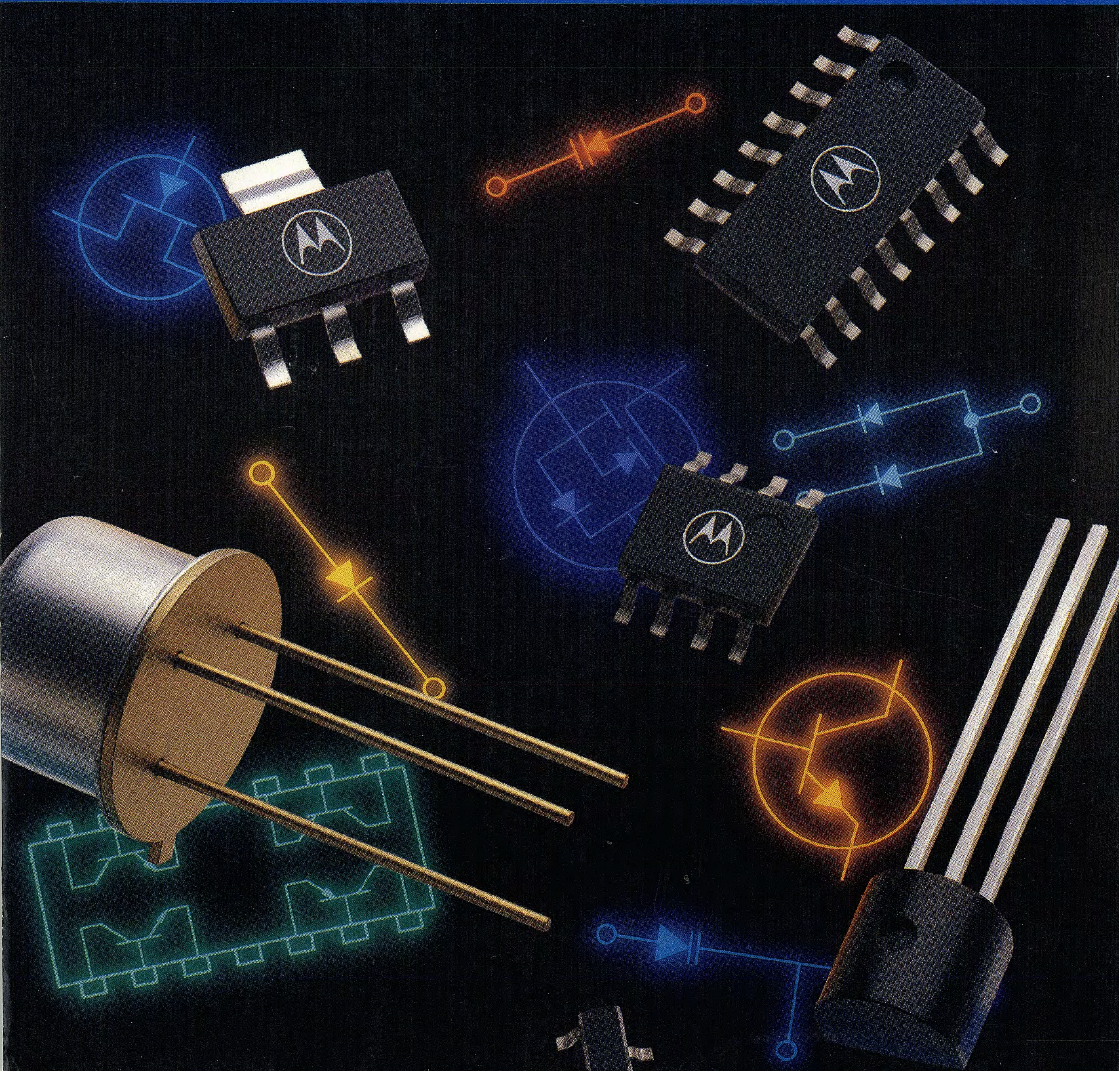
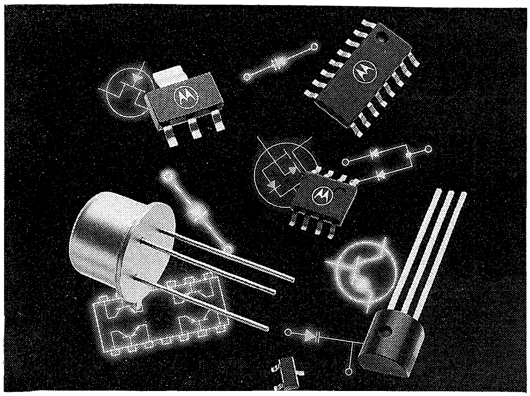
MOTOROLA

DL126/D
REV 4

Small-Signal

Transistors, FETs and Diodes Device Data





Selector Guide 1

Plastic-Encapsulated Transistors 2

Metal-Can Transistors 3

Field-Effect Transistors 4

Medium Power TMOS FETs 5

Small-Signal Tuning and Switching Diodes 6

Tape and Reel Specifications and Packaging Specifications 7

Surface Mount Package Information 8

Package Outline Dimensions and Applications Literature 9

Reliability and Quality Assurance 10

Replacement Devices 11

Alphanumeric Index 12

MOTOROLA

SMALL-SIGNAL TRANSISTORS, FETs AND DIODES

This publication presents technical information for the several product families that comprise the Motorola small-signal semiconductor line. The families include bipolar, field-effect transistors, and diodes. These are available in a variety of packages; metal can, plastic, and surface mount. 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 guide in the first section. The tables will assist in the selection of the proper device for a specific application.

Separate sections are included to describe package outline drawings and footprints and product reliability and quality considerations.

The information in this book has been carefully checked and is believed to be accurate; however, no responsibility is assumed for inaccuracies. Furthermore, this information does not convey to the purchaser of semiconductor devices any license under the patent rights to the manufacturer.

Printed in U.S.A.

About This Revision

The general format of this publication remains the same as its predecessor. There are, however, a significant number of new product offerings throughout this book that are summarized below.

- A separate section (Section 5) has been added to include the new and expanding family of TMOS products.
- Section 1 contains additional new products.
  - — Bias Resistor Transistors (BRT's) in the SOT-23 and the new SC-70/SOT-323 package.
  - — An expanded line of bipolar products in the medium power SOT-223 package.
- Section 6 adds an assortment of popular surface mount switching diodes in the new SC-70/SOT-323 package.

Motorola Device Classifications

In an effort to provide current information to the customer regarding the status of any given device, Motorola has classified all devices into three categories: Preferred devices, Current product and Not Recommended for New Design products.

A Preferred device is a device which is recommended as a first choice for future use. These devices are "preferred" by virtue of their performance, price functionality, or combination of attributes which offer the overall "best" value to the customer. This category contains both advanced and mature devices which will remain available for the foreseeable future (generally 3 to 5 years).

> All Small-Signal transistors, FETs, or Diodes that are classified as a "preferred device" have a star symbol (★) at the end of the device title on the individual data sheets.

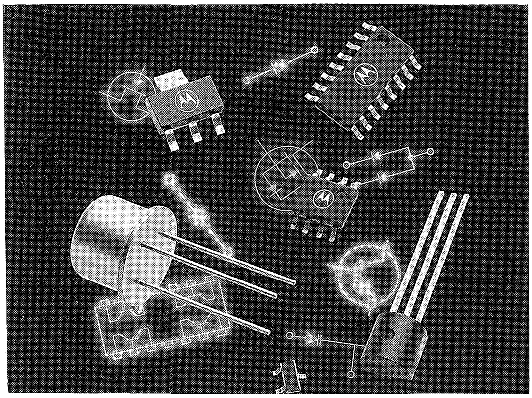
Device types identified as "current" are not a first choice product for **new** designs, but will continue to be available because of the popularity and/or standardization or volume usage in current production designs. These products can be acceptable for new designs but the preferred types are considered better alternatives for long term usage.

> Any device that has not been identified as a "preferred device" is a "current" device.

Products designated as "Not Recommended for New Design" may become obsolete as dictated by poor market acceptance, or a technology or package that is reaching the end of its life cycle. Devices in this category have an uncertain future and do not represent a good selection for new device designs or long term usage.

> All "Not Recommended for New Design" devices have been removed from the data book. In the event the device you need is no longer found within an appropriate section of the data book, refer to the Replacement Devices index at the back of the book to see if there is a Replacement Part for the device in question.

Selector Guide



This selector guide highlights semiconductors that are the most popular and have a history of high usage for the most applications.

It covers a wide range of Small-Signal plastic and metal-can semiconductors.

A large selection of encapsulated plastic transistors, FETs and diodes are available for surface mount and insertion assembly technology. Plastic packages include TO-92 (TO-226AA), 1 Watt TO-92 (TO-226AE), SOT-23, SC-70/SOT-323, SC-59, and SOT-223. Plastic multiples are available in 14-pin and 16-pin dual-in-line packages for insertion applications: SO-14 and SO-16 for surface mount applications.

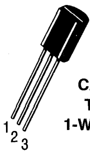
Metal-can packages are available for applications requiring higher power dissipation or having hermetic requirements in TO-18 (TO-206AA) and TO-39 (TO-205AD).

Table of Contents

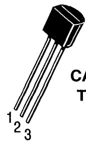
Bipolar Transistors

Plastic-Encapsulated Transistors

Motorola's Small Signal TO-226 plastic transistors encompass hundreds of devices with a wide variety of characteristics for general-purpose, amplifier and switching applications. The popular high-volume package combines proven reliability, performance, economy and convenience to provide the perfect solution for industrial and consumer design problems. All 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.



CASE 29-05
TO-226AE
1-WATT (TO-92)



CASE 29-04
TO-226AA
(TO-92)

Table 1. Plastic-Encapsulated General-Purpose Transistors

These general-purpose transistors are designed for small-signal amplification from dc to low ratio frequencies. They are also useful as oscillators and general-purpose switches. Complementary devices shown where available (Tables 1-4).

		$V_{(BR)CEO}$	f_T @ I_C		I_C	h_{FE} @ I_C			NF	
NPN	PNP	Volts Min	MHz Min	mA	mA Max	Min	Max	mA	dB Max	Style
Case 29-04 — TO-226AA (TO-92)										
MPS8099	***MPS8599***	80	150	10	500	100	300	1.0	—	1
MPSA06	***MPSA56***	80	100	10	500	100	—	100	—	1
2N4410	—	80	60	10	250	60	400	10	—	1
BC546	BC556	65	150	10	100	120	450	2.0	10	17
BC546A	BC556A	65	150	10	100	120	220	2.0	10	17
BC546B	BC556B	65	150	10	100	180	450	2.0	10	17
MPSA05	MPSA55	60	100	10	500	100	—	100	—	1
	MPS2907A	60	200	50	600	100	300	150	—	1
BC182	BC212	50	200(1)	10	100	120	500	2.0	10	14
BC237B	BC307B	45	150	10	100	200	460	2.0	10	17
BC337	BC327	45	210(1)	10	800	100	630	100	—	17
BC547	BC557	45	150	10	100	120	800	2.0	10	17
BC547A	BC557A	45	150	10	100	120	220	2.0	10	17
BC547B	BC557B	45	150	10	100	180	450	2.0	10	17
BC547C	BC557C	45	150	10	100	380	800	2.0	10	17
MPSA20	MPSA70	40	125	5.0	100	40	400	5.0	—	1
MPS2222A		40	300	20	600	100	300	150	—	1
2N4401	***2N4403***	40	200	20	600	100	300	150	—	1
2N4400	2N4402	40	150	20	600	50	150	150	—	1
MPS6602	***MPS6652***	40	100	50	1000	50	—	500	—	1
2N3903	2N3905	40	200	10	200	50	150	10	6.0	1
2N3904	***2N3906***	40	250	10	200	100	300	10	5.0	1
BC548		30	300(1)	10	100	110	800	2.0	10	17
BC548A		30	300(1)	10	100	120	220	2.0	10	17
BC548B	BC558B	30	300(1)	10	100	200	450	2.0	10	17
BC548C		30	300	10	100	420	800	2.0	10	17
2N4123	2N4125	30	200	10	200	50	150	2.0	6.0	1
2N4124	2N4126	25	250	10	200	120	360	2.0	4.0	1
BC338	BC328	25	210(1)	10	800	100	630	100	—	17

(1) Typical

Devices listed in bold, italic are Motorola preferred devices.

Table 1. Plastic-Encapsulated General-Purpose Transistors (continued)

NPN	PNP	$V_{(BR)CEO}$ Volts Min	f_T @ I_C MHz Min	mA	I_C A Max	h_{FE} @ I_C Min	Max	mA	$V_{CE(sat)}$ @ I_C @ I_B Volts Max	mA	mA	Style
Case 29-05 — TO-226AE (1-WATT TO-92)												
BDB01D	BDB02D	100	50	200	0.5	40	400	100	0.7	1000	100	1
BDC01D	BDC02D	100	50	200	0.5	40	400	100	0.7	1000	100	14
BDB01C	BDB02C	80	50	200	0.5	40	400	100	0.7	1000	100	1
MPS6717		80	50	200	0.5	80	—	50	0.5	250	10	1
MPSW06	***MPSW56***	80	50	200	0.5	80	—	50	0.4	250	10	1

Table 2. Plastic-Encapsulated 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	$V_{(BR)CEO}$ Volts	h_{FE} @ I_C Min	Max	mA	V_T(4) mV Typ	NF(5) dB Max	f_T MHz Typ	Style
Case 29-04 — TO-226AA (TO-92)									
—	***2N5087***	50	250	800	0.1	—	2.0	40(2)	1
—	2N5086	50	150	500	0.1	—	3.0	40(2)	1
MPS6428	—	50	250	650	0.1	7.0(7)	3.5(8)	100(2)	1
BC239	—	45	120	800	2.0	9.5	2.0(1)	280	17
BC550B	BC560B	45	180	450	2.0	—	2.5	250	17
BC550C	BC560C	45	380	800	2.0	—	2.5	250	17
MPSA18	—	45	500	—	1.0	6.5(1)	—	160	1
MPS3904	MPS3906	40	100	300	10	—	5.0	200(2)	1
—	MPS4250	40	250	—	10	—	2.0	—	1
BC549B	BC559B	30	200	450	2.0	—	2.5	250	17
BC549C	BC559C	30	380	800	2.0	—	2.5	250	17
2N5088	—	30	350	—	1.0	—	3.0	50	1
2N5089(6)	—	25	450	—	1.0	—	2.0	50	1
MPS6521	MPS6523	25	300	600	2.0	—	3.0	—	1

(1) Typical
(2) Min
(4) V_T: Total Input Noise Voltage (see BC413/BC414 and BC415/BC416 Data Sheets) at R_S = 2.0 kΩ, I_C = 200 μA, V_{CE} = 5.0 Volts.
(5) N_F: Noise Figure at R_S = 2.0 kΩ, I_C = 200 μA, V_{CE} = 5.0 Volts. f = 30 Hz to 15 kHz.
(7) R_S = 10 kΩ, BW = 1.0 Hz, f = 100 MHz
(8) R_S = 500 Ω, BW = 1.0 Hz, f = 10 MHz

Devices listed in bold, italic are Motorola preferred devices.

Table 3. Plastic-Encapsulated Darlington Transistors

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

				h_{FE} @ I_C			$V_{CE(sat)}$ @ I_C & I_B			f_T @ I_C		Style
NPN	PNP	$V_{(BR)CEO}$ Volts	I_C Max	Min	Max	mA	Volts Max	mA	mA	Min	mA	Style
Case 29-05 — TO-226AE (1-WATT TO-92)												
MPSW45A	—	50	1000	25K	150K	200	1.5	1000	2.0	100	200	1
—	***MPSW64***	30	1000	20K	—	100	1.5	100	0.1	125	10	1
Case 29-04 — TO-226AA (TO-92)												
MPSA29	—	100	500	10K	—	100	1.5	100	0.1	125	10	1
BC373	—	80	1000	10K	160K	100	1.1	250	0.25	100	100	1
MPSA27	MPSA77	60	500	10K	—	100	1.5	100	0.1	—	—	1
BC618	—	55	1000	10K	50K	200	1.1	200	0.2	150	500	17
	MPSA75	40	500	10K	—	100	1.5	100	0.1	—	—	1
2N6427	—	40	500	20K	200K	100	1.5	500	0.5	—	—	1
2N6426	—	40	500	30K	300K	100	1.5	500	0.5	125	10	1
MPSA14	***MPSA64***	30	500	20K	—	100	1.5	100	0.1	125	10	1
MPSA13	MPSA63	30	500	10K	—	100	1.5	100	0.1	125	10	1
BC517	—	30	1000	30K	—	20	1.0	100	0.1	200(1)	10	17

Table 4. Plastic-Encapsulated High-Current Transistors

The following table is a listing of devices that are capable of handling a higher current range for small-signal transistors.

			f_T @ I_C			h_{FE} @ I_C			$V_{CE(sat)}$ @ I_C & I_B			
NPN	PNP	$V_{(BR)CEO}$ Volts Min	MHz Min	mA	I_C mA Max	Min	Max	mA	Volts Max	mA	mA	Style
Case 29-05 — TO-226AE (1-WATT TO-92)												
MPS6715	MPS6727	40	—	—	1000	50	—	1000	0.5	1000	100	1
MPSW01A	***MPSW51A***	40	50	50	1000	50	—	1000	0.5/0.7	1000	100	1
Case 29-04 — TO-226AA (TO-92)												
BC489	BC490	80	200/150(1)	50	1000	60	400	100	0.3/0.5	1000	100	17
BC639	BC640	80	60	10	500	40	160	150	0.5	500	50	14
MPS651	***MPS751***	60	75	50	2000	75	—	1000	0.5	2000	200	1
MPS650	MPS750	40	75	50	2000	75	—	1000	0.5	2000	200	1
BC368	BC369	20	65	10	1000	60	—	1000	0.5	1000	100	1

(1) Typical

Devices listed in bold, italic are Motorola preferred devices.

1

Table 5. Plastic-Encapsulated High-Voltage Amplifier Transistors

These high-voltage transistors are designed for driving neon bulbs and 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 ($V_{(BR)CEO}$).

Device Type	$V_{(BR)CEO}$ Volts Min	I_C Amp Max	h_{FE} @ I_C Min	mA	$V_{CE(sat)}$ @ I_C & I_B Volts Max	mA	mA	f_T @ I_C MHz Min	mA	Style
Case 29-05 — TO-226AE (1-WATT TO-92) — NPN										
BDC05	300	0.5	40	25	2.0	20	2.0	60	10	14
MPSW42	300	0.5	40	30	0.5	20	2.0	50	10	1
Case 29-05 — TO-226AE (1-WATT TO-92) — PNP										
MPSW92	300	0.5	25	30	0.5	20	2.0	50	10	1
Case 29-04 — TO-226AA (TO-92) — NPN										
BF844	400	0.3	50	10	0.5	10	1.0	—	—	1
MPSA44	400	0.3	40	100	0.75	50	5.0	—	—	1
2N6517	350	0.5	30	30	0.3	10	1.0	40	10	1
BF393	300	0.5	40	10	0.2	20	2.0	50	10	1
MPSA42	300	0.5	40	10	0.5	20	2.0	50	10	1
2N5551	160	0.6	80	10	0.15	10	1.0	100	10	1
Case 29-04 — TO-226AA (TO-92) — PNP										
BF493S	350	0.5	40	10	20	20	2.0	50	10	1
2N6520	350	0.5	30	30	0.3	10	1.0	40	10	1
MPSA92	300	0.5	40	10	0.5	20	2.0	50	10	1
2N6519	300	0.5	45	30	0.3	10	1.0	40	10	1
2N5401	150	0.6	60	10	0.2	10	1.0	100	10	1

Case 29-04 — TO-226AA (TO-92)

NPN	PNP	$V_{(BR)CEO}$ Volts Min	I_C Amp Cont	h_{FE} @ I_C Min	mA	$V_{CE(sat)}$ @ I_C & I_B Volts Max	mA	mA	f_T @ I_C MHz Min	mA	Style
BF420	BF421	300	0.5	50	25	2.0	20	2.0	60	10	14
BF422	BF423	250	0.5	50	25	2.0	20	2.0	60	10	14

Devices listed in bold, italic are Motorola preferred devices.

Table 6. Plastic-Encapsulated 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.

Device Type	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} @ I_C Min	mA	V_{CE} V	f_T MHz Typ	CRE/CRB pF Max	NF dB Typ	f MHz	Style
Case 29-04 — TO-226AA (TO-92) — NPN										
BF224	30	50	30	7.0	10	600	0.28	2.5	100	21
MPSH24	30	50	30	8.0	10	400(2)	0.36	—	—	2
MPSH20	30	100	25	4.0	10	400(2)	0.65	—	—	2
MPSH07A(9)	30	25	20	3.0	10	400(2)	0.3	3.2(3)	100	1
MPS3866	30	400	10	50	5.0	500(2)	—	—	—	1
MPSH11	25	—	60	4.0	10	650(2)	0.9	—	—	2
MPSH10	25	—	60	4.0	10	650(2)	0.65	—	—	2
BF199	25	100	40	7.0	10	750	0.35	2.5	35	21
BF959	20	100	40	20	10	600(2)	0.65	3.0	200	21
MPS6568A	20	50	20	4.0	5.0	375(2)	0.65	3.3(3)	200	2
MPSH17	15	—	25	5.0	10	800(2)	0.9	6.0(3)	200	2
MPS918	15	50	20	8.0	10	600(2)	1.7	6.0(3)	60	1
MPS5179	12	50	25	3.0	1.0	2000(3)	—	5.0(3)	200	1
MPS3563	12	50	20	8.0	10	800	1.7	6.0(3)	60	1
MPS6595	12	50	25	10	5.0	1200(2)	1.3	—	—	1
Case 29-04 — TO-266AA (TO-92) — PNP										
MPSH81	20	50	60	5.0	10	600(2)	0.85	—	—	2
MPSH69	15	50	30	10	10	2000(2)	0.3	—	—	1

Table 7. Plastic-Encapsulated High-Speed Saturated Switching Transistors

Device Type	t_{on} & t_{off} @ I_C ns Max	ns Max	mA	$V_{(BR)CEO}$ Volts Min	h_{FE} @ I_C Min	mA	$V_{CE(sat)}$ @ I_C & I_B Volts Max	mA	mA	f_T @ I_C MHz Min	mA	Style
Case 29-04 — TO-226AA (TO-92) — NPN												
2N4264	25	35	10	15	40	10	0.22	10	1.0	300	10	1
2N4265	25	35	10	12	100	10	0.22	10	1.0	300	10	1
MPS3646	18	28	300	15	30	30	0.2	30	3.0	350	30	1
MPS2369A	12	18	10	15	40	10	0.2	10	1.0	—	—	1
Case 29-04 — TO-226AA (TO-92) — PNP												
MPS3640	25	35	50	12	30	10	0.2	10	1.0	500	10	1
MPS4258	15	20	10	12	30	50	0.15	10	1.0	700	10	1
MPS5771	15	20	10	15	35	10	0.18	10	1.0	—	—	1

(2) Min
(3) Max
(9) AGC Capable

Devices listed in bold, italic are Motorola preferred devices.

Table 8. Plastic-Encapsulated Choppers

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

Device Type	$V_{(BR)EBO}$ Volts Min	I_C Amp(1) Max	h_{FE} @ I_C		$V_{CE(sat)}$ @ I_C & I_B			f_T @ I_C		Style
			Min	mA	Volts Max	mA	mA	MHz Min	mA	
Case 29-04 — TO-226AA (TO-92) — NPN										
MPSA17	15	100	200	5.0	0.25	10	1.0	80	5.0	1
MPSA16	12	100	200	5.0	0.25	10	1.0	100	5.0	1
Case 29-04 — TO-266AA (TO-92) — PNP										
MPS404A	–25	–150	30	–12	–0.2	–24	1.0	—	—	1

Table 9. Plastic-Encapsulated Telecom Transistors

These devices are special product ranges intended for use in telecom applications.

Device Type	$V_{(BR)CEO}$ Volts	P_D mW 25°C Amb	I_C mA Cont	h_{FE} @ I_C @ V_{CE}				f_T MHz Min	Style
				Min	Max	mA	Volts		
Case 29-04 — TO-226AA (TO-92) — NPN									
P2N2222A	40	625	600	75	—	10	10	300	17
PBF259,S(10)	300	625	500	25	—	1.0	10	40	1
Case 29-04 — TO-226AA (TO-92) — PNP									
P2N2907A	60	625	600	100	—	10	10	200	17
PBF493,S(11)	300	625	500	40	—	1.0	10	40	1

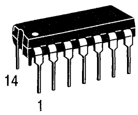
(1) Typical
(10) "S" version, h_{FE} Min 60 @ I_C = 20 mA, V_{CE} = 10 V.
(11) "S" version, h_{FE} Min 40 @ I_C = 0.1 mA, V_{CE} = 1.0 V.

Devices listed in bold, italic are Motorola preferred devices.

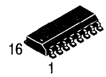
Plastic-Encapsulated Multiple Transistors

The manufacturing trend has been toward printed circuit board design with requirements for smaller packages with more functions. In the case of discrete components the use of the multiple device package helps to reduce board space requirements and assembly costs.

Many of the most popular devices are offered in the standard plastic DIP and surface mount IC packages. This includes small-signal NPN and PNP bipolar transistors, N-channel and P-channel FETs, as well as diode arrays.



CASE 646-06
(TO-116)
STYLE 1



CASE 751B-05
SO-16
STYLE 4

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. This applies to Table 1 and 2 of this section only.

KEY

TYPE NO.	ID	Ref. Point P_D Watts One Die Only	Subscript V_{CE} Volts	I_C Amp Max	Unit h_{FE} @ I_C Min	f_T MHz Min	C_{ob} pF Max	h_{FE1} / h_{FE2} — *t_{on} ns Max*	ΔV_{BE} mV Max — *t_{off} ns Max*	G_p dB Min, NF dB Max @ f — *$V_{CE(sat)}$ Volts Max @ I_C / I_B & I_C Unit*

Alphanumeric listing type numbers

Identification Code

First Letter: Polarity
C — both types in multiple device
N — NPN
P — PNP

Second 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
D — Darlington

Common-emitter DC Current Gain.

Units for test Current:
A — ampere
m — mA
u — µA

Current-Gain-Bandwidth Product

Continuous (DC) Collector Current

G_p — Power Gain
NF — Noise Figure
f — Test Frequency
AUD — 10-15 kHz
Frequency Units:
H — Hertz M — MHz
K — kHz G — GHz

$V_{CE(sat)}$ — Collector-Emitter Saturation Voltage
IC — Test Current
Current Units: u — µA
m — mA
A — Amp

h_{FE1}/h_{FE2} — Current Gain Ratio
V_{BE} — Differential Base Voltage $|V_{BE1} - V_{BE2}|$. Differntial 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

Rated Minimum Collector-Emitter Voltage
Subscript letter identifies base termination listed below in order of preference.
SUBSCRIPT:
0 — V_{CEO}, open

Output Capacitance, common-base. Shown without distinction:
C_{cb} — Collector-Base Capacitance
C_{re} — Common-Emitter Reverse Transfer Capacitance

Table 1. Plastic-Encapsulated Multiple Transistors — Quad

The following table is a listing of the most popular multiple devices available in the plastic DIP package. These devices are available in NPN, PNP, and NPN/PNP configurations. (See note.)

DEVICE	ID	P_D Watts One Die Only	V_{CEO} Volts	I_C Amp Max	h_{FE} Min	@ I_C	f_T MHz Min	C_{ob} pF Max	h_{FE1}/h_{FE2} — t_{on} ns Max	ΔV_{BE} mV Max — t_{off} ns Max	G_p dB Min — V_{CE} (sat) Volts Max	NF dB Max Typ(1) — @ I_C/I_B	@ f — I_C
Case 646-06 — TO-116													
MPQ2222A	NA	0.65	40	0.5	100	150 m	200	8.0	35(1)	285(1)	0.3	10	150 m
MPQ2369	NS	0.5	15	0.5	40	10 m	450	4.0	9.0(1)	15(1)	0.25	10	10 m
MPQ2483	NA	0.625	40	0.05	150	1.0 m	50					**3.0(1)**	**AUD**
MPQ2484	NA	0.625	40	0.05	300	1.0 m	50					**2.0(1)**	**AUD**
MPQ2907A	PA	0.65	60	0.6	100	150 m	200	8.0	45(1)	180(1)	0.4	10	150 m
MPQ3467	PS	0.75	40	1.0	20	500 m	125	25	40	90	0.5	10	500 m
MPQ3725	NS	1.0	40	1.0	25	500 m	250	10	35	60	0.45	10	500 m
MPQ3762	PS	0.75	40	1.5	35	150 m	150	15	50	120	0.55	10	500 m
MPQ3798	PA	0.625	40	0.05	150	0.1 m	60	4.0				**3.0(1)**	**AUD**
MPQ3799	PA	0.625	60	0.05	300	0.1 m	60	4.0				**2.0(1)**	**AUD**
MPQ3904	NG	0.5	40	0.2	75	10 m	250	4.0	37(1)	136(1)	0.2	10	10 m
MPQ3906	PG	0.5	40	0.2	75	10 m	200	4.5	43(1)	155(1)	0.25	10	10 m
MPQ6001	CG	0.65	30	0.5	40	150 m	200	8.0	30(1)	225(1)	0.4	10	150 m
MPQ6002	CG	0.65	30	0.5	100	150 m	200	8.0	30(1)	225(1)	0.4	10	150 m
MPQ6100A	CA	0.5	45	0.05	150	1.0 m	50	4.0				**4.0(1)**	**AUD**
MPQ6426	ND	0.5	30	0.5	10K	100 m	125	8.0	—	—	1.5	10	100 m
MPQ6501	CG	0.65	30	0.5	40	150 m	200	8.0	30(1)	225(1)	0.4	10	150 m
MPQ6502	CG	0.65	30	0.5	100	150 m	200	8.0	30(1)	225(1)	0.4	10	150 m
MPQ6600A1	CA	0.5	45	0.05	150	1.0 m	50	4.0	0.8	20	0.25	10	1.0 m
MPQ6700	CA	0.5	40	0.2	70	10 m	200	4.5			0.25	10	1.0 m
MPQ6842	CA	0.75	40	0.5	70	10 m	300	4.5	45	150	0.15	10	0.5 m
MPQ7043	NA	0.75	250	0.5	25	1.0 m	50	5.0			0.5	10	20 m
MPQ7042	NA	0.75	200	0.5	25	1.0 m	50	5.0			0.5	10	20 m
MPQ7051	CG	0.75	150	0.5	25	1.0 m	50	6.0			0.7	10	20 m
MPQ7093	PA	0.75	250	0.5	25	1.0 m	50	5.0			0.5	10	20 m

Table 2. Plastic-Encapsulated Multiple Transistors — Quad Surface Mount

The following table is a listing of the most popular multiple devices available in the plastic SOIC surface mount package. These devices are available in NPN, PNP, and NPN/PNP configurations.

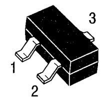
Device	$V_{(BR)CEO}$	$V_{(BR)CBO}$	h_{FE} @ I_C Min	mA	f_T @ I_C MHz Min	mA
Case 751B-05 — SO-16						
MMPQ2222A	40	75	40	500	200	20
MMPQ2369	15	40	20	100	450	10
MMPQ2907A	50	60	50	500	200	50
MMPQ3467	40	40	20	500	125	50
MMPQ3725	40	60	25	500	250	50
MMPQ3799	60	60	300	0.5	60	1.0
MMPQ3904	40	60	75	10	250	10
MMPQ3906	40	40	75	10	200	10
MMPQ6700(12)	40	40	70	10	200	10

(1) Typical
(12) NPN/PNP
NOTE: Some columns show 2 different types of data indicated by either **bold** or *italic* typefaces. See key and headings.

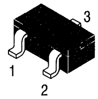
Devices listed in bold, italic are Motorola preferred devices.

Plastic-Encapsulated Surface Mount Transistors

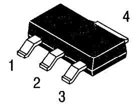
This section of the selector guide lists the small-signal plastic devices that are available for surface mount applications. These devices are encapsulated with the latest state-of-the-art mold compounds that enhance reliability and exhibit excellent performance in high temperature and high humidity environments. This package offers higher power dissipation capability for small-signal applications.



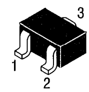
CASE 318-07
TO-236AB
SOT-23



CASE 318D-03
SC-59



CASE 318E-04
SOT-223



CASE 419-02
SC-70/SOT-323

Table 1. Plastic-Encapsulated Surface Mount General-Purpose Transistors

The following tables are a listing of small-signal general-purpose transistors in the SOT-23 and SC-59 surface mount packages. These devices are intended for small-signal amplification for DC, audio, and lower RF frequencies. They also have applications as oscillators and general-purpose, low voltage switches.

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

Devices are listed in order of descending breakdown voltage.

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN						
MMBT8099LT1	KB	80	100	300	1.0	150
BC846ALT1	1A	65	110	220	2.0	100
BC846BLT1	1B	65	200	450	2.0	100
BC817-16LT1	6A	45	100	250	100	200
BC817-25LT1	6B	45	160	400	100	200
BC817-40LT1	6C	45	250	600	100	200
BC847ALT1	1E	45	110	220	2.0	100
BC847BLT1	1F	45	200	450	2.0	100
BC847CLT1	1G	45	420	800	2.0	100
MMBT2222ALT1	1P	40	100	300	150	200
MMBT3904LT1	1AM	40	100	300	10	200
MMBT4401LT1	2X	40	100	300	150	250
BC848ALT1	1J	30	110	220	2.0	100
BC848BLT1	1K	30	200	450	2.0	100
BC848CLT1	1L	30	420	800	2.0	100
Case 318-07 — TO-236AB (SOT-23) — PNP						
MMBT8599LT1	2W	80	100	300	1.0	150
BC856ALT1	3A	65	125	250	2.0	100
BC856BLT1	3B	65	220	475	2.0	100
MMBT2907ALT1	2F	60	100	300	150	200
BC807-16LT1	5A	45	100	250	100	200

Devices listed in bold, italic are Motorola preferred devices.

Table 1. Plastic-Encapsulated Surface Mount General-Purpose Transistors (continued)

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

Devices are listed in order of descending breakdown voltage.

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — PNP						
BC807-25LT1	5B	45	160	400	100	200
BC807-40LT1	5C	45	250	600	100	200
BC857ALT1	3E	45	125	250	2.0	100
BC857BLT1	3F	45	220	475	2.0	100
MMBT3906LT1	2A	40	100	300	10	250
MMBT4403LT1	2T	40	100	300	150	200
BC858ALT1	3J	30	125	250	2.0	100
BC858BLT1	3K	30	220	475	2.0	100
BC858CLT1	3L	30	420	800	2.0	100
Case 318D-03 — SC-59 — NPN						
MSD601-RT1	YR	25	210	340	2.0	150(1)
MSD601-ST1	YS	25	290	460	2.0	150(1)
MSD602-RT1	WR	25	120	240	150	200(1)
MSD1328-RT1	1DR	20	200	350	500	200(1)
Case 318D-03 — SC-59 — PNP						
MSB709-RT1	AR	25	210	340	2.0	100(1)
MSB709-ST1	AS	25	290	460	2.0	100(1)
MSB710-QT1	CQ	25	85	170	150	200(1)
MSB710-RT1	CR	25	120	240	150	200(1)

(1) Typical

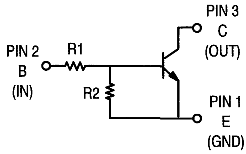


Table 2. Plastic-Encapsulated Surface Mount Bias Resistor Transistors for General Purpose Applications

These devices include bias resistors on the semiconductor chip with the transistor. See the BRT diagram for orientation of resistors.

Device NPN	Device PNP	Marking NPN	Marking PNP	$V_{(BR)CEO}$ Volts (Min)	h_{FE} @ I_C Min	mA	I_C mA Max	R_1 Ohm	R_2 Ohm
Case 318D-03 — SC-59									
MUN2211T1	***MUN2111T1***	8A	6A	50	35	5.0	100	10K	10K
MUN2212T1	***MUN2112T1***	8B	6B	50	60	5.0	100	22K	22K
MUN2213T1	***MUN2113T1***	8C	6C	50	80	5.0	100	47K	47K
MUN2214T1	***MUN2114T1***	8D	6D	50	80	5.0	100	10K	47K

Devices listed in bold, italic are Motorola preferred devices.

1

Table 2. Plastic-Encapsulated Surface Mount Bias Resistor Transistors for General-Purpose Applications (continued)

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

Device		Marking		$V_{(BR)CEO}$ Volts	h_{FE} @ I_C		I_C mA	R_1	R_2
NPN	PNP	NPN	PNP	(Min)	Min	mA	Max	Ohm	Ohm
Case 318-07 — TO-236AB (SOT-23)									
MMUN2211T1	***MMUN2111T1***	A8A	A6A	50	35	5.0	100	10K	10K
MMUN2212T1	***MMUN2112T1***	A8B	A6B	50	60	5.0	100	22K	22K
MMUN2213T1	***MMUN2113T1***	A8C	A6C	50	80	5.0	100	47K	47K
MMUN2214T1	***MMUN2114T1***	A8D	A6D	50	80	5.0	100	10K	47K
Case 419-02 — SC-70/SOT-323									
MUN5211T1	***MUN5111T1***	8A	6A	50	35	5.0	50	10K	10K
MUN5212T1	***MUN5112T1***	8B	6B	50	60	5.0	50	22K	22K
MUN5213T1	***MUN5113T1***	8C	6C	50	80	5.0	50	47K	47K
MUN5214T1	***MUN5114T1***	8D	6D	50	80	5.0	50	10K	47K

Table 3. Plastic-Encapsulated Surface Mount Switching Transistors

The following tables are a listing of devices intended for high-speed, low saturation voltage, switching applications. These devices have very fast switching times and low output capacitance for optimized switching performance.

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

Device	Marking	Switching Time (ns)		$V_{(BR)CEO}$	h_{FE} @ I_C			f_T
		t_{on}	t_{off}		Min	Max	mA	MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN								
MMBT2369LT1	M1J	12	18	15	20	—	100	—
BSV52LT1	B2	12	18	12	40	120	10	400
Case 318-07 — TO-236AB (SOT-23) — PNP								
MMBT3640LT1	2J	25	35	12	20	—	50	500
Pinout: 1-Emitter, 2-Base, 3-Collector								
Case 318D-03 — SC-59 — NPN								
MSC1621T1	RB	20	40	20	40	180	1.0	200

Devices listed in bold, italic are Motorola preferred devices.

Table 4. Plastic-Encapsulated Surface Mount VHF/UHF Amplifiers, Mixers, Oscillators

The following table is a listing of devices intended for small-signal RF amplifier applications to VHF/UHF frequencies. These devices may also be used as VHF/UHF oscillators and mixers.

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

Device	Marking	$V_{(BR)CEO}$	C_{cb}(13) pF Max	f_T @ I_C GHz Min	mA
Case 318-07 — TO-236AB (SOT-23) — NPN					
MMBTH10LT1	3EM	25	0.7	0.65	4.0
MMBT918LT1	M3B	15	1.7(14)	0.6	4.0
MMBTH24LT1	M3A	30	0.45	0.4	8.0
Case 318-07 — TO-236AB (SOT-23) — PNP					
MMBTH81LT1	3D	20	0.85	0.6	5.0
MMBTH69LT1	M3J	15	0.35(13)	2.0	10
Pinout: 1-Emitter, 2-Base, 3-Collector					
Case 318D-03 — SC-59 — NPN					
MSC2295-BT1	VB	20	1.5(13)	0.15	1.0
MSC2295-CT1	VC	20	1.5(13)	0.15	1.0
MSC2404-CT1	UC	20	1.0(13)	0.45	1.0
MSC3130T1	1S	10	—	1.4	5.0
Case 318D-03 — SC-59 — PNP					
MSA1022-BT1	EB	20	2.0(13)	0.15	1.0
MSA1022-CT1	EC	20	2.0(13)	0.15	1.0

(13) C_{re}
(14) C_{ob}

Table 5. Plastic-Encapsulated Surface Mount Choppers

The following table is a listing of small-signal devices intended for chopper applications where a higher than normal $V_{(BR)CEO}$ is required in the circuit application.

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

Device	Marking	$V_{(BR)CEO}$	$V_{(BR)EBO}$	h_{FE} @ I_C Min	Max	mA
Case 318-07 — TO-236AB (SOT-23) — PNP						
MMBT404ALT1	2N	35	25	30	400	12

Table 6. Plastic-Encapsulated Surface Mount Darlingtons

The following table is a listing of small-signal devices that have very high h_{FE} and input impedance characteristics. These devices utilize monolithic, cascade transistor construction.

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

Devices are listed in order of descending h_{FE}.

Device	Marking	$V_{(BR)CES}$	$V_{CE(sat)}$ Volts Max	h_{FE} @ I_C Min	Max	mA
Case 318-07 — TO-236AB (SOT-23) — NPN						
MMBTA14LT1	1N	30	1.5	20K	—	100
MMBTA13LT1	1M	30	1.5	10K	—	100
Case 318-07 — TO-236AB (SOT-23) — PNP						
MMBTA64LT1	2V	30	1.5	20K	—	100

Devices listed in bold, italic are Motorola preferred devices.

1

Table 7. Plastic-Encapsulated Surface Mount Low-Noise Transistors

The following table is a listing of small-signal devices intended for low noise applications in the audio range. These devices exhibit good linearity and are candidates for hi-fi and instrumentation equipment.

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

Devices are listed in order of ascending NF.

Device	Marking	NF dB Typ	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN							
MMBT5089LT1	1R	2.0(15)	25	400	—	10	50
MMBT2484LT1	1U	3.0(15)	60	—	800	10	—
MMBT6428LT1	1KM	3.0	50	250	—	10	100
MMBT6429LT1	1L	3.0	45	500	—	10	100
Case 318-07 — TO-236AB (SOT-23) — PNP							
MMBT5087LT1	2Q	2.0(15)	50	250	—	10	40

(15) Max

Table 8. Plastic-Encapsulated Surface Mount High-Voltage Transistors

The following table is a listing of small-signal high-voltage devices designed for direct line operation requiring high voltage breakdown and relatively low current capability.

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

Devices are listed in order of descending breakdown voltage.

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN						
MMBT6517LT1	1Z	350	15	—	100	40
MMBTA42LT1	1D	300	40	—	30	50
MMBT5551LT1	G1	160	30	—	50	100
Case 318-07 — TO-236AB (SOT-23) — PNP						
MMBT6520LT1	2Z	350	15	—	100	40
MMBTA92LT1	2D	300	25	—	30	50
MMBT5401LT1	2L	150	50	—	50	100

Table 9. Plastic-Encapsulated Surface Mount Drivers

The following is a listing of small-signal devices intended for medium voltage driver applications at fairly high current levels.

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

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN						
MMBTA06LT1	1GM	80	100	—	100	100
BSS64LT1	AM	80	20	—	10	50
Case 318-07 — TO-236AB (SOT-23) — PNP						
BSS63LT1	T1	100	30	—	25	50
MMBTA56LT1	2GM	80	100	—	100	50

Devices listed in bold, italic are Motorola preferred devices.

1

Table 10. Plastic-Encapsulated Surface Mount RF Transistors

The following table is a listing of small-signal RF transistors intended for low-noise, high-power gain, Class A, AB or C amplifiers. These devices are used as pre-drivers in power amplifier applications.

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

Device	Marking	f_T @ I_C @ V_{CE} GHz Typ	mA	Volts	NF @ I_C @ V_{CE} dB Typ	mA	Volts	MAG @ I_C @ V_{CE} @ f dB Typ	mA	Volts	MHz
Case 318-07 — TO-236AB (SOT-23) — NPN											
MMBR571LT1	7X	8.0	50	5.0	2.0	10	6.0	16.5	5.0	6.0	500
MMBR941LT1	7Y	8.0	15	6.0	2.1	5.0	6.0	8.5	5.0	6.0	2000
MMBR951LT1	7Z	8.0	30	8.0	2.1	5.0	6.0	7.5	5.0	6.0	2000
MMBR911LT1	7P	6.0	30	10	2.0	10	10	17	10	10	500
MMBR930LT1	7C	5.5	30	5.0	1.9	2.0	5.0	11	30	5.0	500
MMBR920LT1	7B	4.5	14	10	2.4	2.0	10	15	2.0	10	500
MMBR901LT1	7A	4.0	15	10	1.9	5.0	6.0	12	5.0	6.0	1000
BFR92LT1	P1	3.4	14	10	3.0	3.0	1.5	—	—	—	500
BFR93LT1	R1	3.4	30	5.0	2.5	2.0	5.0	—	—	—	30
MMBR931LT1	7D	3.0	1.0	1.0	4.3	0.25	1.0	10	0.25	1.0	1000
MMBR5179LT1	7H	1.4	5.0	6.0	4.5	1.5	6.0	15	5.0	6.0	200
MMBR2060LT1	7E	1.0	20	1.0	3.5	1.5	10	13	1.5	10	450
MMBR5031LT1	7G	1.0	5.0	6.0	2.5	1.0	6.0	17	1.0	6.0	450
MMBR2857LT1	7K	1.0	4.0	10	4.5	1.5	6.0	12.5	1.5	6.0	450
BFS17LT1	E1	1.0	2.0	5.0	5.0	2.0	5.0	—	—	—	30
Case 318-07 — TO-236AB (SOT-23) — PNP											
MMBR536LT1	7R	5.5	20	5.0	4.5	10	5.0	14	10	5.0	500
MMBR4957LT1	7F	1.2	2.0	10	3.0	2.0	10	17	2.0	10	450

Table 11. Plastic-Encapsulated Surface Mount General Purpose Amplifiers

Pinout: 1-Base, 2-Collector, 3-Emitter, 4-Collector

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA
Case 318E-04 — SOT-223 — NPN					
BCP56T1	BH	80	40	250	150
Case 318E-04 — SOT-223 — PNP					
Pinout: 1-Gate, 2-Drain, 3-Source, 4-Drain					
BCP53T1	AH	80	40	25	150

Table 12. Plastic-Encapsulated Surface Mount Switching Transistors

Pinout: 1-Base, 2-Collector, 3-Emitter, 4-Collector

Device	Marking	t_{on}	t_{off}	$V_{(BR)CEO}$	h_{FE} Min	Max	f_T @ I_C (mA)	Min (MHz)
Case 318E-04 — SOT-223 — NPN								
PZT2222AT1	P1F	35	285	40	100	300	20	300
Case 318E-04 — SOT-223 — PNP								
PZT2907AT1	P2F	45	100	60	100	300	50	200

Devices listed in bold, italic are Motorola preferred devices.

1

Table 13. Plastic-Encapsulated Surface Mount Darlingtons

Pinout: 1-Base, 2-Collector, 3-Emitter, 4-Collector

Device	Marking	$V_{(BR)CER}$	$V_{CE(sat)}$ Max (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)
Case 318E-04 — SOT-223 — NPN						
BSP52T1	AS3	80	1.3	2000	—	500
PZTA14T1	P1N	30	1.5	20k	—	100
Case 318E-04 — SOT-223 — PNP						
BSP62T1	BS3	90	1.3	2000	—	500
PZTA64T1	P2V	30	1.5	20k	—	100

Table 14. Plastic-Encapsulated Surface Mount High-Voltage Transistors

Pinout: 1-Base, 2-Collector, 3-Emitter, 4-Collector

Device	Marking	$V_{(BR)CEO}$	h_{FE} Min	h_{FE} Max	f_T @ I_C (mA)	f_T Min (MHz)
Case 318E-04 — SOT-223 — NPN						
PZTA42T1	P1D	300	40	—	10	50
BF720T1	BF720	250	50	—	10	60
Case 318E-04 — SOT-223 — PNP						
PZTA96T1	ZTA96	450	50	150	10	50
PZTA92T1	P2D	300	40	—	10	50
BSP16T1	BSP16	300	30	150	10	15
BF721T1	BF721	250	50	—	10	60

Table 15. Plastic-Encapsulated Surface Mount High Current Transistors

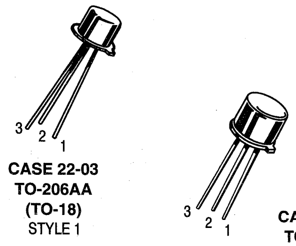
Pinout: 1-Base, 2-Collector, 3-Emitter, 4-Collector

Device	Marking	$V_{(BR)CEO}$	$V_{CE(sat)}$ Volts	h_{FE}@ I_C Min	h_{FE}@ I_C Max	h_{FE}@ I_C mA
Case 318E-04 — SOT-223 — NPN						
BCP68T1	CA	20	0.5	60	—	1000
Case 318E-04 — SOT-223 — PNP						
BCP69T1	CE	20	0.5	60	—	1000

Devices listed in bold, italic are Motorola preferred devices.

Metal-Can Transistors

Metal-can packages are intended for use in industrial applications where harsh environmental conditions are encountered. These packages enhance reliability of the end products due to their resistance to varying humidity and extreme temperature ranges.



CASE 22-03
TO-206AA
(TO-18)
STYLE 1

CASE 79-04
TO-205AD
(TO-39)
STYLE 1

Table 1. Metal-Can General-Purpose Transistors

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.

