	Details and conditions	Class A	Class B
1	Internal visual (precap)	Appendix VI paragraph 4		100%	—
2	High temperature stabilization bake	4.4.1	24H at max. rated storage temperature	100%	100%
3	Temperature cycling	4.4.4	5 cycles 30 min. each at min. max. storage temperature	100%	100%
4	Constant acceleration		As specified and according IEC68-2-7 and IEC147-5 (note 1)	100%	100%
5	Hermetic seal	4.410	A) fine leak: Qk or radio isotope B) gross leak: Qc	100%	100%
6 6.1 6.2	Interim electrical test By variables By attribut		Read and record initial values Check if values are within limits of group A	100% —	— 100%
7	Burn-in a) Diodes b) Bipolar transistors rated at ambient temperature c) Bipolar transistors at case rated temperature d) Field effect transistors e) Rectifiers	4.5.2.1 4.5.2.2 4.5.2.3 4.5.2.3 4.5.2.10 4.5.2.4	Duration hours Tolerances Conditions High temperature reverse bias or Power dissipation Power dissipation High temperature reverse bias High temperature reverse bias (VSB = 0, T = 150°C) Power dissipation for rectifiers rated at ambient temperature High temperature reverse bias for rectifiers rated at case temperature	168 - 8	72 - 4
8 8.1	Final electrical test By variable		Per detail specification delta parameter according CECC 50000 annex VI paragraph 3	100%	—
8.2	By attribute		Check if values are within limit of group A	—	100%
	Quality conformance Group A		Per generic CECC 50000 Level F	Sampling Assessment F	Sampling Assessment F
	Typical reliability improvement compared to commercial products as per MIL HDBK 217C.			25	12

Note (1) applicable only for devices with Au wire.

TABLE 3 — PROCESSED ACCORDING TO MIL-STD-750

Test No.	Screen	MIL-STD-750 method	Condition	Level A requirements	Level B requirements
1	Internal visual (precap) inspection	2072 2074	For Transistors For Diodes	100% 100%	— —
2	High temperature stabilization bake	1032	24H at max. rated storage temperature	100%	100%
3	Temperature cycling	1051	10 cycles 15 mns each at min. max. storage temperature	100%	100%
4	Constant acceleration	2006	Y1 axis at 20000G min. or 10000G(1) for devices with PA10W at TC = 25° C	100%	100%
5	Serialization			100%	—
6	High temperature reverse bias (HTRB)	1038 1039	For Diodes For Transistors Condition A	Option R	Option R
7	Interim electrical test		As specified By variables (read and record)	100%	—
8	Power burn-in	1038 1039 1040	For Diodes Condition B For Transistors Condition B For Thyristors Condition B	100% 160H	100% 160H
9	Final electrical test		As specified - by variables (read and - record) by attributs (GO NO GO)	100% —	— 100%
10	PDA (lot acceptance)		Applicable on electrical rejects found on pos. 9	10% max.	10% max.
11	Hermetic seal A) fine B) gross	1071	Condition G or H Condition C	100%	100%
12	Radiography	2076	See foot note(2)	100%	—
13	Electrical group A inspection (Quality conformance)		- DC parameters TA = 25° C - DC parameters at high and low temperature - Dynamic tests at TA = 25° C - AC test at TA = 25° C	AQL 0.4% Level II 0.65% Level S3 0.65% Level S3 0.65% Level S3	
14	External visual examination	2071	To be performed after complete marking	100%	100%
15	Quality conformance Group B test		See Program Options	Option Q	Option Q
	Typical reliability improvement compared to commercial products as per MIL HDBK 217C			35	18

Note (1) applicable only for devices with Au wire.

Note (2) not applicable for devices with Al wire.

Test Descriptions

The following tests are frequently used for screening, acceptance and evaluation of semiconductor devices.

A. Steady State Operating Life (SSOL)

The purpose of this test is to evaluate the bulk stability of the die and to generate defects resulting from manufacturing aberrations that are manifested as time and stress-dependent failures.

Conditions: $T_A = 25^\circ\text{C}$, PD = max rated power

B. Intermittent Operating Life (IOL)

The purpose of this test is the same as Operating Life in addition to checking the integrity of both the wire and die bonds by means of thermal stressing.

Conditions: $T_A = 25^\circ\text{C}$, PD = max rated power. $T_{(\text{on})} = T_{(\text{off})} = 1$ min.

C. High Temperature Storage Life

The purpose of this test is to generate time/temperature failure mechanisms and to evaluate long-term storage stability.

Conditions: $T_A = 150^\circ\text{C}$ no bias applied

D. High Temperature Reverse Bias (HTRB)

The purpose of this test is to align mobile ions by means of temperature and voltage stresses to form a high-current leakage path between two or more terminals.

Conditions: $T_A = 150^\circ\text{C}$, $V_{CB} = 80\%$ max rated V_{CB} .

E. High Temperature High Humidity Reverse Bias (H²TRB)

The purpose of this test is to evaluate the moisture resistance of non-hermetic components. The addition of voltage bias accelerates the corrosive effect after moisture penetration has taken place. With time, this is a catastrophically destructive test.

Conditions: $T_A = 85^\circ\text{C}$, RH = 85%, $V_{CB} = 80\%$ max rated V_{CB} .