Device Type	$V_{(BR)CEO}$ Volts Min	f_T @ I_C MHz Min	f_T @ I_C mA	I_C mA Max	h_{FE} @ I_C Min	h_{FE} @ I_C Max	h_{FE} @ I_C mA
Case 22-03 — TO-206AA (TO-18) — NPN							
2N720A	80	50	50	150	40	120	150
2N3700	80	80	50	1000	50	—	500
BC107	45	150	10	200	110	450	2.0
BC107A	45	150	10	200	110	220	2.0
BC107B	45	150	10	200	200	450	2.0
BCY59-IX	45	125	10	200	250	460	2.0
BCY59-VIII	45	125	10	200	180	310	2.0
2N2222A	40	300	20	800	100	300	150
2N3947	40	300	10	200	100	300	10
BCY58-VIII	32	125	10	200	180	310	2.0
BC109C	25	150	10	200	420	800	2.0
Case 22-03 — TO-206AA (TO-18) — PNP							
2N2906A	60	200	50	600	40	120	150
2N2907A	60	200	50	600	100	300	150
2N3251A	60	300	10	200	100	300	10
BC177B	45	200	10	200	180	460	2.0
BCY79-IX	45	180	10	200	250	460	2.0
BCY79-VIII	45	180	10	200	180	310	2.0
Case 79-04 — TO-205AD (TO-39) — NPN							
2N3019	80	100	50	1000	100	300	150
2N3020	80	80	50	1000	40	120	150
2N1893	80	50	50	500	40	120	150
2N2219A	40	300	20	800	100	300	150
2N2218A	40	250	20	800	40	120	150
Case 79-04 — TO-205AD (TO-39) — PNP							
MM5007	100	30	50	2000	50	250	250
2N4033	80	—	—	1000	25	—	1000
2N4036	65	60	50	1000	40	140	150
2N2904A	60	200	50	600	40	120	150
2N2905A	60	200	50	600	100	300	150
2N4032	60	—	—	1000	40	—	1000

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Metal-Can High-Gain/Low-Noise Transistors

These transistors are characterized for high-gain and low-noise applications. Devices are listed in decreasing order of NF.

Device Type	NF Wideband dB Typ Max	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} @ I_C Min	Max	µA mA	f_T @ I_C MHz Min	mA
Case 22-03 — TO-206AA (TO-18) — NPN								
2N2484	8.0(1)	60	50	100	500	10	15	0.05
2N930A	3.0	45	30	—	600	10	45	0.5
2N930	3.0	45	30	—	600	10	30	0.5
Case 22-03 — TO-206AA (TO-18) — PNP								
2N3964	4.0	45	200	250	600	1.0(24)	50	0.5
2N3799	2.5	60	50	300	900	500	30	0.5

Table 3. Metal-Can High-Voltage/High-Current Transistors

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.

Device Type	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} @ I_C Min	mA	$V_{CE(sat)}$ @ I_C & I_B Volts Max	mA	mA	f_T @ I_C MHz Min	mA
Case 22-03 — TO-206AA (TO-18) — NPN									
2N6431	300	50	50	30	0.5	20	2.0	50	10
BSS73	300	500	40	30	1.0	50	5.0	50	20
Case 22-03 — TO-206AA (TO-18) — PNP									
2N6433	300	500	30	30	0.5	20	20	50	10
BSS76	300	500	35	30	0.5	50	5.0	50	20
2N3497	120	100	40	10	0.35	10	1.0	150	20
Case 79-04 — TO-205AD (TO-39) — NPN									
2N5058	300	150	35	30	1.0	30	3.0	30	10
BF259	300	100	25	30	1.0	30	6.0	110(1)	30
2N4927	250	50	20	30	2.0	30	3.0	30	10
2N3500	150	300	40	150	0.4	150	15	150	20
2N3501	150	300	100	150	0.4	150	15	150	20
2N3499	100	500	100	150	0.6	300	30	150	20
MM3007	100	2500	50	250	0.35	150	15	50	50
Case 79-04 — TO-205AD (TO-39) — PNP									
2N4931	250	50	20	30	5.0	10	1.0	20	20
2N3636	175	1000	50	50	0.5	50	5.0	150	30
2N3637	175	1000	100	50	0.5	50	5.0	200	30
MM5007	100	2000	50	250	0.5	150	15	30	50

(1) Typical
(24) $T_A = 25°C$

Devices listed in bold, italic are Motorola preferred devices.

Table 4. Metal-Can 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}).

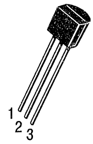
Device Type	t_{on} & t_{off} @ I_C			$V_{(BR)CEO}$	I_C	h_{FE} @ I_C		$V_{CE(sat)}$ @ I_C @ I_B			f_T	I_C
	ns Max	ns Max	mA	Volts Min	mA Max	Min	mA	Volts Max	mA	mA	MHz Min	mA
Case 22-03 — TO-206AA (TO-18) — NPN												
2N4014	35	60	500	40	1000	35	500	0.52	500	50	300	50
2N2369A	12	18	10	15	200	40	10	0.2	10	1.0	500	10
BSX20	7.0	21	100	15	500	20	10	0.25	10	1.0	500	10
Case 22-03 — TO-206AA (TO-18) — PNP												
2N2894	60	90	30	12	200	40	30	0.2	30	3.0	400	30
2N869A	50	80	30	18	200	40	30	0.2	30	3.0	400	10
2N3546	40	30	50	12	200	25	50	0.25	50	5.0	700	10
MM4209	15	20	10	15	50	35	10	0.6	50	5.0	850	10
Case 79-04 — TO-205AD (TO-39) — NPN												
MM3725	35	60	500	40	2000	35	500	0.52	500	50	300	50
Case 79-04 — TO-205AD (TO-39) — PNP												
2N3467	40	90	500	40	1000	40	500	0.5	500	50	175	50
2N3468	40	90	500	50	1000	25	500	0.6	500	50	150	50
2N3762	11.5	105	1000	40	1500	30	1000	0.9	1000	100	180	50

Devices listed in bold, italic are Motorola preferred devices.

Field-Effect Transistors

JFETs

JFETs operate in the depletion mode. They are available in both P- and N-channel and are offered in both Through-hole and Surface Mount 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.



CASE 29-04
TO-226AA
(TO-92)

Table 1. JFET Low-Frequency/Low-Noise

The following table is a listing of small-signal JFETs intended for low-noise applications in the audio range. These devices exhibit good linearity and are candidates for hi-fi and instrumentation equipment.

Device	Re |Yfs| mmho Min	@ f kHz	Re |Yos| µmho Max	@ f kHz	Ciss pF Max	Crss pF Max	V(BR)GSS V(BR)GDO Volts Min	VGS(off) Volts Min	VGS(off) Volts Max	IDSS mA Min	IDSS mA Max	Style
Case 29-04 — TO-226AA (TO-92) — N-Channel												
J202	—	—	—	—	—	—	40	0.8	4.0	0.9	4.5	5
2N5458	1.5	1.0	50	1.0	7.0	3.0	25	1.0	7.0	2.0	9.0	5
J203	—	—	—	—	—	—	40	2.0	10	4.0	20	5
MPF3821	1.5	1.0	10	1.0	6.0	3.0	50	—	4.0	0.5	2.5	5
2N5457	1.0	1.0	50	1.0	7.0	3.0	25	0.5	6.0	1.0	5.0	5
2N5459	2.0	1.0	50	1.0	7.0	3.0	25	2.0	8.0	4.0	16	5
MPF3822	3.0	1.0	20	1.0	6.0	3.0	50	—	6.0	2.0	10	5
Case 29-04 — TO-226AA (TO-92) — P-Channel												
2N5460	1.0	1.0	75	1.0	7.0	2.0	40	0.75	6.0	1.0	5.0	7
2N5461	1.5	1.0	75	1.0	7.0	2.0	40	1.0	7.5	2.0	9.0	7
2N5462	2.0	1.0	75	1.0	7.0	2.0	40	1.8	9.0	4.0	16	7

Table 2. JFET High-Frequency Amplifiers

The following is a listing of small-signal JFETs that are intended for hi-frequency applications. These are candidates for VHF/UHF oscillators, mixers and front-end amplifiers.

Device	Re |Yfs| mmho Min	@ f MHz	Re |Yos| µmho Max	@ f MHz	Ciss pF Max	Crss pF Max	NF @ RG = 1K dB Max	NF @ RG = 1K f MHz	V(BR)GSS V(BR)GDO Volts Min	VGS(off) Volts Min	VGS(off) Volts Max	IDSS mA Min	IDSS mA Max	Style
Case 29-04 — TO-226AA (TO-92) — N-Channel														
2N5669	1.6	100	100	100	7.0	3.0	2.5	100	25	1.0	6.0	4.0	10	5
MPF102	1.6	100	200	100	7.0	3.0	—	—	25	—	8.0	2.0	20	5
2N5668	1.0	100	50	100	7.0	3.0	2.5	100	25	0.2	4.0	1.0	5.0	5
2N5484	2.5	100	75	100	5.0	1.0	3.0	100	25	0.3	3.0	1.0	5.0	5
2N5670	2.5	100	150	100	7.0	3.0	2.5	100	25	2.0	8.0	8.0	20	5
2N5485	3.0	400	100	400	5.0	1.0	4.0	400	25	0.5	4.0	4.0	10	5
2N5486	3.5	400	100	400	5.0	1.0	4.0	400	25	2.0	6.0	8.0	20	5
J300	4.5	0.001	200	0.001	5.5	1.7	—	—	25	1.0	6.0	6.0	30	5
J308	12(1)	100	250(1)	100	7.5	2.5	1.5(1)	100	25	1.0	6.5	12	60	5
J309	12(1)	100	250(1)	100	7.5	2.5	1.5(1)	100	25	1.0	4.0	12	30	5
J310	12(1)	100	250(1)	100	7.5	2.5	1.5(1)	100	25	2.0	6.5	24	60	5

(1)Typical

Devices listed in bold, italic are Motorola preferred devices.

Table 3. JFET Switches and Choppers

The following is a listing of JFETs intended for switching and chopper applications.

Device	$R_{DS(on)}$ @ I_D Ω Max	mA	$V_{GS(off)}$ Volts Min	Max	I_{DSS} mA Min	Max	$V_{(BR)GSS}$ $V_{(BR)GDO}$ Volts Min	C_{iss} pF Max	C_{rss} pF Max	t_{on} ns Max	t_{off} ns Max	Style
Case 29-04 — TO-226AA (TO-92) — N-Channel												
MPF4856	25	—	4.0	10	50	—	40	18	8.0	9.0	25	5
MPF4859	25	—	4.0	10	50	—	30	18	8.0	9.0	25	5
2N5638	30	1.0	—	(12)(1)	50	—	30	10	4.0	9.0	15	5
J111	30	—	3.0	10	20	—	35	28	5.0	—	—	5
MPF4857	40	—	2.0	6.0	20	100	40	18	8.0	10	50	5
MPF4860	40	—	2.0	6.0	20	100	30	18	8.0	10	50	5
J112	50	—	1.0	5.0	5.0	—	35	28	5.0	—	—	5
MPF4392	60	—	—	—	25	75	30	10	3.5	15	35	5
2N5639	60	1.0	—	(8.0)(1)	25	—	30	10	4.0	—	—	5
MPF4858	60	—	0.8	4.0	8.0	80	40	18	8.0	20	100	5
MPF4861	60	—	0.8	4.0	8.0	80	30	18	8.0	20	100	5
MPF4393	100	—	—	(12)(1)	5.0	30	30	10	3.5	15	55	5
2N5640	100	1.0	—	(6.0)(1)	5.0	—	30	10	4.0	18	45	5
J113	100	—	0.5	3.0	2.0	—	35	28	5.0	—	—	5
2N5555	150	—	—	1.0(16)	15	—	25	5.0	1.2	10	25	5
BF246	—	—	0.6	14	30	250	25	—	—	—	—	22
BF246A	35(1)	1.0	0.6	14	30	80	25	—	—	—	—	22
BF246B	50(1)	1.0	0.6	14	60	140	25	—	—	—	—	22
BF246C	65(1)	1.0	0.6	14	110	250	25	—	—	—	—	22
J109	12	—	2.0	6.0	40	—	25	—	—	—	—	5
J110	18	—	0.5	4.0	10	—	25	—	—	—	—	5
Case 29-04 — TO-226AA (TO-92) — P-Channel												
MPF970	100	1.0	5.0	12	15	100	30	12	5.0	8.0	25	5
MPF971	250	1.0	1.0	7.0	2.0	50	30	12	5.0	10	120	5
J174	85	—	5.0	10	2.0	100	30	—	—	—	—	30
J175	125	—	3.0	6.0	7.0	60	30	—	—	—	—	30
J176	250	—	1.0	4.0	2.0	25	30	—	—	—	—	30
J177	300	—	0.8	2.5	1.5	20	30	—	—	—	—	30

(1)Typical
(16)$V_{GS(f)}$

Devices listed in bold, italic are Motorola preferred devices.

MOSFETs

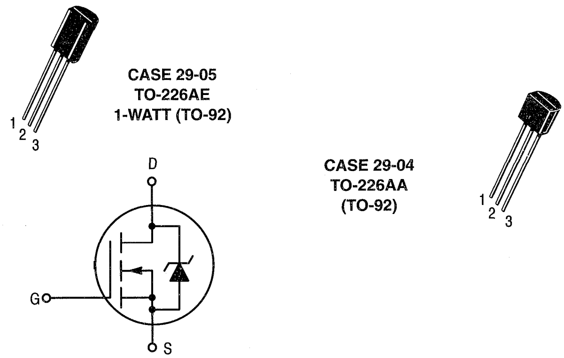


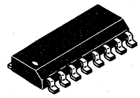
Table 1. TMOS Switches and Choppers

The following is a listing of small-signal TMOS devices that are intended for switching and chopper applications. These devices offer low $R_{DS(on)}$ characteristics.

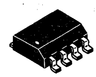
Device	$R_{DS(on)}$ @ I_D Ω Max	A	$V_{GS(th)}$ Volts Min	Max	$V_{(BR)DSS}$ Volts Min	C_{iss} pF Max	C_{rss} pF Max	t_{on} ns Max	t_{off} ns Max	Style
Case 29-05 — TO-226AE (1-WATT TO-92) — N-Channel										
MPF930	1.4	1.0	1.0	3.5	35	70(1)	20(1)	15	15	22
MPF960	1.7	1.0	1.0	3.5	60	70(1)	20(1)	15	15	22
MPF6659	1.8	1.0	0.8	2.0	35	30(1)	4(1)	5.0	5.0	22
MPF990	2.0	1.0	1.0	3.5	90	70(1)	20(1)	15	15	22
MPF6660	3.0	1.0	0.8	2.0	60	30(1)	4(1)	5.0	5.0	22
MPF6661	4.0	1.0	0.8	2.0	90	30(1)	4(1)	5.0	5.0	22
MPF910	5.0	0.5	0.3	2.5	60	—	—	—	—	22
VN10LM	5.0	0.5	0.8	2.5	60	60	5.0	10	10	22
MPF89	6.0	0.30	1.0	2.7	200	70(1)	3(1)	6(1)	12(1)	7
Case 29-04 — TO-226AA (TO-92) — N-Channel										
VN0300L	1.2	1.0	0.8	2.5	60	100	25	30	30	22
2N7000	5.0	0.5	0.8	3.0	60	60	5.0	10	10	22
BS170	5.0	0.2	0.8	3.0	60	25(1)	3.0(1)	10	10	30
VN0610LL	5.0	0.5	0.8	2.5	60	60	5.0	10	10	22
VN1706L	6.0	0.5	0.8	2.0	170	125	20	8.0	18	22
VN2406L	6.0	0.5	0.8	2.0	240	125	20	8.0	23	22
BSS89	6.0	0.30	1.0	2.7	200	72(1)	3.0(1)	6.0(1)	12(1)	7
BS107A	6.4	0.25	1.0	3.0	200	60(1)	6.0(1)	15	15	30
2N7008	7.5	0.5	1.0	2.5	60	50	5.0	20	20	22
VN2222LL	7.5	0.5	0.6	2.5	60	60	5.0	10	10	22
VN2410L	10	0.5	0.8	2.0	240	125	20	8.0	23	22
BS107	14	0.2	1.0	3.0	200	60(1)	6.0(1)	15	15	30

(1)Typical

Devices listed in bold, italic are Motorola preferred devices.



CASE 751B-05
SO-16
STYLE 7



CASE 751-04
SO-8
STYLE 11

Medium Power TMOS FETs

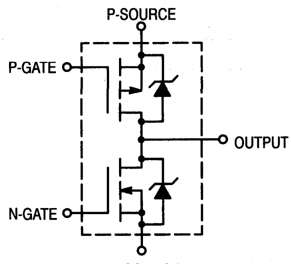
Multiple Chip TMOS Products in SOIC Surface Mount Packages

Multiple chip surface mount TMOS MOSFETs in SOIC packages simplify circuit design through component count and board space reduction. These devices are designed for use in bridge circuits in low voltage, motor control applications such as disk drives, tape drives, optical drives, printers and plotters and they can also be used for driving relays and solenoids. Both devices feature low $R_{DS(on)}$ and a specially designed leadframe for maximum power dissipation. These devices fit the standard SO-8 and SO-16 footprints.

Table 2. Multiple Chip Products in SOIC

V_{DSS} (Volts) Min	P-Channel $R_{DS(on)}$ Ohms	N-Channel $R_{DS(on)}$ Ohms	Part Number	I_D (cont) Amps	P_D(24) (Watts) Max	Description
50	0.3	0.3	***MMDF2C05E***	2.0	2.0(26)	Complementary Half-Bridge
20	—	0.1	***MMDF2N02E***	2.2	1.5(25)	Dual N-Channel

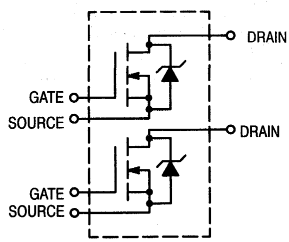
(24) $T_A = 25°C$
(25) Power rating with both die "on" when mounted on FR-4 glass epoxy printed circuit board with the recommended footprint
(26) P or N Channel device only



MMDF2C05E
Half-Bridge

Use MMDF2C05ER1 to order the 7 inch/500 unit reel.
Use MMDF2C05ER2 to order the 13 inch/2500 unit reel.

Tape Size = 16 mm



MMDF2N02E
Dual N-Channel

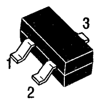
Use MMDF2N02ER1 to order the 7 inch/500 unit reel.
Use MMDF2N02ER2 to order the 13 inch/2500 unit reel.

Tape Size = 12 mm

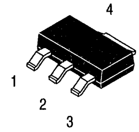
Devices listed in bold, italic are Motorola preferred devices.

Surface Mount FETs

This section contains the FET plastic packages available for surface mount applications. Most of these devices are the most popular metal-can and insertion type parts carried over to the new surface mount packages.



CASE 318-07
TO-236AB
SOT-23



CASE 318E-04
SOT-223

Table 1. Surface Mount RF JFETs

The following is a list of surface mount FETs which are intended for VHF/UHF RF amplifier applications.
Pinout: 1-Drain, 2-Source, 3-Gate

		NF		Y_{fs} @ V_{DS}				
Device	**Marking**	**dB Typ**	**f MHz**	**mmhos Min**	**mmhos Max**	**Volts**	$V_{(BR)GSS}$	**Style**
Case 318-07 — TO-236AB (SOT-23) — N-Channel								
MMBFJ309LT1	6U	1.5	450	10	20	10	25	10
MMBFJ310LT1	6T	1.5	450	8.0	18	10	25	10
MMBFU310LT1	M6C	1.5	450	10	18	10	25	10
MMBF4416LT1	M6A	2[3]	100	4.5	7.5	15	30	10
MMBF5484LT1	M6B	2.0	100	3.0	6.0	15	25	10
MMBF5486LT1	6H	2.0	100	4.0	8.0	15	25	10

Table 2. Surface Mount General-Purpose JFETs

The following table is a listing of surface mount small-signal general purpose FETs. These devices are intended for small-signal amplification for DC, audio, and lower RF frequencies. They also have applications as oscillators and general-purpose, low-voltage switches.
Pinout: 1-Drain, 2-Source, 3-Gate

			Y_{fs} @ V_{DS}			I_{DSS}		
Device	**Marking**	$V_{(BR)GSS}$	**mmhos Min**	**mmhos Max**	**Volts**	**mA Min**	**mA Max**	**Style**
Case 318-07 — TO-236AB (SOT-23) — N-Channel								
MMBF5457LT1	6D	25	1.0	5.0	15	1.0	5.0	10
MMBF5459LT1	6L	25	2.0	6.0	15	4.0	16	10
Case 318-07 — TO-236AB (SOT-23) — P-Channel								
MMBF5460LT1	M6E	40	1.0	4.0	15	1.0	5.0	10

[3] Max

Devices listed in bold, italic are Motorola preferred devices.

Surface Mount FETs (continued)

Table 3. Surface Mount Choppers/Switches JFETs

The following is a listing of small-signal surface mount JFET devices intended for switching and chopper applications.
Pinout: 1-Drain, 2-Source, 3-Gate

Device	Marking	$R_{DS(on)}$ Ohms Max	t_{off} ns Max	$V_{(BR)GSS}$	$V_{GS(off)}$ Volts Min	$V_{GS(off)}$ Volts Max	I_{DSS} mA Min	I_{DSS} mA Max	Style
Case 318-07 — TO-236AB (SOT-23) — N-Channel									
MMBF4856LT1	AAA	25	25	40	4.0	10	50	—	10
MMBF4391LT1	6J	30	20	30	4.0	10	50	150	10
MMBF4860LT1	6F	40	50	30	2.0	6.0	20	100	10
MMBF4392LT1	6K	60	35	30	2.0	5.0	25	75	10
MMBF4393LT1	6G	100	50	30	0.5	3.0	5.0	30	10
Case 318-07 — TO-236AB (SOT-23) — P-Channel									
MMBFJ175LT1	6W	125	—	–30	3.0	6.0	7.0	60	10
MMBFJ177LT1	6Y	300	—	–30	0.8	2.5	1.5	20	10

Table 4. TMOS FETs

The following is a listing of small-signal surface mount TMOS FETs which exhibit low $R_{DS(on)}$ characteristics.
Pinout: 1-Gate, 2-Source, 3-Drain

Device	Marking	$R_{DS(on)}$ @ I_D Ohm	$R_{DS(on)}$ @ I_D mA	V_{DSS}	$V_{GS(th)}$ Volts Min	$V_{GS(th)}$ Volts Max	Switching Time t_{on} ns	Switching Time t_{off} ns	Style
Case 318-07 — TO-236AB (SOT-23) — N-Channel									
MMBF170LT1	6Z	5.0	200	60	0.8	3.0	10	10	21
BSS123LT1	SA	6.0	100	100	0.8	2.8	20	40	21
2N7002LT1	702	7.5	500	60	1.0	2.5	20	20	21

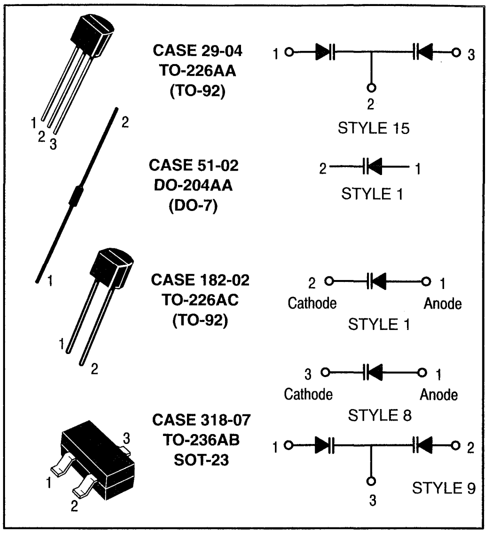
Pinout: 1-Gate, 2-Drain, 3-Source, 4-Drain

Device	Marking	$R_{DS(on)}$ Ohm	$R_{DS(on)}$ mA	V_{DSS}	$V_{GS(th)}$ Volts Min	$V_{GS(th)}$ Volts Max	Switching Time t_{on} ns	Switching Time t_{off} ns	Style
Case 318E-04 — SOT-223 — N-Channel									
MMFT3055ET1	3055E	0.15	850	60	2.0	4.5	—	—	3
MMFT2N02ELT1	2N02L	0.15	1000	20	1.0	2.0	—	—	3
MMFT3055ELT1	3055L	0.18	750	60	1.0	2.0	—	—	3
MMFT1N10ET1	1N10	0.25	500	100	2.0	4.5	—	—	3
MMFT960T1	FT960	1.7	1000	60	1.0	3.5	15	15	3
MMFT3166T1	T3166	2	500	60	1.6	3.5	—	—	3
MMFT1N10T1	T1N10	3.4	250	100	2.0	4.0	—	—	3
MMFT6661T1	T6661	4.0	1000	90	0.8	2.0	5.0	5.0	3
MMFT2406T1	T2406	10	200	240	0.8	2.0	—	—	3
MMFT107T1	FT107	14	200	200	1.0	3.0	15	15	3
Case 318E-04 — SOT-223 — P-Channel									
MMFT2955ET1	2955E	0.3	600	60	2.0	4.5	—	—	3

Devices listed in bold, italic are Motorola preferred devices.

Tuning and Switching Diodes

Tuning Diodes — Abrupt Junction



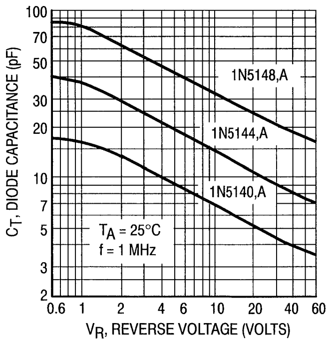
Motorola supplies voltage-variable capacitance diodes serving the entire range of frequencies from HF through UHF. Used in RF receivers and transmitters, they have a variety of applications, including:

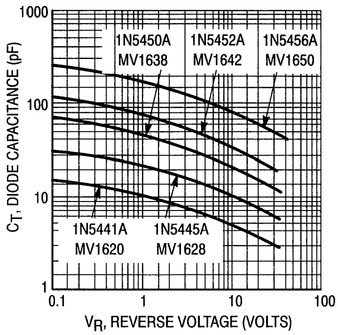
- Phase-locked loop tuning systems
- Local oscillator tuning
- Tuned RF preselectors
- RF filters
- RF phase shifters
- RF amplifiers
- Automatic frequency control
- Video filters and delay lines
- Harmonic generators
- FM modulators

Two families of devices are available: Abrupt Junction and Hyper Abrupt Junction. The Abrupt Junction family includes devices suitable for virtually all tuned-circuit and narrow-range tuning applications throughout the spectrum.

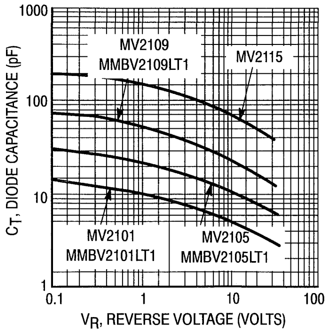
Typical Characteristics

Diode Capacitance versus Reverse Voltage

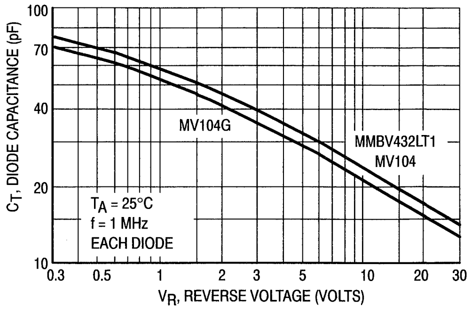




(See Tables 1 Thru 3)



(See Tables 4 and 5)



(See Table 6)

Table 1. General-Purpose Glass Abrupt Tuning Diodes

High Q Capacitance Ratio @ 4.0 Volts/60 Volts

The following is a listing of axial leaded, general-purpose, abrupt tuning diodes. These devices exhibit high Q characteristics.

Device[19]	C_T @ V_R = 4.0 V, 1.0 MHz pF Min	pF Nominal	pF Max	$V_{(BR)R}$ Volts	Cap Ratio C4/C60 Min	Q 4.0 V, 50 MHz Min
Case 51-02 — DO-204AA (DO-7)						
1N5139	6.1	6.8	7.5	60	2.7	350
1N5140	9.0	10	11	60	2.8	300
1N5141	10.8	12	13.2	60	2.8	300
1N5142	13.5	15	16.5	60	2.8	250
1N5143	16.2	18	19.8	60	2.8	250
1N5144	19.8	22	24.2	60	3.2	200
1N5145	24.3	27	29.7	60	3.2	200
1N5146	29.7	33	36.3	60	3.2	200
1N5147	35.1	39	42.9	60	3.2	200
1N5148	42.3	47	51.7	60	3.2	200

Table 2. General-Purpose Glass Abrupt Tuning Diodes

High Q Capacitance Ratio @ 2.0 Volts/30 Volts

The following is a listing of axial leaded, general-purpose, abrupt tuning diodes. These devices exhibit very high Q characteristics.

Device[20]	C_T @ V_R = 4.0 V, 1.0 MHz pF Min	pF Nominal	pF Max	$V_{R(BR)R}$ Volts	Cap Ratio C2/C30 Min	Q 4.0 V, 50 MHz Min
Case 51-02 — DO-204AA (DO-7)						
1N5441A	6.1	6.8	7.5	30	2.5	450
1N5443A	9.0	10	11	30	2.6	400
1N5444A	10.8	12	13.2	30	2.6	400
1N5445A	13.5	15	16.5	30	2.6	400
1N5446A	16.2	18	19.8	30	2.6	350
1N5448A	19.8	22	24.2	30	2.6	350
1N5449A	24.3	27	29.7	30	2.6	350
1N5450A	29.7	33	36.3	30	2.6	350
1N5451A	35.1	39	42.9	30	2.6	300
1N5452A	42.3	47	51.7	30	2.6	250
1N5453A	50.4	56	61.6	30	2.6	200
1N5455A	73.8	82	90.2	30	2.7	175
1N5456A	90	100	110	30	2.7	175

(19)Suffix A = 5.0%
(20)Suffix B = 5.0%

Devices listed in bold, italic are Motorola preferred devices.

1

Table 3. General-Purpose Glass Abrupt Tuning Diodes

Capacitance Ratio @ 2.0 Volts/20 Volts

The following is a listing of axial leaded, general-purpose, abrupt tuning diodes. These devices exhibit high Q characteristics.

Device	C_T @ V_R = 4.0 V, 1.0 MHz pF Min	pF Nominal	pF Max	$V_{(BR)R}$ Volts	Cap Ratio C2/C20 Min	Q 4.0 V, 50 MHz Typ
Case 51-02 — DO-204AA (DO-7)						
MV1620	6.1	6.8	7.5	20	2.0	300
MV1624	9.0	10	11	20	2.0	300
MV1626	10.8	12	13.2	20	2.0	300
MV1628	13.5	15	16.5	20	2.0	250
MV1630	16.2	18	19.8	20	2.0	250
NV1634	19.8	22	24.2	20	2.0	250
MV1636	24.3	27	29.7	20	2.0	200
MV1638	29.7	33	36.3	20	2.0	200
MV1640	35.1	39	42.9	20	2.0	200
MV1642	42.3	47	51.7	20	2.0	200
MV1644	50.4	56	61.6	20	2.0	150
MV1648	73.8	82	90.2	20	2.0	150
MV1650	90	100	110	20	2.0	150

Table 4. General-Purpose Plastic Abrupt Tuning Diodes

Capacitance Ratio @ 2.0 Volts/30 Volts

The following is a listing of plastic package, general-purpose, abrupt tuning diodes. These devices exhibit high Q characteristics.

Device	C_T @ V_R = 4.0 V, 1.0 MHz pF Min	pF Nominal	pF Max	$V_{R(BR)R}$ Volts	Cap Ratio C4/C30 Min	Q 4.0 V, 50 MHz Typ
Case 182-02 — TO-226AC (TO-92) — 2-Lead						
MV2101	6.1	6.8	7.5	30	2.5	400
MV2103	9.0	10	11	30	2.5	350
MV2104	10.8	12	13.2	30	2.5	350
MV2105	13.5	15	16.5	30	2.5	350
MV2107	19.8	22	24.2	30	2.5	300
MV2108	24.3	27	29.7	30	2.5	250
MV2109	29.7	33	36.3	30	2.5	200
MV2111	42.3	47	51.7	30	2.5	150
MV2113	61.2	68	74.8	30	2.5	150
MV2114	73.8	82	90.2	30	2.5	100
MV2115	90	100	110	30	2.6	100

Devices listed in bold, italic are Motorola preferred devices.

1

Table 5. Surface Mount Abrupt Tuning Diodes

Capacitance Ratio @ 2.0 Volts/30 Volts

The following is a listing of surface mount abrupt junction tuning diodes intended for general-purpose variable capacitance circuit applications.

Device	C_T @ V_R = 4.0 V, 1.0 MHz pF Min	pF Nominal	pF Max	$V_{R(BR)R}$ Volts	Cap Ratio C2/C30 Min	Q 4.0 V, 50 MHz Typ
Case 318-07 — DO-236AB (SOT-23)						
MMBV2101LT1	6.1	6.8	7.5	30	2.5	400
MMBV2103LT1	9.0	10	11	30	2.5	350
MMBV2104LT1	10.8	12	13.2	30	2.5	350
MMBV2105LT1	13.5	15	16.5	30	2.5	350
MMBV2107LT1	19.8	22	24.2	30	2.5	300
MMBV2108LT1	24.3	27	29.7	30	2.5	250
MMBV2109LT1	29.7	33	36.3	30	2.5	200

Table 6. Abrupt Tuning Diodes for FM Radio — Dual

The following is a listing of abrupt tuning diodes that are available as dual units in a single package.

Device	C_T @ V_R(22) pF Min	pF Max	Volts	Cap Ratio C3/C30 Min	Q 3.0 V, 50 MHz Min	$V_{(BR)R}$ Volts	Device Marking	Style
Case 29-04 — TO-226AA (TO-92)								
MV104	37	42	3.0	2.5	100	32	—	15
Case 318-07 — TO-236AB (SOT-23)								
MMBV432LT1	43	48.1	2.0	1.5(21)	100	14	M4B	9

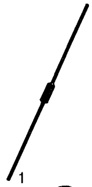
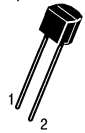
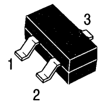
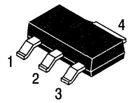
(21)C2/C8
(22)Each Diode

Devices listed in bold, italic are Motorola preferred devices.

Tuning Diodes — Hyper-Abrupt Junction

The Hyper Abrupt family exhibits higher capacitance, and a much larger capacitance ratio. It is particularly well suited for wider-range applications such as AM/FM radio and TV tuning.

1

	**CASE 51-02 DO-204AA (DO-7)**	1 Cathode — 2 Anode, STYLE 1
	**CASE 182-02 TO-226AC (TO-92)**	2 Anode — 1 Cathode, STYLE 1
	**CASE 318-07 TO-236AB SOT-23**	3 Cathode — 1 Anode, STYLE 8
	**CASE 318E-04 SOT-223**	1 — 2,4, STYLE 2

Typical Characteristics

Diode Capacitance versus Reverse Voltage

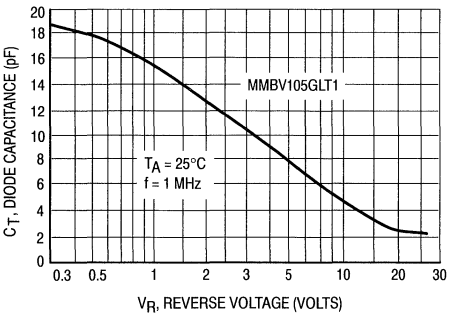


Figure 1. Diode Capacitance

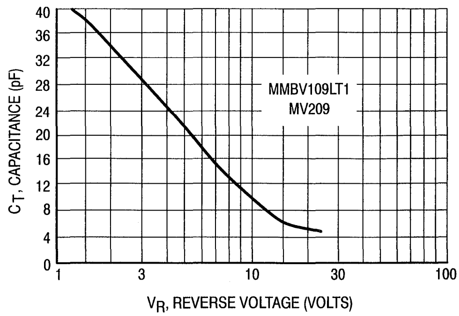


Figure 2. Diode Capacitance

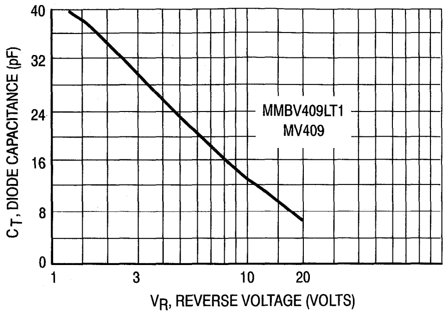


Figure 3. Diode Capacitance

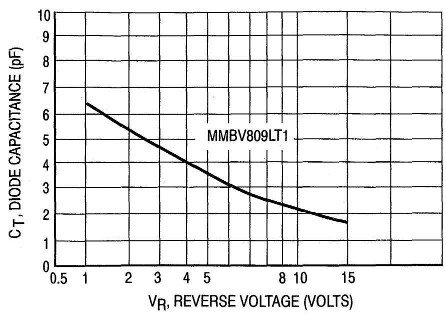


Figure 4. Diode Capacitance

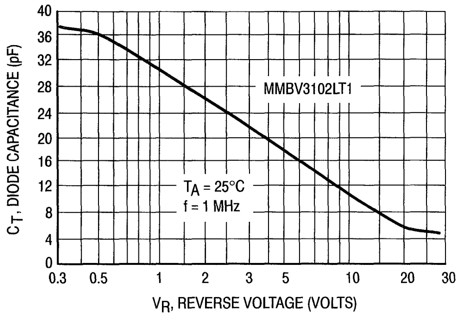


Figure 5. Diode Capacitance

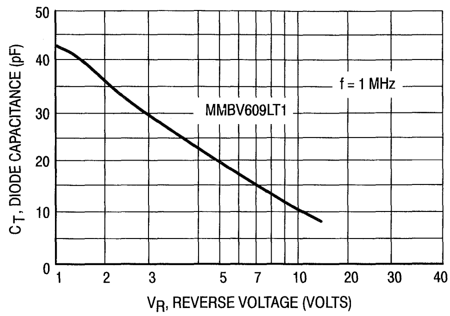


Figure 6. Diode Capacitance Each Die

MVAM108

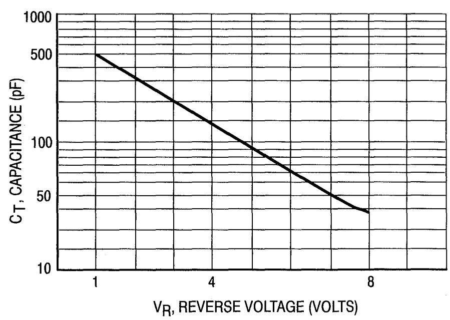


Figure 7. Capacitance versus Reverse Voltage

MVAM109/MV7005T1

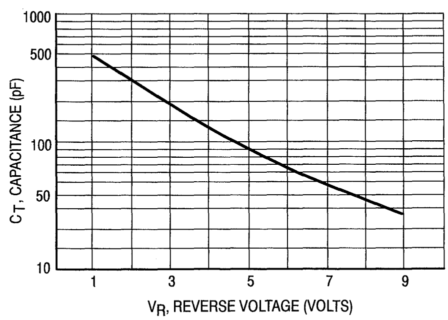


Figure 8. Capacitance versus Reverse Voltage

Tuning Diodes — Hyper-Abrupt Junction (continued)

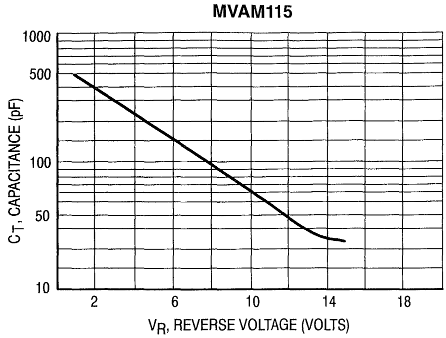


Figure 9. Capacitance versus Reverse Voltage

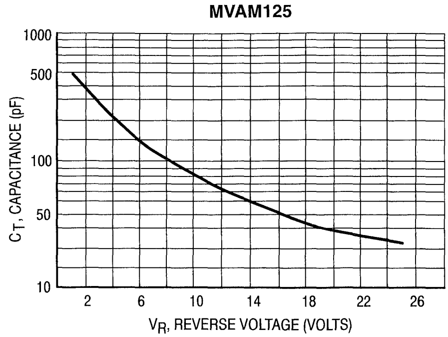


Figure 10. Capacitance versus Reverse Voltage

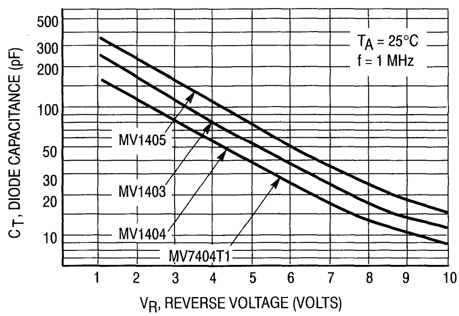


Figure 11. Diode Capacitance versus Reverse Voltage

Table 1. Hyper-Abrupt Tuning Diodes for Telecommunications — Single

The following is a listing of hyper-abrupt tuning diodes intended for high frequency, FM radio, and TV tuner applications.

Device	C_T @ V_R (f = 1.0 MHz) pF Min	pF Max	Volts	Cap Ratio @ V_R Min	Max	Volts	Q 3.0 V Min	50 MHz Max	$V_{(BR)R}$ Volts	Device Marking	Case Style	CV Curve Fig
Case 182-02 — TO-226AC (TO-92)												
MV209	26	32	3.0	5.0	6.5	3/25	200	—	30	—	1	2
MV409	26	32	3.0	1.5	2.0	3/8	200	—	20	—	1	3
Case 318-07 — TO-236AB (SOT-23)												
MMBV105GLT1	1.8	2.8	25	4.0	6.0	3/25	200	—	30	M4E	8	1
MMBV109LT1	26	32	3.0	5.0	6.5	3/25	200	—	30	M4A	8	2
MMBV409LT1	26	32	3.0	1.5	2.0	3/8	200	—	20	X5	8	3
MMBV809LT1	4.5	6.1	2.0	1.8	2.6	2/8	300	—	20	5K	8	4
MMBV3102LT1	20	25	3.0	4.5	—	3/25	200	—	30	M4C	8	5

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Hyper-Abrupt Tuning Diodes for Communications — Dual

Device	C_T @ V_R (f = 1.0 MHz) pF Min	pF Max	Volts	Cap Ratio @ V_R Min	Max	Volts	Q 3.0 V Min	50 MHz Max	$V_{(BR)R}$ Volts	Device Marking	Case Style	CV Curve Fig
Case 318-07 — TO-236AB (SOT-23)												
MMBV609LT1	26	32	3.0	1.8	2.4	3/8	250	—	20	5L	9	6

Table 3. Hyper-Abrupt Tuning Diodes for Low Frequency Applications — Single

The following is a listing of AM, hyper-abrupt tuning diodes that have a large capacity range and are designed for low frequency circuit applications.

Device	C_T @ 1.0 MHz pF Min	pF Max	Volts	Cap Ratio @ V_R Min	Volts	$V_{(BR)R}$ Volts	Style	CV Curve Figure
Case 182-02 — TO-226AC (TO-92)								
MVAM108	440	560	1.0	15	1.0/8.0	12	1	7
MVAM109	400	520	1.0	12	1.0/9.0	15	1	8
MVAM115	440	560	1.0	15	1.0/15	18	1	9
MVAM125	440	560	1.0	15	1.0/25	28	1	10

Table 4. Hyper-Abrupt High Capacitance Voltage Variable Diode — Surface Mount

The following are high capacitance voltage variable diodes intended for low frequency applications and circuits requiring large tuning capacitance.

Device	$V_{(BR)R}$ Volts	I_R nA	C_T @ f = 1.0 MHz Min pF	Max pF	Cap Ratio Min	Q Min	Style	CV Curve Figure
Case 318E-04 — SOT-223								
Pinout: 1-Anode, 2, 4-Cathode, 3-NC								
MV7005T1	15	100	400	520	12(26)	150(28)	2	8
MV7404T1	12	100	96	144	10(27)	200(29)	2	11

Table 5. Hyper-Abrupt High Capacitance Tuning Diodes — Axial Lead Glass Package

Device	C_T @ V_R pF Min	pF Max	Volts	Cap Ratio C2/C10 Min	Q 2.0 V, 1.0 MHz Min	$V_{(BR)R}$ Volts	Style	CV Curve Figure
Case 51-02 — DO-204AA (DO-7)								
MV1404	96	144	2.0	10	200	12	1	11
MV1403	140	210	2.0	10	200	12	1	11
MV1405	200	300	2.0	10	200	12	1	11

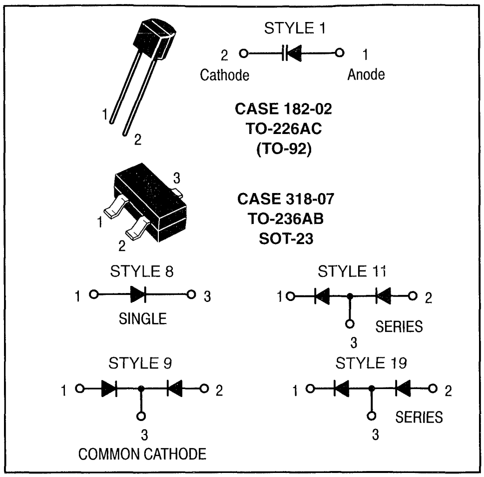
(26) $V_R = 1.0$ V/$V_R = 9.0$ V
(27) $V_R = 2.0$ V/$V_R = 10$ V
(28) $V_R = 1.0$ V, f = 1.0 MHz
(29) $V_R = 2.0$ V, f = 1.0 MHz

Devices listed in bold, italic are Motorola preferred devices.

1

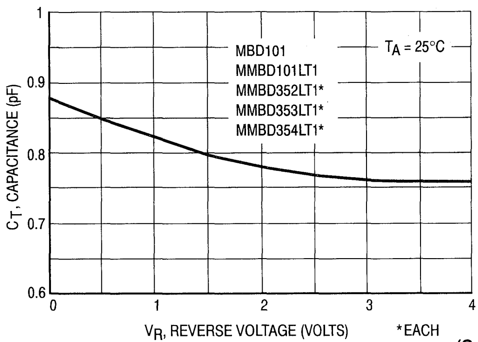
Hot-Carrier (Schottky) Diodes

Hot-Carrier diodes are ideal for VHF and UHF mixer and detector applications as well as many higher frequency applications. They provide stable electrical characteristics by eliminating the point-contact diode presently used in many applications.



Typical Characteristics

Capacitance versus Reverse Voltage



*EACH DIODE (See Table 1)

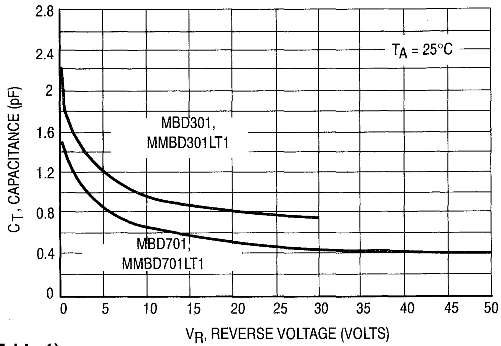


Table 1. Hot-Carrier (Schottky) Diodes

The following is a listing of hot carrier (Schottky) diodes that exhibit low forward voltage drop for improved circuit efficiency.

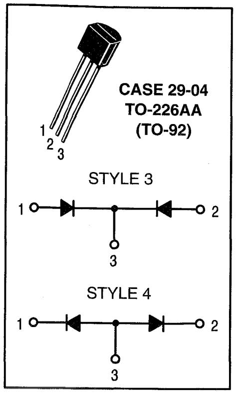
Device	$V_{(BR)R}$ Volts	C_T @ V_R pF Max	V_F @ 10 mA Volts Max	I_R @ V_R nA Max	Minority Lifetime pS (TYP)	Device Marking	Style
Case 182-02 — TO-226AC (TO-92)							
MBD701	70	1.0 @ 20 V	1.0	200 @ 35 V	15	—	1
MBD301	30	1.5 @ 15 V	0.6	200 @ 25 V	15	—	1
MBD101	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	—	1
Case 318-07 — TO-236AB (SOT-23)							
MMBD701LT1	70	1.0 @ 20 V	1.0	200 @ 35 V	15	5H	8
MMBD301LT1	30	1.5 @ 15 V	0.6	200 @ 25 V	15	4T	8
MMBD101LT1	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	4M	8
MMBD352LT1 (23)	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	M5G	11
MMBD353LT1 (23)	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	M4F	19
MMBD354LT1 (23)	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	M6H	9

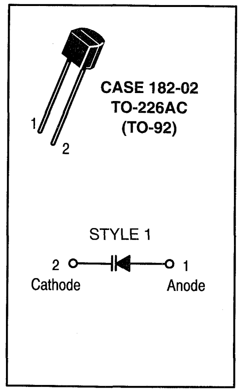
(23)Dual Diodes

Devices listed in bold, italic are Motorola preferred devices.

Switching Diodes

Small-signal switching diodes are intended for low current switching and steering applications. Hot-Carrier, PIN and general-purpose diodes allow a wide selection for specific application requirements.

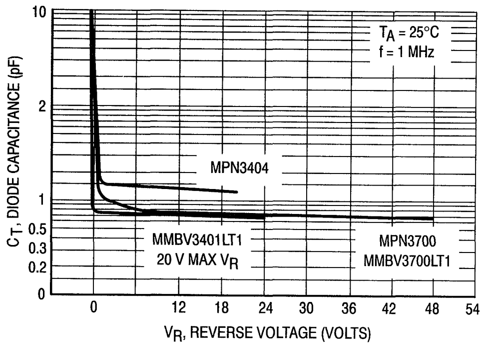




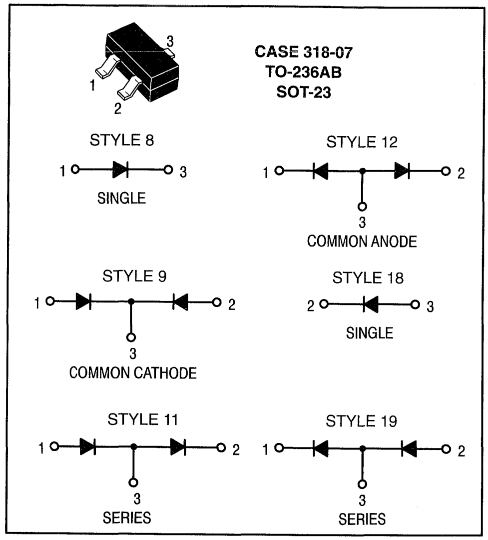
1

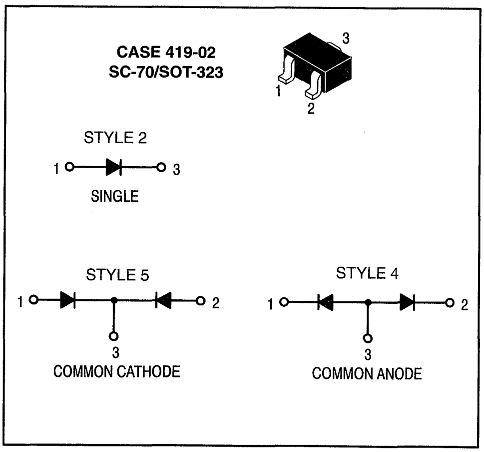
Typical Characteristics

Capacitance versus Reverse Voltage



(See Table 1)





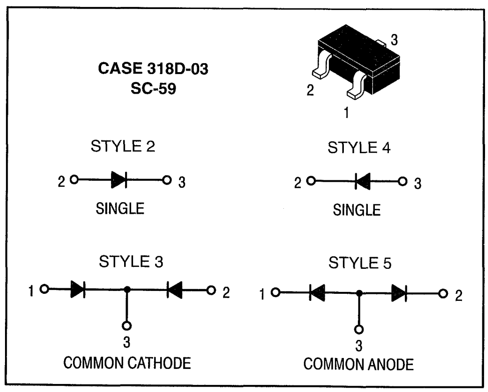


Table 1. PIN Switching Diodes

The following PIN diodes are designed for VHF band switching and general-purpose low current switching applications.

Device	$V_{(BR)R}$ Volts Min	C_T @ V_R @ 1.0 MHz pF Max	Volts	I_R @ V_R nA Max	Series Resistance Ohm Max	Device Marking	Style
Case 182-02 — TO-226AC (TO-92)							
MPN3700	200	1.0	20	0.1 @ 150	1.0 @ 10 mA	—	1
MPN3404	20	2.0	15	0.1 @ 25 V	0.85 @ 10 mA	—	1
Case 318-07 — TO-236AB (SOT-23)							
MMBV3700LT1	200	1.0	20	0.1 @ 150	1.0 @ 10 mA	4R	8
MMBV3401LT1	35	1.0	20	0.1 @ 25 V	0.7 @ 10 mA	4D	8

Table 2. General-Purpose Signal and Switching Diodes — Single

The following is a listing of small-signal switching diodes in surface mount packages. These diodes are intended for low current switching and signal steering applications.

Device	Marking	$V_{(BR)R}$ Min Volts	$V_{(BR)R}$ @ I_{BR} (μA)	I_R Max (μA)	I_R @ V_R Volts	V_F Min Volts	V_F Max Volts	V_F @ I_F (mA)	C_T(30) Max (pF)	t_{rr} Max (ns)	Pin Out Case Style
Case 318-07 — TO-236AB (SOT-23)											
BAS21LT1	JS	250	100	0.1	200		1.0	100	5.0	50	8
MMBD914LT1	5D	100	100	5.0	75		1.0	10	4.0	4.0	8
BAS16LT1	A6	75	100	1.0	75		1.0	50	2.0	6.0	8
MMBD6050LT1	5A	70	100	0.1	50	0.85	1.1	100	2.5	4.0	8
BAL99LT1	JF	70	100	2.5	70		1.0	50	1.5	6.0	18

Device	Marking	$V_{(BR)R}$ Min Volts	$V_{(BR)R}$ @ I_{BR} (μA)	I_R Max (μA)	I_R @ V_R Volts	V_F Min Volts	V_F Max Volts	V_F @ I_R (mA)	C_J(30) Max (pF)	t_{rr} Max (ns)	Case Style
Case 318D-03 — SC-59											
M1MA151AT1	MA	40	100	0.1	35	—	1.2	100	2.0	3.0	4
M1MA151KT1	MH	40	100	0.1	35	—	1.2	100	2.0	3.0	2
Case 419-02 — SC-70/SOT-323											
M1MA141KT1	MH	40	100	0.1	35	—	1.2	100	2.0	3.0	2
M1MA142KT1	MI	80	100	0.1	75	—	1.2	100	2.0	3.0	2

(30) V_R = 0 V, f = 1.0 MHz

Devices listed in bold, italic are Motorola preferred devices.

Table 3. General-Purpose Signal and Switching Diodes — Dual

The following is a listing of small-signal switching diodes in surface mount packages. These diodes are intended for low current switching and signal steering applications.

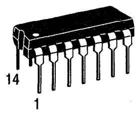
		$V_{(BR)R}$		I_R		V_F			C_T(30)	t_{rr}	Pin Out
Device	**Marking**	**Min Volts**	**@ I_{BR} (µA)**	**Max (µA)**	**@ V_R Volts**	**Min Volts**	**Max Volts**	**@ I_F (mA)**	**Max (pF)**	**Max (ns)**	**Case Style**
Case 318-07 — TO-236AB (SOT-23)											
MMBD7000LT1	M5C	100	100	0.3	50	0.75	1.1	100	1.5	4.0	11
MMBD2836LT1	A2	75	100	0.1	50		1.0	10	4.0	4.0	12
MMBD2838LT1	A6	75	100	0.1	50		1.0	10	4.0	4.0	9
BAV70LT1	A4	70	100	5.0	70		1.0	50	1.5	6.0	9
BAV99LT1	A7	70	100	2.5	70		1.0	50	1.5	4.0	11
BAW56LT1	A1	70	100	2.5	70		1.0	50	2.0	6.0	12
MMBD6100LT1	5BM	70	100	0.1	50	0.85	1.1	100	2.5	4.0	9
BAV74LT1	JA	50	5.0	0.1	50		1.0	100	2.0	4.0	9
MMBD2835LT1	A3	35	100	0.1	30		1.0	10	4.0	4.0	12
MMBD2837LT1	A5	35	100	0.1	30		1.0	10	4.0	4.0	9
Case 318D-03 — SC-59											
M1MA151WAT1	MN	40	100	0.1	35	—	1.2	100	15	10	5
M1MA151WKT1	MT	40	100	0.1	35	—	1.2	100	2.0	3.0	3
Case 419-02 — SC-70/SOT-323											
M1MA141WKT1	MT	40	100	0.1	35	—	1.2	100	2.0	3.0	5
M1MA142WKT1	MU	80	100	0.1	75	—	1.2	100	2.0	3.0	5
M1MA141WAT1	MN	40	100	0.1	35	—	1.2	100	15	10	4
M1MA142WAT1	MO	80	100	0.1	75	—	1.2	100	15	10	4

(30) V_R = 0 V, f = 1.0 MHz

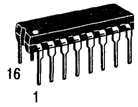
Devices listed in bold, italic are Motorola preferred devices.

Multiple Switching Diodes

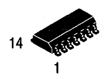
Multiple diode configurations utilize monolithic structures fabricated by the planar process. They are designed to satisfy fast switching requirements as in core driver and encoding/decoding applications where their monolithic configurations offer lower cost, higher reliability and space savings.



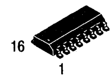
CASE 646-06
PIN DIP
PLASTIC



CASE 648-08
PIN DIP
PLASTIC

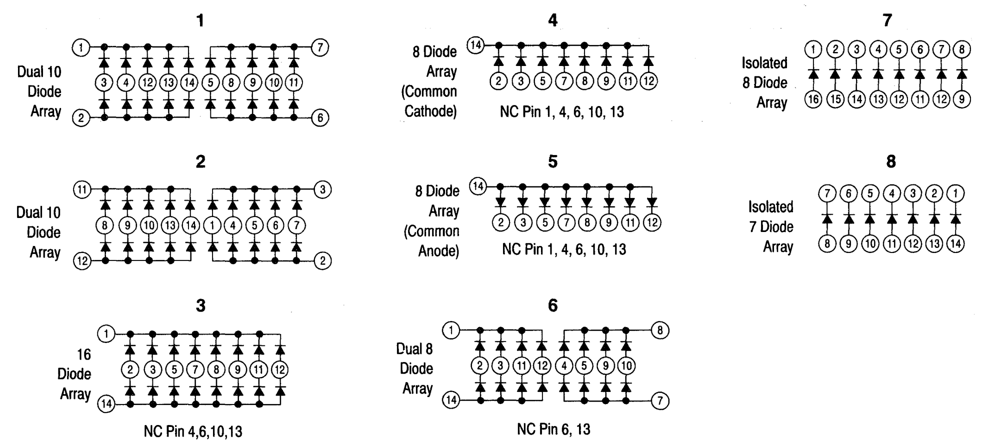


CASE 751A-03
SO-14
PLASTIC



CASE 751B-05
SO-16
PLASTIC

Diode Array Diagrams



Multiple Switching Diodes (continued)

Table 1. Diode Arrays

Case 646-06 — TO-116

Device	Function	Pin Connections Diagram Number
MAD130P	Dual 10 Diode Array	1
MAD1103P	16 Diode Array	3
MAD1105P	8 Diode Common Cathode Array	4
MAD1107P	Dual 8 Diode Array	6
MAD1109P	7 Isolated Diode Array	8

Case 648-08

MAD1108P	8 Isolated Diode Array	7

Case 751A-03 — SO-14

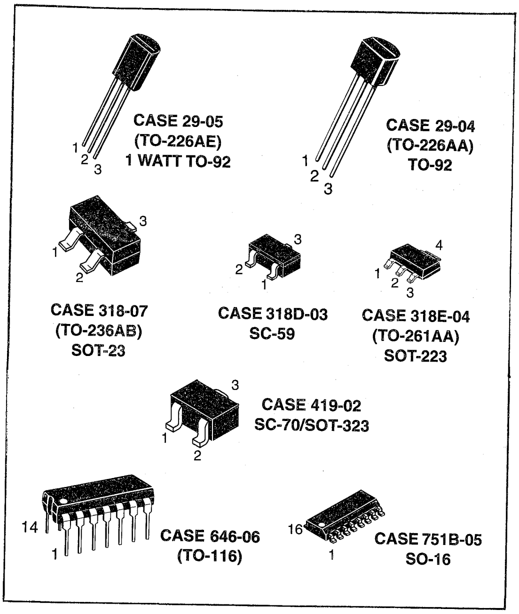
MMAD130	Dual 10 Diode Array	2
MMAD1103	16 Diode Array	3
MMAD1105	8 Diode Common Cathode Array	4
MMAD1106	8 Diode Common Anode Array	5
MMAD1107	Dual 8 Diode Array	6
MMAD1109	7 Isolated Diode Array	8

Case 751B-05 — SO-16

MMAD1108	8 Isolated Diode Array	7

Devices listed in bold, italic are Motorola preferred devices.

1



Plastic-Encapsulated Transistors

2

Motorola's plastic transistors and diodes 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 TO-92, 1-Watt TO-92 and TO-116 combine proven reliability performance and economy for through-the-hole manufacturing, while the SOT-23, SC-59, SC-70/SOT-323, SOT-223, and SO-16 offer the same solutions for surface mount manufacturing.

As an additional service to our customers Motorola will, upon request, supply many of these devices in tape and reel for automatic insertion.

Contact your Motorola representative for ordering information.

.his section contains both single and multiple plastic-encapsulated transistors.

NOTE: All SOT-23 package devices have had a "T1" suffix added to the device title.

EMBOSSED TAPE AND REEL

SOT-23, SC-59, SC-70/SOT-323, SOT-223 and SO-16 packages are available only in Tape and Reel. Use the appropriate suffix indicated below to order any of the SOT-23, SC-59, SC-70/SOT-323, SOT-223 and SO-16 packages. (See Section 7 on Packaging for additional information).

SOT-23: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SC-59: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SC-70/SOT-323: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SOT-223: available in 12 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/1000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/4000 unit reel.

SO-16: available in 16 mm Tape and Reel
Add an "R1" suffix to the device title to order the 7 inch/500 unit reel.
Add an "R2" suffix to the device title to order the 13 inch/2500 unit reel.

RADIAL TAPE IN FAN FOLD BOX OR REEL

TO-92 packages are available in both bulk shipments and in Radial Tape in Fan Fold Boxes or Reels. Fan Fold Boxes and Radial Tape Reel are the best methods for capturing devices for automatic insertion in printed circuit boards.

TO-92: available in Fan Fold Box
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Fan Fold box.

available in 365 mm Radial Tape Reel
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Radial Tape Reel.

*Refer to Section 7 on Packaging for Style code characters and additional information on ordering requirements.

DEVICE MARKINGS/DATE CODE CHARACTERS

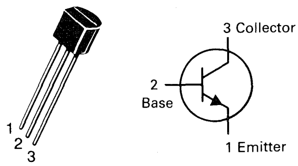
SOT-23, SC-59 and the SC-70/SOT-323 packages have a device marking and a date code etched on the device. The generic example below depicts both the device marking and a representation of the date code that appears on the SC-70/SOT-323, SC-59 and SOT-23 packages.

ABCD

The "D" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

2N3903
2N3904★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltge	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

*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 = 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)		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		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

2

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

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

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
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)	2N3903	t_s	—	175	ns
		2N3904		—	200	
Fall Time			t_f	—	50	ns

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

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

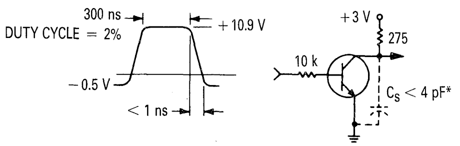
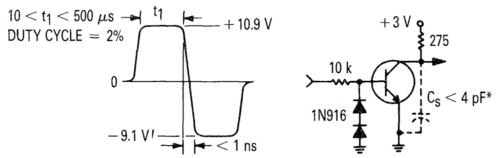


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

—— T_J = 25°C - - - T_J = 125°C

FIGURE 3 – CAPACITANCE

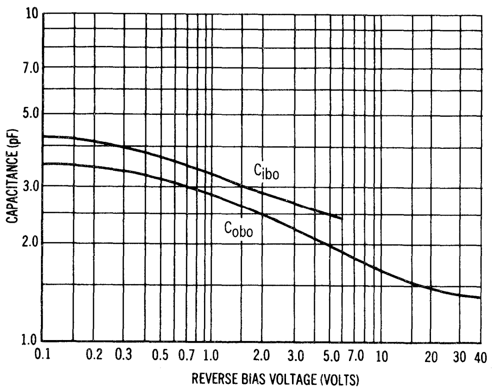


FIGURE 4 – CHARGE DATA

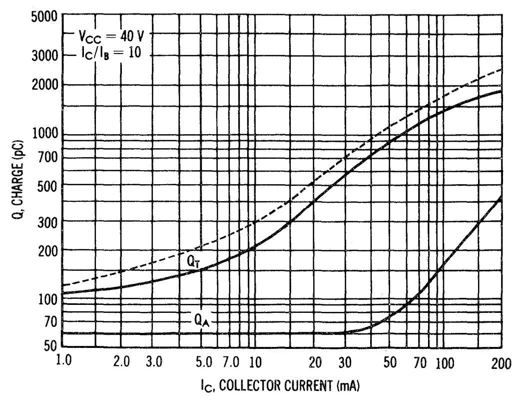


FIGURE 5 — TURN-ON TIME

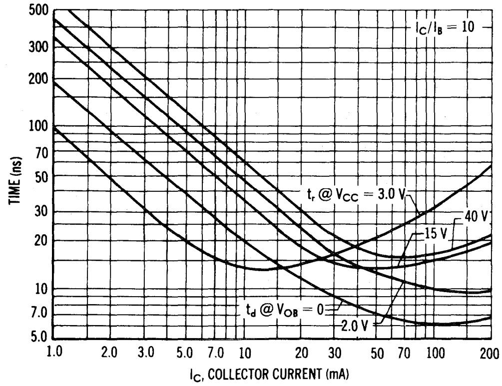


FIGURE 6 — RISE TIME

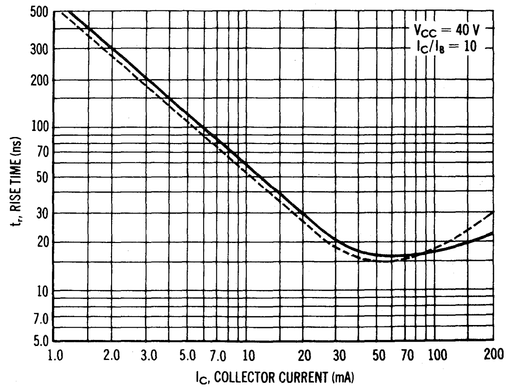


FIGURE 7 — STORAGE TIME

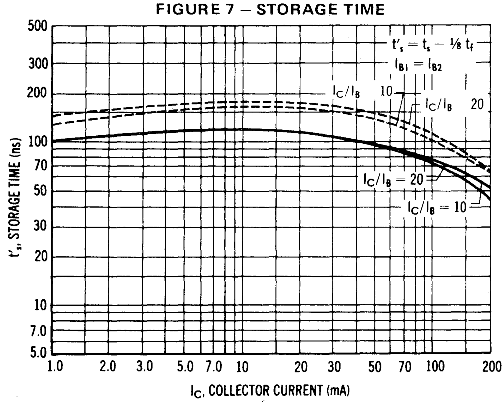
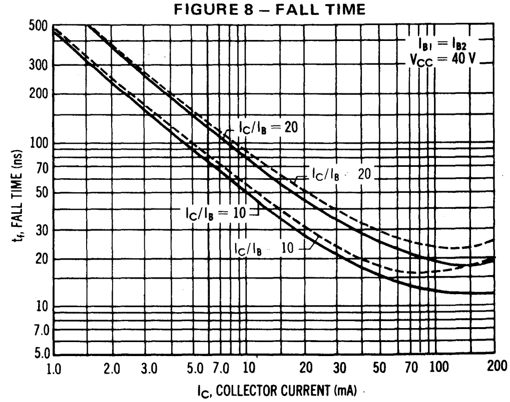


FIGURE 8 — FALL TIME



TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C, Bandwidth = 1.0 Hz

FIGURE 9

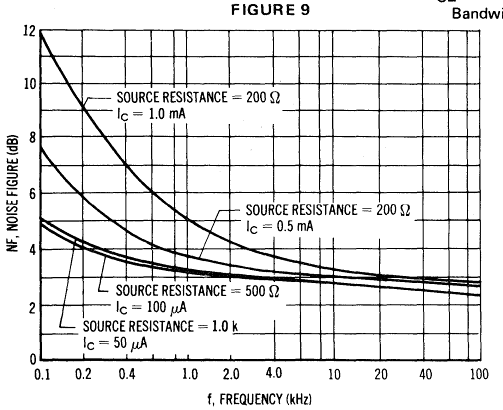
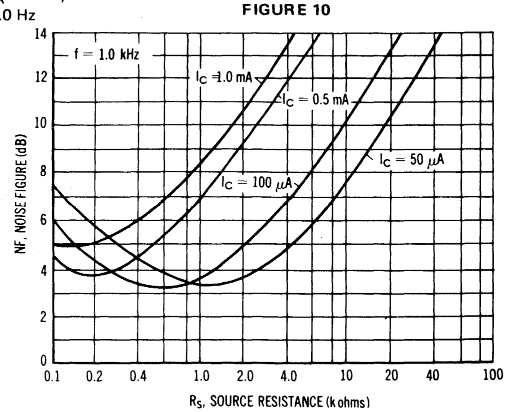


FIGURE 10



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 11 — CURRENT GAIN

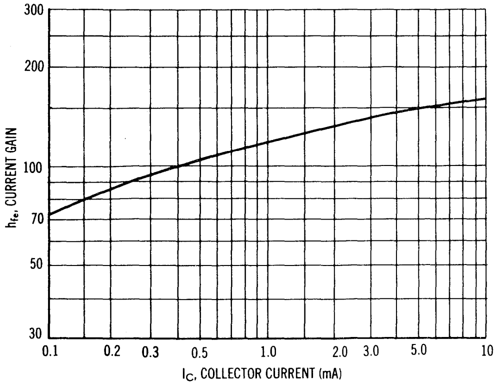


FIGURE 12 — OUTPUT ADMITTANCE

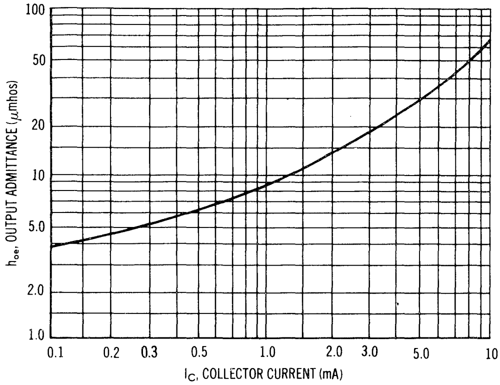


FIGURE 13 — INPUT IMPEDANCE

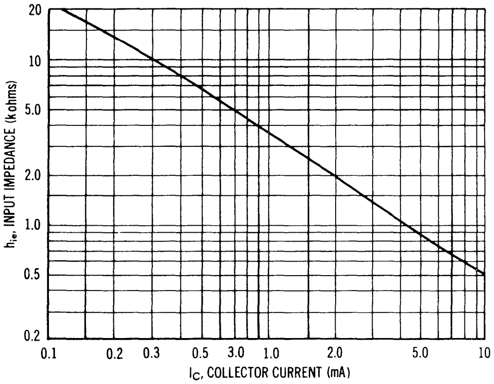
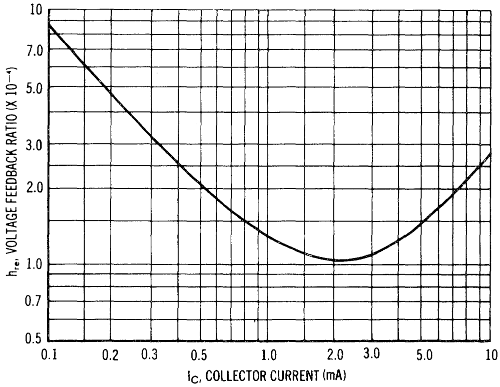


FIGURE 14 — VOLTAGE FEEDBACK RATIO



TYPICAL STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

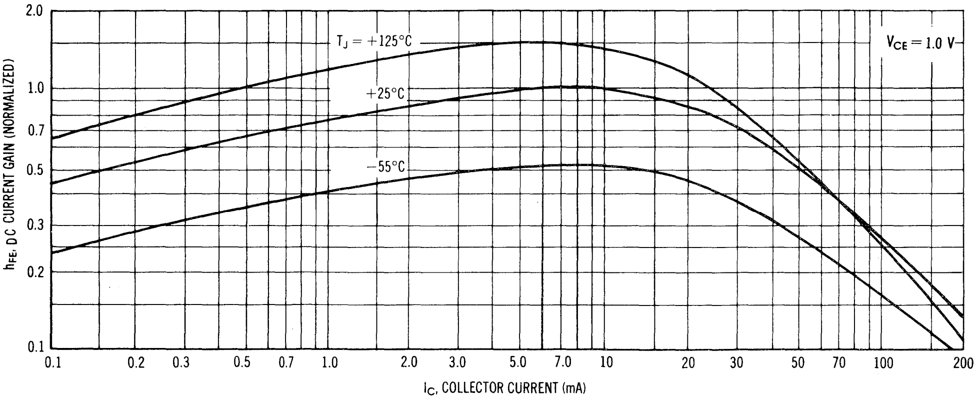


FIGURE 16 — COLLECTOR SATURATION REGION

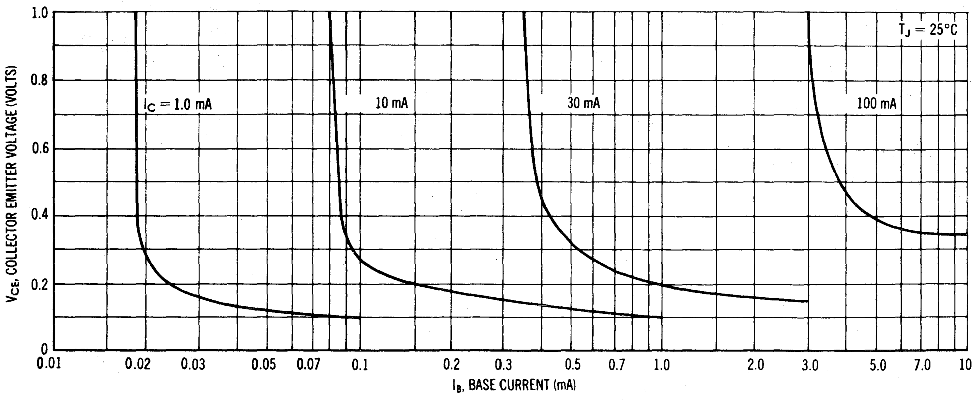


FIGURE 17 — "ON" VOLTAGES

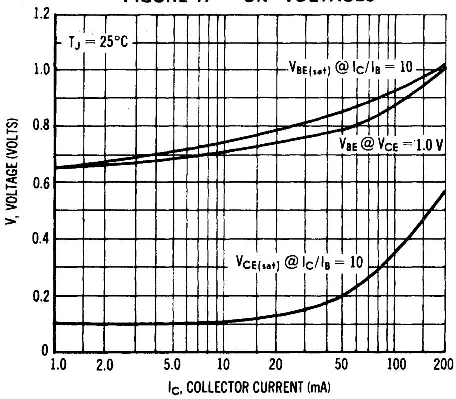
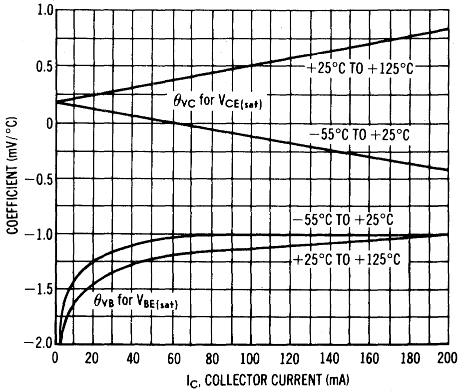


FIGURE 18 — TEMPERATURE COEFFICIENTS

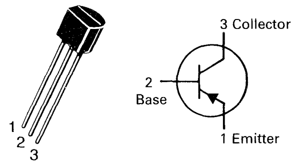


2

2

2N3905
2N3906★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★**This is a Motorola designated preferred device.**

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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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)		$V_{(BR)CEO}$	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_{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(1)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	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 2N3506		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)	 2N3905 2N3906	f_T	 200 250	 — —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.5	pF

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

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	–	10.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{ie}	0.5 2.0	8.0 12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{re}	0.1 0.1	5.0 10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{fe}	50 100	200 400	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{oe}	1.0 3.0	40 60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)	2N3905 2N3906	NF	– –	5.0 4.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
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)	2N3905 2N3906	t_s	– –	200 225	ns
Fall Time		2N3905 2N3906	t_f	– –	60 75	ns

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

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

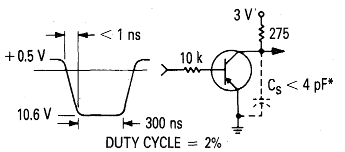
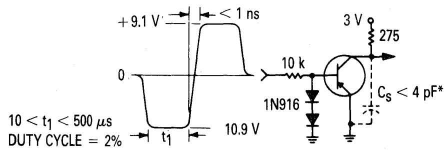


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

—— T_J = 25°C - - - T_J = 125°C

FIGURE 3 – CAPACITANCE

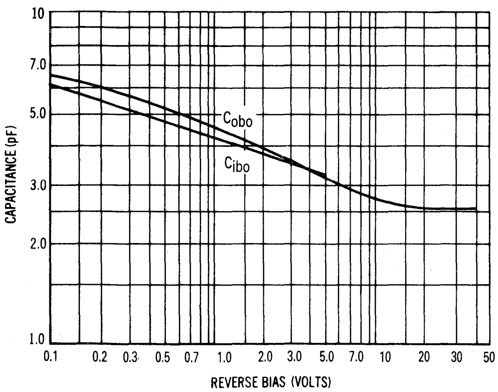


FIGURE 4 – CHARGE DATA

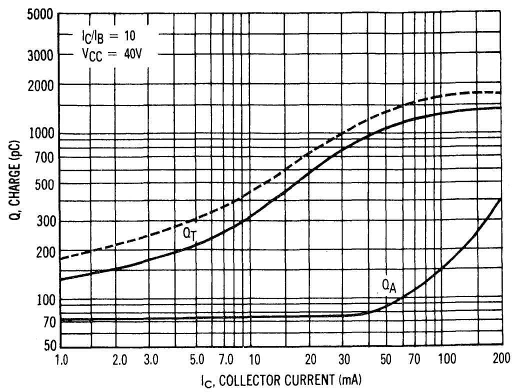


FIGURE 5 — TURN-ON TIME

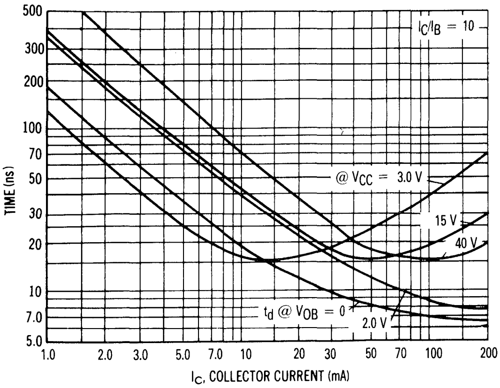
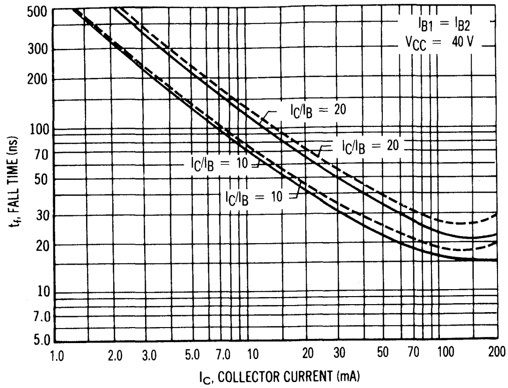


FIGURE 6 — FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

$V_{CE} = -5.0$ Vdc, $T_A = 25°C$,
Bandwidth = 1.0 Hz

FIGURE 7 —

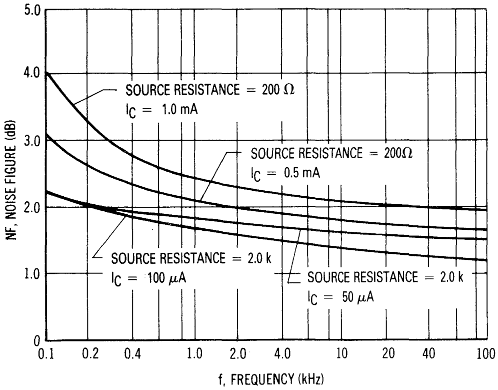
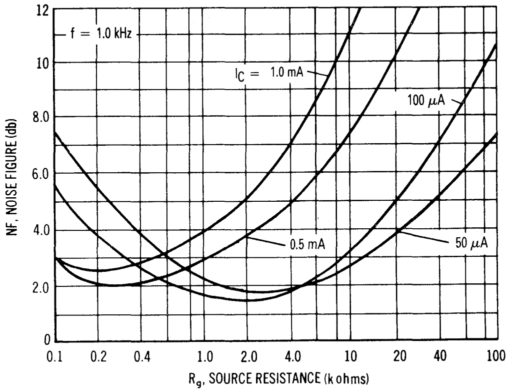


FIGURE 8 —



h PARAMETERS

($V_{CE} = -10$ Vdc, f = 1.0 kHz, $T_A = 25$ °C)

FIGURE 9 — CURRENT GAIN

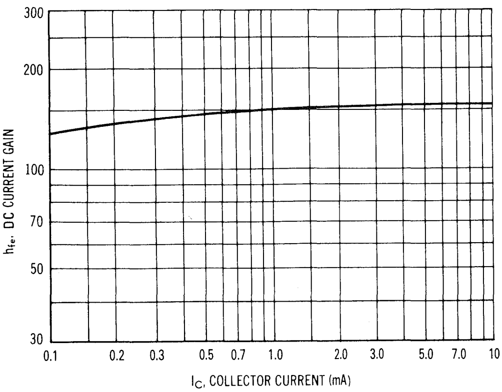


FIGURE 10 — OUTPUT ADMITTANCE

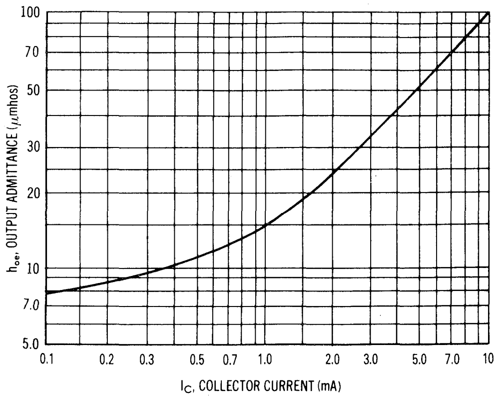


FIGURE 11 — INPUT IMPEDANCE

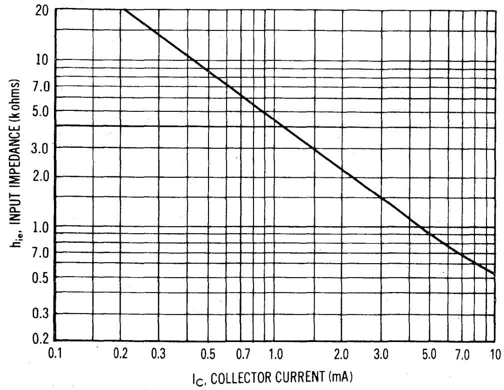
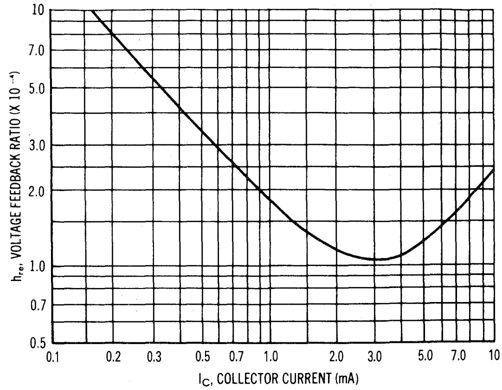


FIGURE 12 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 13 — DC CURRENT GAIN

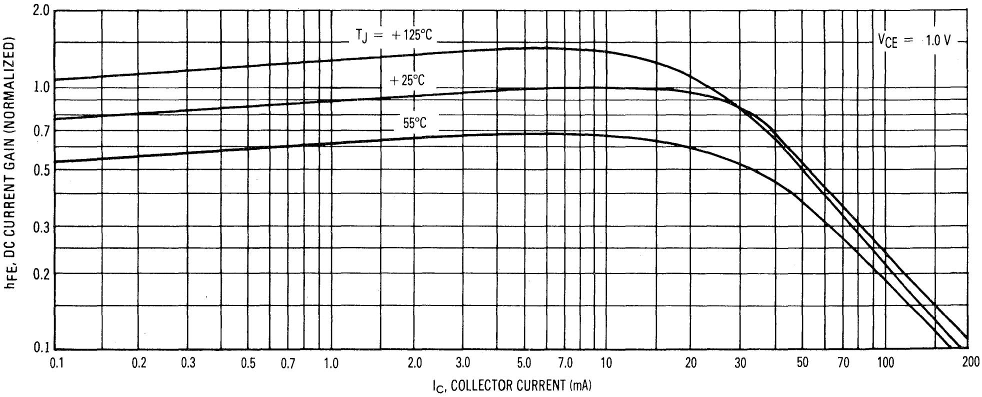
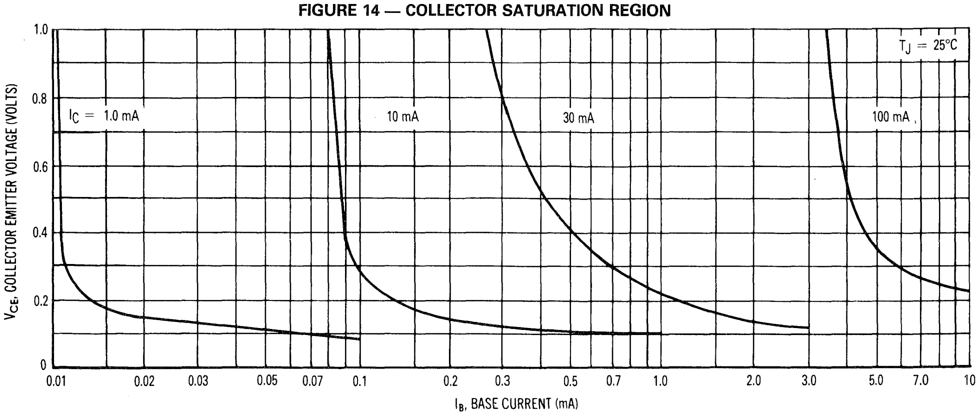


FIGURE 14 — COLLECTOR SATURATION REGION



2

FIGURE 15 — "ON" VOLTAGES

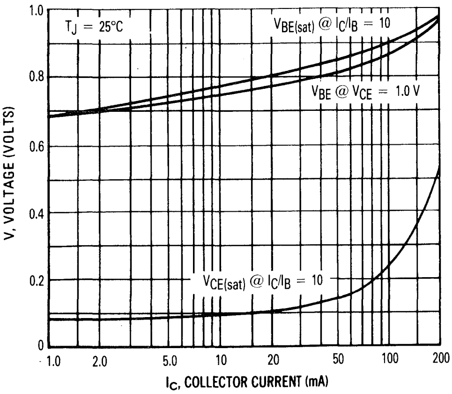
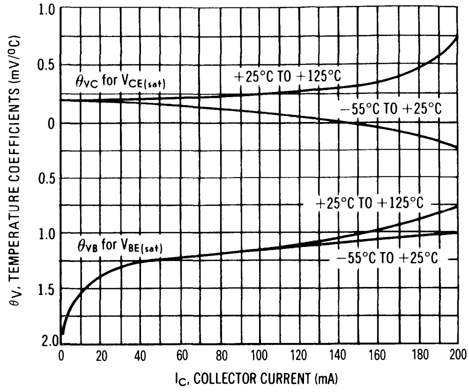
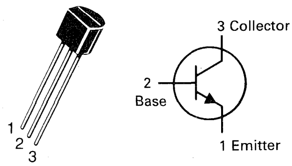


FIGURE 16 — TEMPERATURE COEFFICIENTS



2N4123
2N4124

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

2

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 @ $T_A = 25°C$ 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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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, $I_E = 0$)	 2N4123 2N4124	$V_{(BR)CEO}$	 30 25	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	 2N4123 2N4124	$V_{(BR)CBO}$	 40 30	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$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 ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 2.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	 2N4123 2N4124 2N4123 2N4124	h_{FE}	 50 120 25 60	 150 360 — —	—
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)	 2N4123 2N4124	f_T	 250 300	 — —	MHz
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Collector-Base Capacitance ($I_E = 0$, $V_{CB} = 5.0$ V, f = 1.0 MHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 10$ k ohm, f = 1.0 kHz)	 2N4123 2N4124	h_{fe}	 50 120	 200 480	—

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

Characteristic		Symbol	Min	Max	Unit
Current Gain — High Frequency		$\|h_{fe}\|$			—
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123		2.5	—	
	2N4124		3.0	—	
(I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz)	2N4123		50	200	
(I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz)	2N4124		120	480	
Noise Figure		NF			dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm,	2N4123		—	6.0	
f = 1.0 kHz)	2N4124		—	5.0	

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

FIGURE 1 — CAPACITANCE

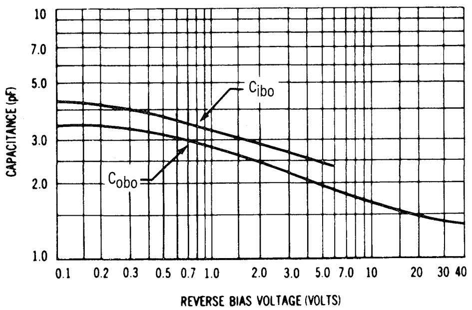
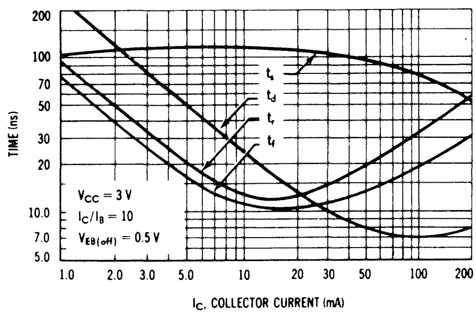


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

(V_{CE} = 5 Vdc, T_A = 25°C)
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

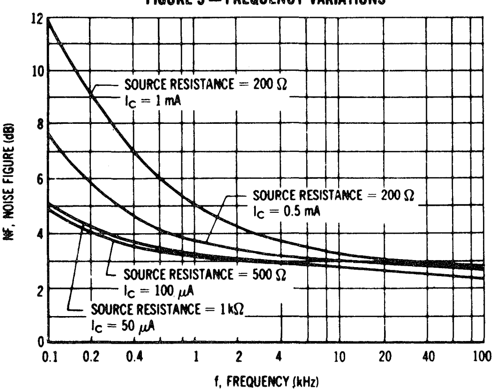
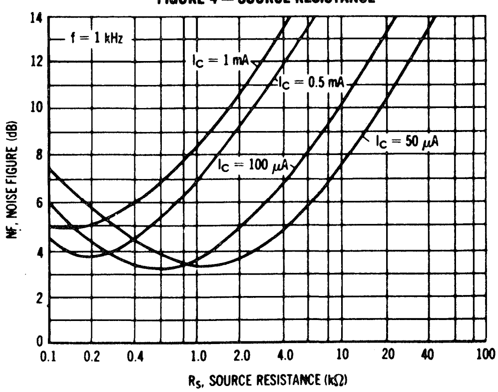


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

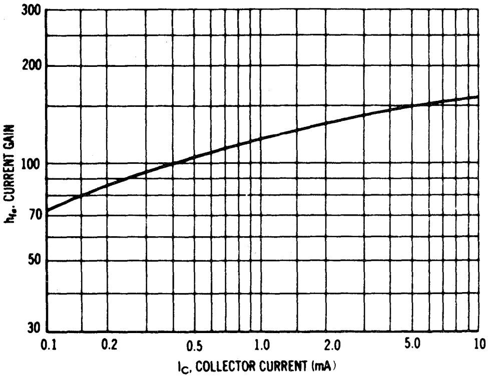
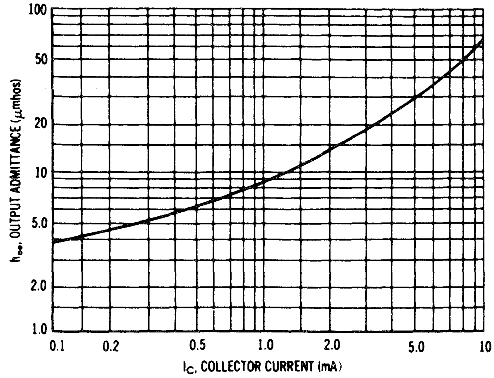


FIGURE 6 — OUTPUT ADMITTANCE



2

FIGURE 7 — INPUT IMPEDANCE

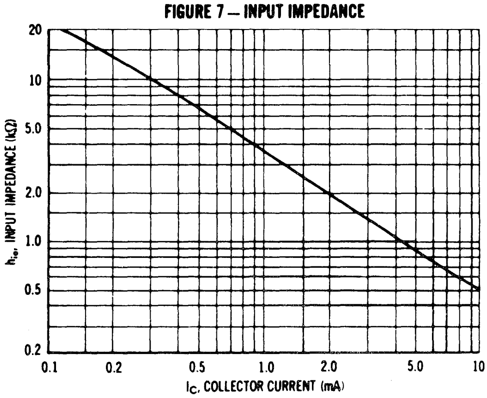
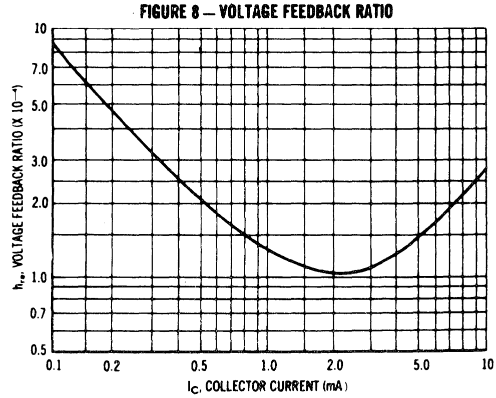
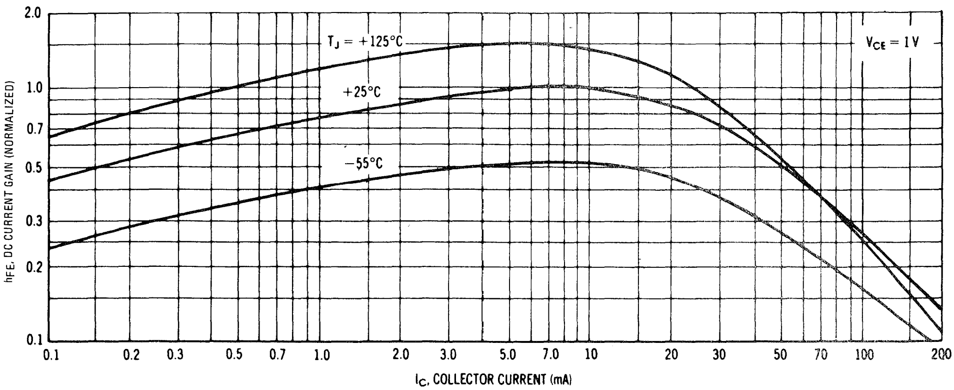


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — DC CURRENT GAIN



2

FIGURE 10 — COLLECTOR SATURATION REGION

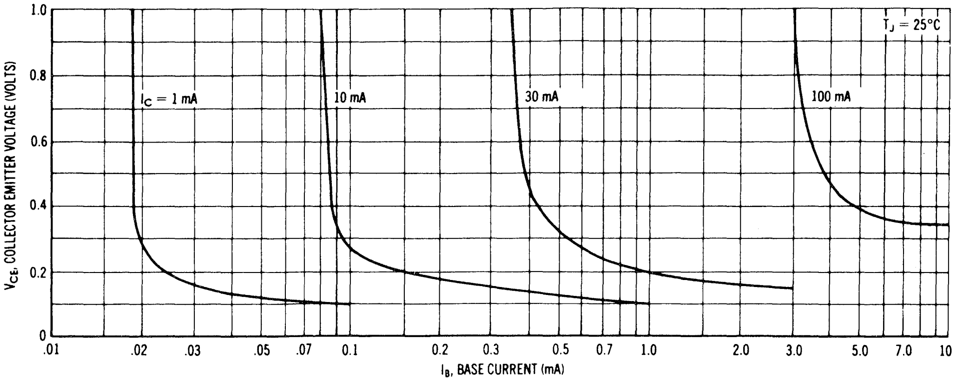


FIGURE 11 — "ON" VOLTAGES

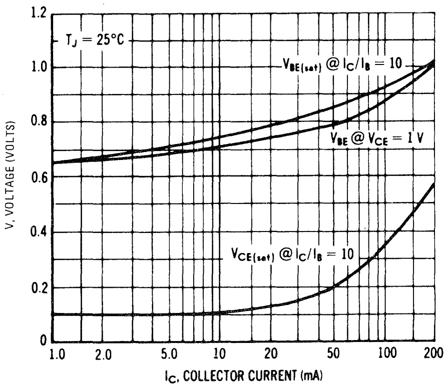
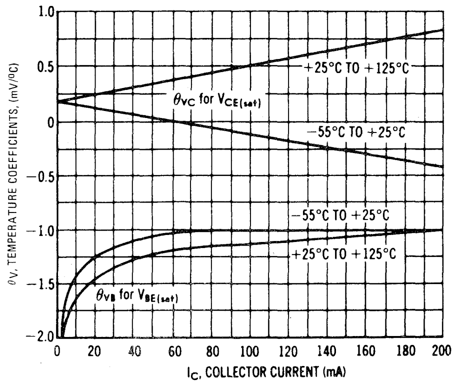
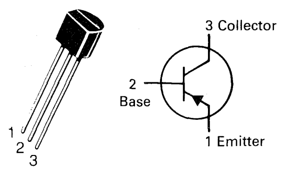


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4125
2N4126

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

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		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		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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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, $I_E = 0$)	2N4125 2N4126	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	2N4125 2N4126	$V_{(BR)CBO}$	30 25	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ 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(1) ($I_C = 2.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4125 2N4126	h_{FE}	50 120	150 360	—
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4125 2N4126		25 60	— —	
Collector-Emitter Saturation Voltage (1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	—	0.4	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)	2N4125 2N4126	f_T	200 250	— —	MHz
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	10	pF
Collector-Base Capacitance ($V_{CB} = 5.0$ V_{dc}, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	4.5	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	2N4125 2N4126	h_{fe}	50 120	200 480	—
Current Gain — High Frequency ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	2N4125 2N4126	$\|h_{fe}\|$	2.0 2.5	— —	—
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ k ohm, f = 1.0 KHz)	2N4125 2N4126	NF	— —	5.0 4.0	dB