F. Moisture Resistance

The purpose of this test is to evaluate the moisture resistance of components under temperature/humidity conditions typical of tropical environments.

Conditions: Mil-Std-750, Method 1021, or CECC 50000, Method 4.4.3

G. Pressure Cooker

The purpose of this test is to evaluate the moisture resistance of non-hermetic components under pressure/temperature conditions.

Conditions: $T = 121^\circ\text{C}$, $P = 1$ atmosphere (15 psig)

H. Temperature Cycle (Air to Air)

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperatures and the transition between temperature extremes, and to expose excessive thermal mismatch between materials.

Conditions: Mil-Std-750, Method 1051, -55°C to 150°C , 15 minutes dwell time at each temperature, or CECC 50000, Method 4.4.4 - Na

I. Thermal Shock (Liquid to Liquid)

This test is an accelerated version of temperature cycle.

Conditions: Mil-Std-750, Method 1056, 0°C to 100°C , 15 seconds dwell time at each temperature, or CECC 50000, Method 4.4.4 - Nc

J. Terminal Strength

The purpose of this test is to evaluate the ability of the device terminals to withstand the lead forming and tension associated with component installation into a circuit.

Conditions: Mil-Std-750, Method 2036, Condition E, or CECC 50000, Method 4.4.9

K. Solderability

The purpose of this test is to determine the solderability of the device terminals.

Conditions: Mil-Std-750, Method 2026, or CECC 50000, Method 4.4.7

L. Salt Atmosphere (Corrosion)

The purpose of this test is to accelerate the corrosion effects of an environment in which salt (NaCl) is present.

Conditions: Mil-Std-750, Method 1041

M. Mechanical Stress Tests

Vibration, shock and constant acceleration tests are infrequently used since they rarely generate failures in small-signal transistors. However, they are still specified for acceptance of military product.

Glossary of Reliability and Quality Terms

Acceptable Quality Level (AQL) — A measure of quality for which a given lot will be accepted most of the time. This is usually established at a probability of acceptance equal to 95%. It is referred to as the producer's risk because the probability of rejecting a good lot is 5%.

Acceptance Number (Ac) — The largest number of defectives in an inspection sample under consideration that will permit acceptance of the lot.

Acceptance Tests — Tests to determine conformance to specification requirements as a basis for lot acceptance.

Average Outgoing Quality (AOQ) — The average quality of outgoing product after 100% screening of rejected lots. This is usually measured in parts per million (PPM).

Average Outgoing Quality Limit (AOQL) — The maximum average outgoing quality that is possible for a given sampling plan.

Defect — Any deviation of a device that does not conform to specified requirements. One device may contain more than one defect.

Defective — A device which contains one or more defects.

Double Sampling — Sampling inspection in which the inspection of the first sample leads to a decision to accept, to reject, or to take a second sample. The inspection of a second sample, when required, always leads to a decision to accept or to reject.

Failure — The inability of a device to perform a specified function within previously-established limits.

Failure Rate — The statistical probability of a failure occurring within a stated period of time. For electronic components it is usually assumed that failures follow an exponential distribution, in which case the failure rate over any stated period of time is constant. The failure rate of semiconductor devices is generally given in percent per thousand hours.

Infant Mortality — Premature failures occurring at a failure rate substantially greater than that observed during subsequent life prior to wear-out.

Lot — A group of devices from which samples are drawn and inspected to determine compliance with acceptance criteria (inspection lot).

Lot Tolerance Percent Defective (LTPD) — A measure of quality for which a given lot will be rejected most of the time. This is usually established at a probability of acceptance equal to 10%. It is referred to as the consumer's risk because the probability of accepting a bad lot is 10%.

Mean Time Between Failures (MTBF) — The total measured operating time of a group of equipments divided by the total number of failures of a repairable equipment. In the case of an exponential failure distribution, this ratio is the reciprocal of failure rate.

Operating Characteristic Curve (OC curve) — A graph of the probability of acceptance as a function of the lot quality or process average quality, whichever is applicable.

Percent Defective — The number of defective devices in a lot divided by the total number of devices in that lot, multiplied by 100.

Probability of Acceptance (Pa) — The fractional probability that a lot will be accepted, usually expressed as a decimal.

Process Average Quality — The expected quality of product from a given process, usually estimated from first sample results of previous inspection lots.

Quality — A measure of the degree to which a product conforms to specification and workmanship requirements.

Rejection Number (Re) — The smallest number of defectives in an inspection sample under consideration that will prevent acceptance of the lot.

Reliability — A measure of the performance of a product over a specified period of time.

Sample — One or more devices selected at random from an inspection lot to represent that lot for acceptance purposes.

Sampling Plan — A specific plan which defines the sample size and the criteria for accepting or rejecting a lot.

Screening Tests — Tests employing nondestructive environmental, electrical, thermal and/or mechanical stresses, for the purpose of identifying anomalous devices.

Single Sampling — Sampling inspection in which a decision to accept or to reject is reached after the inspection of a single sample.

Wearout Failures — Those failures which occur as a result of deterioration processes and whose probability of occurrence increases with time.

100% Inspection — Inspection of every device, in which each device is accepted or rejected individually for the characteristic concerned, on the basis of its own inspection only.

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