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

2

FIGURE 1 — CAPACITANCE

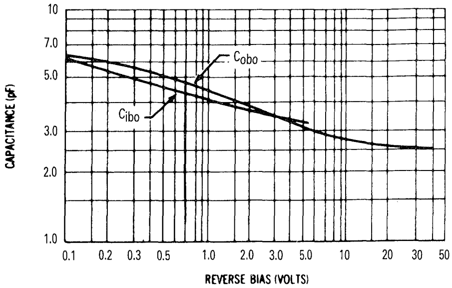
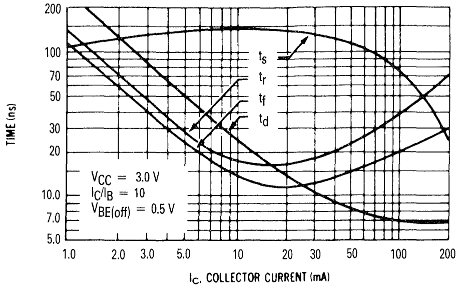


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = -5.0$ Vdc, $T_A = 25°C$,
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

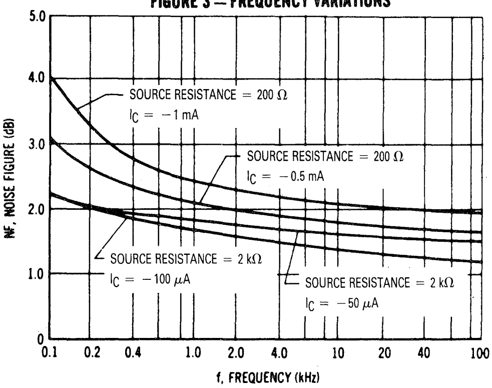
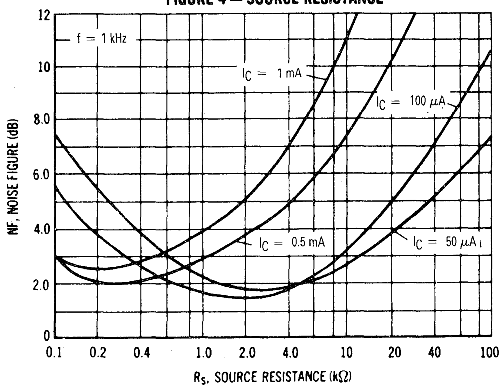


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

$V_{CE} = 10$ V, f = 1 kHz, $T_A = 25°C$

FIGURE 5 — CURRENT GAIN

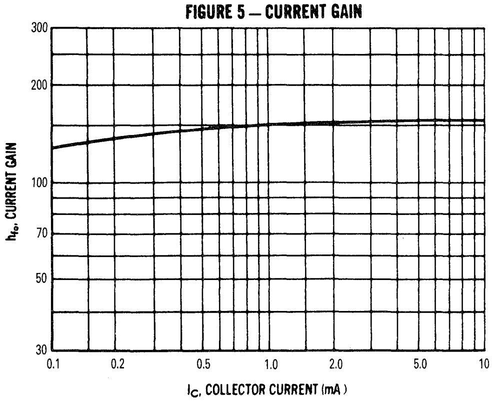


FIGURE 6 — OUTPUT ADMITTANCE

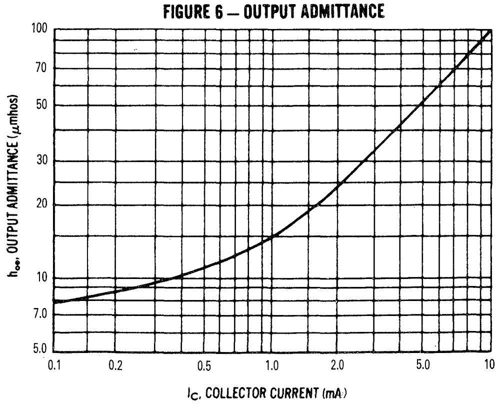


FIGURE 7 — INPUT IMPEDANCE

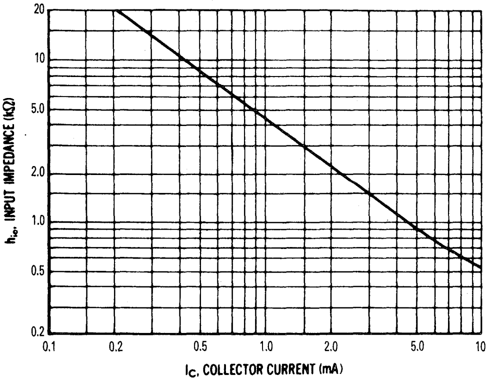
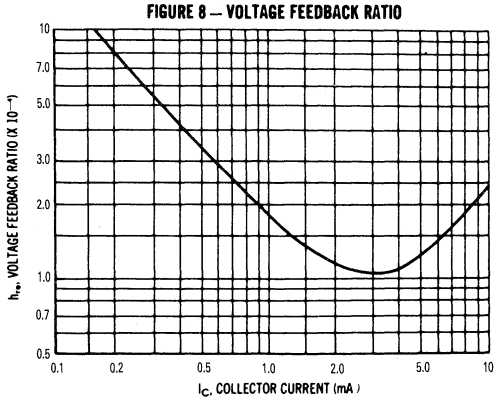


FIGURE 8 — VOLTAGE FEEDBACK RATIO



2

STATIC CHARACTERISTICS

FIGURE 9 — DC CURRENT GAIN

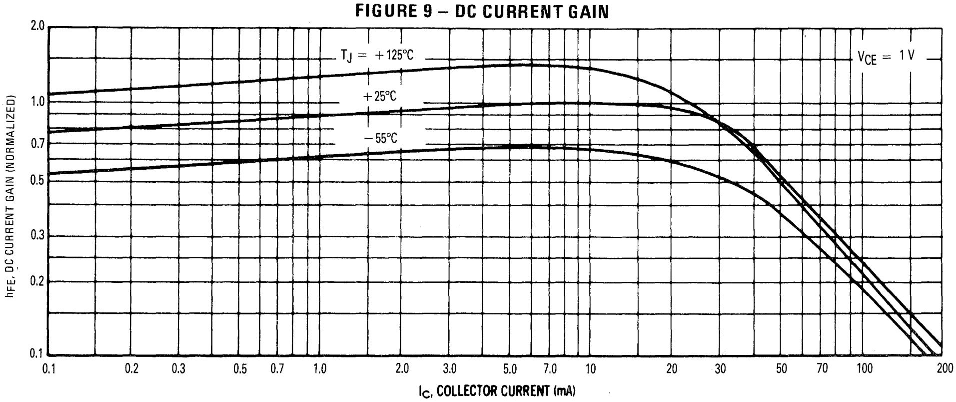
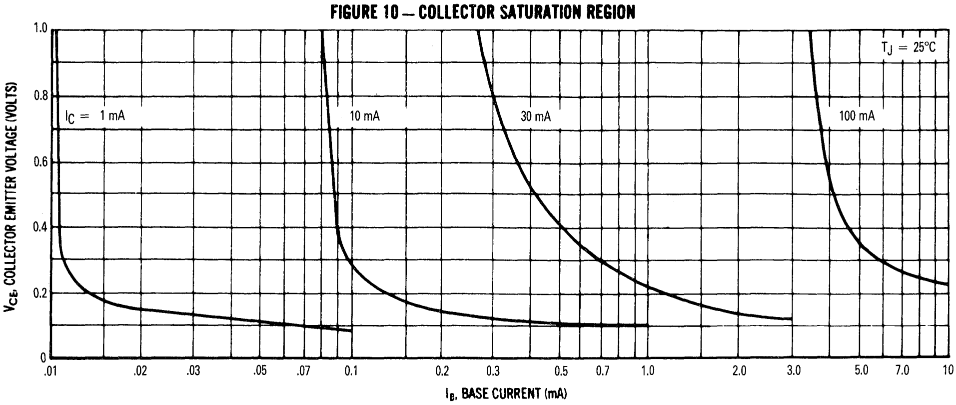


FIGURE 10 — COLLECTOR SATURATION REGION



2

FIGURE 11 — "ON" VOLTAGES

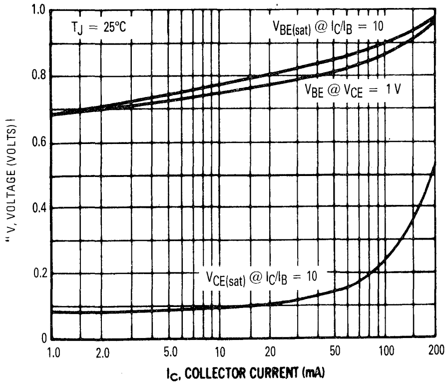
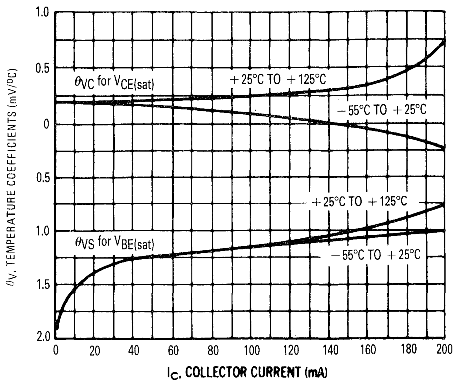
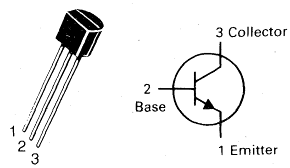


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4264
2N4265

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Characteristic	Symbol	2N4264	2N4265	Unit
Collector-Emitter Voltage	V_{CEO}	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 @ $T_A = 25°C$ 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		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	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_E = 0$)	 2N4264 2N4265	$V_{(BR)CEO}$	 15 12	 — —	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, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 12$ Vdc, $V_{EB(off)} = 0.25$ Vdc) ($V_{CE} = 12$ Vdc, $V_{EB(off)} = 0.25$ Vdc, $T_A = 100°C$)		I_{BEV}	 — —	 0.1 10	µAdc
Collector Cutoff Current ($V_{CE} = 12$ Vdc, $V_{EB(off)} = 0.25$ Vdc)		I_{CEX}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	 2N4264 2N4265	h_{FE}	 25 50	 — —	—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4264 2N4265		40 100	160 400	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)	2N4264 2N4265		20 45	— —	
($I_C = 30$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4264 2N4265		40 90	— —	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	2N4264 2N4265		30 55	— —	
($I_C = 200$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	2N4264 2N4265		20 55	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)(1)		$V_{CE(sat)}$	 — —	 0.22 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)(1)		$V_{BE(sat)}$	 0.65 0.75	 0.8 0.95	Vdc

2

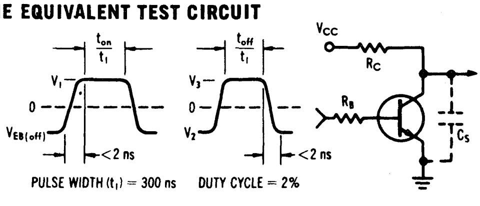
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	—	MHz
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz, I_E = 0)		C_{obo}	—	4.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 10 Vdc, $V_{EB(off)}$ = 2.0 Vdc, I_C = 100 mAdc, I_{B1} = 10 mAdc) (Fig. 1, Test Condition C)	t_d	—	8.0	ns
Rise Time		t_r	—	15	ns
Storage Time	V_{CC} = 10 Vdc, (I_C = 10 mAdc, for t_s) (I_C = 100 mA for t_f) (I_{B1} = −10 mA) (I_{B2} = 10 mA) (Fig. 1, Test Condition C)	t_s	—	20	ns
Fall Time		t_f	—	15	ns
Turn-On Time	(V_{CC} = 3.0 Vdc, $V_{EB(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Fig. 1, Test Condition A)	t_{on}	—	25	ns
Turn-Off Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc) (Fig. 1, Test Condition A)	t_{off}	—	35	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 10 mA, I_{B1} = I_{B2} = 10 mAdc) (Fig. 1, Test Condition B)	t_s	—	20	ns
Total Control Charge	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_B = mAdc) (Fig. 3, Test Condition A)	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_S	R_C	$C_{S(max)}$	$V_{BE(off)}$	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

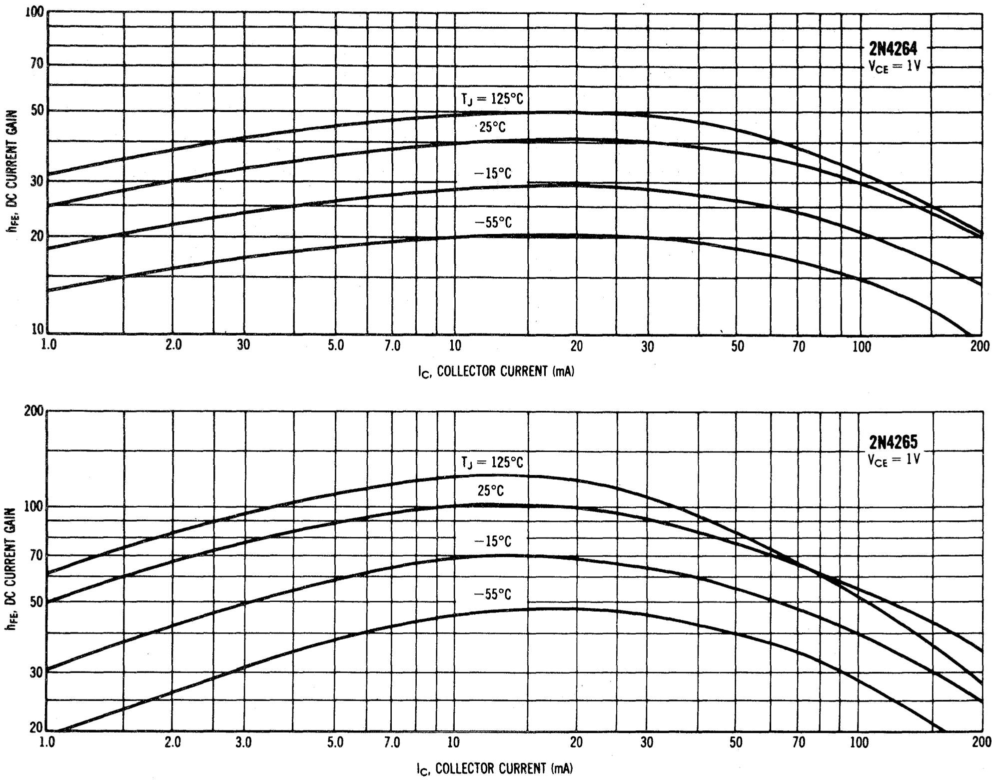


FIGURE 3 — Q_T TEST CIRCUIT

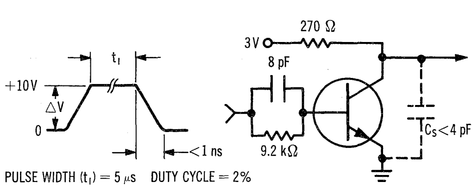
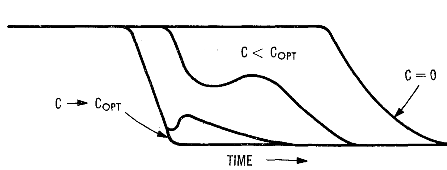


FIGURE 4 — TURN-OFF WAVEFORM



NOTE 1

When a transistor is held in a conductive state by a base current, I_B, a charge, Q_S, is developed or "stored" in the transistor. Q_S may be written: $Q_S = Q_I + Q_V + Q_X$.

Q_I is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_V is the charge required to charge the collector-base feedback capacity. Q_X 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_I and Q_V which is defined as the active region charge, Q_A. $Q_A = I_{B1}t_r$ when the transistor is driven by a constant current step (I_{B1}) and $I_{B1} << \frac{I_C}{h_{FE}}$.

If I_B were suddenly removed, the transistor would continue to conduct until Q_S 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_T, 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_T from Figure 13, the external C for worst-case turn-off in any circuit is: $C = Q_T/\triangle V$, where $\triangle V$ is defined in Figure 3.

2

"ON" CONDITION CHARACTERISTICS

FIGURE 5 — COLLECTOR SATURATION REGION

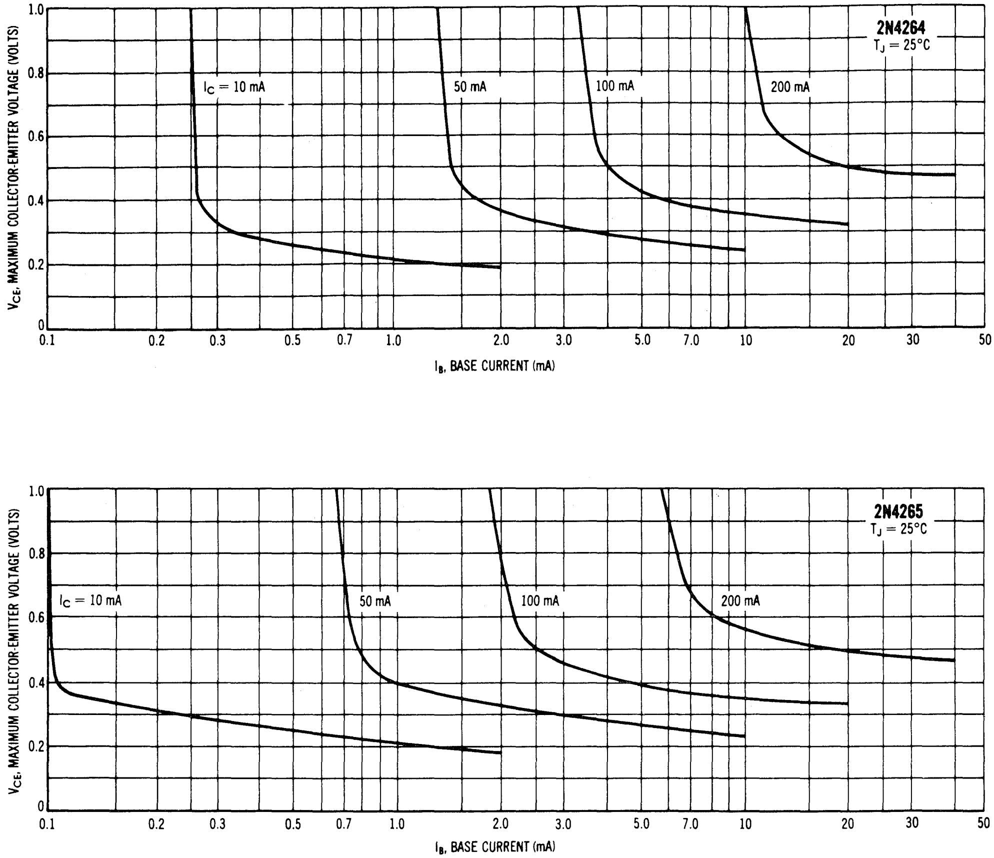


FIGURE 6 — SATURATION VOLTAGE LIMITS

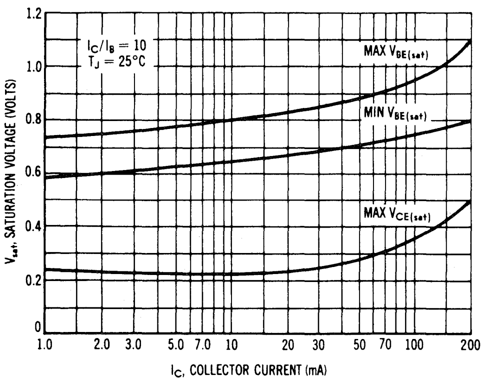
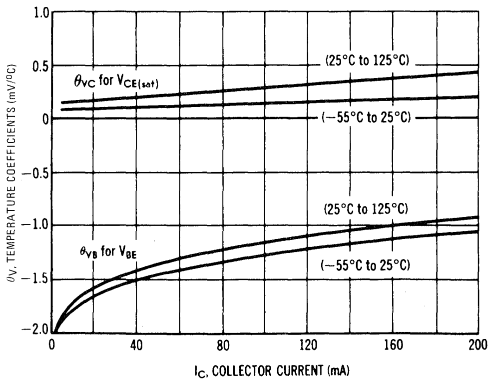


FIGURE 7 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 8 — DELAY TIME

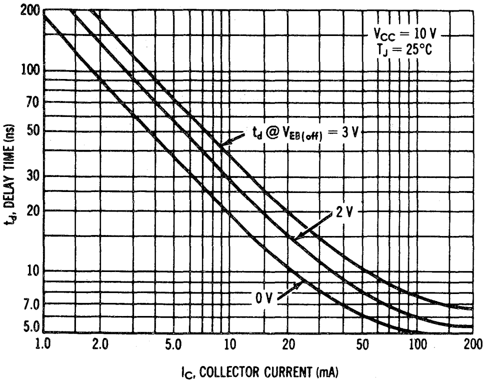


FIGURE 9 — RISE TIME

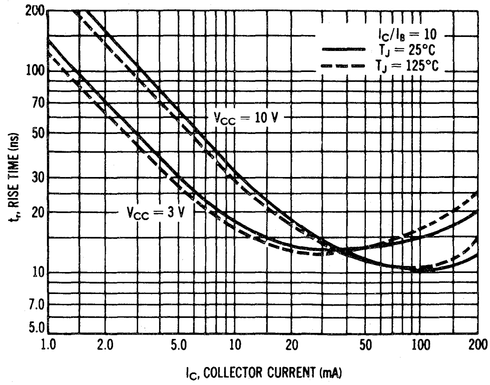


FIGURE 10 — STORAGE TIME

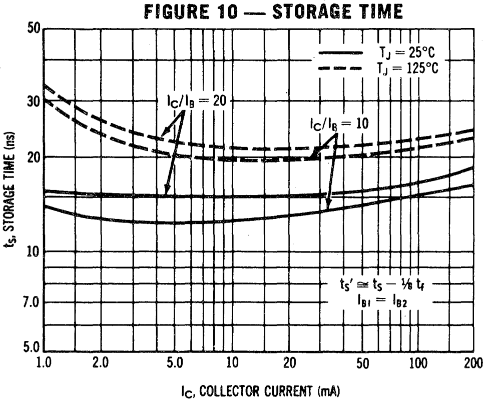


FIGURE 11 — FALL TIME

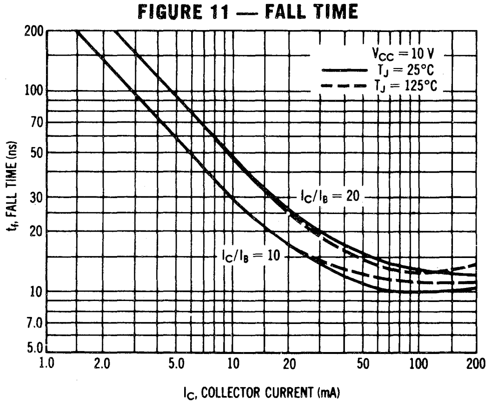


FIGURE 12 — JUNCTION CAPACITANCE

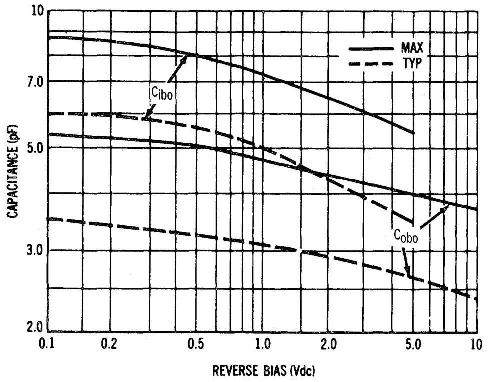
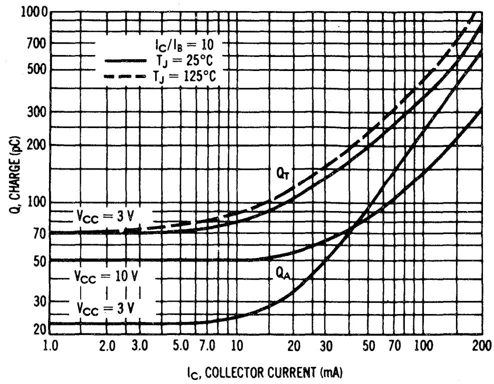
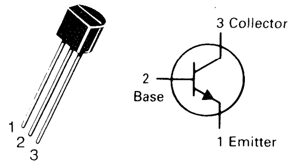


FIGURE 13 — MAXIMUM CHARGE DATA



2N4400
2N4401★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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)		$V_{(BR)CEO}$	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)	2N4401	h_{FE}	20	—	—
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N4400 2N4401		20 40	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4400 2N4401		40 80	— —	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N4400 2N4401		50 100	150 300	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N4400 2N4401		20 40	— —	
Collector-Emitter Saturation Voltage (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 (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)	2N4400 2N4401	f_T	200 250	— —	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	6.5	pF

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

Characteristic		Symbol	Min	Max	Unit
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400 2N4401	h_{ie}	0.5 1.0	7.5 15	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400 2N4401	h_{fe}	20 40	250 500	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	30	μmhos

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
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 ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

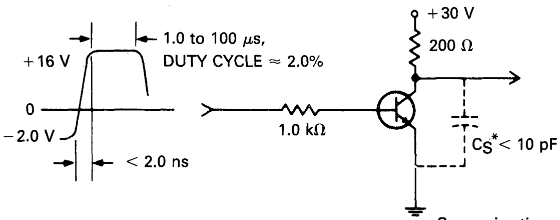
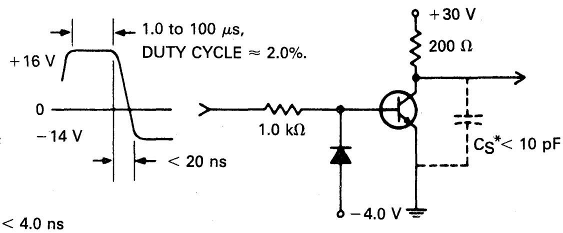


FIGURE 2 — TURN-OFF TIME



Scope rise time < 4.0 ns
*Total shunt capacitance of test jig connectors, and oscilloscope

TRANSIENT CHARACTERISTICS

——— 25°C — — — 100°C

FIGURE 3 — CAPACITANCES

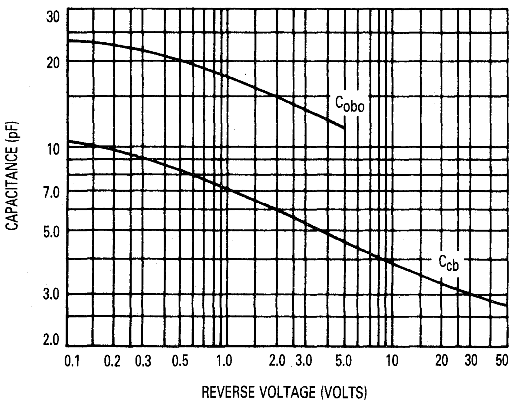


FIGURE 4 — CHARGE DATA

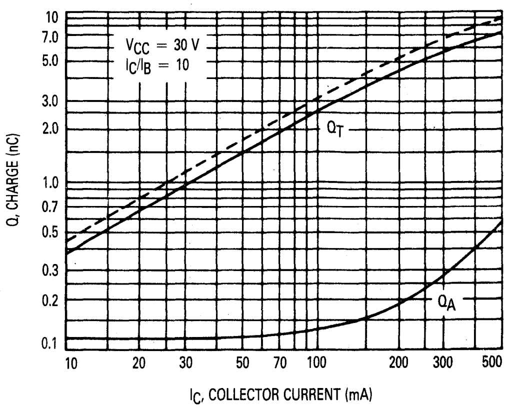


FIGURE 5 — TURN-ON TIME

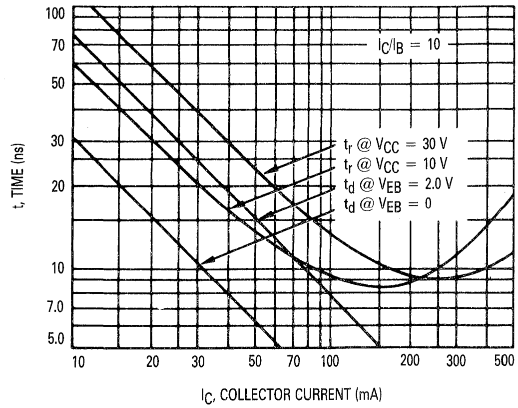


FIGURE 6 — RISE AND FALL TIMES

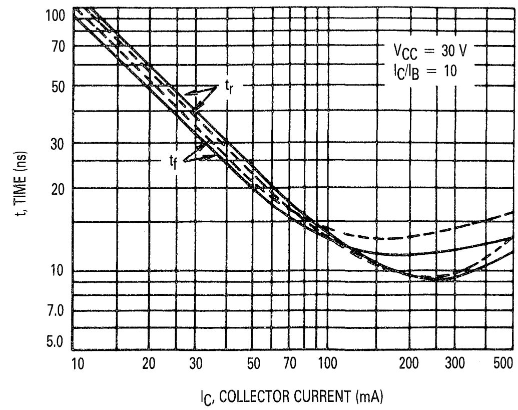


FIGURE 7 — STORAGE TIME

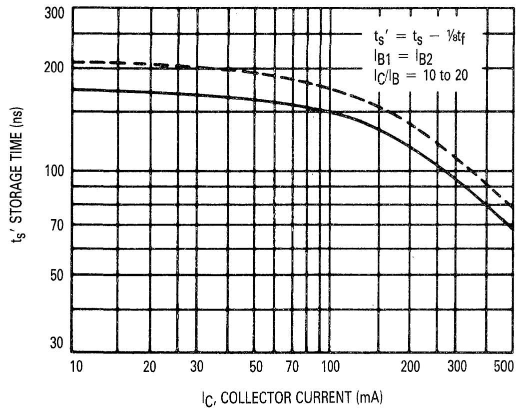
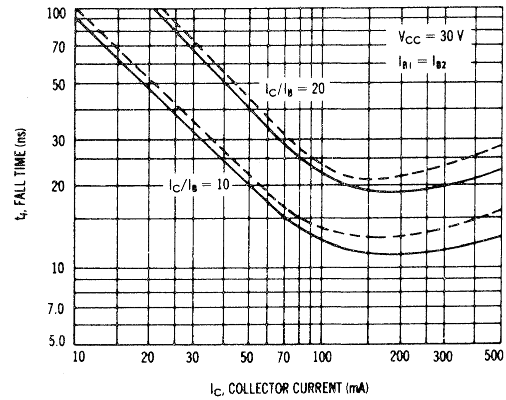


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C
Bandwidth = 1.0 Hz

FIGURE 9 — FREQUENCY EFFECTS

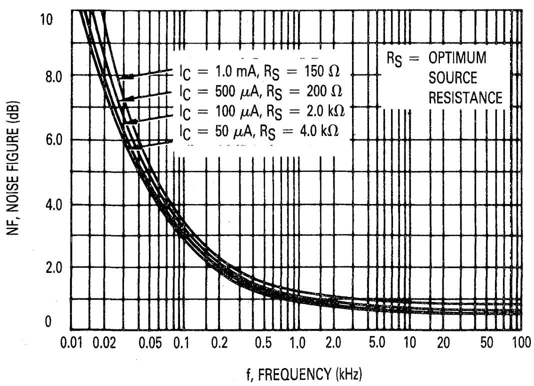
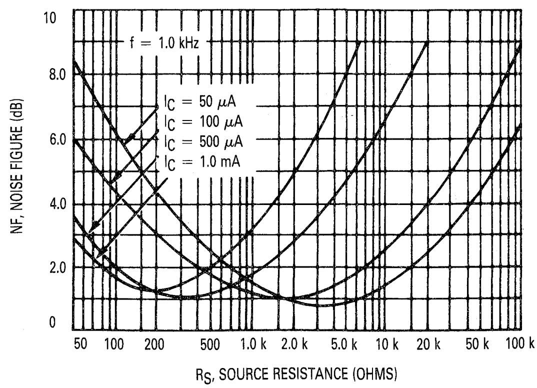


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°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

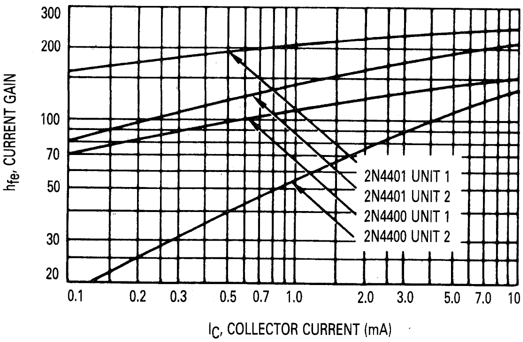


FIGURE 12 — INPUT IMPEDANCE

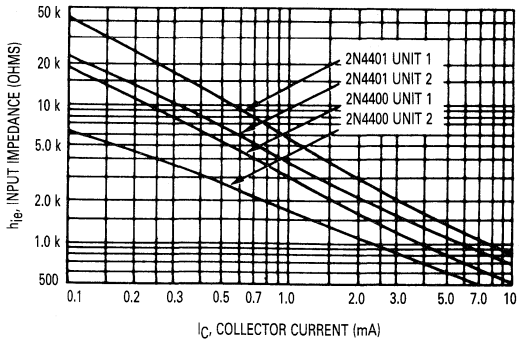


FIGURE 13 — VOLTAGE FEEDBACK RATIO

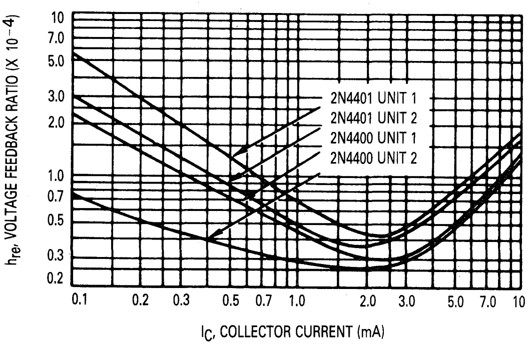
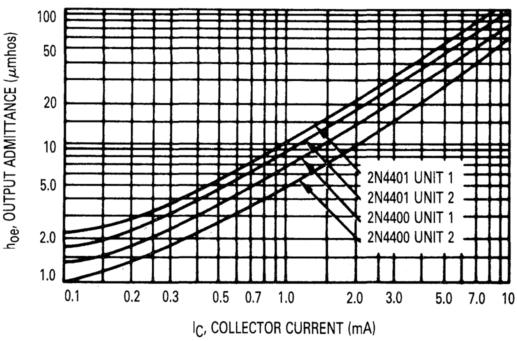
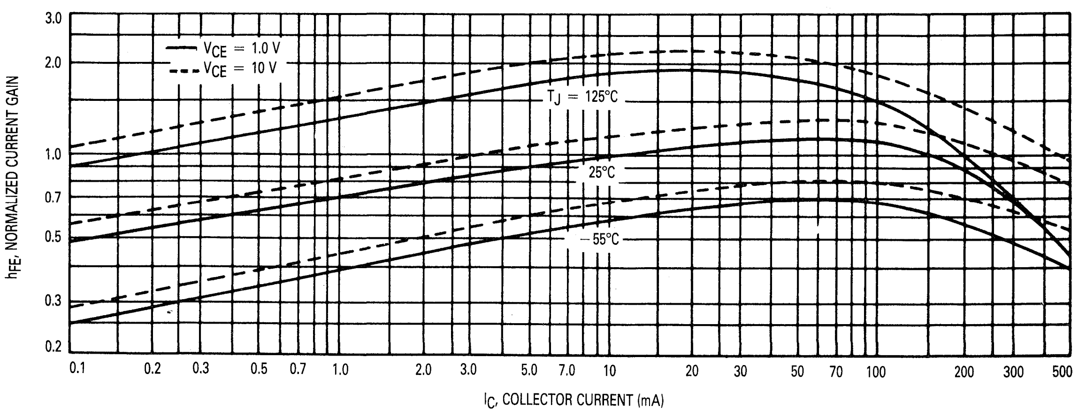


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN



2

FIGURE 16 — COLLECTOR SATURATION REGION

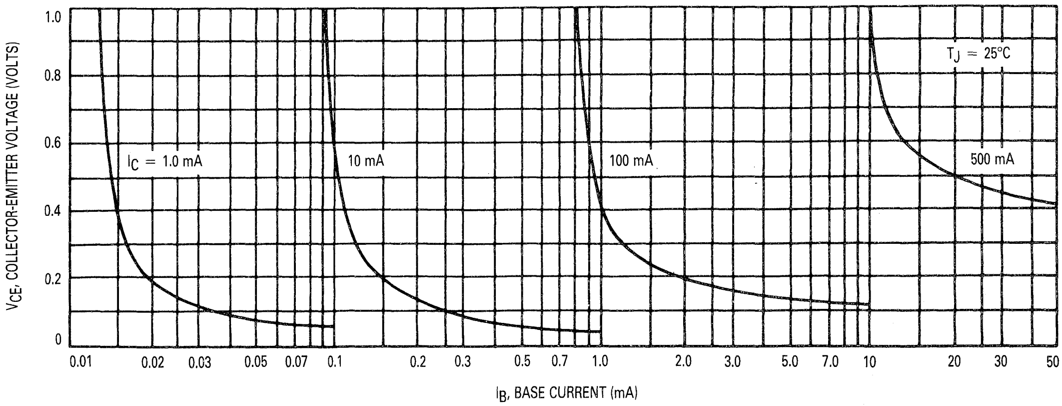


FIGURE 17 — "ON" VOLTAGES

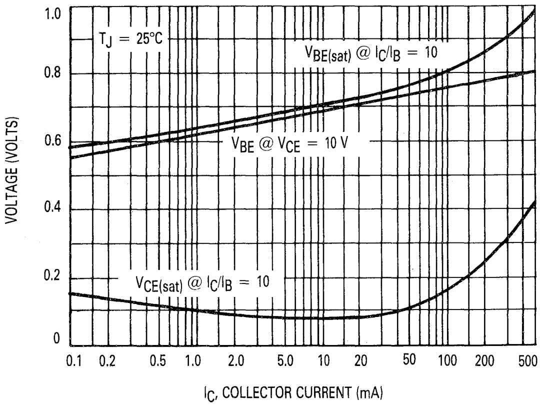
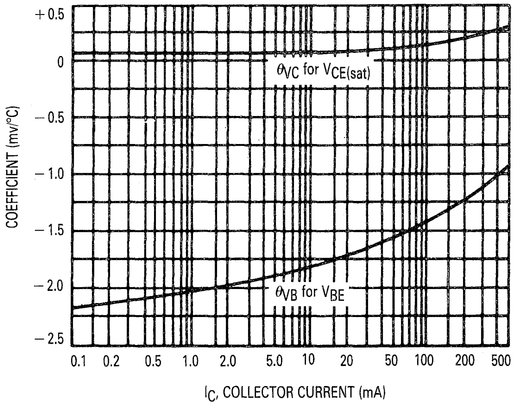
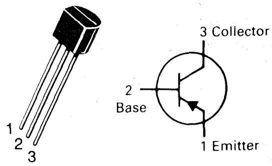


FIGURE 18 — TEMPERATURE COEFFICIENTS



2N4402
2N4403★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

2

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
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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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, $I_B = 0$)		$V_{(BR)CEO}$	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, $V_{EB} = 0.4$ 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					
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 = 1.0 MHz)		C_{cb}	—	8.5	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		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

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

Characteristic		Symbol	Min	Max	Unit
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4402 2N4403	h_{fe}	30 60	250 500	—
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} = 15 mA, I_{B2} = 15 mA)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

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

SWITCHING TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 — TURN-ON TIME

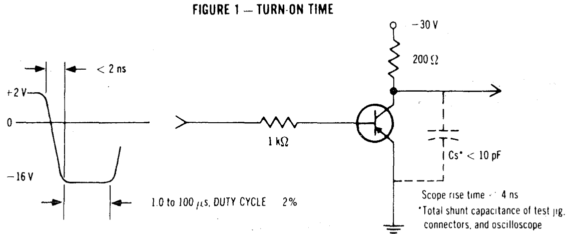
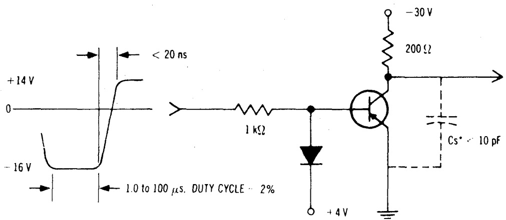


FIGURE 2 — TURN-OFF TIME



TRANSIENT CHARACTERISTICS

—— 25°C – – – 100°C

FIGURE 3 — CAPACITANCES

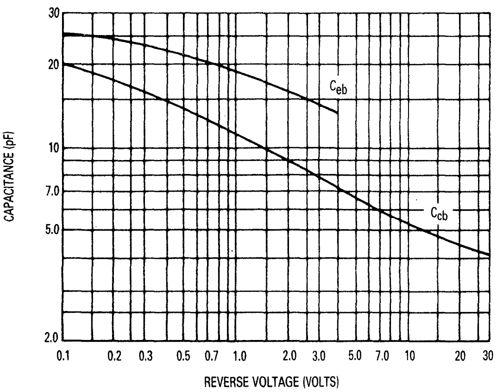


FIGURE 4 — CHARGE DATA

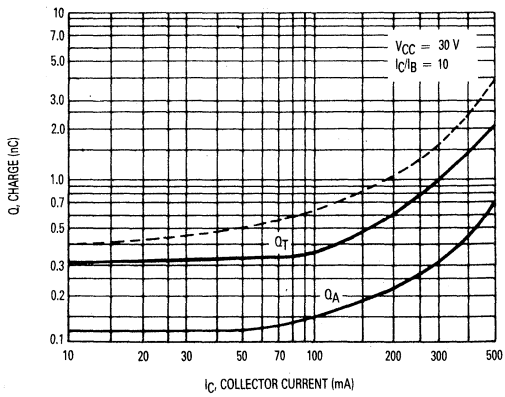


FIGURE 5 — TURN-ON TIME

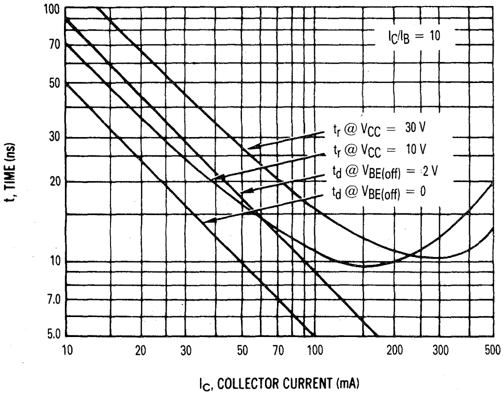


FIGURE 6 — RISE TIME

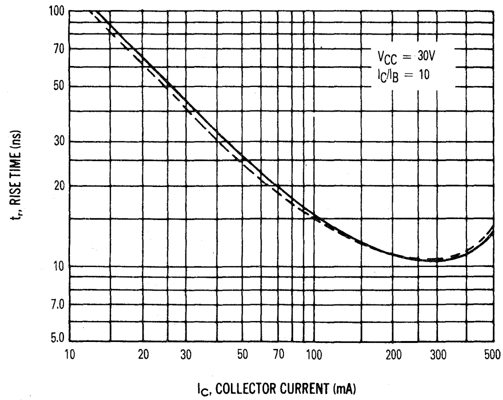
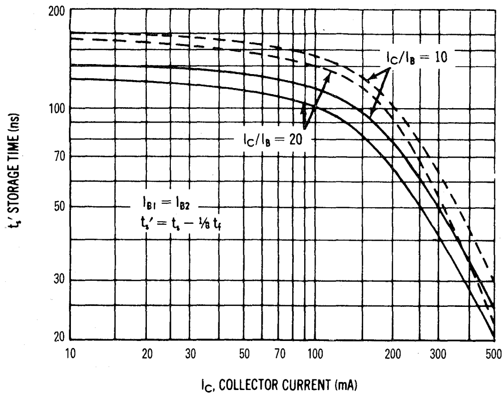


FIGURE 7 — STORAGE TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = -10$ Vdc, $T_A = 25°C$

Bandwidth = 1.0 Hz

FIGURE 8 — FREQUENCY EFFECTS

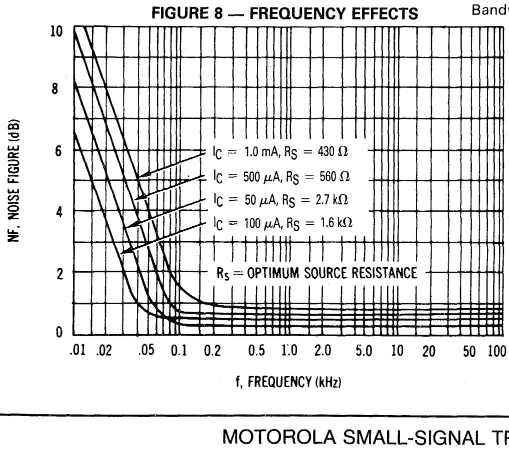
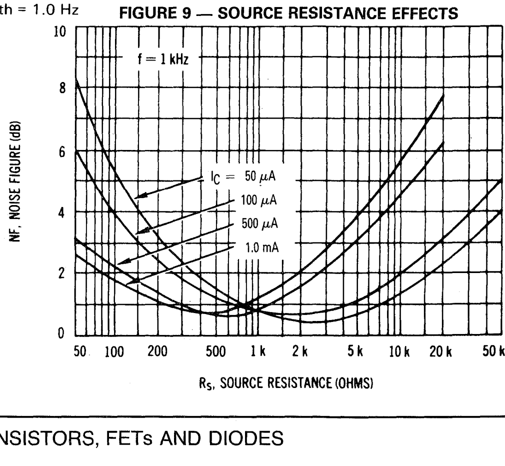


FIGURE 9 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

$V_{CE} = -10$ Vdc, f = 1.0 kHz, $T_A = 25°C$

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.

2

FIGURE 10 — CURRENT GAIN

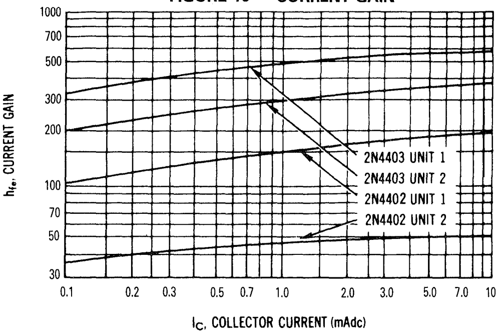


FIGURE 11 — INPUT IMPEDANCE

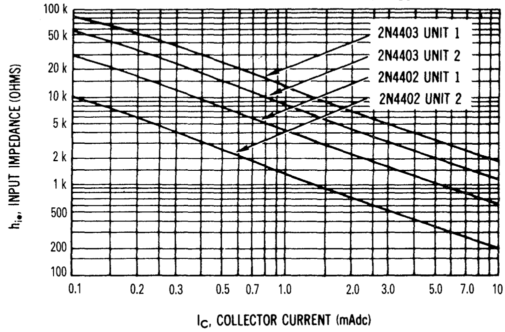


FIGURE 12 — VOLTAGE FEEDBACK RATIO

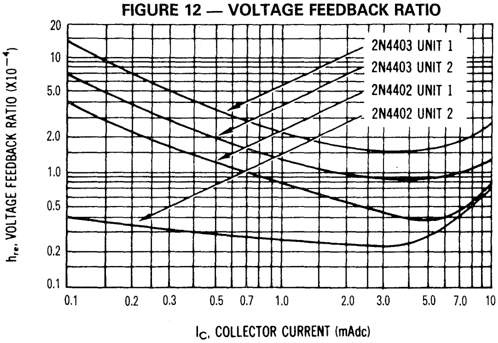
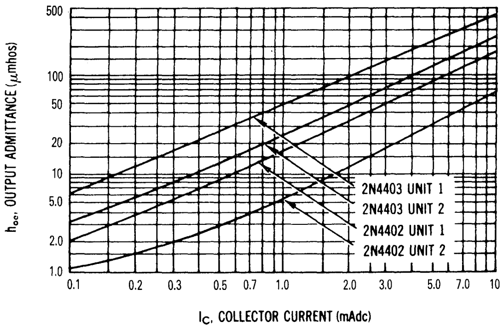


FIGURE 13 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 14 — DC CURRENT GAIN

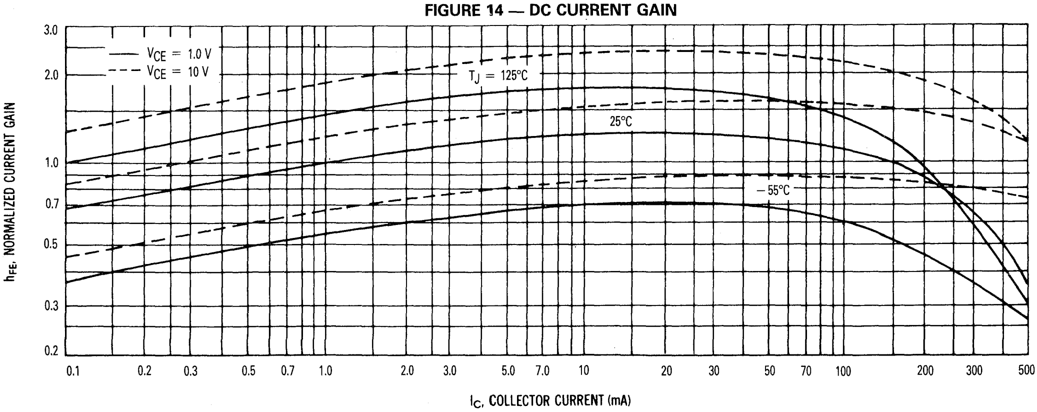


FIGURE 15 — COLLECTOR SATURATION REGION

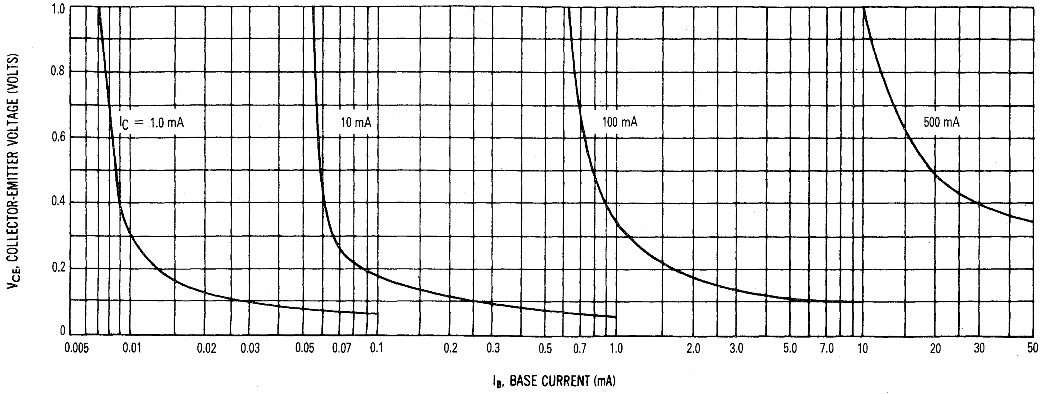


FIGURE 16 — "ON" VOLTAGES

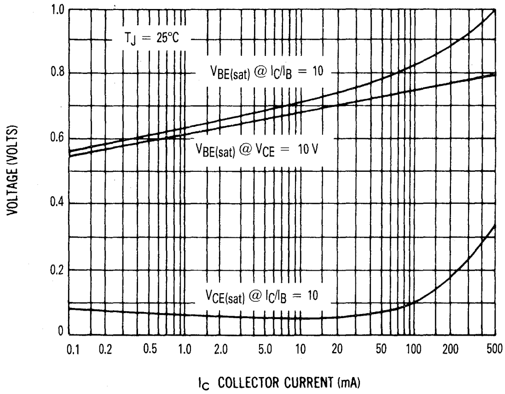
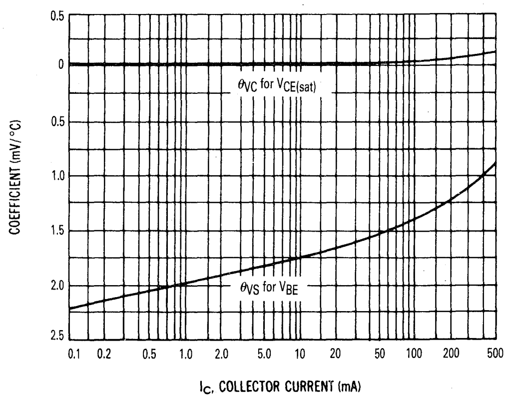


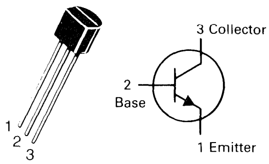
FIGURE 17 — TEMPERATURE COEFFICIENTS



2

2N4410

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

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	250	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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

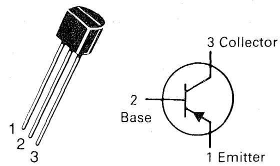
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 500 μAdc, V_{BE} = 5.0 Vdc, R_{BE} = 8.2 k ohms)	$V_{(BR)CEX}$	120	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	120	—	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 = 100°C)	I_{CBO}	 — —	 0.01 1.0	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} = 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 = 20 MHz)	f_T	60	300	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded)	C_{cb}	—	12	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz, collector guarded)	C_{eb}	—	50	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2N5086
2N5087★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON
★This is a Motorola designated preferred device.

2

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

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)		$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, 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_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, 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 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	40	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		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 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	2N5086 2N5087	NF	— —	3.0 2.0	dB
(I_C = 100 μAdc, 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 μs, Duty Cycle ≤ 2.0%.

2

TYPICAL NOISE CHARACTERISTICS
(V_{CE} = −5.0 Vdc, T_A = 25°C)

FIGURE 1 — NOISE VOLTAGE

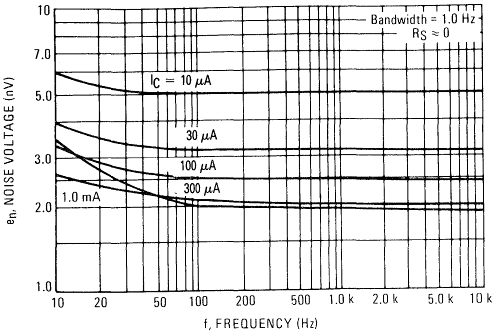
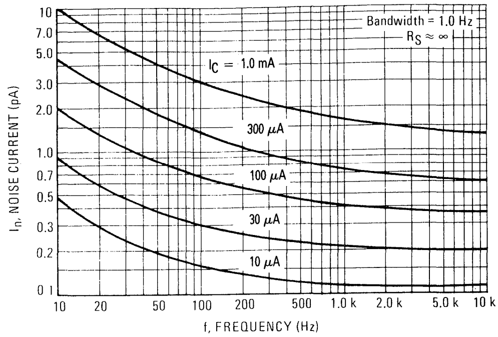


FIGURE 2 — NOISE CURRENT



NOISE FIGURE CONTOURS
(V_{CE} = −5.0 Vdc, T_A = 25°C)

FIGURE 3 — NARROW BAND, 100 Hz

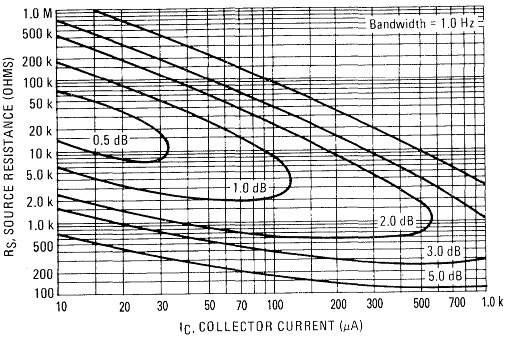


FIGURE 4 — NARROW BAND, 1.0 KHz

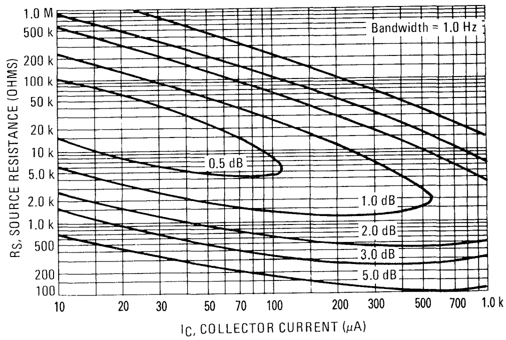
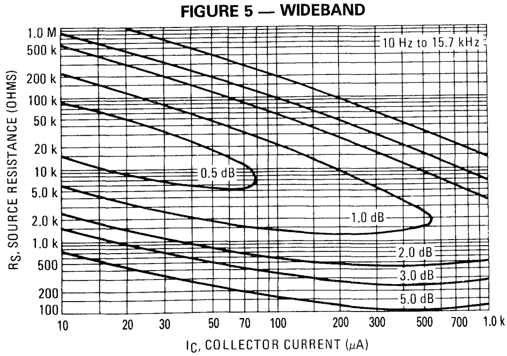


FIGURE 5 — WIDEBAND



Noise Figure is Defined as:

$$NF = 20 \log_{10} \left[\frac{e_n{}^2 + 4KTR_S + I_n{}^2 R_S{}^2}{4KTR_S} \right]^{1/2}$$

e_n = Noise Voltage of the Transistor referred to the input. (Figure 3)
I_n = Noise Current of the transistor referred to the input (Figure 4)
K = Boltzman's Constant (1.38×10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

FIGURE 6 — DC CURRENT GAIN

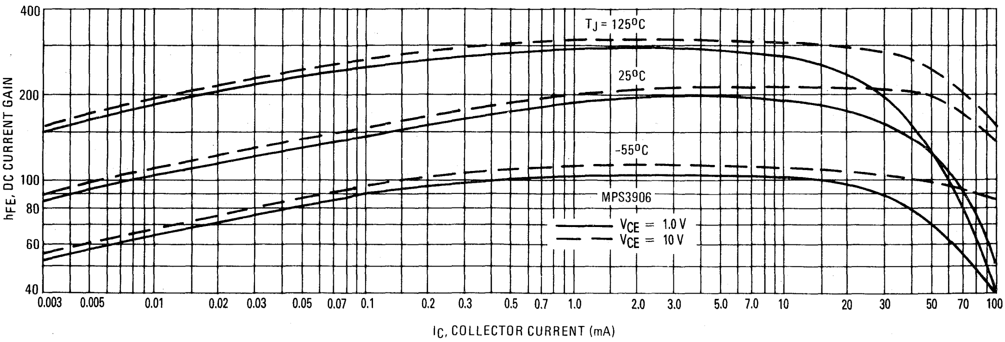


FIGURE 7 — COLLECTOR SATURATION REGION

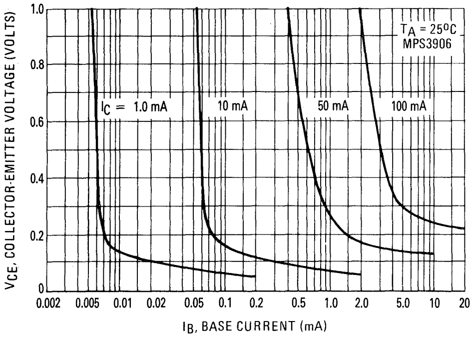


FIGURE 8 — COLLECTOR CHARACTERISTICS

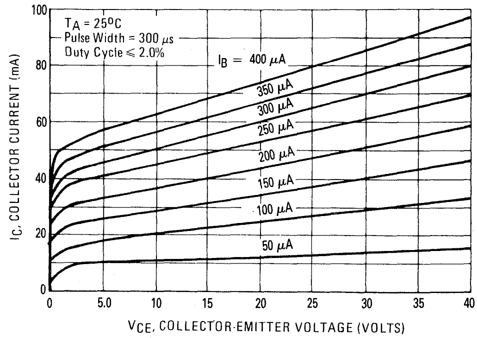


FIGURE 9 — "ON" VOLTAGES

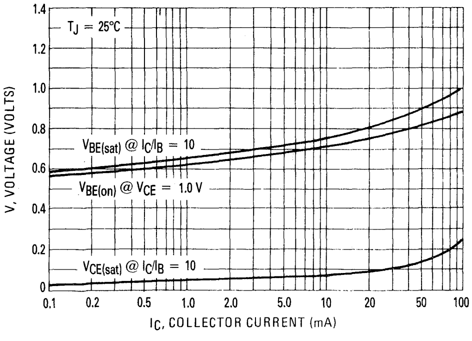
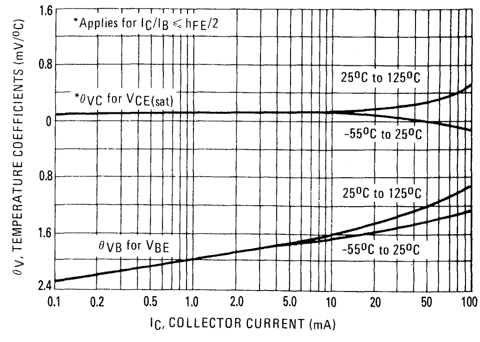


FIGURE 10 — TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

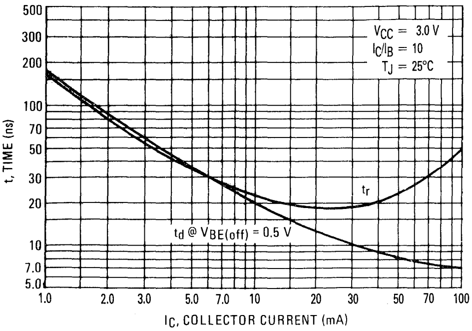


FIGURE 12 — TURN-OFF TIME

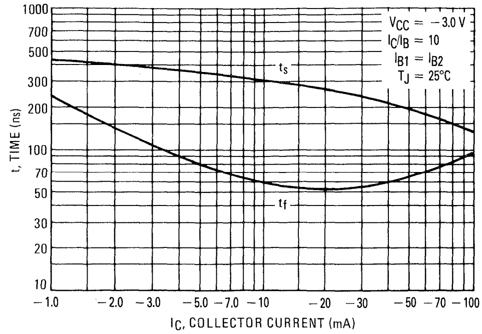


FIGURE 13 — CURRENT-GAIN — BANDWIDTH PRODUCT

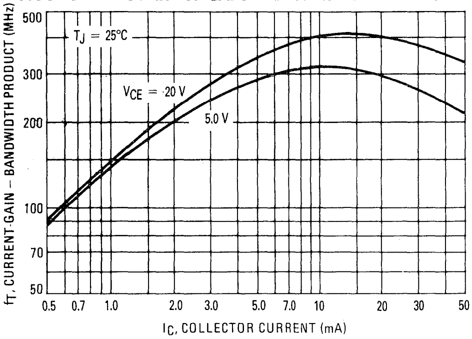


FIGURE 14 — CAPACITANCE

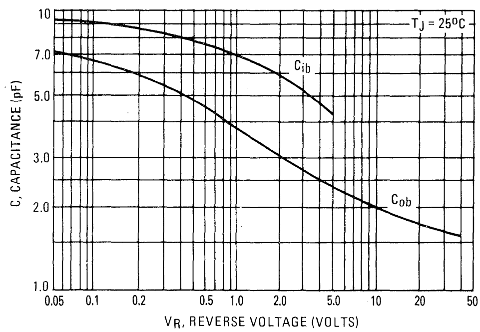


FIGURE 15 — INPUT IMPEDANCE

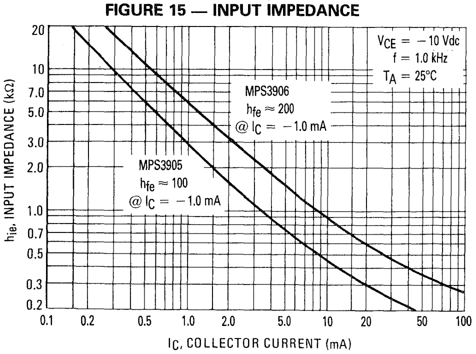


FIGURE 16 — OUTPUT ADMITTANCE

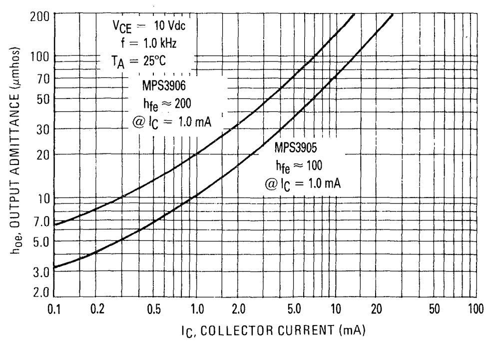


FIGURE 17 — THERMAL RESPONSE

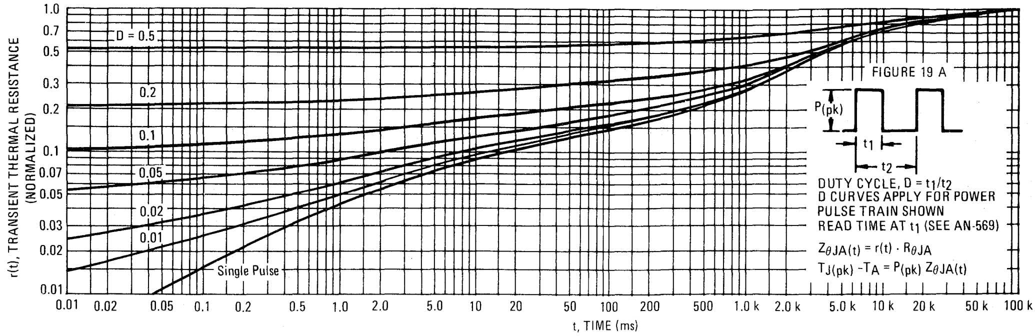
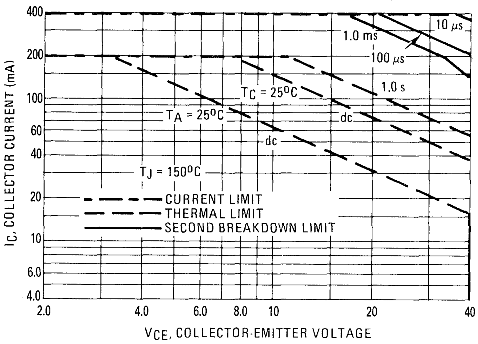


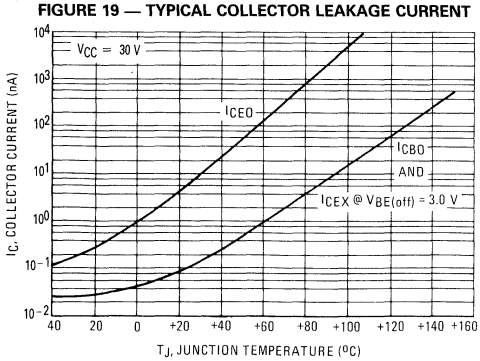
FIGURE 18 — ACTIVE-REGION SAFE OPERATING AREA



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 20 is based upon $T_{J(pk)} = 150°C$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 19. At high case or ambient temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 19 — TYPICAL COLLECTOR LEAKAGE CURRENT



DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19A. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 19 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 19 by the steady state value $R_{\theta JA}$.

Example:

The MPS3905 is dissipating 2.0 watts peak under the following conditions:

$t1 = 1.0$ ms, $t2 = 5.0$ ms $(D = 0.2)$

Using Figure 19 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

The peak rise in junction temperature is therefore

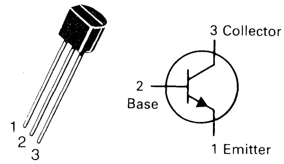
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C$.

For more information, see AN-569.

2

2N5088
2N5089

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

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}	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 Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

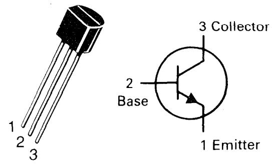
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	2N5088 2N5089	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N5088 2N5089	$V_{(BR)CBO}$	35 30	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0)	2N5088 2N5089	I_{CBO}	— —	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0) ($V_{EB(off)}$ = 4.5 Vdc, I_C = 0)		I_{EBO}	— —	50 100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	 2N5088 2N5089	h_{FE}	 300 400	 900 1200	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5088 2N5089		350 450	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)	2N5088 2N5089		300 400	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)		$V_{BE(on)}$	—	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	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	4.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	—	10	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 2N5088 2N5089	h_{fe}	 350 450	 1400 1800	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 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 ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N5209
2N5210

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MPSA18 for graphs.

2

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

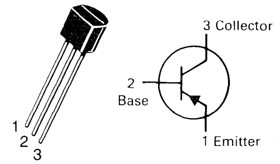
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	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_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	50	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)(1)	 2N5209 2N5210 2N5209 2N5210 2N5209 2N5210	h_{FE}	 100 200 150 250 150 250	 300 600 — — — —	—
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 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	30	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 2N5209 2N5210	h_{fe}	 150 250	 600 900	—
Noise Figure (I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 22 k ohms, f = 1.0 kHz) (I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	 2N5209 2N5210 2N5209 2N5210	NF	 — — — —	 3.0 2.0 4.0 3.0	dB

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

2N5400
2N5401★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	2N5400	2N5401	Unit
Collector-Emitter Voltage	V_{CEO}	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 @ $T_A = 25°C$ 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		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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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, $I_B = 0$)	 2N5400 2N5401	$V_{(BR)CEO}$	 120 150	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 2N5400 2N5401	$V_{(BR)CBO}$	 130 160	 — —	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, $I_E = 0$) ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 100°C$) ($V_{CB} = 120$ Vdc, $I_E = 0$, $T_A = 100°C$)	 2N5400 2N5401 2N5400 2N5401	I_{CBO}	 — — — —	 100 50 100 50	 nAdc μAdc
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) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc) 	 2N5400 2N5401 2N5400 2N5401 2N5400 2N5401	h_{FE}	 30 50 40 60 40 50	 — — 180 240 — —	—
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)	 2N5400 2N5401	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

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

Characteristic		Symbol	Min	Max	Unit
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5400 2N5401	h_{fe}	30 40	200 200	—
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)		NF	—	8.0	dB

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

2

FIGURE 1 — DC CURRENT GAIN

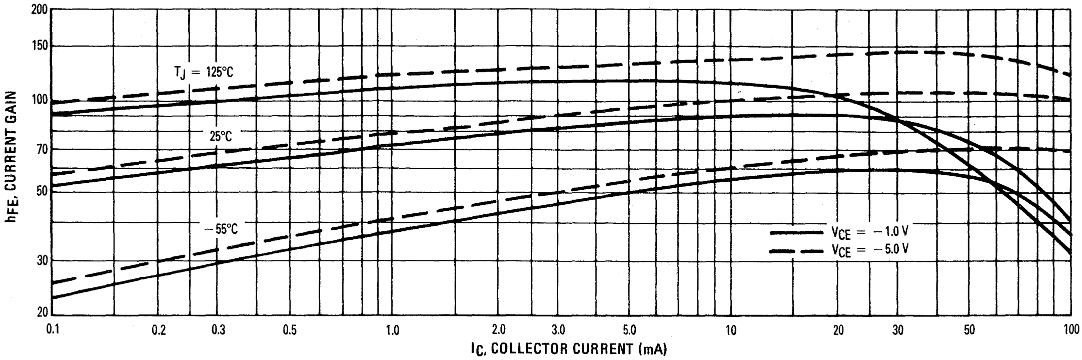


FIGURE 2 — COLLECTOR SATURATION REGION

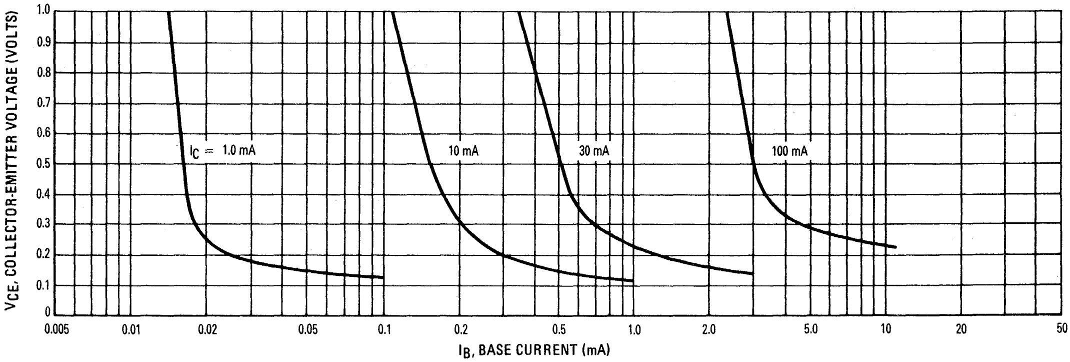
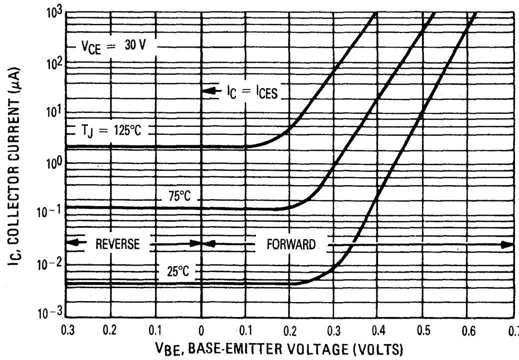


FIGURE 3 — COLLECTOR CUT-OFF REGION



2

FIGURE 4 — "ON" VOLTAGES

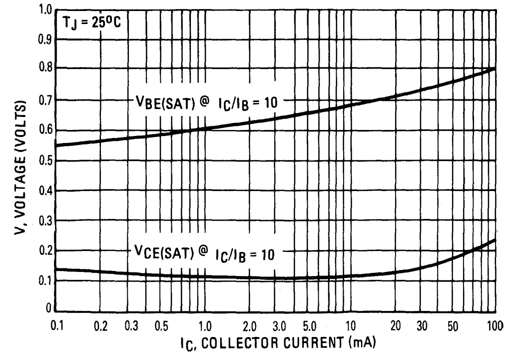


FIGURE 5 — TEMPERATURE COEFFICIENTS

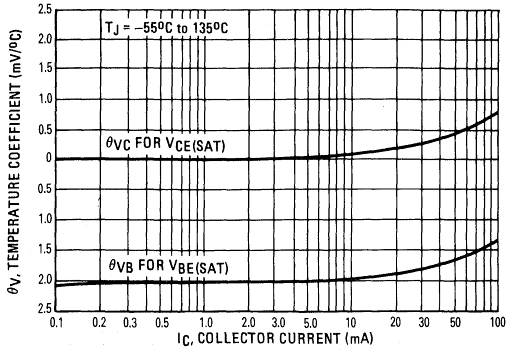


FIGURE 6 — SWITCHING TIME TEST CIRCUIT

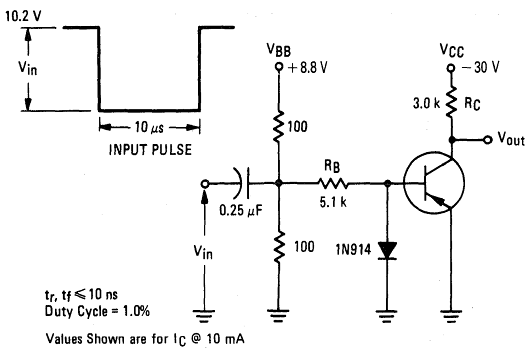


FIGURE 7 — CAPACITANCES

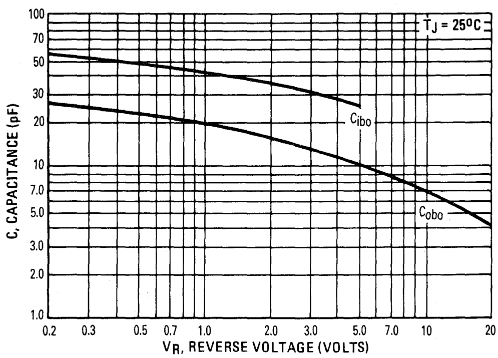


FIGURE 8 — TURN-ON TIME

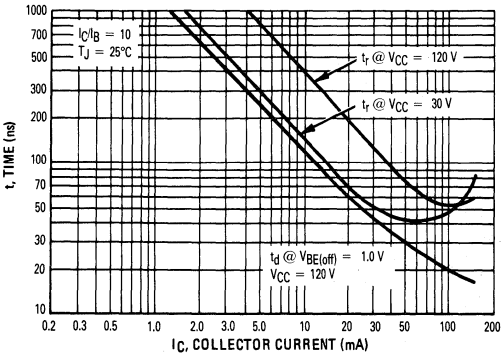
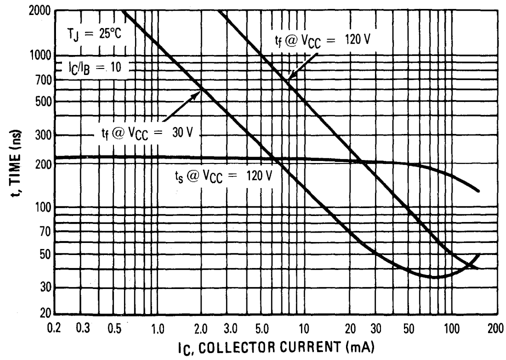
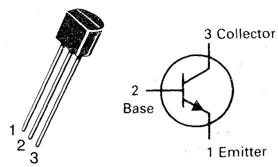


FIGURE 9 — TURN-OFF TIME



2N5550
2N5551★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	2N5550	2N5551	Unit
Collector-Emitter Voltage	V_{CEO}	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 @ 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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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)	 2N5550 2N5551	$V_{(BR)CEO}$	 140 160	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N5550 2N5551	$V_{(BR)CBO}$	 160 180	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, 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°C) (V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	 2N5550 2N5551 2N5550 2N5551	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(1)					
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)	 2N5550 2N5551 2N5550 2N5551 2N5550 2N5551	h_{FE}	 60 80 60 80 20 30	 — — 250 250 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types 2N5550 2N5551	$V_{CE(sat)}$	 — — —	 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 2N5550 2N5551	$V_{BE(sat)}$	 — — —	 1.0 1.2 1.0	Vdc

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

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 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_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N5550 2N5551	C_{ibo}	— —	30 20	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	50	200	—
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)	2N5550 2N5551	NF	— —	10 8.0	dB

FIGURE 1 — DC CURRENT GAIN

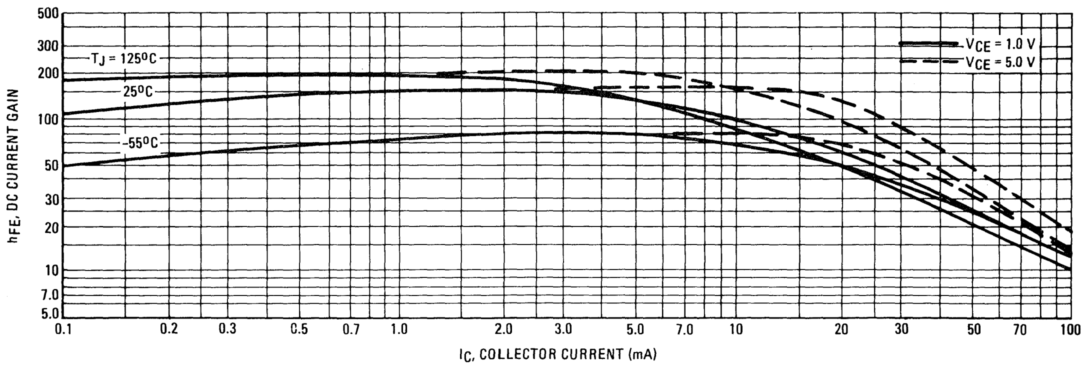


FIGURE 2 — COLLECTOR SATURATION REGION

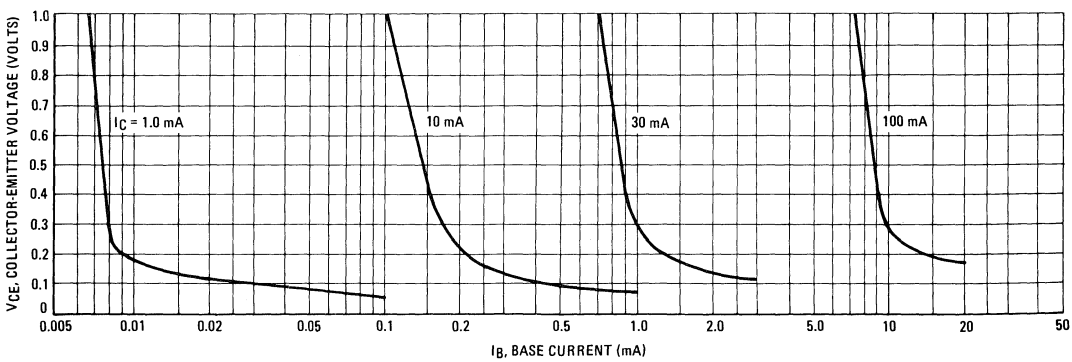


FIGURE 3 – COLLECTOR CUT-OFF REGION

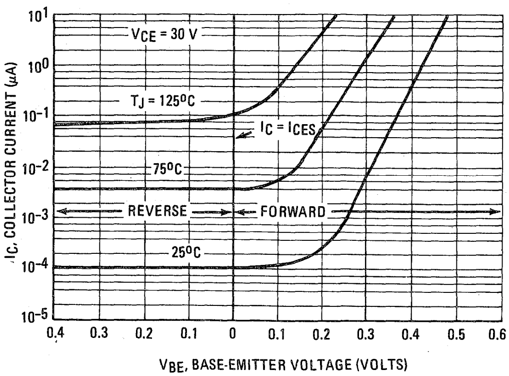


FIGURE 4 – "ON" VOLTAGES

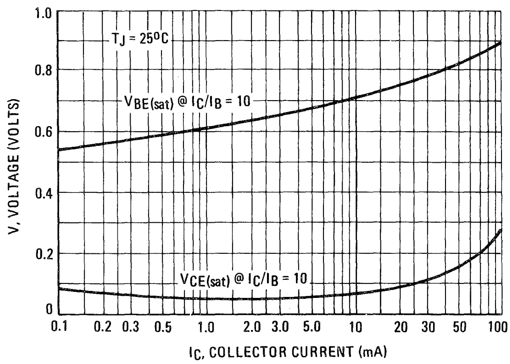


FIGURE 5 – TEMPERATURE COEFFICIENTS

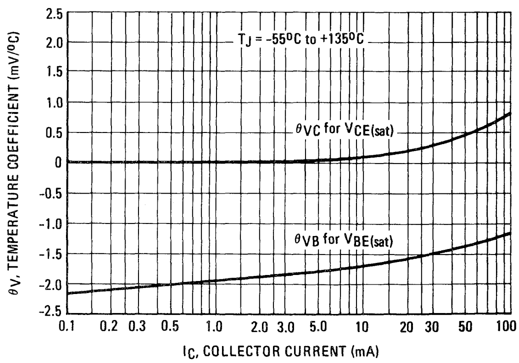


FIGURE 6 – SWITCHING TIME TEST CIRCUIT

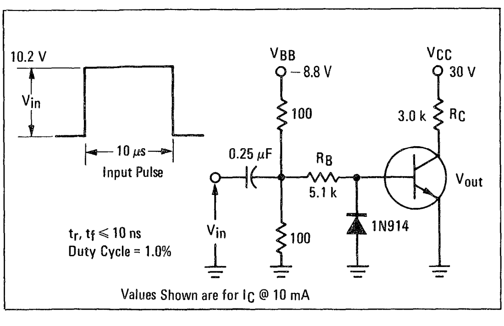
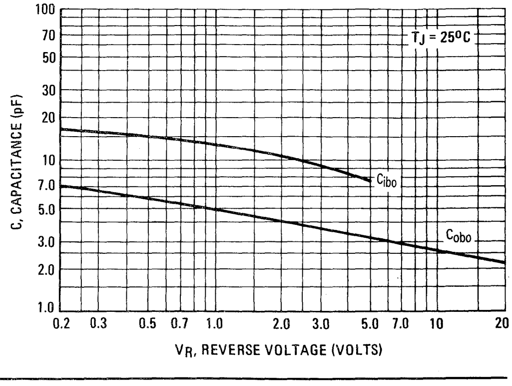


FIGURE 7 – CAPACITANCES



2

FIGURE 8 — TURN-ON TIME

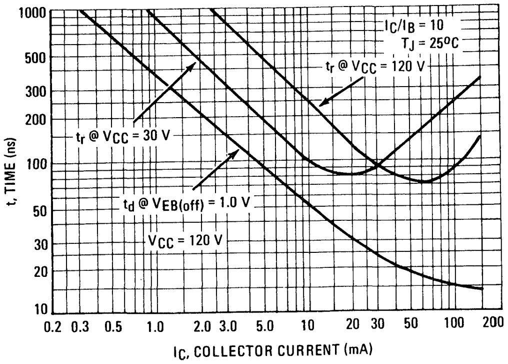
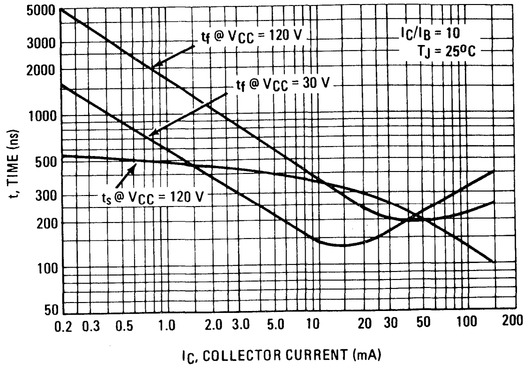
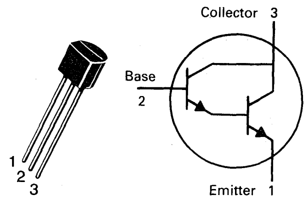


FIGURE 9 — TURN-OFF TIME



2N6426★
2N6427

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

2

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

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, V_{BE} = 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)		$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)		I_{CES}	—	—	1.0	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (1)		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N6426 2N6427		20,000 10,000	— —	200,000 100,000	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	2N6426 2N6427		30,000 20,000	— —	300,000 200,000	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N6426 2N6427		20,000 14,000	— —	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)		$V_{CE(sat)}$	 — —	 0.71 0.9	 1.2 1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 0.5 mAdc)		$V_{BE(sat)}$	—	1.52	2.0	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	1.24	1.75	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	5.4	7.0	pF
Input Capacitance (V_{EB} = 1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	10	15	pF

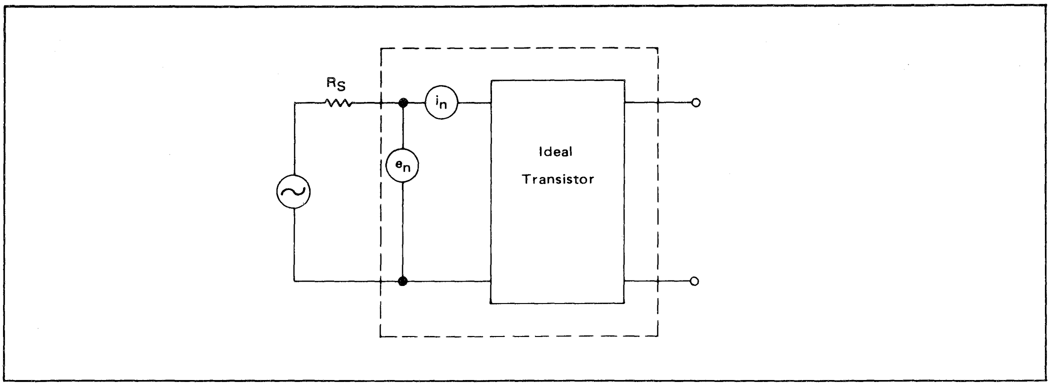
2

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

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

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

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 2 – NOISE VOLTAGE

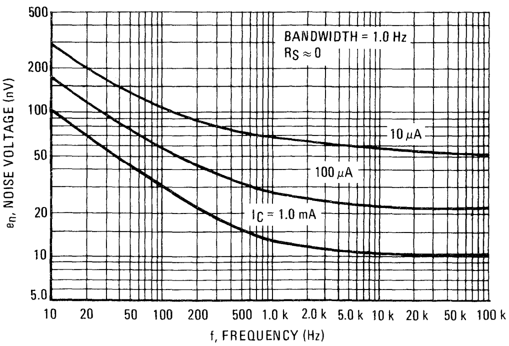


FIGURE 3 – NOISE CURRENT

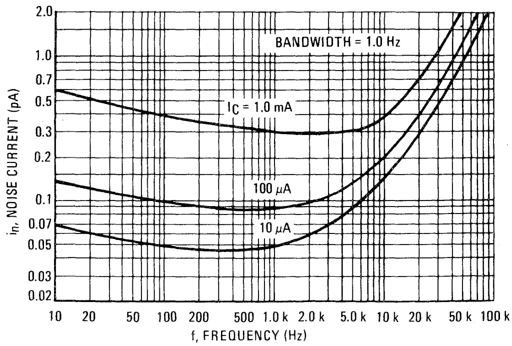


FIGURE 4 — TOTAL WIDEBAND NOISE VOLTAGE

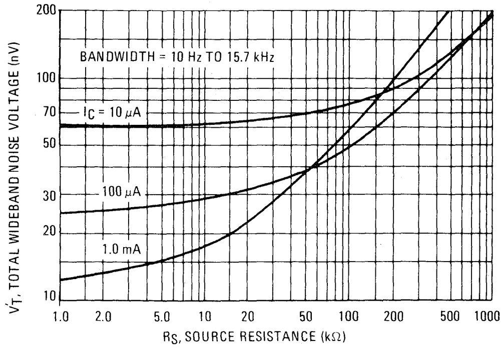
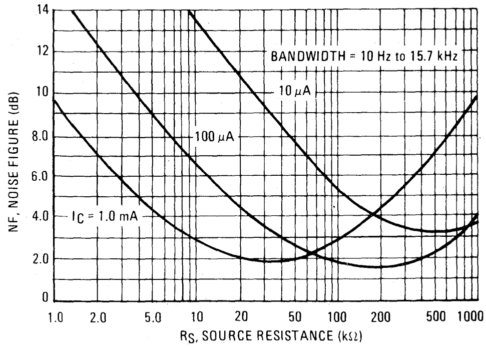


FIGURE 5 — WIDEBAND NOISE FIGURE



SMALL-SIGNAL CHARACTERISTICS

FIGURE 6 — CAPACITANCE

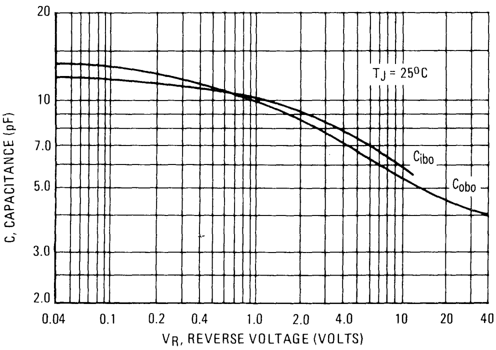


FIGURE 7 — HIGH FREQUENCY CURRENT GAIN

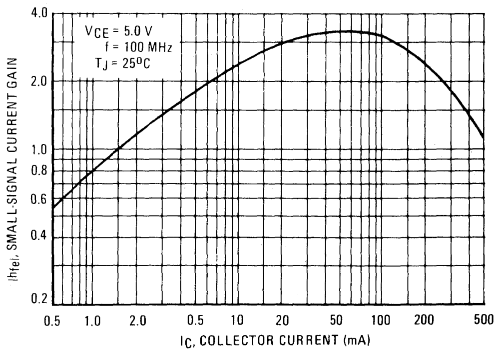


FIGURE 8 — DC CURRENT GAIN

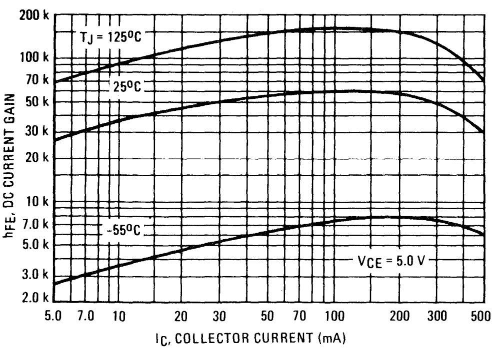
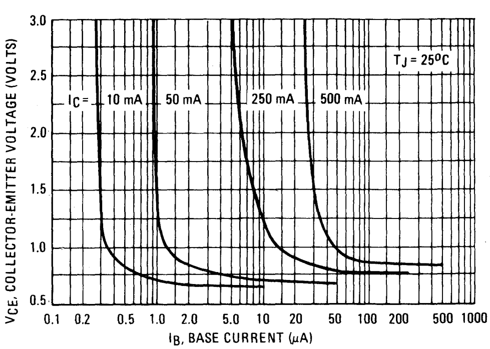


FIGURE 9 — COLLECTOR SATURATION REGION



2

FIGURE 10 – "ON" VOLTAGES

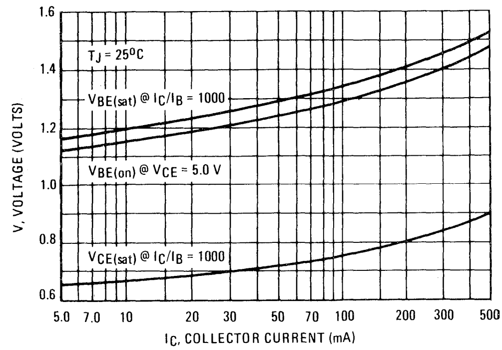


FIGURE 11 – TEMPERATURE COEFFICIENTS

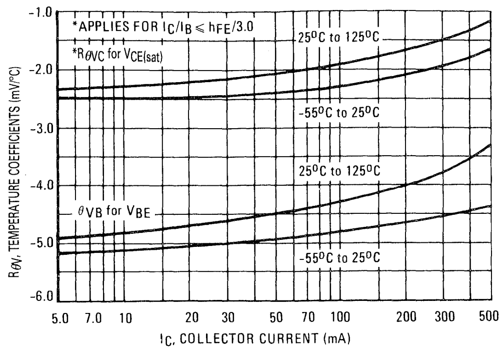


FIGURE 12 – THERMAL RESPONSE

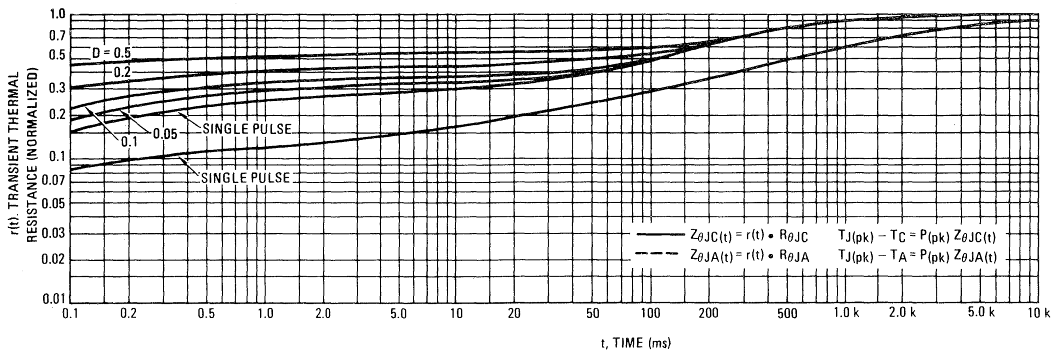
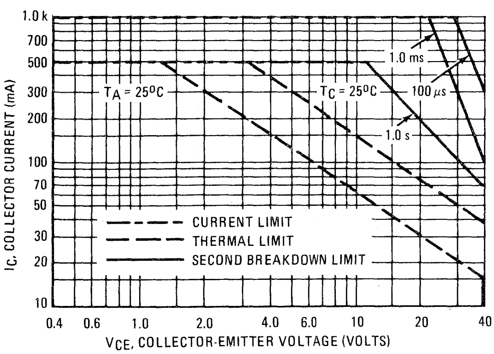
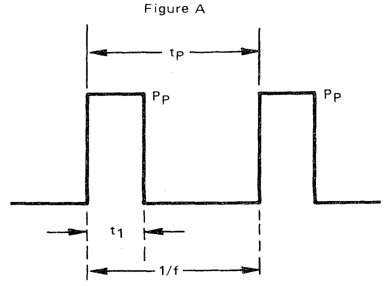


FIGURE 13 – ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

Figure A



Duty Cycle = $t_1 f = \frac{t_1}{t_P}$

Peak Pulse Power = P_P

MAXIMUM RATINGS

Rating	Symbol	2N6515	2N6516 2N6519	2N6517 2N6520	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	350	Vdc
Collector-Base Voltage	C_{CBO}	250	300	350	Vdc
Emitter-Base Voltage 2N6515, 2N6516, 2N6517 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	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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

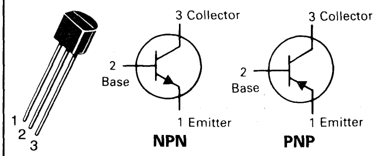
NPN

2N6515 thru 2N6517★

PNP

2N6519(2) 2N6520★(2)

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

★This is a Motorola designated preferred device.

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)	 2N6515 2N6516, 2N6519 2N6517, 2N6520	$V_{(BR)CEO}$	 250 300 350	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N6515 2N6516, 2N6519 2N6517, 2N6520	$V_{(BR)CBO}$	 250 300 350	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 2N6515, 2N6516, 2N6517 2N6519, 2N6520	$V_{(BR)EBO}$	 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)	 2N6515 2N6516, 2N6519 2N6517, 2N6520	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)	 2N6515, 2N6516, 2N6517 2N6519, 2N6520	I_{EBO}	 — —	 50 50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	 2N6515 2N6516, 2N6519 2N6517, 2N6520	h_{FE}	 35 30 20	 — — —	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N6515 2N6516, 2N6519 2N6517, 2N6520		50 45 30	— — —	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)	2N6515 2N6516, 2N6519 2N6517, 2N6520		50 45 30	300 270 200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N6515 2N6516, 2N6519 2N6517, 2N6520		45 40 20	220 200 200	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N6515 2N6516, 2N6519 2N6517, 2N6520		25 20 15	— — —	

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

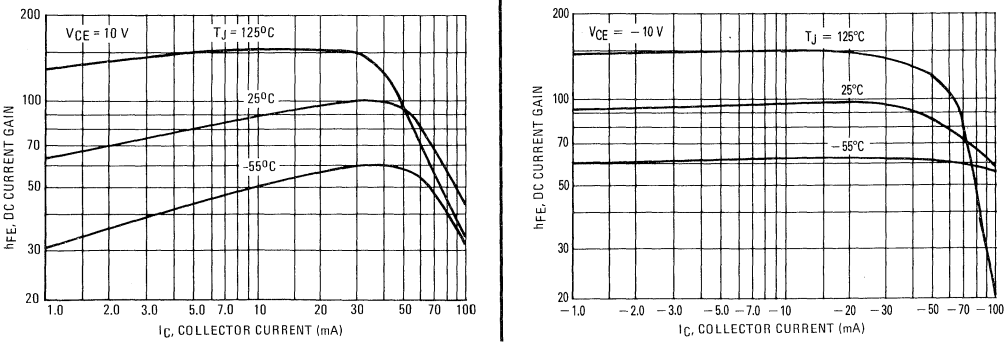
Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.30	
(I_C = 20 mAdc, I_B = 2.0 mAdc)		—	0.35	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		—	0.50	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.75	
(I_C = 20 mAdc, I_B = 2.0 mAdc)		—	0.85	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		—	0.90	
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance	C_{eb}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) 2N6515 thru 2N6517		—	80	
2N6519, 2N6520		—	100	
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 50 mAdc, I_{B1} = 10 mAdc)	t_{on}	—	200	μs
Turn-Off Time (V_{CC} = 100 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_{off}	—	3.5	μs

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Voltage and current are negative for PNP transistors.

NPN | PNP

FIGURE 1 — DC CURRENT GAIN

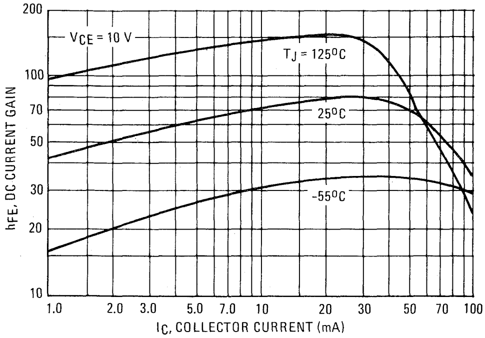
2N6515, 2N6516 | 2N6519



2

FIGURE 2 – DC CURRENT GAIN

2N6517



2N6520

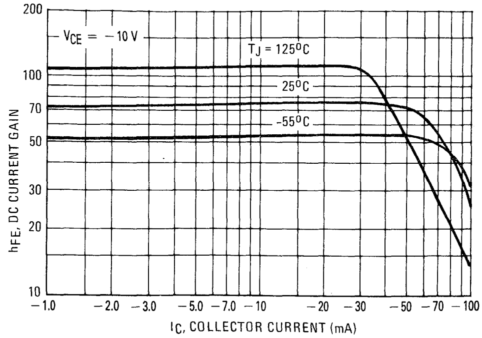
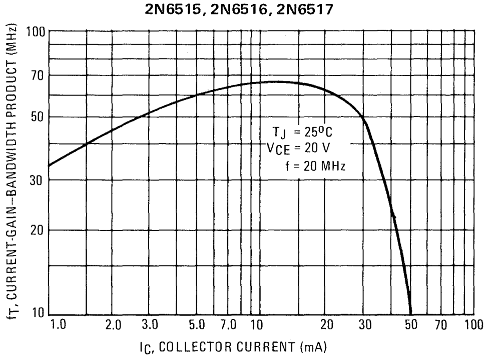


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

2N6515, 2N6516, 2N6517



2N6519, 2N6520

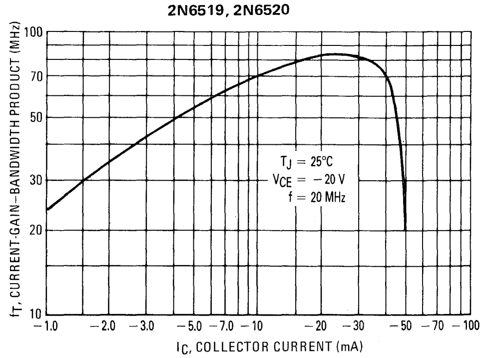
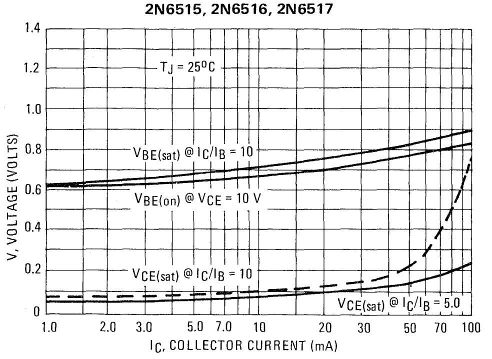


FIGURE 4 – "ON" VOLTAGES

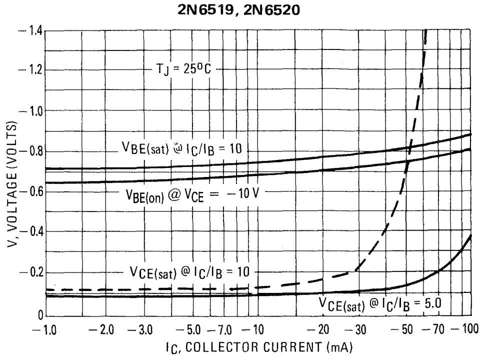
NPN

2N6515, 2N6516, 2N6517



PNP

2N6519, 2N6520



2

FIGURE 5 — TEMPERATURE COEFFICIENTS

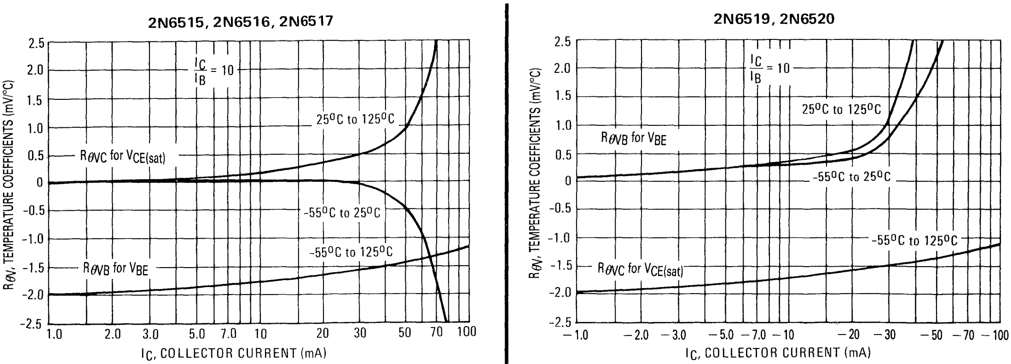
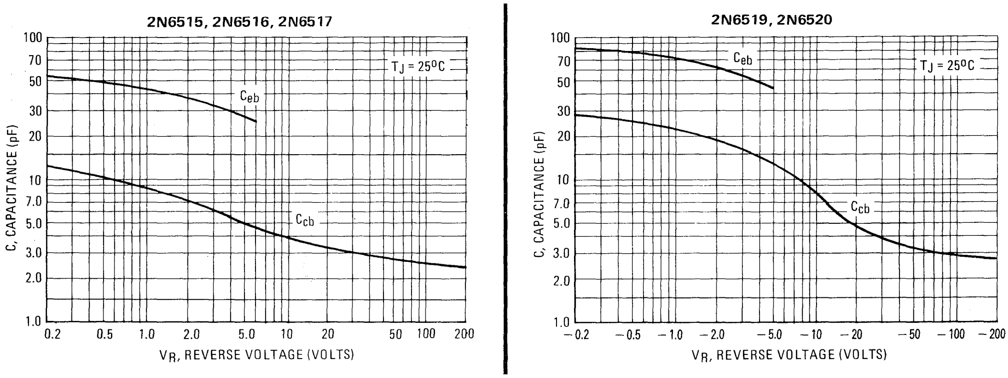


FIGURE 6 — CAPACITANCE



NPN

PNP

FIGURE 7 — TURN-ON TIME

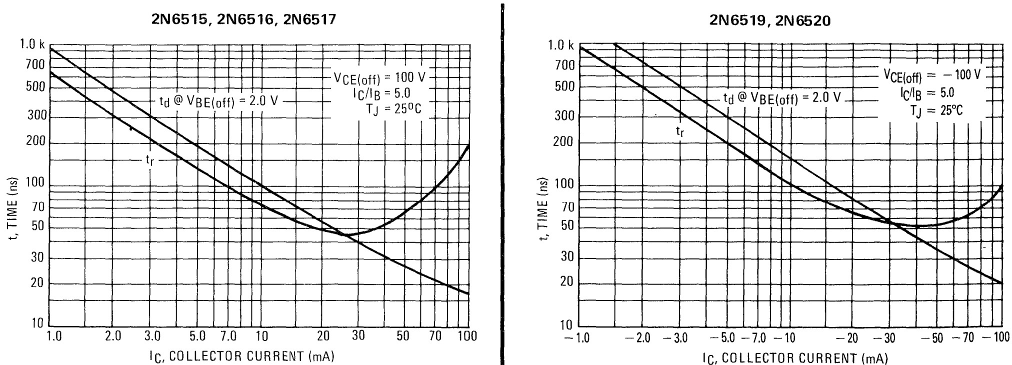


FIGURE 8 – TURN-OFF TIME

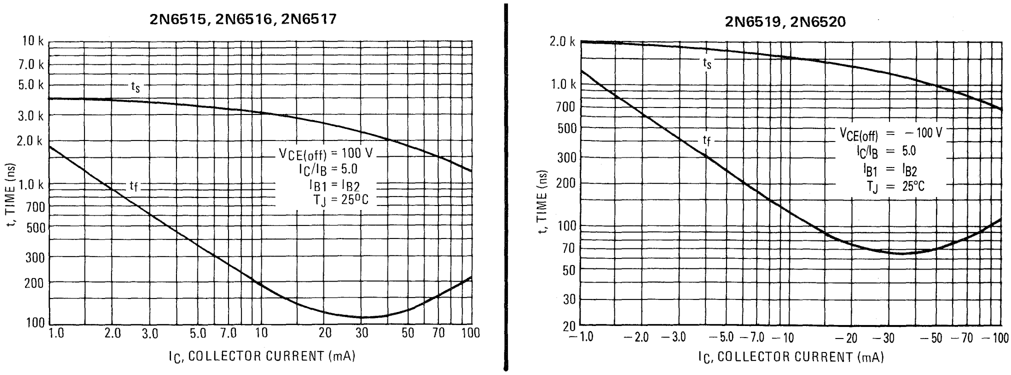


FIGURE 9 – SWITCHING TIME TEST CIRCUIT

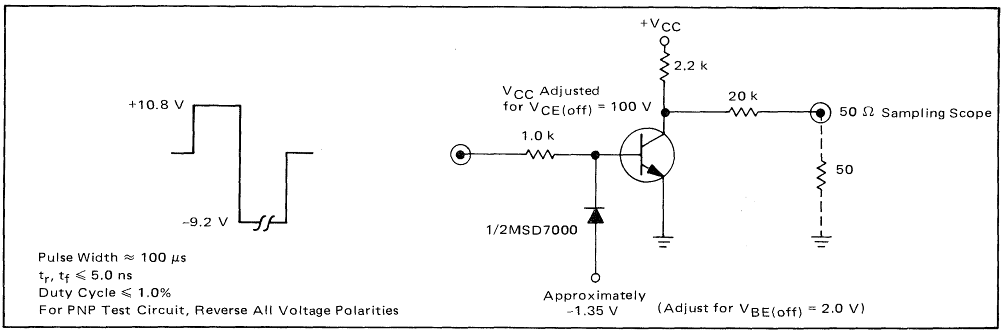
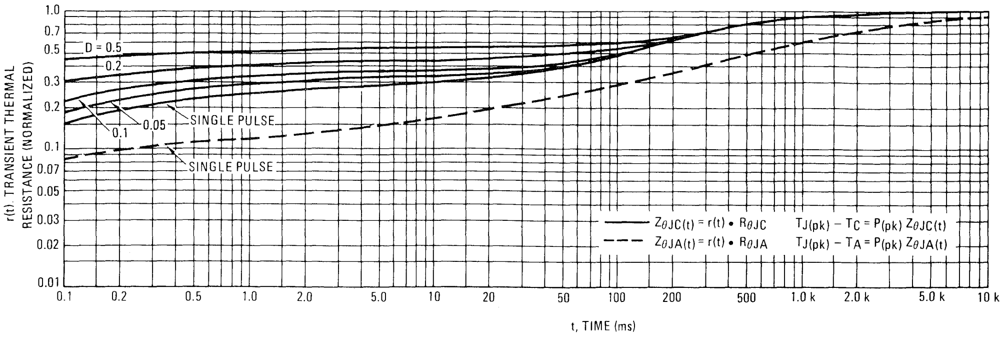
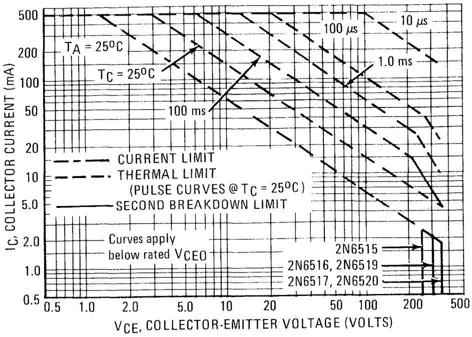


FIGURE 10 – THERMAL RESPONSE



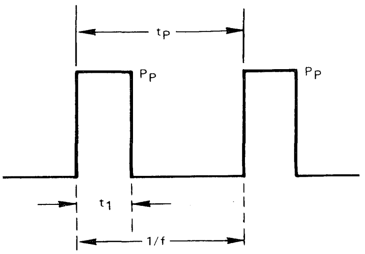
2

FIGURE 11 — ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

Figure A

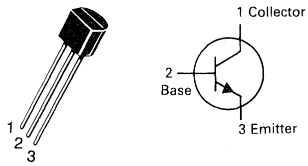


Duty Cycle = $t_1 f = \frac{t_1}{t_P}$

Peak Pulse Power = P_P

BC182,A,B
BC183
BC184

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

2

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°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 Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

Refer to BC237 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 = 2.0 mA, I_B = 0)	BC182 BC183 BC184	$V_{(BR)CEO}$	50 30 30	— — —	— — —	V
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)	BC182 BC183 BC184	$V_{(BR)CBO}$	60 45 45	— — —	— — —	V
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	V
Collector Cutoff Current (V_{CB} = 50 V, V_{BE} = 0) (V_{CB} = 30 V, V_{BE} = 0)	BC182 BC183 BC184	I_{CBO}	— — —	0.2 0.2 0.2	15 15 15	nA
Emitter-Base Leakage Current (V_{EB} = 4.0 V, I_C = 0)		I_{EBO}	—	—	15	nA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5.0 V)	BC182 BC183 BC184	h_{FE}	40 40 100	— — —	— — —	
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC182 BC183 BC184		120 120 250	— — —	500 800 800	
(I_C = 100 mA, V_{CE} = 5.0 V)	BC182 BC183 BC184		80 80 130	— — —	— — —	
Collector-Emitter On Voltage	(I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5.0 mA)*	$V_{CE(sat)}$	— —	0.07 0.2	0.25 0.6	V
Base-Emitter Saturation Voltage	(I_C = 100 mA, I_B = 5.0 mA)*	$V_{BE(sat)}$	—	—	1.2	V
Base-Emitter On Voltage	(I_C = 100 μA, V_{CE} = 5.0 V) (I_C = 2.0 mA, V_{CE} = 5.0 V) (I_C = 100 mA, V_{CE} = 5.0 V)*	$V_{BE(on)}$	— 0.55 —	0.5 0.62 0.83	— 0.7 —	V

*Pulse Test: Tp 300 s, Duty Cycle 2.0%.

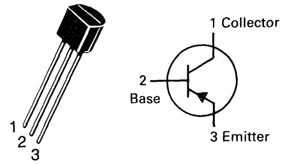
2

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

Characteristic		Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product		f_T				MHz
(I_C = 0.5 mA, V_{CE} = 3.0 V, f = 100 MHz)	BC182		—	100	—	
	BC183		—	120	—	
	BC184		—	140	—	
(I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)	BC182		150	200	—	
	BC183		150	240	—	
	BC184		150	280	—	
Common Base Output Capacitance (V_{CB} = 10 V, I_C = 0, f = 1.0 MHz)		C_{ob}	—	—	5.0	pF
Common Base Input Capacitance (V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz)		C_{ib}	—	8.0	—	pF
Small-Signal Current Gain		h_{fe}				
(I_C = 2.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	BC182		125	—	500	
	BC183		125	—	900	
	BC184		240	—	900	
	BC182A		125	—	260	
	BC182B		240	—	500	
Noise Figure		NF				dB
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 k ohms, f = 1.0 kHz)						
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 k ohms, f = 1.0 kHz, f = 200 Hz)	BC184		—	2.0	4.0	
	BC182		—	2.0	10	
	BC183		—	2.0	10	
	BC184		—	2.0	4.0	

BC212,B
BC213
BC214

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

Refer to BC307 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 212	BC 213	BC 214	Unit
Collector-Emitter Voltage	V_{CEO}	−50	−30	−30	Vdc
Collector-Base Voltage	V_{CBO}	−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°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 Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

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

Characteristic	Type	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$				Vdc
(I_C = −2.0 mAdc, I_B = 0)	BC212		−50	—	—	
	BC213		−30	—	—	
	BC214		−30	—	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$				Vdc
(I_C = −10 μA, I_E = 0)	BC212		−60	—	—	
	BC213		−45	—	—	
	BC214		−45	—	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$				Vdc
(I_E = −10 μAdc, I_C = 0)	BC212		−5	—	—	
	BC213		−5	—	—	
	BC214		−5	—	—	
Collector-Emitter Leakage Current		I_{CBO}				nAdc
(V_{CB} = −30 V)	BC212		—	—	−15	
	BC213		—	—	−15	
	BC214		—	—	−15	
Emitter-Base Leakage Current		I_{EBO}				nAdc
(V_{EB} = −4.0 V, I_C = 0)	BC212		—	—	−15	
	BC213		—	—	−15	
	BC214		—	—	−15	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	BC212		40	—	—	
	BC213		40	—	—	
	BC214		100	—	—	
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	BC212		60	—	—	
	BC213		80	—	—	
	BC214		140	—	600	
(I_C = −100 mAdc, V_{CE} = −5.0 Vdc)*	BC212, BC214		—	120	—	
	BC213		—	140	—	

2

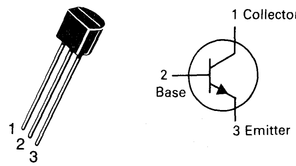
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted).

Characteristic	Type	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = −10 mAdc, I_B = −0.5 mAdc)			—	−0.10	—	
(I_C = −100 mAdc, I_B = −5.0 mAdc)*			—	−0.25	−0.6	
Base-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −5.0 mAdc)		$V_{BE(sat)}$	—	−1.0	−1.4	Vdc
Base-Emitter On Voltage (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	−0.6	−0.62	−0.72	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)		f_T				MHz
	BC212		—	280	—	
	BC214		—	320	—	
	BC213		—	360	—	
Common-Base Output Capacitance (V_{CB} = −10 Vdc, I_C = 0, f = 1.0 MHz)		C_{ob}	—	—	6.0	pF
Noise Figure		NF				dB
(I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 k ohms, f = 1.0 kHz)	BC214		—	—	2	
(I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 k ohms, f = 1.0 kHz, f = 200 Hz)	BC213		—	—	10	
	BC212		—	—	10	
Small Signal Current Gain (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)		h_{fe}				
	BC212		60	—	—	
	BC213		80	—	—	
	BC214		140	—	—	
	BC212B		200	—	400	

* Pulst-test: Tp 300 s, Duty-cycle 2%.

BC237,A,B,C
BC238,B,C
BC239,C

CASE 29-04, 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	Vdc
Collector-Emitter Voltage	V_{CES}	50	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	5.0	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 Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°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) (V_{CE} = 50 V, V_{BE} = 0)	BC238 BC239 BC237	I_{CES}		0.20 0.20 0.20	15 15 15	nA
(V_{CE} = 30 V, V_{BE} = 0) T_A = 125°C (V_{CE} = 50 V, V_{BE} = 0) T_A = 125°C	BC238 BC239 BC237			0.20 0.20 0.20	4 4 4	μA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5 V)	BC237A BC237B/238B BC237C/238C/239C	h_{FE}		90 150 270		
(I_C = 2 mA, V_{CE} = 5 V)	BC237 BC238 BC239 BC237A BC237B/238B BC237C/238C/239C		120 120 120 120 200 380	 170 290 500	800 800 800 220 460 800	
(I_C = 100 mA, V_{CE} = 5 V)	BC237A BC237B/238B BC237C/238C/239C			120 180 300		
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

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

Characteristic	Type	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 0.5 mA, V_{CE} = 3.0 V, f = 100 MHz)	BC237		—	100	—	
	BC238		—	120	—	
	BC239		—	140	—	
(I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHZ)	BC237		150	200	—	
	BC238		150	240	—	
	BC239		150	280	—	
Collector-Base Capacitance (V_{CB} = 10 V, I_C = 0, f = 1.0 MHz)		C_{obo}	—	—	4.50	pF
Emitter-Base Capacitance (V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	—	pF
Noise Figure		NF				dB
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 K ohms, f = 1.0 kHz)	BC239		—	2.0	4.0	
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 K ohms f = 1.0 kHz, Δf = 200 Hz)	BC237		—	2.0	10	
	BC238		—	2.0	10	
	BC239		—	2.0	4.0	

FIGURE 1 – NORMALIZED DC CURRENT GAIN

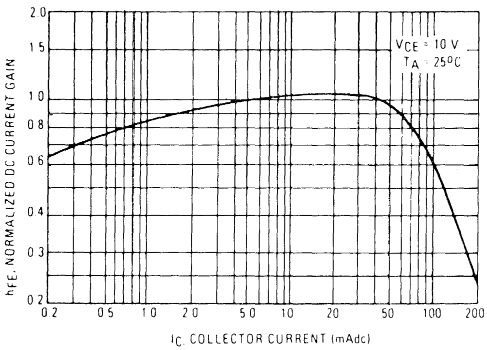


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

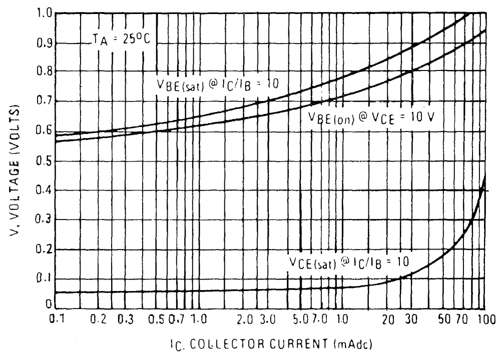


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

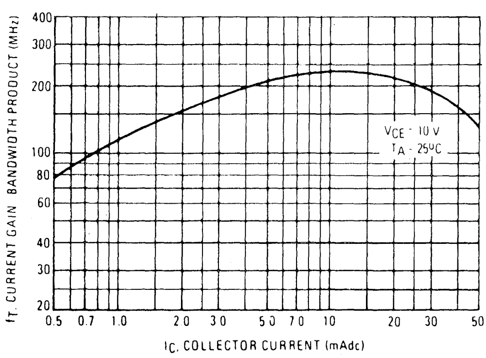


FIGURE 4 – CAPACITANCES

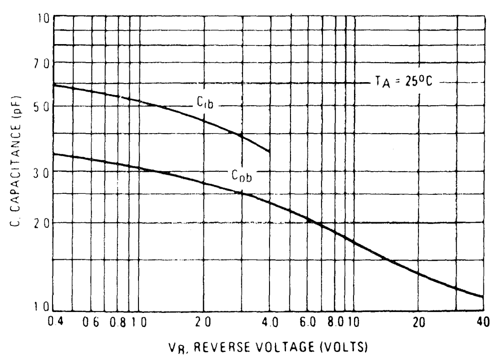
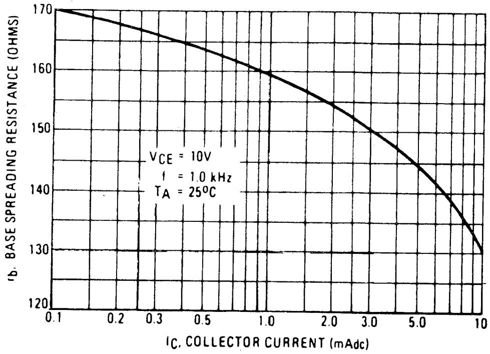
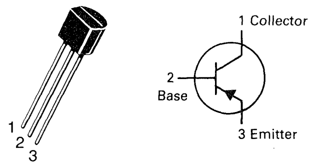


FIGURE 5 – BASE SPREADING RESISTANCE



BC307,B,C
BC308C
BC309B

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC307	BC308C	BC309	Unit
Collector-Emitter Voltage	V_{CEO}	−45	−25	−25	Vdc
Collector-Base Voltage	V_{CBO}	−50	−30	−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 Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°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)	BC307 BC308C BC309B	$V_{(BR)CEO}$	−45 −25 −25	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	BC307 BC308C BC309B	$V_{(BR)EBO}$	−5 −5 −5	— — —	— — —	Vdc Vdc
Collector-Emitter Leakage Current		I_{CES}				nAdc
(V_{CES} = −50 V, V_{BE} = 0)	BC307			−0.2	−15	
(V_{CES} = −30 V, V_{BE} = 0)	BC308C			−0.2	−15	
	BC309B			−0.2	−15	
(V_{CES} = −50 V, V_{BE} = 0) T_A = 125°C	BC307			−0.2	−4.0	μA
(V_{CES} = −30 V, V_{BE} = 0) T_A = 125°C	BC308C			−0.2	−4.0	
	BC309B			−0.2	−4.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	BC307B/309B BC307C/308C		— —	150 270	— —	
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	BC307 BC308C		120 120	— —	800 800	
(I_C = −100 mAdc, V_{CE} = −5.0 Vdc)	BC307B/309B BC307C/308C		200 420	290 500	460 800	
	BC307B/309B BC307C/308C		— —	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 = −5.0 mAdc)		$V_{CE(sat)}$	— — —	−0.10 −0.30 −0.25	−0.30 −0.60 —	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc) (I_C = −100 mAdc, I_B = −5.0 mAdc)		$V_{BE(sat)}$	— —	−0.70 −1.00	— —	Vdc
Base-Emitter On Voltage (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	−0.55	−0.62	−0.70	Vdc

Note 1: I_C = −10 mAdc on the constant base current characteristic, which yields the point I_C = −11 mAdc, V_{CE} = −1.0 V

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 = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	BC307 BC308C BC309B	f_T	— — —	280 320 360	— — —	MHz
Common-Base Capacitance (V_{CB} = −10 Vdc, I_C = 0, f = 1.0 MHz)		C_{cbo}	—	—	6.0	pF
Noise Figure (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 k ohms, f = 1.0 kHz)	BC309 BC307	NF	— —	2 2	4 10	dB
(I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 k ohms, f = 1 kHz, f = 200 Hz)	BC308C BC309B		— —	2 2	10 4	

2

FIGURE 1 – NORMALIZED DC CURRENT GAIN

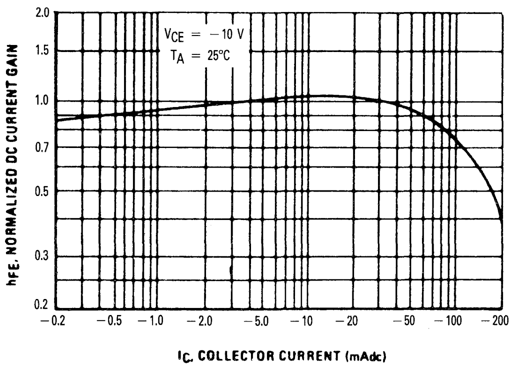


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

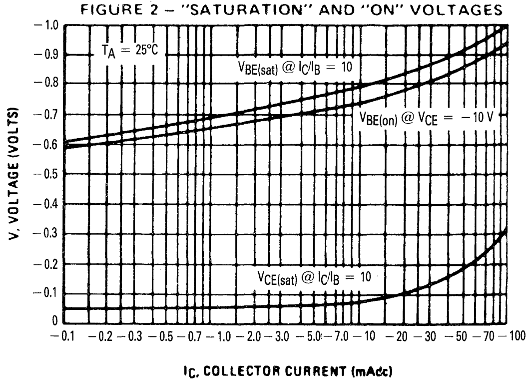


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

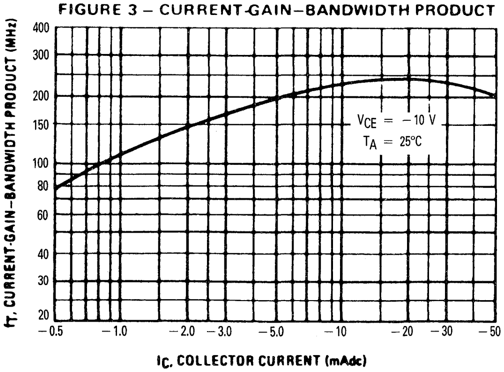
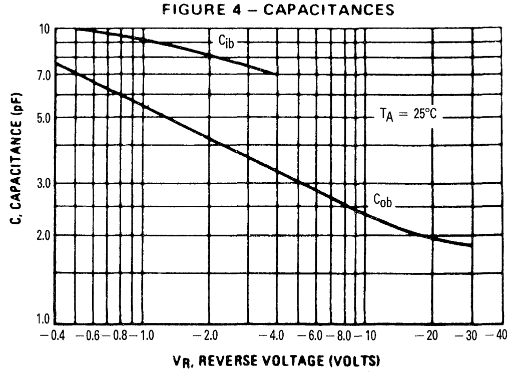


FIGURE 4 – CAPACITANCES



2

FIGURE 5 – OUTPUT ADMITTANCE

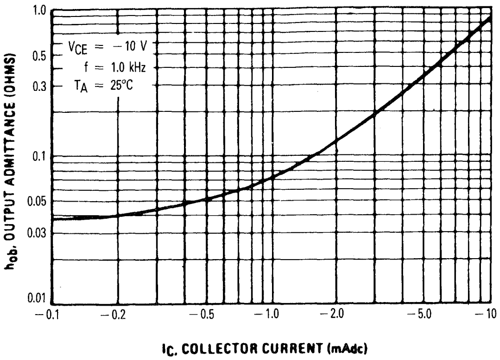
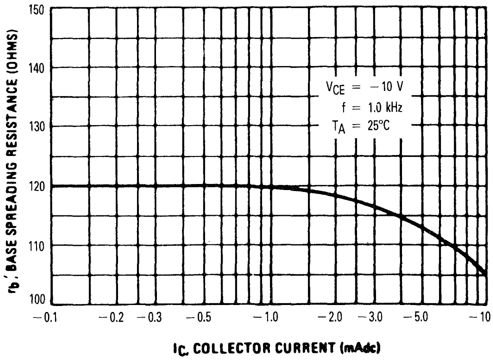
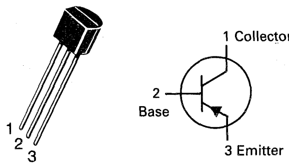


FIGURE 6 – BASE SPREADING RESISTANCE



BC327,-16,-25
BC328,-16,-25

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BC327	BC328	Unit
Collector-Emitter Voltage	V_{CEO}	−45	−25	Vdc
Collector-Base Voltage	V_{CBO}	−50	−30	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−800		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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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)	BC327 BC328	$V_{(BR)CEO}$	−45 −25	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μA, I_E = 0)	BC327 BC328	$V_{(BR)CES}$	−50 −30	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μA, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −30 V, I_E = 0) (V_{CB} = −20 V, I_E = 0)	BC327 BC328	I_{CBO}	— —	— —	−100 −100	nAdc
Collector Cutoff Current (V_{CE} = −45 V, V_{BE} = 0) (V_{CE} = −25 V, V_{BE} = 0)	BC327 BC328	I_{CES}	— —	— —	−100 −100	nAdc
Emitter Cutoff Current (V_{EB} = −4.0 V, I_C = 0)		I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = −100 mA, V_{CE} = −1.0 V) (I_C = −300 mA, V_{CE} = −1.0 V)	BC327/BC328 BC327-16/BC328-16 BC327-25/BC328-25	h_{FE}	100 100 160 40	— — — —	630 250 400 —	—
Base-Emitter On Voltage (I_C = −300 mA, V_{CE} = −1.0 V)		$V_{BE(on)}$	—	—	−1.2	Vdc
Collector-Emitter Saturation Voltage (I_C = −500 mA, I_B = −50 mA)		$V_{CE(sat)}$	—	—	−0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz)		C_{ob}	—	11	—	pF
Current-Gain — Bandwidth Product (I_C = −10 mA, V_{CE} = −5.0 V, f = 100 MHz		f_T	—	260	—	MHz

2

FIGURE 1 — THERMAL RESPONSE

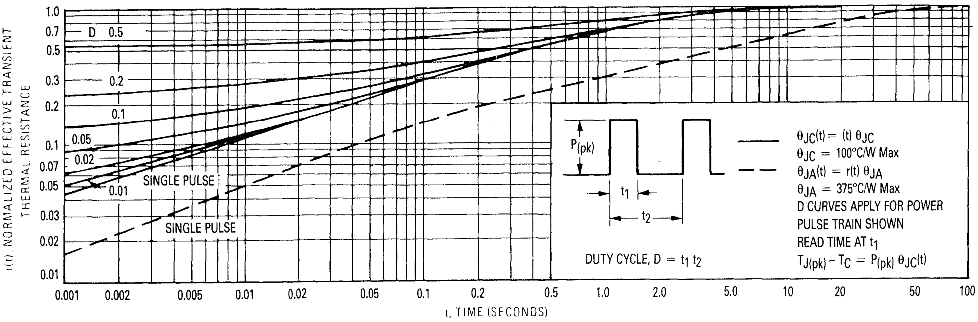


FIGURE 2 — ACTIVE REGION SAFE OPERATING AREA

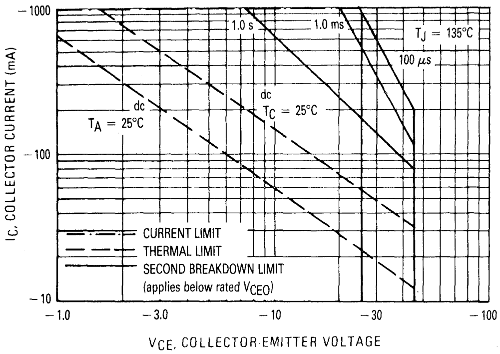


FIGURE 3 — DC CURRENT GAIN

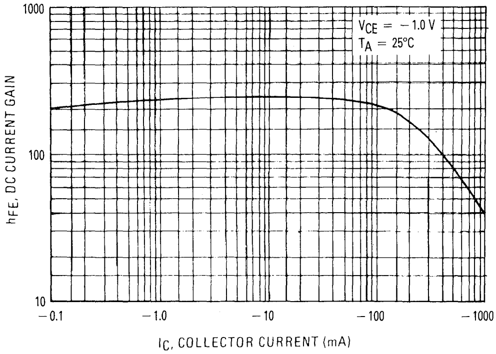


FIGURE 4 — SATURATION REGION

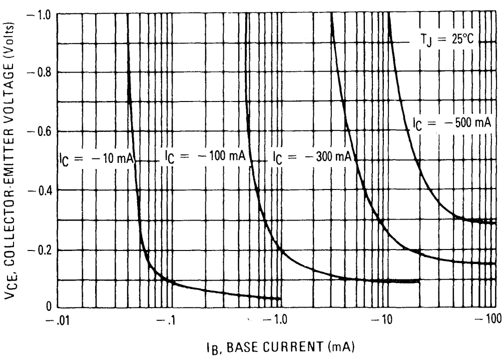


FIGURE 5 — "ON" VOLTAGES

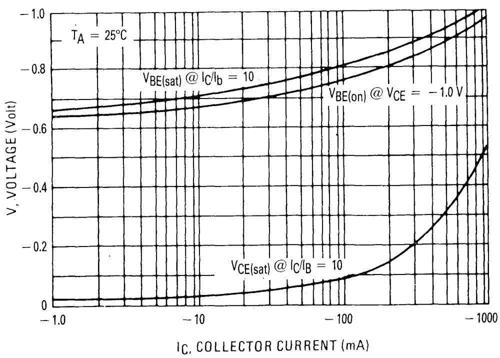


FIGURE 6 — TEMPERATURE COEFFICIENTS

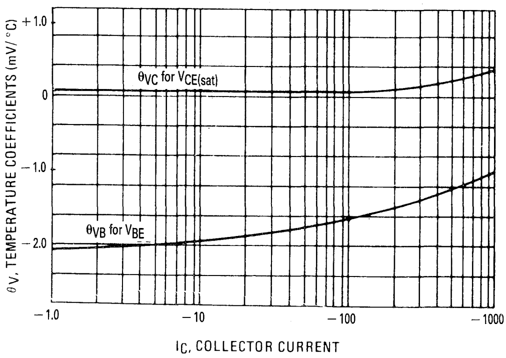
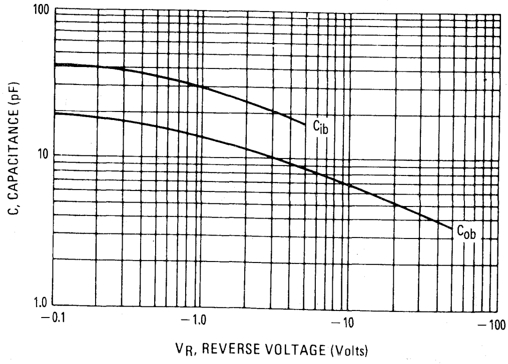
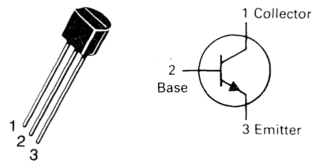


FIGURE 7 — CAPACITANCES



BC337, -16, -25, -40
BC338, -16, -25, -40

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC337	BC338	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	800		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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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)	 BC337 BC338	$V_{(BR)CEO}$	 45 25	 — —	 — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μA, I_E = 0)	 BC337 BC338	$V_{(BR)CES}$	 50 30	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 V, I_E = 0) (V_{CB} = 20 V, I_E = 0)	 BC337 BC338	I_{CBO}	 — —	 — —	 100 100	nAdc
Collector Cutoff Current (V_{CE} = 45 V, V_{BE} = 0) (V_{CE} = 25 V, V_{BE} = 0)	 BC337 BC338	I_{CES}	 — —	 — —	 100 100	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 V, I_C = 0)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 100 mA, V_{CE} = 1.0 V) (I_C = 300 mA, V_{CE} = 1.0 V)	 BC337/BC338 BC337-16/BC338-16 BC337-25/BC338-25 BC337-40/BC338-40	h_{FE}	 100 100 160 250 60	 — — — — —	 630 250 400 630 —	—
Base-Emitter On Voltage (I_C = 300 mA, V_{CE} = 1.0 V)		$V_{BE(on)}$	—	—	1.2	Vdc
Collector-Emitter Saturation Voltage (I_C = 500 mA, I_B = 50 mA)		$V_{CE(sat)}$	—	—	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz)		C_{ob}	—	15	—	pF
Current-Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)		f_T	—	210	—	MHz

FIGURE 1 – THERMAL RESPONSE

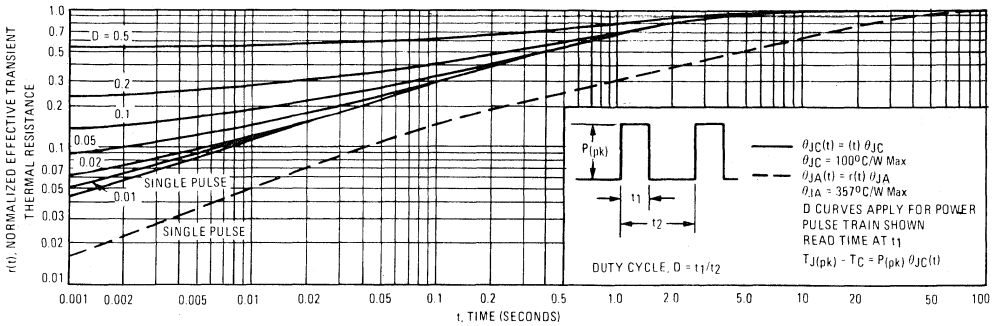


FIGURE 2 – ACTIVE REGION SAFE OPERATING AREA

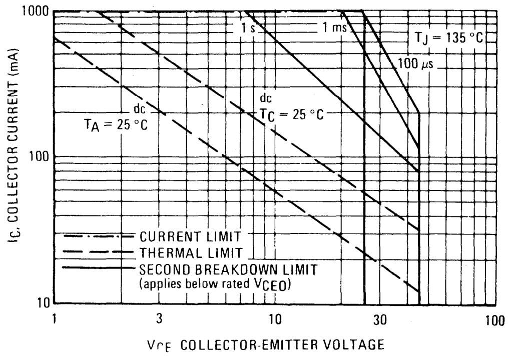


FIGURE 3 – DC CURRENT GAIN

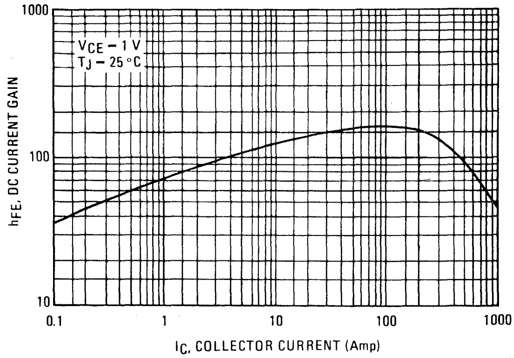


FIGURE 4 – SATURATION REGION

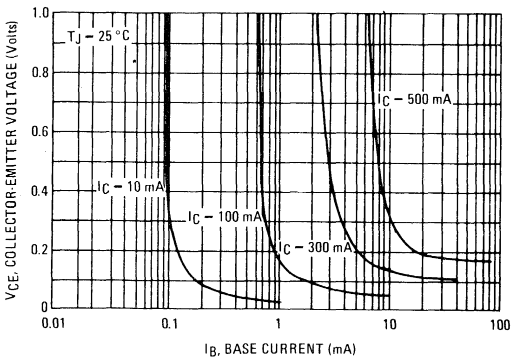
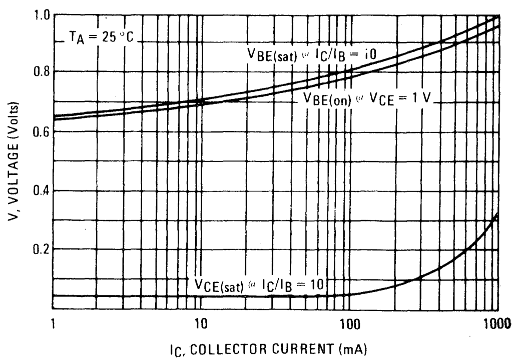


FIGURE 5 – "ON" VOLTAGES



2

FIGURE 6 — TEMPERATURE COEFFICIENTS

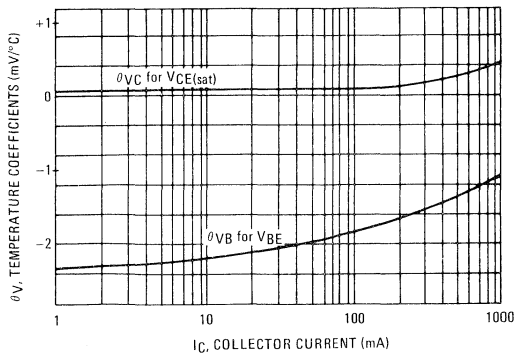
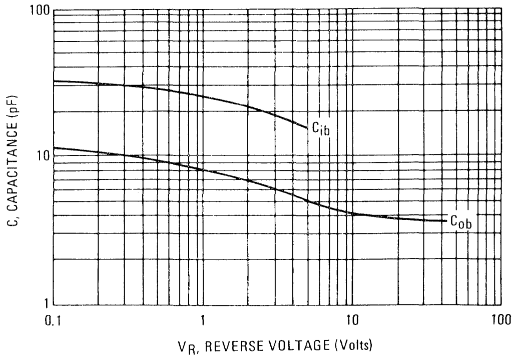
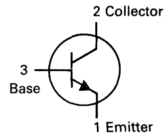


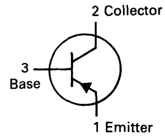
FIGURE 7 — CAPACITANCES

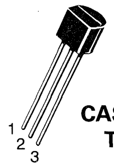


NPN BC368



PNP BC369(1)





CASE 29-04, STYLE 14
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	25	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	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 25 V, I_E = 0) (V_{CB} = 25 V, I_E = 0, T_J = 150°C)	I_{CBO}	 — —	 — —	 10 1.0	 μAdc mAdc
Emitter Cutoff Current (V_{EB} = 5.0 V, I_C = 0)	I_{EBO}	—	—	10	μAdc
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 —	—
Bandwidth Product (I_C = 10 mA, V_{CE} = 5.0 V, f = 20 MHz)	f_T	65	—	—	MHz
Collector-Emitter Saturation Voltage (I_C = 1.0 A, I_B = 100 mA)	$V_{CE(sat)}$	—	—	0.5	V
Base-Emitter On Voltage (I_C = 1.0 A, V_{CE} = 1.0 V)	$V_{BE(on)}$	—	—	1.0	V

(1) Voltage and current are negative for PNP Transistors.

FIGURE 1 — DC CURRENT GAIN

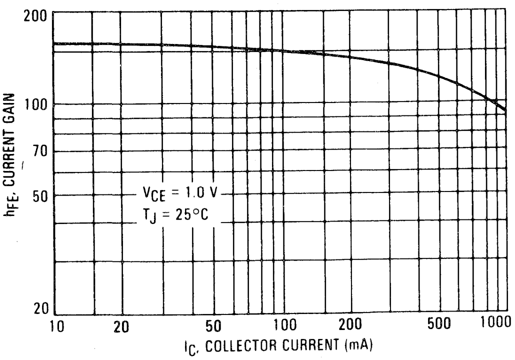


FIGURE 2 — COLLECTOR SATURATION REGION

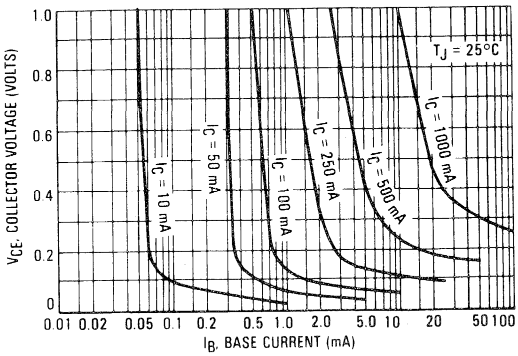


FIGURE 3 — ON VOLTAGES

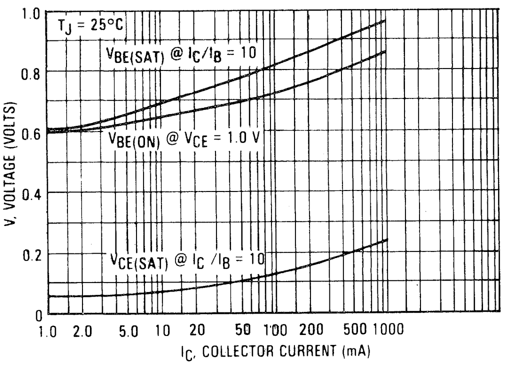


FIGURE 4 — TEMPERATURE COEFFICIENT

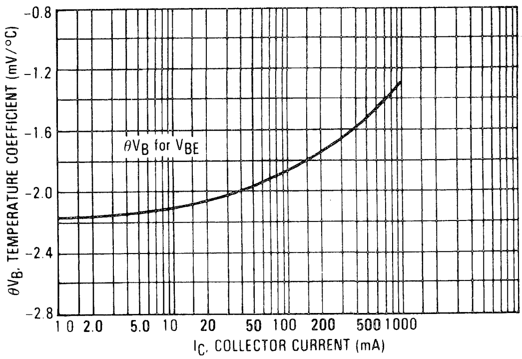


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

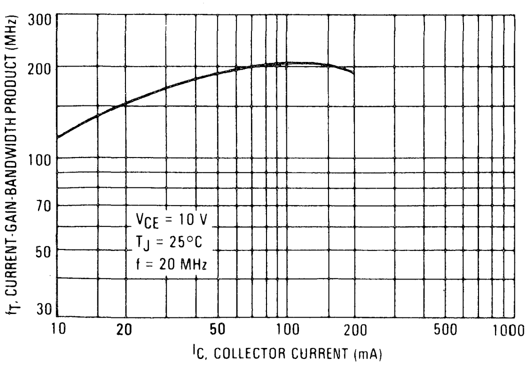
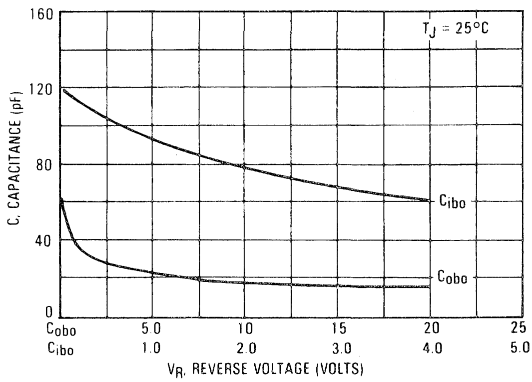
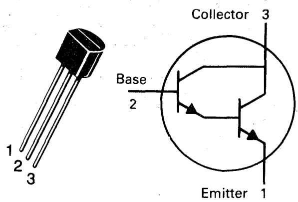


FIGURE 6 — CAPACITANCE



BC372
BC373

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE DARLINGTON TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BC372	BC373	Unit
Collector-Emitter Voltage	V_{CES}	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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	$V_{(BR)CES}$	100	—	—	Vdc
	BC373		80	—	—	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BC372	$V_{(BR)CBO}$	100	—	—	Vdc
	BC373		80	—	—	
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	I_{CBO}	—	—	100	nAdc
(V_{CB} = 60 Vdc, I_E = 0)	BC373		—	—	100	
Emitter Cutoff Current (V_{EB} = 10 V, I_C = 0)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS*						
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	8.0	—	—	K
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)			10	—	160	
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	—	1.0	1.1	Vdc
Base-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	—	1.4	2.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 100 mAdc, 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}	—	10	25	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_g = 100 k ohm, f = 1.0 kHz)		NF	—	2.0	—	dB

*Pulse Test: Pulse Width = 300 μs, Duty Cycle 2.0%.

FIGURE 1 — DC CURRENT GAIN

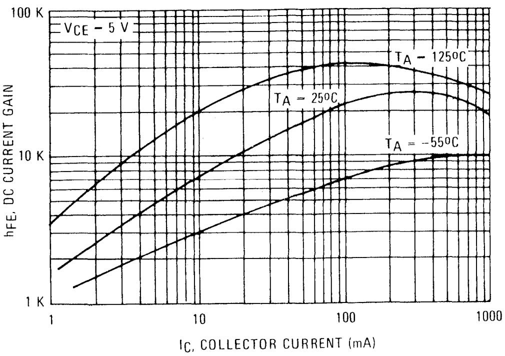


FIGURE 2 — "SATURATION" AND "ON" VOLTAGES

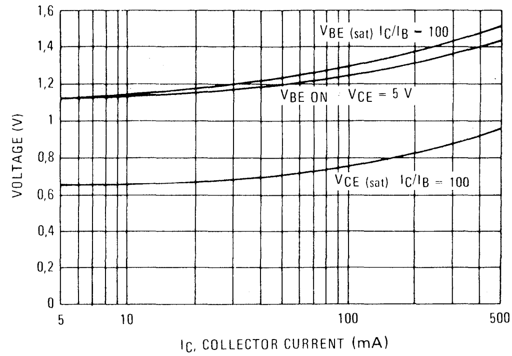


FIGURE 3 — CURRENT GAIN BANDWIDTH PRODUCT

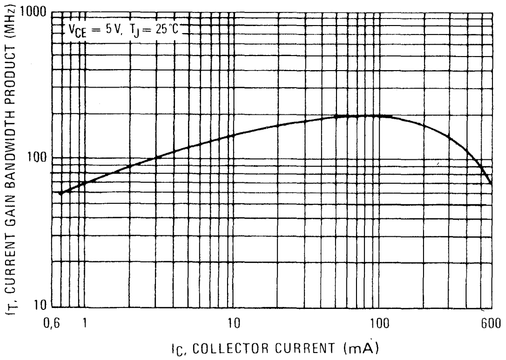
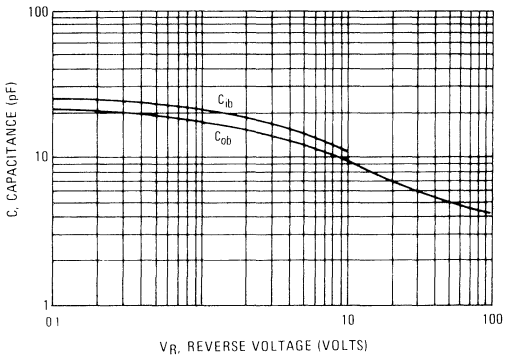
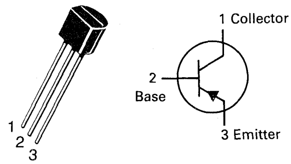


FIGURE 4 — CAPACITANCES



BC450,A

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

2

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

Refer to MPS8598 for graphs.

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

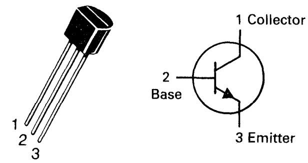
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = −1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−100	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μA, I_E = 0)		$V_{(BR)CBO}$	−100	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −80 Vdc, I_E = 0)		I_{CBO}	—	—	−100	nAdc
ON CHARACTERISTICS*						
DC Current Gain		h_{FE}				
(I_C = −2.0 mA, V_{CE} = −5.0 V)	BC450		50	—	460	
	BC450A		120	—	220	
(I_C = −10 mA, V_{CE} = −5.0 V)	BC450		50	—	—	
	BC450A		100	—	—	
(I_C = −100 mA, V_{CE} = −5.0 V)	BC450		50	—	—	
	BC450A		60	—	—	
Collector-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −10 mAdc)		$V_{CE(sat)}$	—	−0.125	−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		$V_{BE(on)}$				Vdc
(I_C = −2.0 mA, V_{CE} = −5.0 V)			−0.55	—	−0.7	
(I_C = −100 mA, V_{CE} = −5.0 V)*			—	−0.76	−1.2	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)		f_T	100	200	—	MHz

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

2

BC489,A,B

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH CURRENT TRANSISTORS

NPN SILICON

Refer to MPSA05 for graphs.

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

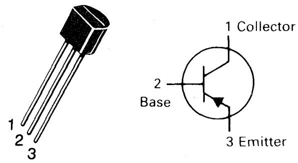
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	80	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60, Vdc — I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS*					
DC Current Gain	h_{FE}				
(I_C = 10 mAdc — V_{CE} = 2.0 Vdc)		40	—	—	—
(I_C = 100 mAdc — V_{CE} = 2.0 Vdc) BC489		60	—	400	—
BC489A		100	160	250	—
BC489B		160	260	400	—
(I_C = 1.0 Adc — V_{CE} = 5.0 Vdc)*		15	—	—	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 500 mAdc — I_B = 50 mAdc)		—	0.2	0.50	
(I_C = 1.0 Adc — I_B = 100 mAdc)		—	0.3	—	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.85	1.20	
(I_C = 1.0 Adc — I_B = 100 mAdc)*		—	0.90	—	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)	f_T	—	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	7	—	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	50	—	pF

*Pulse Test — Pulse Width = 300 μs — Duty Cycle 2%.

BC490,A

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH CURRENT TRANSISTORS

PNP SILICON

Refer to MPSA55 for graphs in MPSA05 data sheet.

2

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}	−4.0	Vdc
Collector Current — Continuous	I_C	−0.5	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

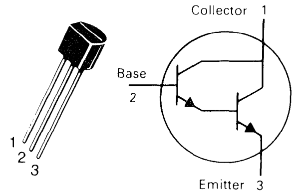
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−80	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −60 Vdc — I_E = 0)	I_{CBO}	—	—	−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) BC490 BC490A (I_C = −1.0 Adc — V_{CE} = −5.0 Vdc)	h_{FE}	 40 60 100 15	 — — 140 —	 — 400 250 —	—
Collector-Emitter Saturation Voltage (I_C = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc)	$V_{CE(sat)}$	 — —	 −0.25 −0.50	 −0.50 —	Vdc
Base-Emitter Saturation Voltage (I_C = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc)	$V_{BE(sat)}$	 — —	 −0.90 −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_{EB} = −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 29-04, STYLE 17
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	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	1.0	Adc
Total Power Dissipation $T_A = 25°C$ Derate above 25°C	P_D	625 12	mW mW/°C
Total Power 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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

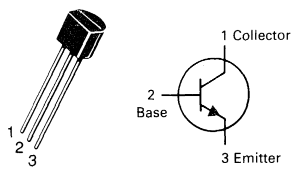
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ nAdc, $I_C = 0$)	$V_{(BR)EBO}$	10	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ V)	I_{CES}	—	—	500	nA
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current $V_{EB} = 10$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 20$ mAdc, $V_{CE} = 2.0$ V)	h_{FE}	30,000	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	—	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	f_T	—	200	—	MHz

(1) Pulse Test Pulse Width ≤ 2.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$

BC546, A, B
BC547, A, B, C
BC548, A, B, C

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 546	BC 547	BC 548	Unit
Collector-Emitter Voltage	V_{CEO}	65	45	30	Vdc
Collector-Base Voltage	V_{CBO}	80	50	30	Vdc
Emitter-Base Voltage	V_{EBO}		6.0		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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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 mA, I_B = 0)	BC546	$V_{(BR)CEO}$	65	—	—	V
	BC547		45	—	—	
	BC548		30	—	—	
Collector-Base Breakdown Voltage (I_C = 100 μAdc)	BC546	$V_{(BR)CBO}$	80	—	—	V
	BC547		50	—	—	
	BC548		30	—	—	
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BC546	$V_{(BR)EBO}$	6.0	—	—	V
	BC547		6.0	—	—	
	BC548		6.0	—	—	
Collector Cutoff Current		I_{CES}				
(V_{CE} = 70 V, V_{BE} = 0)	BC546		—	0.2	15	nA
(V_{CE} = 50 V, V_{BE} = 0)	BC547		—	0.2	15	
(V_{CE} = 35 V, V_{BE} = 0)	BC548		—	0.2	15	
(V_{CE} = 30 V, T_A = 125°C)	BC546/547/548		—	—	4.0	μA
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 10 μA, V_{CE} = 5.0 V)	BC546A/547A/548A		—	90	—	
	BC546B/547B/548B		—	150	—	
	BC548C		—	270	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC546		110	—	450	
	BC547		110	—	800	
	BC548		110	—	800	
	BC546A/547A/548A		110	180	220	
	BC546B/547B/548B		200	290	450	
	BC547C/BC548C		420	520	800	
(I_C = 100 mA, V_{CE} = 5.0 V)	BC546A/547A/548A		—	120	—	
	BC546B/547B/548B		—	180	—	
	BC548C		—	300	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				V
(I_C = 10 mA, I_B = 0.5 mA)			—	0.09	0.25	
(I_C = 100 mA, I_B = 5.0 mA)			—	0.2	0.6	
(I_C = 10 mA, I_B = See Note 1)			—	0.3	0.6	
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA)		$V_{BE(sat)}$	—	0.7	—	V
Base-Emitter On Voltage		$V_{BE(on)}$				V
(I_C = 2.0 mA, V_{CE} = 5.0 V)			0.55	—	0.7	
(I_C = 10 mA, V_{CE} = 5.0 V)			—	—	0.77	

NOTE 1: I_B is value for which I_C = 11 mA at V_{CE} = 1.0 V.

2

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

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product		f_T				MHz
(I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)	BC546		150	300	—	
	BC547		150	300	—	
	BC548		150	300	—	
Output Capacitance (V_{CB} = 10 V, I_C = 0, f = 1.0 MHz)		C_{obo}	—	1.7	4.5	pF
Input Capacitance (V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	10	—	pF
Small-Signal Current Gain		h_{fe}				—
(I_C = 2.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	BC546		125	—	500	
	BC547/548		125	—	900	
	BC546A/547A/548A		125	220	260	
	BC546B/547B/548B		240	330	500	
	BC547C/548C		450	600	900	
Noise Figure		NF				dB
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2 kohms,	BC546		—	2.0	10	
f = 1.0 kHz, Δf = 200 Hz)	BC547		—	2.0	10	
	BC548		—	2.0	10	

FIGURE 1 — NORMALIZED DC CURRENT GAIN

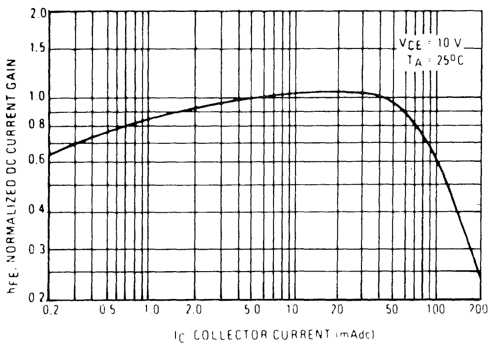


FIGURE 2 — "SATURATION" AND "ON" VOLTAGES

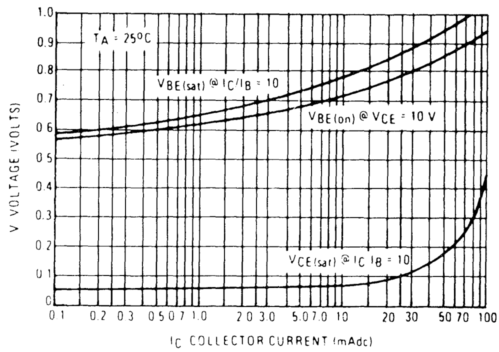


FIGURE 3 — COLLECTOR SATURATION REGION

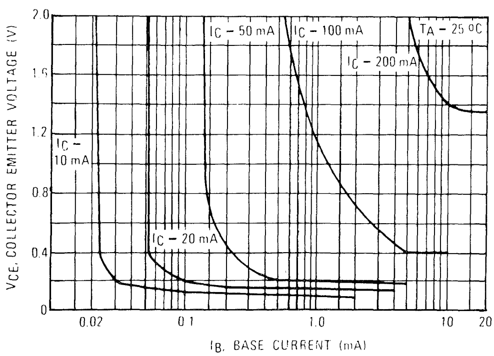
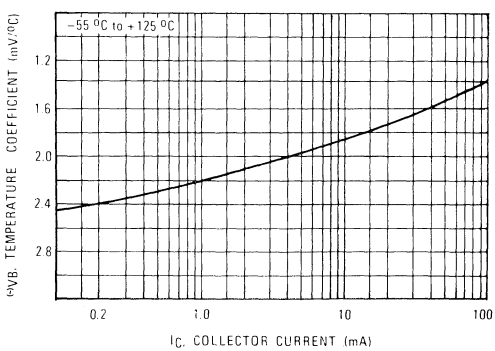


FIGURE 4 — BASE EMITTER TEMPERATURE COEFFICIENT



BC547/BC548

FIGURE 5 — CAPACITANCES

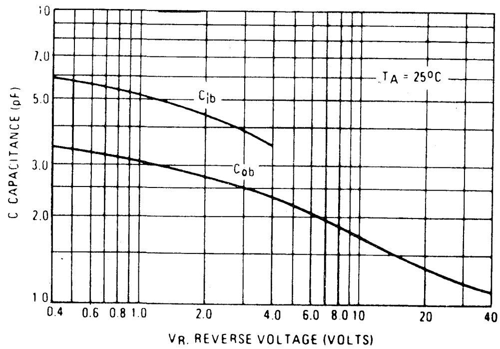


FIGURE 6 — CURRENT GAIN–BANDWIDTH PRODUCT

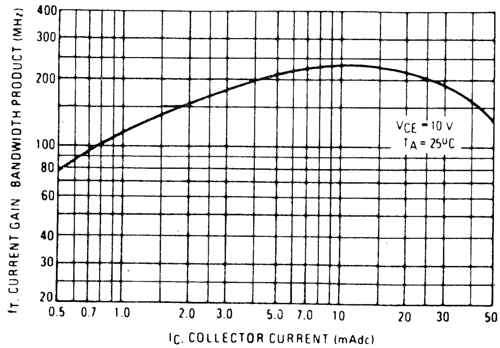


FIGURE 7 — DC CURRENT GAIN

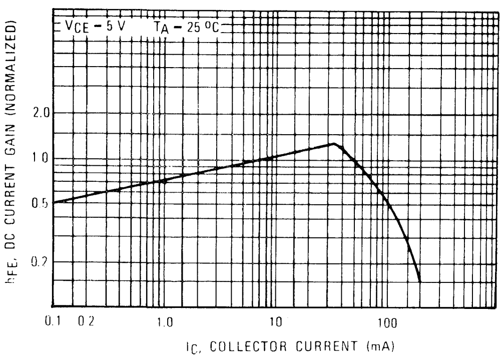


FIGURE 8 — "ON" VOLTAGE

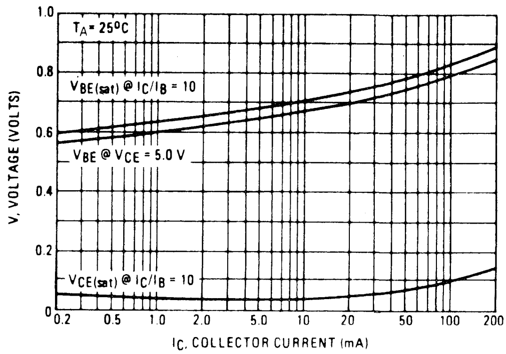


FIGURE 9 — COLLECTOR SATURATION REGION

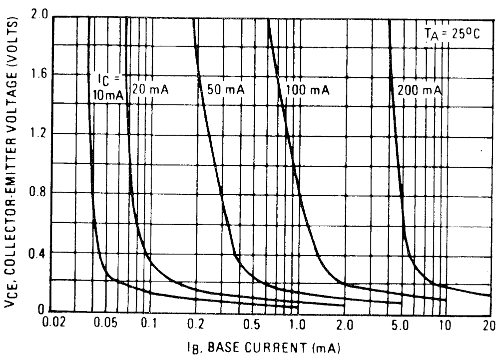
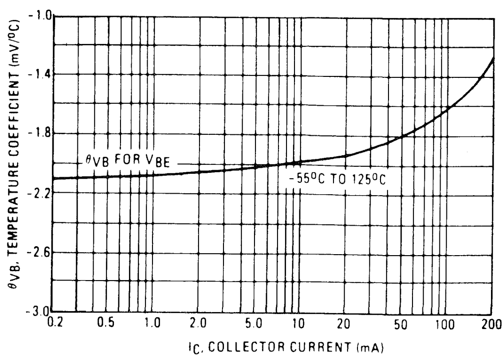


FIGURE 10 — BASE EMITTER TEMPERATURE COEFFICIENT



BC546

2

FIGURE 11 — CAPACITANCE

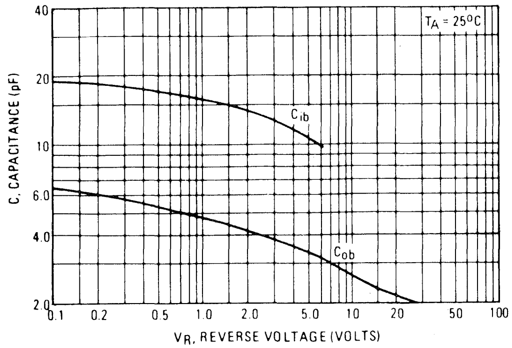
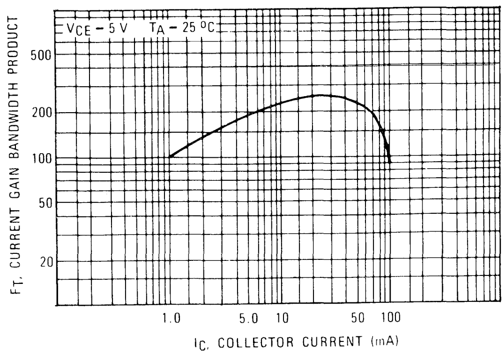
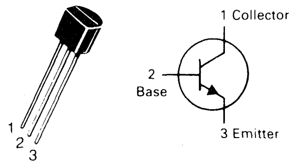


FIGURE 12 — CURRENT GAIN–BANDWIDTH PRODUCT



BC549B,C
BC550B,C

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



LOW NOISE TRANSISTORS

NPN SILICON

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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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 mAdc, I_B = 0) BC549B,C BC550B,C	$V_{(BR)CEO}$	 30 45			Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) BC549B,C BC550B,C	$V_{(BR)CBO}$	 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) BC549B/550B BC549C/550C	h_{FE}	 100 100 200 420	 150 270 290 500	 450 800	
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	 0.7	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_{CB} = 10 Vdc, I_E = 0, f = 1.0 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%

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

Characteristic		Symbol	Min	Typ	Max	Unit
Small-Signal Current Gain		h_{fe}				—
(I_C = 2.0 mAdc, V_{CE} = 5.0 V, f = 1.0 kHz)	BC549B/BC550B		240	330	500	
	BC549C/BC550C		450	600	900	
Noise Figure						dB
(I_C = 200 μAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz)		NF_1	—	0.6	2.5	
(I_C = 200 μAdc, V_{CE} = 5.0 Vdc, R_S = 100 kΩ, f = 1.0 kHz)		NF_2	—	—	10	

FIGURE 1 – TRANSISTOR NOISE MODEL

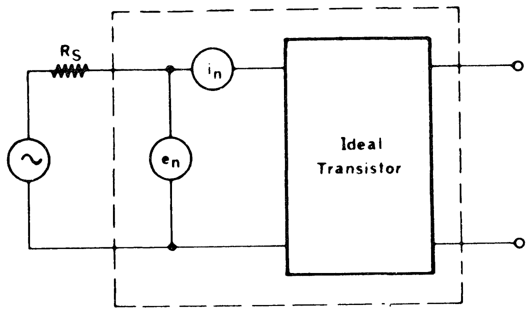


FIGURE 2 — NORMALIZED DC CURRENT GAIN

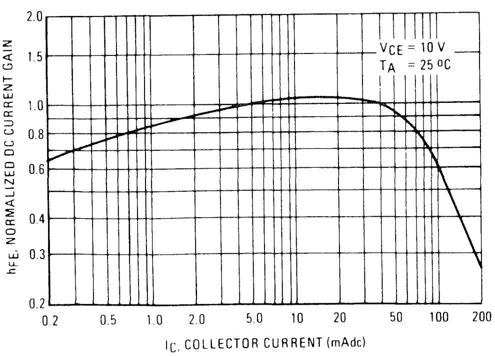


FIGURE 3 — "SATURATION" AND "ON" VOLTAGES

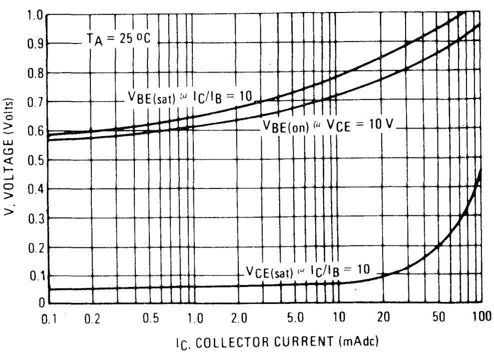


FIGURE 4 — CURRENT-GAIN BANDWIDTH PRODUCT

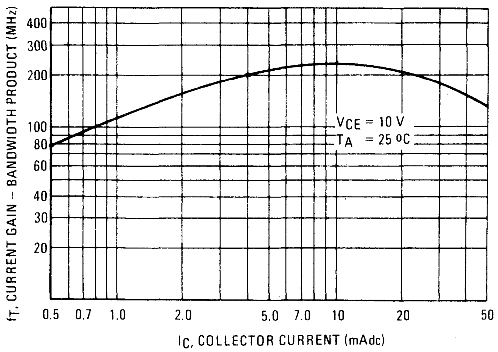


FIGURE 5 — CAPACITANCE

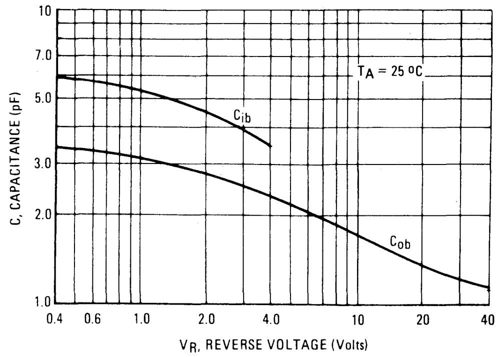
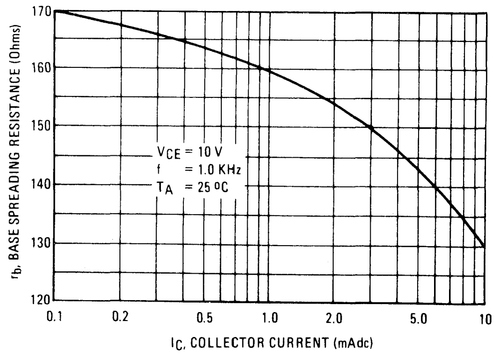
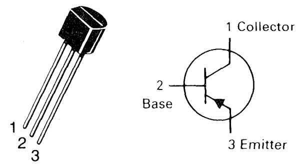


FIGURE 6 — BASE SPREADING RESISTANCE



BC556,B
BC557,A,B,C
BC558B

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC556	BC557	BC558	Unit
Collector-Emitter Voltage	V_{CEO}	−65	−45	−30	Vdc
Collector-Base Voltage	V_{CBO}	−80	−50	−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		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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$				V
($I_C = -2.0$ mAdc, $I_B = 0$)	BC556		−65	—	—	
	BC557		−45	—	—	
	BC558		−30	—	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$				V
($I_C = -100$ μAdc)	BC556		−80	—	—	
	BC557		−50	—	—	
	BC558		−30	—	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$				V
($I_E = -100$ μAdc, $I_C = 0$)	BC556		−5.0	—	—	
	BC557		−5.0	—	—	
	BC558		−5.0	—	—	
Collector-Emitter Leakage Current		I_{CES}				nA
($V_{CES} = -40$ V)	BC556		—	−2.0	−100	
($V_{CES} = -20$ V)	BC557		—	−2.0	−100	
	BC558		—	−2.0	−100	
($V_{CES} = -20$ V, $T_A = 125°C$)	BC556		—	—	−4.0	
	BC557		—	—	−4.0	μA
	BC558		—	—	−4.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
($I_C = -10$ μAdc, $V_{CE} = -5.0$ V)	BC557A		—	90	—	
	BC556B/557B/558B		—	150	—	
	BC557C		—	270	—	
($I_C = -2.0$ mAdc, $V_{CE} = -5.0$ V)	BC556		120	—	500	
	BC557		120	—	800	
	BC558		120	—	800	
	BC557A		120	170	220	
	BC556B/557B/558B		180	290	460	
	BC557C		420	500	800	
($I_C = -100$ mAdc, $V_{CE} = -5.0$ V)	BC557A		—	120	—	
	BC556B/557B/558B		—	180	—	
	BC557C		—	300	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				V
($I_C = -10$ mAdc, $I_B = -0.5$ mAdc)			—	−0.075	−0.3	
($I_C = -10$ mAdc, I_B = see Note 1)			—	−0.3	−0.6	
($I_C = -100$ mAdc, $I_B = -5.0$ mAdc)			—	−0.25	−0.65	

NOTE 1: $I_C = -10$ mAdc on the constant base current characteristics, which yields the point $I_C = -11$ mAdc, $V_{CE} = -1.0$ V.

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (continued)						
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				V
(I_C = −10 mAdc, I_B = −0.5 mAdc)			—	−0.7	—	
(I_C = −100 mAdc, I_B = −5.0 mAdc)			—	−1.0	—	
Base-Emitter On Voltage		$V_{BE(on)}$				V
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)			−0.55	−0.62	−0.7	
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)			—	−0.7	−0.82	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product		f_T				MHz
(I_C = −10 mA, V_{CE} = −5.0 V, f = 100 MHz)	BC556		—	280	—	
	BC557		—	320	—	
	BC558		—	360	—	
Output Capacitance (V_{CB} = −10 V, I_C = 0, f = 1.0 MHz)		C_{ob}	—	3.0	6.0	pF
Noise Figure		NF				dB
(I_C = −0.2 mAdc, V_{CE} = −5.0 V,	BC556		—	2.0	10	
R_S = 2 k ohms, f = 1.0 kHz, Δf = 200 Hz)	BC557		—	2.0	10	
	BC558		—	2.0	10	
Small-Signal Current Gain		h_{fe}				—
(I_C = −2.0 mAdc, V_{CE} = −5.0 V, f = 1.0 kHz)	BC556		125	—	500	
	BC557/558		125	—	900	
	BC557A		125	220	260	
	BC556B/557B/558B		240	330	500	
	BC557C		450	600	900	

2

BC557/BC558

FIGURE 1 — NORMALIZED DC CURRENT GAIN

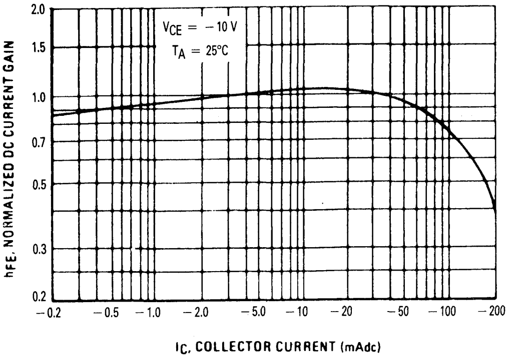


FIGURE 2 — "SATURATION" AND "ON" VOLTAGES

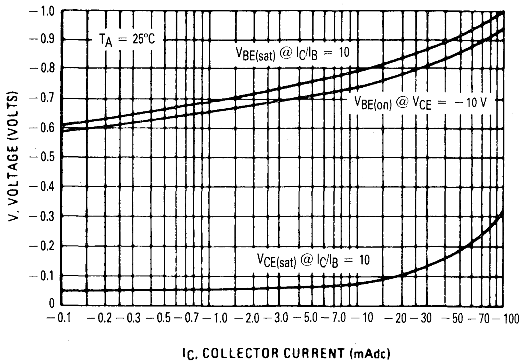


FIGURE 3 — COLLECTOR SATURATION REGION

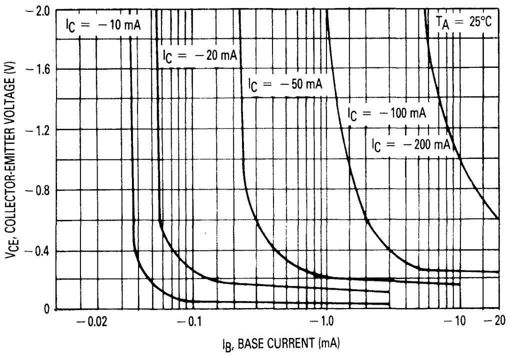


FIGURE 4 — BASE EMITTER TEMPERATURE COEFFICIENT

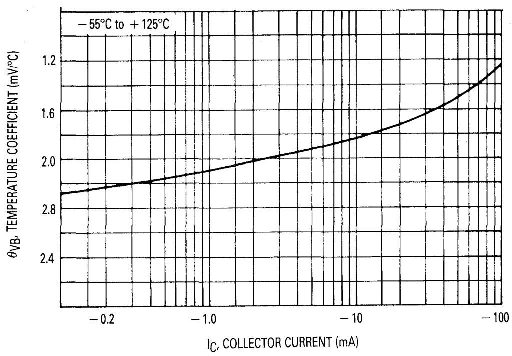


FIGURE 5 — CAPACITANCES

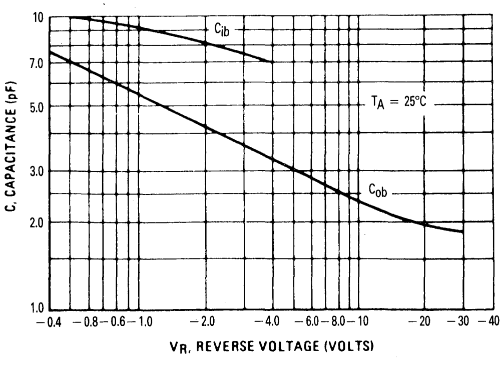
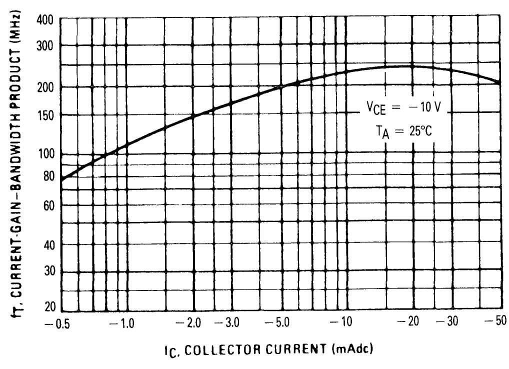


FIGURE 6 — CURRENT GAIN—BANDWIDTH PRODUCT



BC556

FIGURE 7 — DC CURRENT GAIN

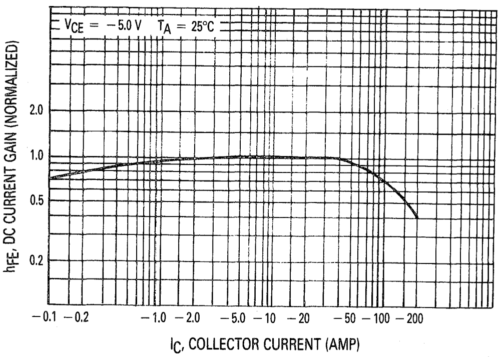


FIGURE 8 — "ON" VOLTAGE

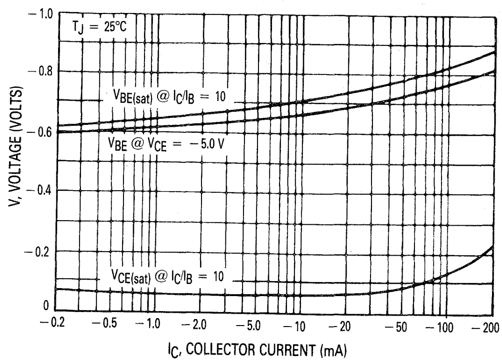


FIGURE 9 — COLLECTOR SATURATION REGION

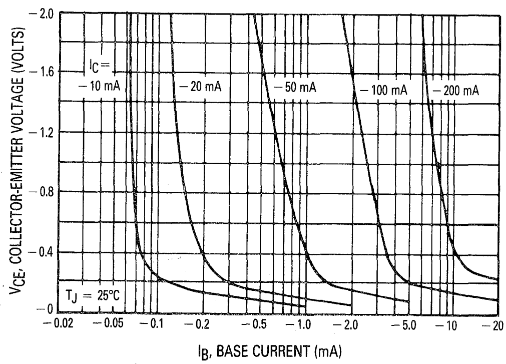


FIGURE 10 — BASE EMITTER TEMPERATURE COEFFICIENT

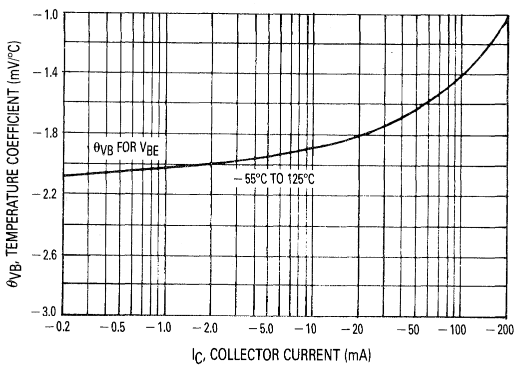


FIGURE 11 — CAPACITANCE

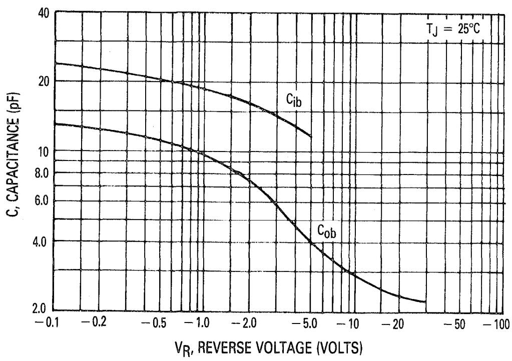


FIGURE 12 — CURRENT GAIN—BANDWIDTH PRODUCT

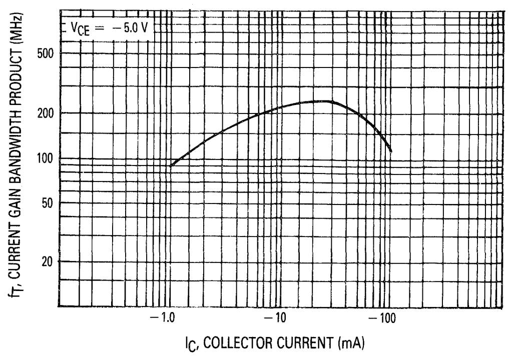


FIGURE 13 – THERMAL RESPONSE

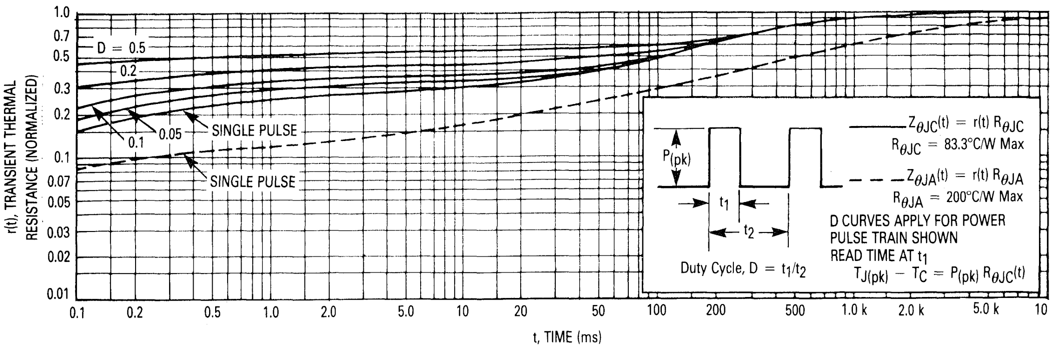
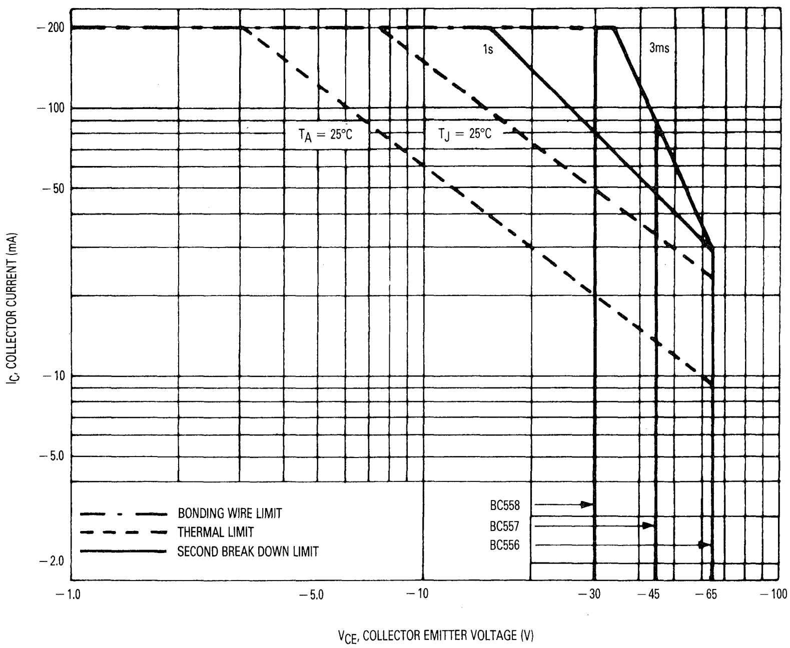


FIGURE 14 – ACTIVE REGION SAFE OPERATING AREA

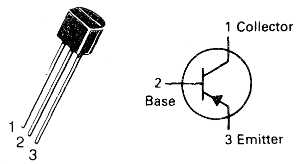


The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 14 is based upon $T_{J(pk)}=150°C$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ 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.

BC559, B, C
BC560B, C

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



LOW NOISE TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BC559	BC560	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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 mAdc, I_B = 0) BC559	$V_{(BR)CEO}$	−30	—	—	Vdc
BC560		−45	—	—	
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0) BC559	$V_{(BR)CBO}$	−30	—	—	Vdc
BC560		−50	—	—	
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)	I_{CBO}	—	—	−15	nAdc
(V_{CB} = −30 Vdc, I_E = 0, T_A = +125°C)		—	—	−5	μAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	—	−15	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 μAdc, V_{CE} = −5.0 Vdc) BC559B/560B	h_{FE}	100	150	—	—
BC559C/560C		100	270	—	
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc) BC559B/560B		180	290	460	
BC559C/560C		380	500	800	
BC559		120	—	800	
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc)	$V_{CE(sat)}$	—	−0.075	−0.25	Vdc
(I_C = −10 mAdc, I_B = see note 1)		—	−0.3	−0.6	
(I_C = −100 mAdc, I_B = −5.0 mAdc, see note 2)		—	−0.25	—	
Base-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	—	−1.1	—	Vdc
Base-Emitter On Voltage (I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	$V_{BE(on)}$	—	−0.52	—	Vdc
(I_C = −100 μAdc, V_{CE} = −5.0 Vdc)		—	−0.55	—	
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)		−0.55	−0.62	−0.7	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	—	250	—	MHz
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cbo}	—	2.5	—	pF
Small-Signal Current Gain (I_C = −2.0 mAdc, V_{CE} = −5.0 V, f = 1.0 kHz) BC559B/BC560B	h_{fe}	240	330	500	—
BC559C/BC560C		450	600	900	
Noise Figure (I_C = −200 μAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz)	NF_1	—	0.5	2.0	dB
(I_C = −200 μA, V_{CE} = −5.0 V, R_S = 100 kΩ, f = 1.0 kHz, Δf = 200 Hz)	NF_2	—	—	10	

Note 1: I_B is value for which I_C = −11 mA at V_{CE} = −1.0 V

Note 2: Pulse test = 300 μs — Duty cycle = 2%.

2

FIGURE 1 — NORMALIZED DC CURRENT GAIN

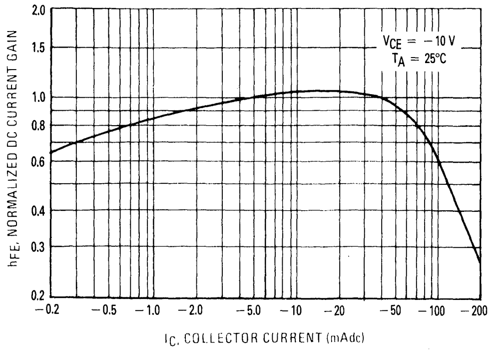


FIGURE 2 — "SATURATION" AND "ON" VOLTAGES

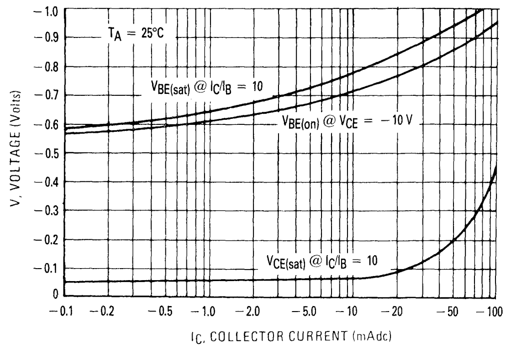


FIGURE 3 — CURRENT-GAIN BANDWIDTH PRODUCT

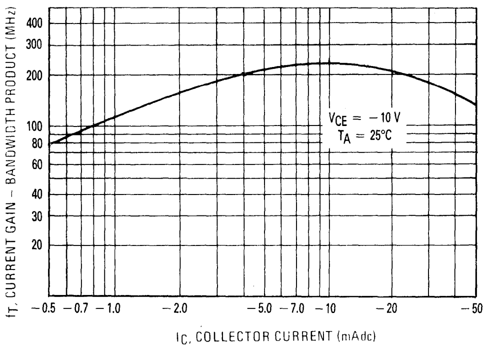


FIGURE 4 — CAPACITANCE

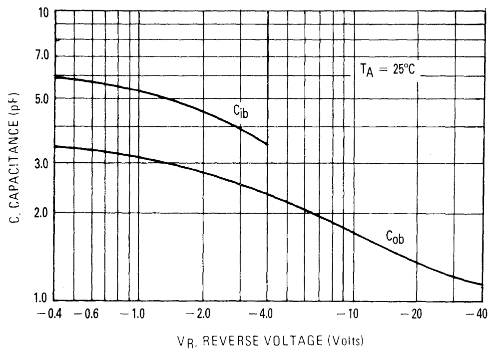
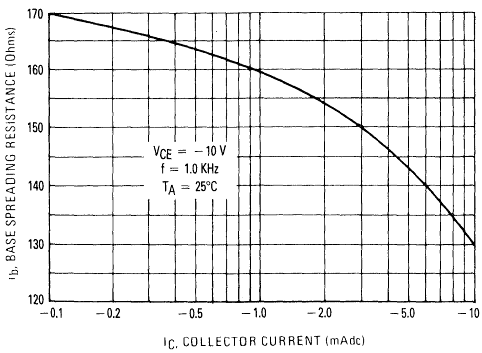
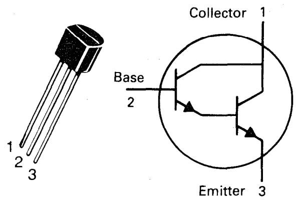


FIGURE 5 — BASE SPREADING RESISTANCE



BC618

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	55	Vdc
Collector-Base Voltage	V_{CBO}	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

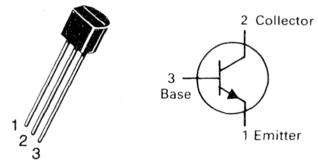
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	$V_{(BR)CEO}$	55	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_{CES}	— —	— —	 50	nAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 200 mA, I_B = 0.2 mA)	$V_{CE(sat)}$	—	—	1.1	Vdc
Base-Emitter Saturation Voltage (I_C = 200 mA, I_B = 0.2 mA)	$V_{BE(sat)}$	—	—	1.6	Vdc
Current Gain (I_C = 100μA, V_{CE} = 5.0 V) (I_C = 10 mA, V_{CE} = 5.0 V) (I_C = 200 mA, V_{CE} = 5.0 V) (I_C = 1.0 A, V_{CE} = 5.0 V)	h_{FE}	 2000 4000 10000 4000	 — — — —	 — — 50000 —	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 mA, V_{CE} = 5.0 V, P = 100 MHz)	f_T	150	—	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	4.5	7.0	pF
Input Capacitance (V_{EB} = 5.0 V, I_E = 0, f = 1.0 MHz)	C_{ib}	—	5.0	9.0	pF

BC635
BC637
BC639

CASE 29-04, 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_{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	0.5			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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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 mAdc, I_B = 0)	 BC635 BC637 BC639	$V_{(BR)CEO}$	 45 60 80	 — — —	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 BC635 BC637 BC639	$V_{(BR)CBO}$	 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, (V_{CB} = 30 Vdc, I_E = 0, T_A = 125°C)		I_{CBO}	 — —	 — —	 100 10	 nAdc μAdc
ON CHARACTERISTICS*						
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 2.0 Vdc) (I_C = 150 mAdc, V_{CE} = 2.0 Vdc) (I_C = 500 mA, V_{CE} = 2.0 V)	 BC635 BC637 BC639 	h_{FE}	 25 40 40 40 25	 — — — — —	 — 250 160 160 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	—	—	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		f_T	—	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	—	7.0	—	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	—	50	—	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

FIG. 1 — ACTIVE REGION SAFE OPERATING AREA

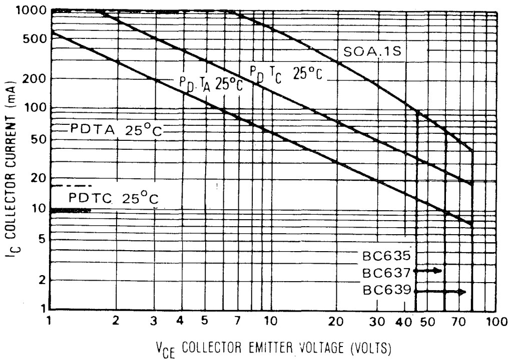


FIG. 2 — DC CURRENT GAIN

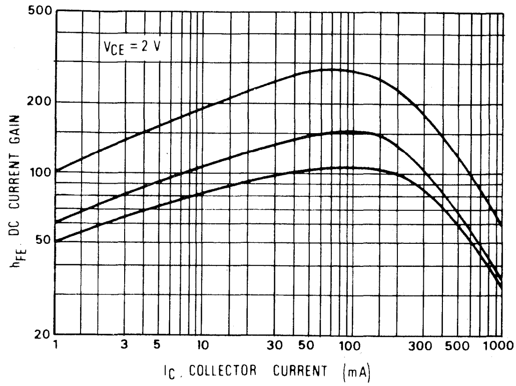


FIG. 3 — CURRENT GAIN BANDWIDTH PRODUCT

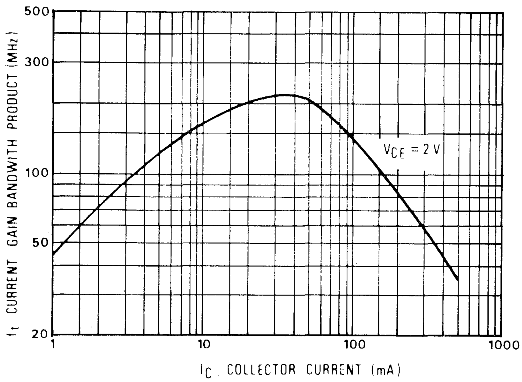


FIG. 4 — "SATURATION" AND "ON" VOLTAGES

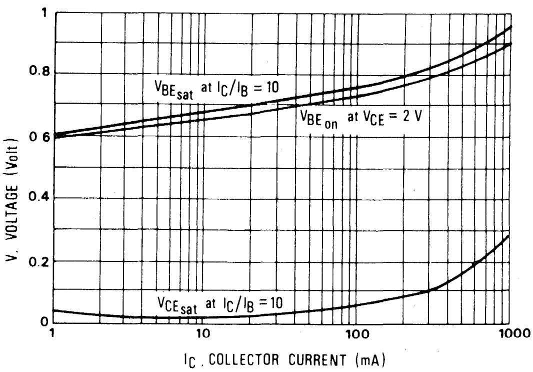
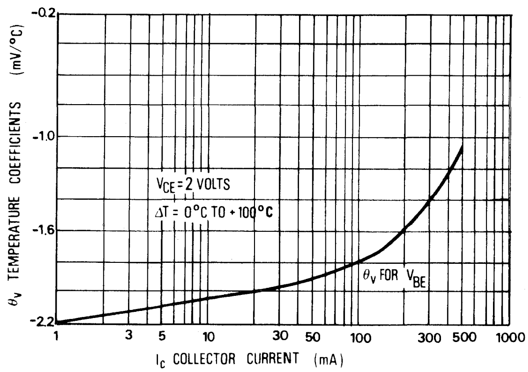
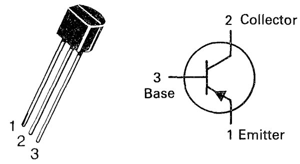


FIG. 5 — TEMPERATURE COEFFICIENTS



BC636
BC638
BC640

CASE 29-04, STYLE 14
TO-92 (TO-226AA)



HIGH CURRENT TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC636	BC638	BC640	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	−0.5			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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage*		$V_{(BR)CEO}$				Vdc
(I_C = −10 mAdc, I_B = 0)	BC636		−45	—	—	
	BC638		−60	—	—	
	BC640		−80	—	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$				Vdc
(I_C = −100 μAdc, I_E = 0)	BC636		−45	—	—	
	BC638		−60	—	—	
	BC640		−80	—	—	
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current		I_{CBO}				
(V_{CB} = −30 Vdc, I_E = 0)			—	—	−100	nAdc
(V_{CB} = −30 Vdc, I_E = 0, T_A = 125°C)			—	—	−10	μAdc
ON CHARACTERISTICS*						
DC Current Gain		h_{FE}				—
(I_C = −5.0 mAdc, V_{CE} = −2.0 Vdc)			25	—	—	
(I_C = −150 mAdc, V_{CE} = −2.0 Vdc)	BC636		40	—	250	
	BC638		40	—	160	
	BC640		40	—	160	
(I_C = −500 mA, V_{CE} = −2.0 V)			25	—	—	
Collector-Emitter Saturation Voltage (I_C = −500 mAdc, I_B = −50 mAdc)		$V_{CE(sat)}$	— —	−0.25 −0.5	−0.5 —	Vdc
Base-Emitter On Voltage (I_C = −500 mAdc, V_{CE} = −2.0 Vdc)		$V_{BE(on)}$	—	—	−1.0	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}	—	9.0	—	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	—	110	—	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

FIG. 1 — ACTIVE REGION SAFE OPERATING AREA

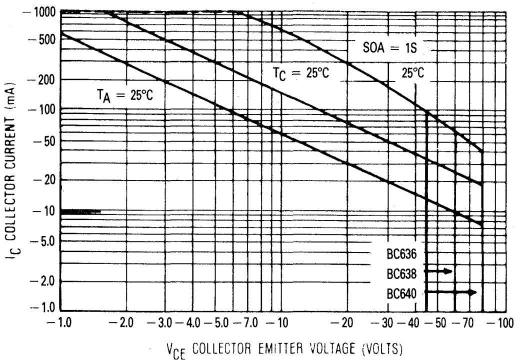


FIG. 2 — DC CURRENT GAIN

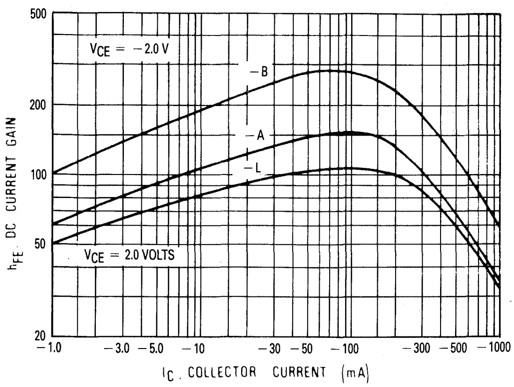


FIG. 3 — CURRENT GAIN BANDWIDTH PRODUCT

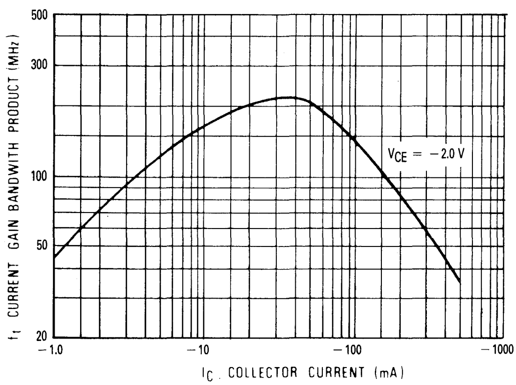


FIG. 4 — "SATURATION" AND "ON" VOLTAGES

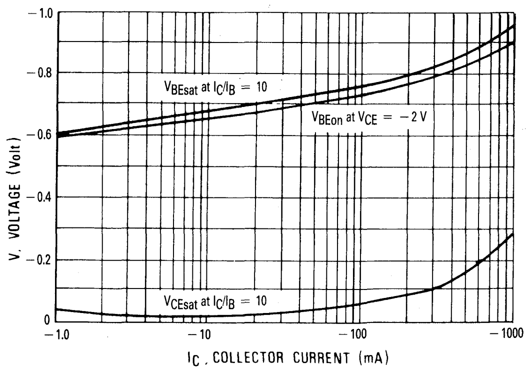
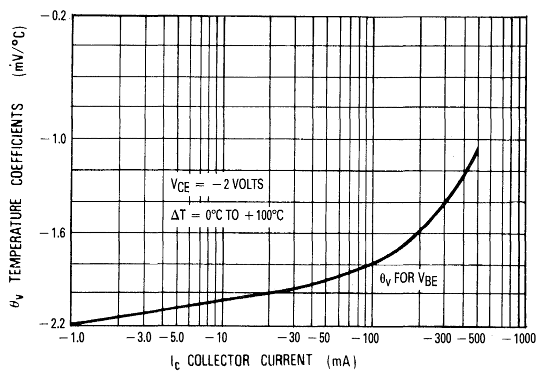
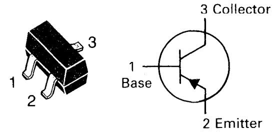


FIG. 5 — TEMPERATURE COEFFICIENTS



BC807-16LT1
BC807-25LT1
BC807-40LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−45	V
Collector-Base Voltage	V_{CBO}	−50	V
Emitter-Base Voltage	V_{EBO}	−5.0	V
Collector Current — Continuous	I_C	−500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BC807-16LT1 = 5A; BC807-25LT1 = 5B; BC807-40LT1 = 5C

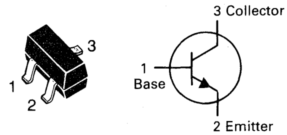
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −10 mA)	$V_{(BR)CEO}$	−45	—	—	V
Collector-Emitter Breakdown Voltage (V_{EB} = 0, I_C = −10 μA)	$V_{(BR)CES}$	−50	—	—	V
Emitter-Base Breakdown Voltage (I_E = −1.0 μA)	$V_{(BR)EBO}$	−5.0	—	—	V
Collector Cutoff Current (V_{CB} = −20 V) (V_{CB} = −20 V, T_J = 150°C)	I_{CBO}	 — —	 — —	 −100 −5.0	 nA μA
ON CHARACTERISTICS					
DC Current Gain (I_C = −100 mA, V_{CE} = −1.0 V) BC807-16 BC807-25 BC807-40 (I_C = −500 mA, V_{CE} = −1.0 V)	h_{FE}	 100 160 250 40	 — — — —	 250 400 600 —	
Collector-Emitter Saturation Voltage (I_C = −500 mA, I_B = −50 mA)	$V_{CE(sat)}$	—	—	−0.7	V
Base-Emitter On Voltage (I_C = −500 mA, I_B = −1.0 V)	$V_{BE(on)}$	—	—	−1.2	V
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mA, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	200	—	—	MHz
Output Capacitance (V_{CB} = −10 V, f = 1.0 MHz)	C_{obo}	—	10	—	pF

Note: "LT1" must be used when ordering SOT-23 devices.

BC817-16LT1
BC817-25LT1
BC817-40LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	V
Collector-Base Voltage	V_{CBO}	50	V
Emitter-Base Voltage	V_{EBO}	5.0	V
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BC817-16LT1 = 6A; BC817-25LT1 = 6B; BC817-40LT1 = 6C

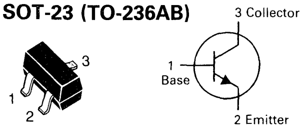
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −10 mA)	$V_{(BR)CEO}$	45	—	—	V
Collector-Emitter Breakdown Voltage (V_{EB} = 0, I_C = −10 μA)	$V_{(BR)CES}$	50	—	—	V
Emitter-Base Breakdown Voltage (I_E = −1.0 μA)	$V_{(BR)EBO}$	5.0	—	—	V
Collector Cutoff Current (V_{CB} = 20 V) (V_{CB} = 20 V, T_A = 150°C)	I_{CBO}	 — —	 — —	 100 5.0	 nA μA
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 1.0 V) BC817-16 BC817-25 BC817-40 (I_C = 500 mA, V_{CE} = 1.0 V)	h_{FE}	 100 160 250 40	 — — — —	 250 400 600 —	
Collector-Emitter Saturation Voltage (I_C = 500 mA, I_B = 50 mA)	$V_{CE(sat)}$	—	—	0.7	V
Base-Emitter On Voltage (I_C = 500 mA, V_{CE} = 1.0 V)	$V_{BE(on)}$	—	—	1.2	V
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	200	—	—	MHz
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)	C_{obo}	—	10	—	pF

Note: "LT1" must be used when ordering SOT-23 devices.

BC846ALT1★, BLT1★
BC847ALT1★, BLT1★, CLT1★
BC848ALT1★, BLT1★, CLT1★
BC849ALT1, BLT1, CLT1
BC850ALT1, BLT1, CLT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★These are Motorola designated preferred devices.

Refer to BC546 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC846	BC847 BC850	BC848 BC849	Unit
Collector-Emitter Voltage	V_{CEO}	65	45	30	V
Collector-Base Voltage	V_{CBO}	80	50	30	V
Emitter-Base Voltage	V_{EBO}	6.0	6.0	5.0	V
Collector Current — Continuous	I_C	100	100	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,*	P_D		
T_A = 25°C		225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation	P_D		
Alumina Substrate,** T_A = 25°C		300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 × 0.75 × 0.062 in **Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

DEVICE MARKING

BC846ALT1 = 1A; BC846BLT1 = 1B; BC847ALT1 = 1E; BC847BLT1 = 1F; BC847CLT1 = 1G; BC848ALT1 = 1J; BC848BLT1 = 1K; BC848CLT1 = 1L

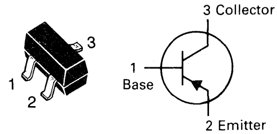
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage	BC846A,B	$V_{(BR)CEO}$	65	—	—	V
(I_C = 10 mA)	BC847A,B,C, BC850A,B,C		45	—	—	
	BC848A,B,C, BC849A,B,C		30	—	—	
Collector-Emitter Breakdown Voltage	BC846A,B	$V_{(BR)CES}$	80	—	—	V
(I_C = 10 μA, V_{EB} = 0)	BC847A,B,C, BC850A,B,C		50	—	—	
	BC848A,B,C, BC849A,B,C		30	—	—	
Collector-Base Breakdown Voltage	BC846A,B	$V_{(BR)CBO}$	80	—	—	V
(I_C = 10 μA)	BC847A,B,C, BC850A,B,C		50	—	—	
	BC848A,B,C, BC849A,B,C		30	—	—	
Emitter-Base Breakdown Voltage	BC846A,B	$V_{(BR)/ebo}$	6.0	—	—	V
(I_E = 1.0 μA)	BC847A,B,C		6.0	—	—	
	BC848A,B,C, BC849A,B,C, BC850A,B,C		5.0	—	—	
Collector Cutoff Current (V_{CB} = 30V)		I_{CBO}	—	—	15	nA
(V_{CB} = 30 V, T_A = 150°C)			—	—	5.0	μA
ON CHARACTERISTICS						
DC Current Gain	BC846A, BC847A, BC848A	h_{FE}	—	90	—	—
(I_C = 10 μA, V_{CE} = 5.0 V)	BC846B, BC847B, BC848B		—	150	—	
	BC847C, BC848C		—	270	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC846A, BC847A, BC848A, BC849A, BC850A		110	180	220	
	BC846B, BC847B, BC848B, BC849B, BC850B		200	290	450	
	BC847C, BC848C, BC849C, BC850C		420	520	800	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA)		$V_{CE(sat)}$	—	—	0.25	V
(I_C = 100 mA, I_B = 5.0 mA)			—	—	0.6	
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA)		$V_{BE(sat)}$	—	0.7	—	V
(I_C = 100 mA, I_B = 5.0 mA)			—	0.9	—	
Base-Emitter Voltage (I_C = 2.0 mA, V_{CE} = 5.0 V)		$V_{BE(on)}$	580	660	700	mV
(I_C = 10 mA, V_{CE} = 5.0 V)			—	—	770	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	—	—	MHz
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)		C_{obo}	—	—	4.5	pF
Noise Figure (I_C = 0.2 mA,	BC846A, BC847A, BC848A	N_F				dB
V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ,	BC846B, BC847B, BC848B					
f = 1.0 kHz, BW = 200 Hz)	BC847C, BC848C		—	—	10	
	BC849A,B,C, BC850A,B,C		—	—	4.0	

Note: "LT1" must be used when ordering SOT-23 devices.

BC856ALT1★, BLT1★
BC857ALT1★, BLT1★, CLT1★
BC858ALT1★, BLT1★, CLT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★These are Motorola designated preferred devices.

Refer to BC556 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC856	BC857	BC858	Unit
Collector-Emitter Voltage	V_{CEO}	−65	−45	−30	V
Collector-Base Voltage	V_{CBO}	−80	−50	−30	V
Emitter-Base Voltage	V_{EBO}	−5.0	−5.0	−5.0	V
Collector Current — Continuous	I_C	−100	−100	−100	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in. **Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BC856ALT1 = 3A; BC856BLT1 = 3B; BC857ALT1 = 3E; BC857BLT1 = 3F; BC857CLT1 = 3G; BC858ALT1 = 3J; BC858BLT1 = 3K; BC858CLT1 = 3L

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)	BC856 Series	$V_{(BR)CEO}$	−65	—	—	V
	BC857 Series		−45	—	—	
	BC858 Series		−30	—	—	
Collector-Emitter Breakdown Voltage (I_C = −10 μA, V_{EB} = 0)	BC856 Series	$V_{(BR)CES}$	−80	—	—	V
	BC857 Series		−50	—	—	
	BC858 Series		−30	—	—	
Collector-Base Breakdown Voltage (I_C = −10 μA)	BC856 Series	$V_{(BR)CBO}$	−80	—	—	V
	BC857 Series		−50	—	—	
	BC858 Series		−30	—	—	
Emitter-Base Breakdown Voltage (I_E = −1.0 μA)	BC856 Series	$V_{(BR)EBO}$	−5.0	—	—	V
	BC857 Series		−5.0	—	—	
	BC858 Series		−5.0	—	—	
Collector Cutoff Current (V_{CB} = −30 V)		I_{CBO}	—	—	−15	nA
(V_{CB} = −30 V, T_A = 150°C)			—	—	−4.0	μA
ON CHARACTERISTICS						
DC Current Gain (I_C = −10 μA, V_{CE} = −5.0 V)	BC856A, BC857A, BC585A	h_{FE}	—	90	—	—
	BC856A, BC857A, BC858A		—	150	—	
	BC857C, BC858C		—	270	—	
(I_C = −2.0 mA, V_{CE} = −5.0 V)	BC856A, BC857A, BC858A		125	180	250	
	BC856B, BC857B, BC858B		220	290	475	
	BC857C, BC858C		420	520	800	
Collector-Emitter Saturation Voltage (I_C = −10 mA, I_B = −0.5 mA)		$V_{CE(sat)}$	—	—	−0.3	V
($_C$ = −100 mA, I_B = −5.0 mA)			—	—	−0.65	
Base-Emitter Saturation Voltage (I_C = −10 mA, I_B = −0.5 mA)		$V_{BE(sat)}$	—	−0.7	—	V
(I_C = −100 mA, I_B = −5.0 mA)			—	−0.9	—	
Base-Emitter On Voltage (I_C = −2.0 mA, V_{CE} = −5.0 V)		$V_{BE(on)}$	−0.6	—	−0.75	V
(I_C = −10 mA, V_{CE} = −5.0 V)			—	—	−0.82	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = −10 mA, V_{CE} = −5.0 Vdc, f = 100 MHz)		f_T	100	—	—	MHz
Output Capacitance (V_{CB} = −10 V, f = 1.0 MHz)		C_{ob}	—	—	4.5	pF
Noise Figure (I_C = −0.2 mA, V_{CE} = −5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	—	10	dB

Note: "LT1" must be used when ordering SOT-23 devices.

PNP Silicon Epitaxial Transistor

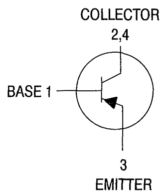
BCP53T1

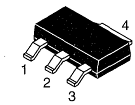
Motorola Preferred Device

MEDIUM POWER PNP SILICON HIGH CURRENT TRANSISTOR SURFACE MOUNT

This PNP Silicon Epitaxial transistor is designed for use in audio amplifier applications. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- High Current: 1.5 Amps
- NPN Complement is BCP56
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use BCP53T1 to order the 7 inch/1000 unit reel.
  Use BCP53T3 to order the 13 inch/4000 unit reel.





CASE 318E-04, STYLE 1
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−80	Vdc
Collector-Base Voltage	V_{CBO}	−100	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current	I_C	1.5	Adc
Total Power Dissipation @ T_A = 25°C* Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

AH

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Lead Temperature for Soldering, 0.0625″ from case Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 sq. in.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristics	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = –100 μAdc, I_E = 0)	$V_{(BR)CBO}$	–100	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = –1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	–80	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = –100 μAdc, R_{BE} = 1.0 kohm)	$V_{(BR)CER}$	–100	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = –10 μAdc, I_C = 0)	$V_{(BR)EBO}$	–5.0	—	—	Vdc
Collector-Base Cutoff Current (V_{CB} = –30 Vdc, I_E = 0)	I_{CBO}	—	—	–100	nAdc
Emitter-Base Cutoff Current (V_{EB} = –5.0 Vdc, I_C = 0)	I_{EBO}	—	—	–10	μAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
(I_C = –5.0 mAdc, V_{CE} = –2.0 Vdc)		25	—	—	
(I_C = –150 mAdc, V_{CE} = –2.0 Vdc)		40	—	250	
(I_C = –500 mAdc, V_{CE} = –2.0 Vdc)		25	—	—	
Collector-Emitter Saturation Voltage (I_C = –500 mAdc, I_B = –50 mAdc)	$V_{CE(sat)}$	—	—	–0.5	Vdc
Base-Emitter On Voltage (I_C = –500 mAdc, V_{CE} = –2.0 Vdc)	$V_{BE(on)}$	—	—	–1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = –10 mAdc, V_{CE} = –5.0 Vdc, f = 35 MHz)	f_T	—	50	—	MHz

2

TYPICAL ELECTRICAL CHARACTERISTICS

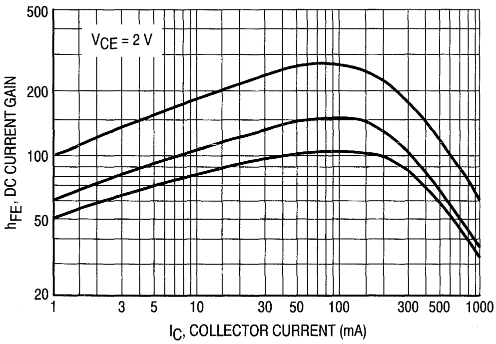


Figure 1. DC Current Gain

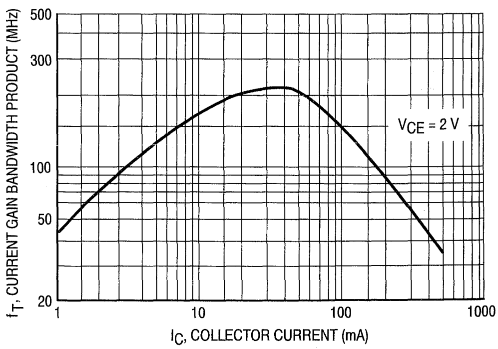


Figure 2. Current Gain Bandwidth Product

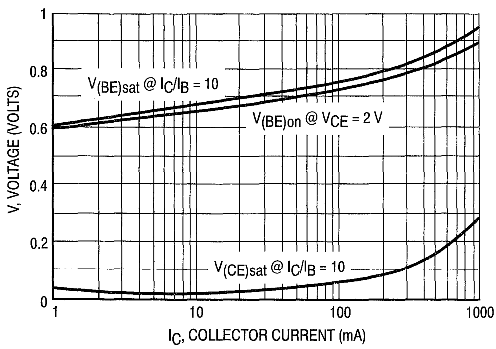


Figure 3. Saturation and "ON" Voltages

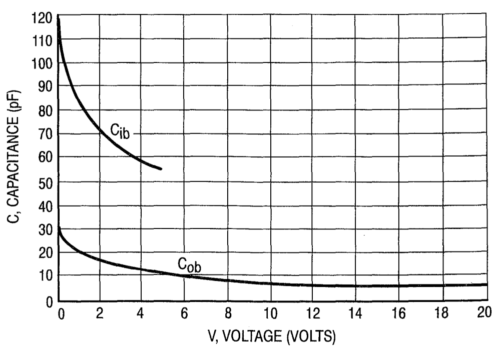


Figure 4. Capacitances

2

BCP56T1 SERIES

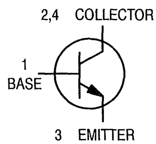
Motorola Preferred Device

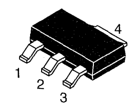
NPN Silicon Epitaxial Transistors

These NPN Silicon Epitaxial transistors are designed for use in audio amplifier applications. The device is housed in the SOT-223 package, which is designed for medium power surface mount applications.

- High Current: 1.0 Amp
- The SOT-223 package can be soldered using Wave or Reflow. The formed leads absorb thermal stress during soldering, eliminating the possibility of damage to the die
- Available in 12 mm Tape and Reel
  Use BCP56T1 to order the 7 inch/1000 unit reel
  Use BCP56T3 to order the 13 inch/4000 unit reel
- PNP Complement is BCP53T1

MEDIUM POWER NPN SILICON HIGH CURRENT TRANSISTORS SURFACE MOUNT





CASE 318E-04, STYLE 1
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	1	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

BCP56T1 = BH
BCP56-10T1 = BK
BCP56-16T1 = BL

THERMAL CHARACTERISTICS

Thermal Resistance Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a FR-4 glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.0625 in.; mounting pad for the collector lead = 0.93 sq. in.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristics		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	100	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	100	nAdc
Emitter-Base Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	—	10	μAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				—
(I_C = 5.0 mA, V_{CE} = 2.0 V)	All Part Types		25	—	—	
(I_C = 150 mA, V_{CE} = 2.0 V)	BCP56T1		40	—	250	
	BCP56-10T1		63	—	160	
	BCP56-16T1		100	—	250	
(I_C = 500 mA, V_{CE} = 2.0 V)	All Types		25	—	—	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	—	—	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 35 MHz)		f_T	—	130	—	MHz

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

TYPICAL ELECTRICAL CHARACTERISTICS

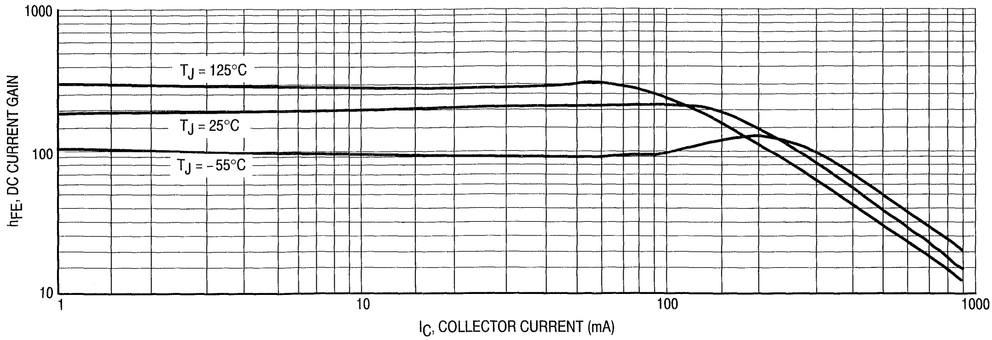


Figure 1. DC Current Gain

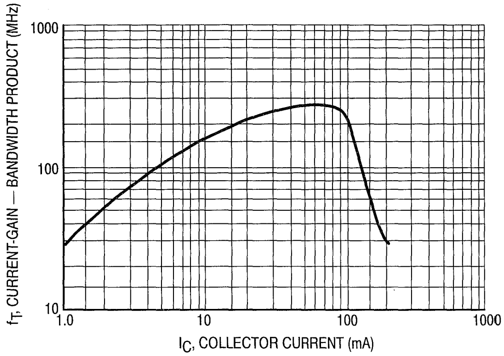


Figure 2. Current-Gain — Bandwidth Product

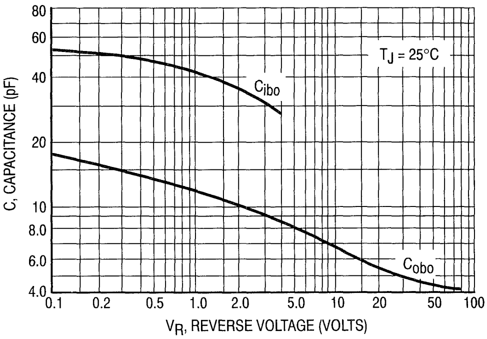


Figure 3. Capacitance

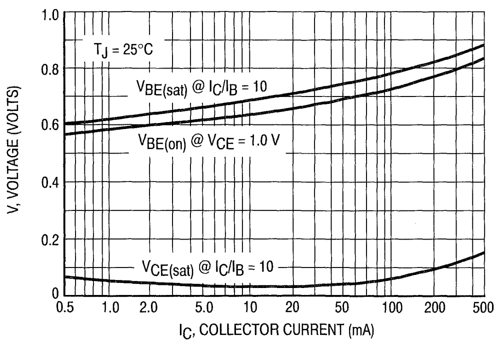


Figure 4. "On" Voltages

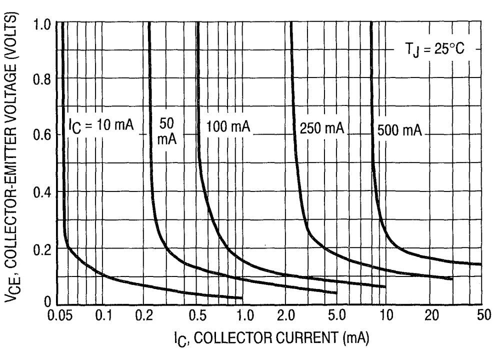


Figure 5. Collector Saturation Region

NPN Silicon Epitaxial Transistor

BCP68T1

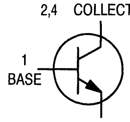
Motorola Preferred Device

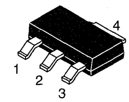
2

MEDIUM POWER NPN SILICON HIGH CURRENT TRANSISTOR SURFACE MOUNT

This NPN Silicon Epitaxial Transistor is designed for use in low voltage, high current applications. The device is housed in the SOT-223 package, which is designed for medium power surface mount applications.

- High Current: I_C = 1.0 Amp
- The SOT-223 Package can be Soldered Using Wave or Reflow.
- SOT-223 package ensures level mounting, resulting in improved thermal conduction, and allows visual inspection of soldered joints. The formed leads absorb thermal stress during soldering, eliminating the possibility of damage to the die
- Available in 12 mm Tape and Reel
  Use BCP68T1 to order the 7 inch/1000 unit reel.
  Use BCP68T3 to order the 13 inch/4000 unit reel.
- The PNP Complement is BCP69T1





CASE 318E-04, STYLE 1
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	1	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

CA

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a FR-4 glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.0625 in.; mounting pad for the collector lead = 0.93 sq. in.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

2

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

Characteristics	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CES}$	25	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
Emitter-Base Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	10	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				—
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc)		50	—	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		85	—	375	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		60	—	—	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	—	—	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	f_T	—	60	—	MHz

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

TYPICAL ELECTRICAL CHARACTERISTICS

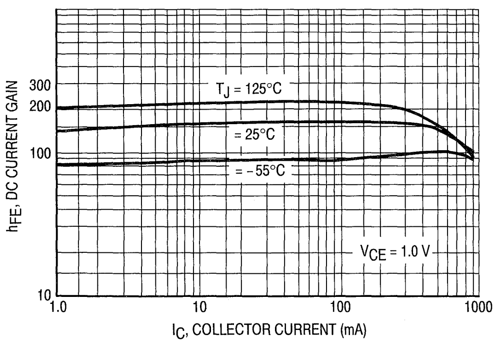


Figure 1. DC Current Gain

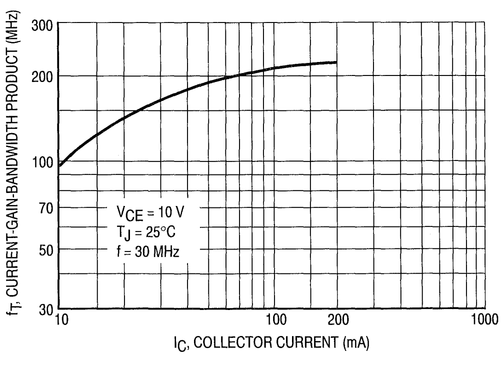


Figure 2. Current-Gain-Bandwidth Product

TYPICAL ELECTRICAL CHARACTERISTICS

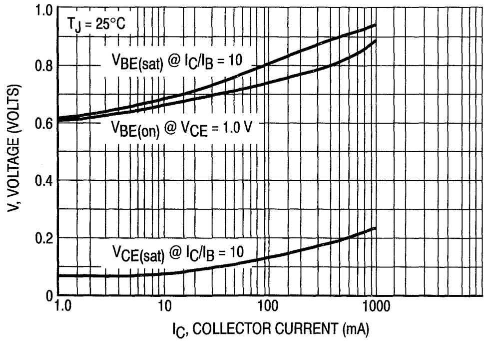


Figure 3. "On" Voltage

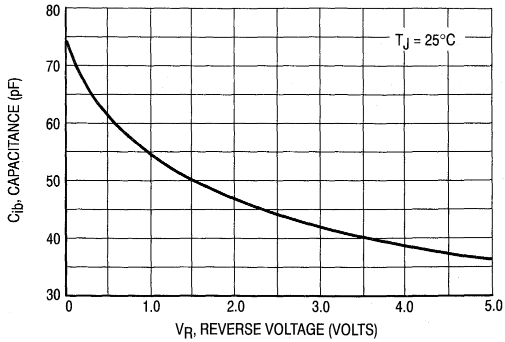


Figure 4. Capacitance

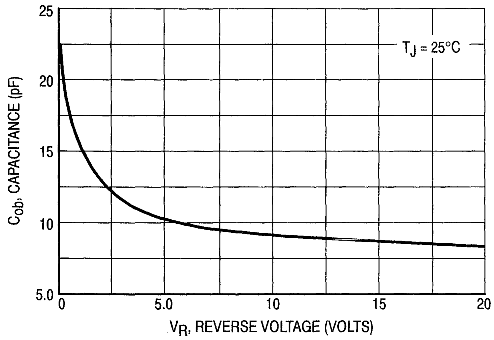


Figure 5. Capacitance

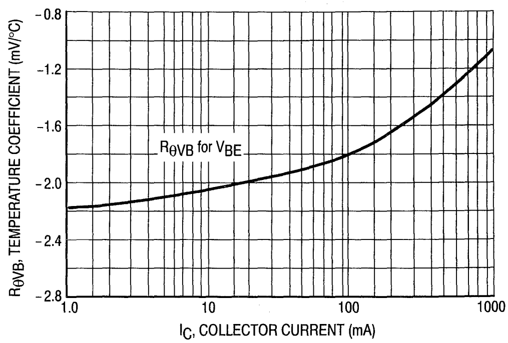


Figure 6. Base-Emitter Temperature Coefficient

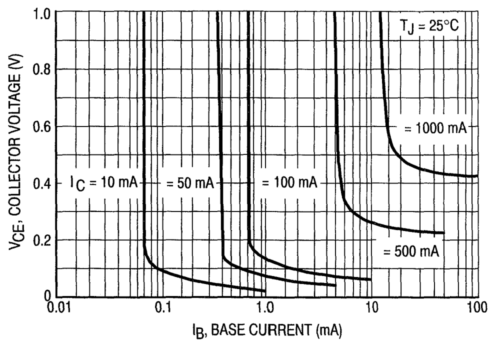


Figure 7. Saturation Region

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

PNP Silicon Epitaxial Transistor

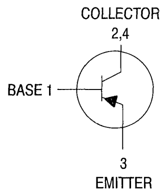
BCP69T1

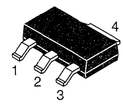
Motorola Preferred Device

MEDIUM POWER PNP SILICON HIGH CURRENT TRANSISTOR SURFACE MOUNT

This PNP Silicon Epitaxial Transistor is designed for use in low voltage, high current applications. The device is housed in the SOT-223 package, which is designed for medium power surface mount applications.

- High Current: $I_C = -1.0$ Amp
- The SOT-223 Package can be Soldered Using Wave or Reflow.
- SOT-223 Package Ensures Level Mounting, Resulting in Improved Thermal Conduction, and Allows Visual Inspection of Soldered Joints. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die.
- Available in 12 mm Tape and Reel
  Use BCP69T1 to order the 7 inch/1000 unit reel.
  Use BCP69T3 to order the 13 inch/4000 unit reel.
- NPN Complement is BCP68





CASE 318E-04, STYLE 1
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−25	Vdc
Collector-Base Voltage	V_{CBO}	−20	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current	I_C	−1.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

CE

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Lead Temperature for Soldering, 0.0625″ from case Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 sq. in.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristics	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = –100 μAdc, I_E = 0)	$V_{(BR)CES}$	–25	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = –1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	–20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = –10 μAdc, I_C = 0)	$V_{(BR)EBO}$	–5.0	—	—	Vdc
Collector-Base Cutoff Current (V_{CB} = –25 Vdc, I_E = 0)	I_{CBO}	—	—	–10	μAdc
Emitter-Base Cutoff Current (V_{EB} = –5.0 Vdc, I_C = 0)	I_{EBO}	—	—	–10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = –5.0 mAdc, V_{CE} = –10 Vdc) (I_C = –500 mAdc, V_{CE} = –1.0 Vdc) (I_C = –1.0 Adc, V_{CE} = –1.0 Vdc)	h_{FE}	 50 85 60	 — — —	 — 375 —	—
Collector-Emitter Saturation Voltage (I_C = –1.0 Adc, I_B = –100 mAdc)	$V_{CE(sat)}$	—	—	–0.5	Vdc
Base-Emitter On Voltage (I_C = –1.0 Adc, V_{CE} = –1.0 Vdc)	$V_{BE(on)}$	—	—	–1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = –10 mAdc, V_{CE} = –5.0 Vdc)	f_T	—	60	—	MHz

2

TYPICAL ELECTRICAL CHARACTERISTICS

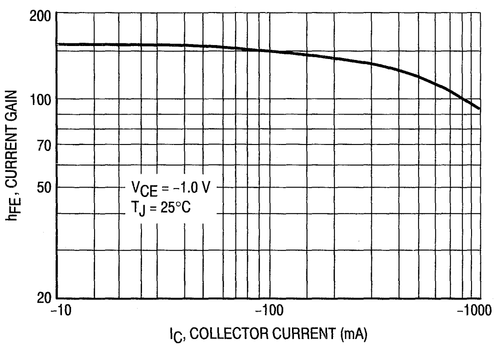


Figure 1. DC Current Gain

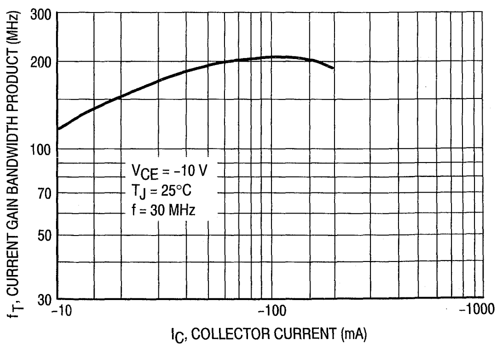


Figure 2. Current Gain Bandwidth Product

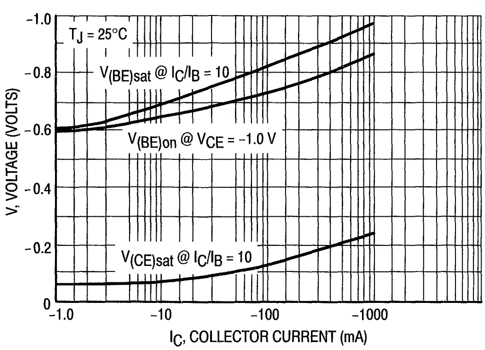


Figure 3. Saturation and "ON" Voltages

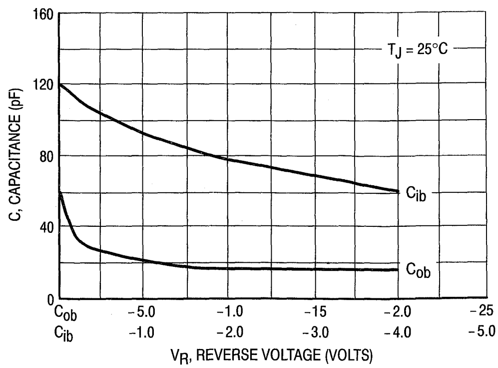


Figure 4. Capacitances

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	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

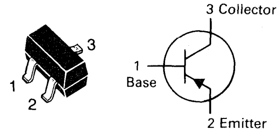
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW29LT1 = C1; BCW30LT1 = C2

BCW29LT1
BCW30LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

Refer to 2N5086 for graphs.

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −2.0 mAdc, I_E = 0)	$V_{(BR)CEO}$	−32	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{EB} = 0)	$V_{(BR)CES}$	−32	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_C = 0)	$V_{(BR)CBO}$	−32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −32 Vdc, I_E = 0) (V_{CB} = −32 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) 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_{CB} = −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 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	10	dB

Note: "LT1" must be used when ordering SOT-23 devices.

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

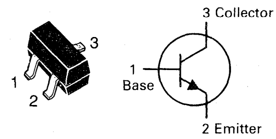
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW31LT1 = D1; BCW33LT1 = D3

BCW33LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to MPS3904 for graphs.

2

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	32	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_B = 0)	$V_{(BR)CBO}$	32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 32 V, I_E = 0) (V_{CB} = 32 V, 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)	h_{FE}	420	800	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	0.55	0.70	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{obo}	—	4.0	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

Note: "LT1" must be used when ordering SOT-23 devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	V
Collector-Base Voltage	V_{CBO}	32	V
Emitter-Base Voltage	V_{EBO}	5.0	V
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

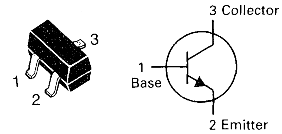
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW60ALT1 = AA; BCW60BLT1 = AB; BCW60DLT1 = AD

BCW60ALT1
BCW60BLT1
BCW60DLT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to MPS3904 for graphs.

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)		$V_{(BR)CEO}$	32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)		I_{CES}	 — —	 20 20	 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 μAdc, V_{CE} = 5.0 Vdc)	 BCW60A BCW60B BCW60D	h_{FE}	 20 30 100	 — — —	—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCW60A BCW60B BCW60D		120 175 380	220 310 630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCW60A BCW60B BCW60D		60 70 100	— — —	
AC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 BCW60A BCW60B BCW60D	h_{fe}	 125 175 350	 250 350 700	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 10 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	 — —	 0.55 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 50 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	 0.7 0.6	 1.05 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

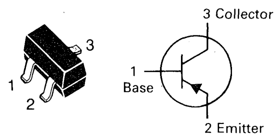
Note: "LT1" must be used when ordering SOT-23 devices.

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 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)	C_{obo}	—	4.5	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	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

BCW61BLT1
BCW61CLT1
BCW61DLT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−32	V
Collector-Base Voltage	V_{CBO}	−32	V
Emitter-Base Voltage	V_{EBO}	−5.0	V
Collector Current — Continuous	I_C	−100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW61BLT1 = BB; BCW61CLT1 = BC; BCW61DLT1 = BD

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CE} = −32 Vdc) (V_{CE} = −32 Vdc, T_A = 150°C)		I_{CES}	 — —	 −20 −20	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	 BCW61B BCW61C BCW61D	h_{FE}	 30 40 100	 — — —	—
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	BCW61B BCW61C BCW61D		140 250 380	310 460 630	
(I_C = −50 mAdc, V_{CE} = −1.0 Vdc)	BCW61B BCW61C BCW61D		80 100 100	— — —	
AC Current Gain (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)	 BCW61A BCW61B BCW61C BCW61D	h_{fe}	 125 175 250 350	 250 350 500 700	—
Collector-Emitter Saturation Voltage (I_C = −50 mAdc, I_B = −1.25 mAdc) (I_C = −10 mAdc, I_B = −0.25 mAdc)		$V_{CE(sat)}$	 — —	 −0.55 −0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −50 mAdc, I_B = −1.25 mAdc) (I_C = −10 mAdc, I_B = −0.25 mAdc)		$V_{BE(sat)}$	 −0.68 −0.6	 −1.05 −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

Note: "LT1" must be used when ordering SOT-23 devices.

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

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CE} = −10 Vdc, I_C = 0, f = 1.0 MHz)	C_{obo}	—	6.0	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	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = −1.0 mAdc, V_{BB} = −3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

2

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 FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$ Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

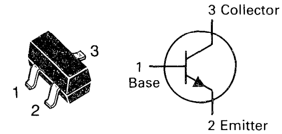
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW65ALT1 = EA

BCW65ALT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTOR

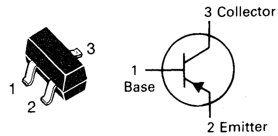
NPN SILICON

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)	$V_{(BR)CEO}$	32	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{EB} = 0)	$V_{(BR)CES}$	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} = 32 Vdc, I_E = 0, T_A = 150°C)	I_{CES}	 — —	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 35 75 100 35	 — — — —	 — 220 250 —	—
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 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	—	10	dB
SWITCHING CHARACTERISTICS					
Turn-On Time (I_{B1} = I_{B2} = 15 mAdc)	t_{on}	—	—	100	ns
Turn-Off Time (I_C = 150 mAdc, R_L = 150 Ω)	t_{off}	—	—	400	ns

BCW68GLT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−45	Vdc
Collector-Base Voltage	V_{CBO}	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−800	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

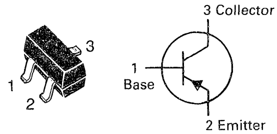
BCW68GLT1 = DH

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	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −10 μAdc, V_{EB} = 0)	$V_{(BR)CES}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = −45 Vdc, I_E = 0) (V_{CE} = −45 Vdc, I_B = 0, T_A = 150°C)	I_{CES}	 — —	 — —	 −20 −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) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc) (I_C = −300 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 120 160 60	 — — —	 400 — —	—
Collector-Emitter Saturation Voltage (I_C = −300 mAdc, I_B = −30 mAdc)	$V_{CE(sat)}$	—	—	−1.5	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}	—	—	105	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)	N_F	—	—	10	dB

BCW69LT1
BCW70LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

Refer to 2N5086 for graphs.

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 CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW69LT1 = H1; BCW70LT1 = H2

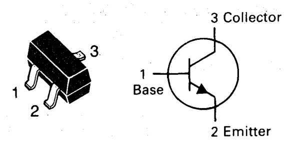
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−45	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{EB} = 0)		$V_{(BR)CES}$	−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)	BCW69 BCW70	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_{CB} = −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 kΩ, f = 1.0 kHz, BW = 200 Hz)		N_F	—	10	dB

Note: "LT1" must be used when ordering SOT-23 devices.

BCW72LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW72LT1 = K2

Refer to MPS3904 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 = 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)	h_{FE}	200	—	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 = 100 MHz)	f_T	—	300	—	MHz
Output Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Input Capacitance (I_E = 0, V_{CB} = 10 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

Note: "LT1" must be used when ordering SOT-23 devices.

MAXIMUM RATINGS

Rating	Symbol	Value: BCX17LT1 BCX19LT1	Value: BCX18LT1 BCX20LT1	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

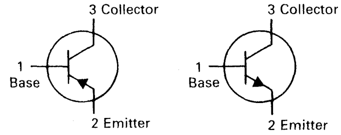
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

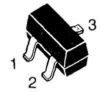
BCX17LT1 = T1; BCX18LT1 = T2; BCX19LT1 = U1; BCX20LT1 = U2

PNP | **NPN**

BCX17LT1(1) BCX19LT1
BCX18LT1(1) BCX20LT1



CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

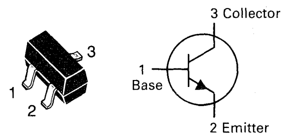
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BCX17, 19 BCX18, 20	$V_{(BR)CEO}$	45 25	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, I_C = 0)	BCX17, 19 BCX18, 20	$V_{(BR)CES}$	50 30	— —	— —	Vdc
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_{EB} = 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	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	—	1.2	Vdc

(1) Voltage and current are negative for PNP transistors.
Note: "LT1" must be used when ordering SOT-23 devices.

BCX70GLT1
BCX70JLT1
BCX70KLT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

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	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCX70GLT1 = AG; BCX70JLT1 = AJ; BCX70KLT1 = AK

Refer to MPS3904 for graphs.

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)		$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)		I_{CES}	— —	20 20	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 μAdc, V_{CE} = 5.0 Vdc)	BCX70G BCX70J BCX70K	h_{FE}	— 40 100	— — —	—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCX70G BCX70J BCX70K		120 250 380	220 460 630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCX70G BCX70J BCX70K		60 90 100	— — —	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 10 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	— —	0.55 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 50 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	0.7 0.6	1.05 0.85	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.55	0.75	Vdc

Note: "LT1" must be used when ordering SOT-23 devices.

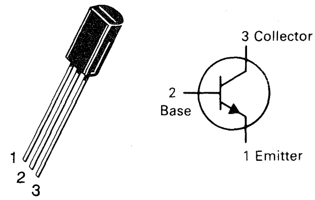
2

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 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 1.0 MHz)		C_{obo}	—	4.5	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BCX70G	h_{fe}	125	250	—
	BCX70J		250	500	
	BCX70K		350	700	
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	—	6.0	dB
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R1 = R2 = 5.0 kΩ, R_L = 990 Ω)		t_{off}	—	800	ns

BDB01C,D

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



ONE WATT
AMPLIFIER TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BDB01C	BDB01D	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CES}	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	0.5		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 Ambient	$R_{\theta JA}$	125	°c/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°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)	BDB01C BDB01D	$V_{(BR)CEO}$	80 100	— —	Vdc
Collector Cutoff Current (V_{CB} = 80 V, I_E = 0) (V_{CB} = 100 V, I_E = 0)	BDB01C BDB01D	I_{CBO}	— —	.01 .01	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} = 1.0 V) (I_C = 500 mA, V_{CE} = 2.0 V)		h_{FE}	40 25	400 —	—
Collector-Emitter Saturation Voltage* (I_C = 1000 mA, I_B = 100 mA)		$V_{CE(sat)}$	—	0.7	Vdc
Collector-Emitter On Voltage* (I_C = 1000 mA, V_{CE} = 1.0 V)		$V_{BE(on)}$	—	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 200 mA, V_{CE} = 5.0 V, f = 20 MHz		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz		C_{ob}	—	30	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

2

FIGURE 1 – D.C. CURRENT GAIN

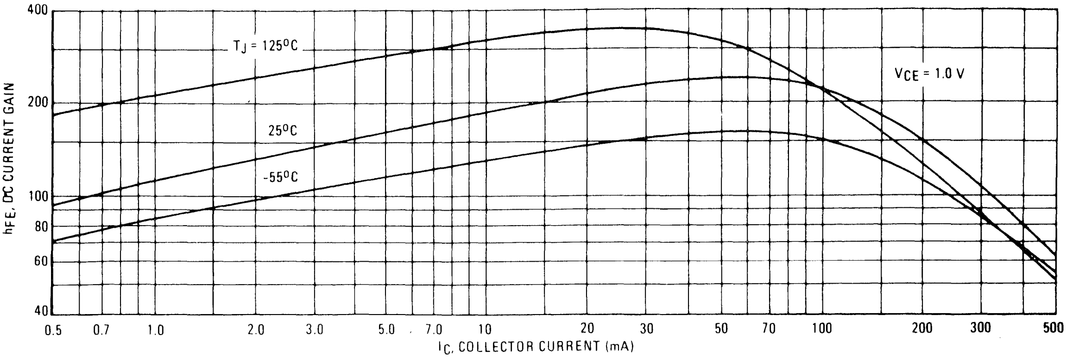


FIGURE 2 – COLLECTOR SATURATION REGION

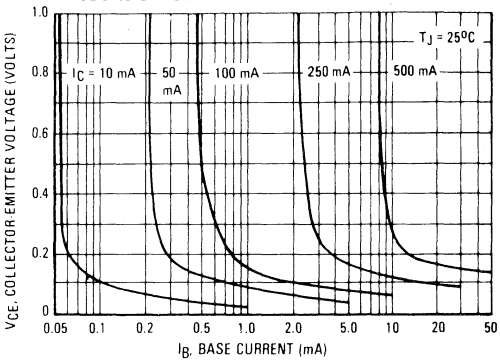


FIGURE 3 – ON VOLTAGES

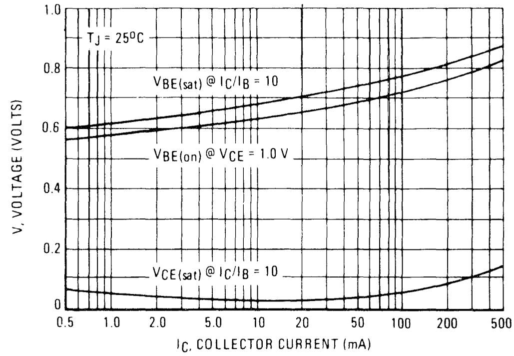


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT

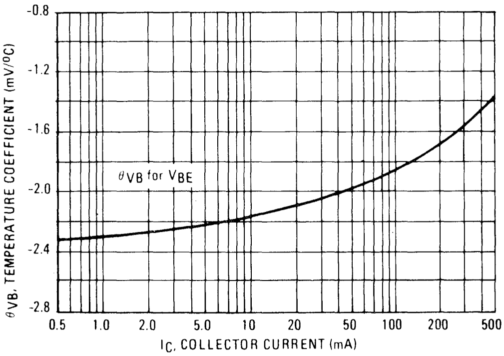


FIGURE 5 – CAPACITANCE

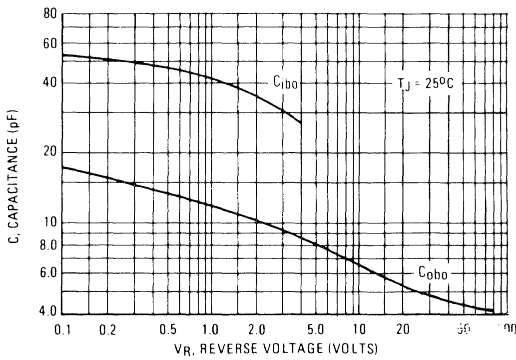


FIGURE 6 – CURRENT GAIN-BANDWIDTH PRODUCT

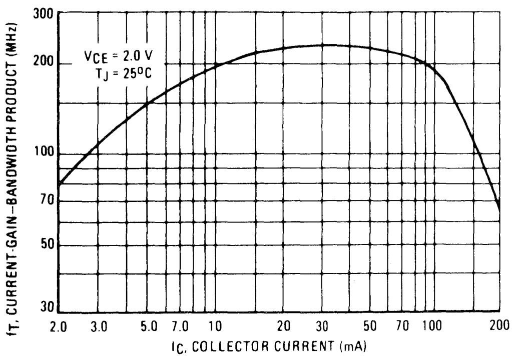
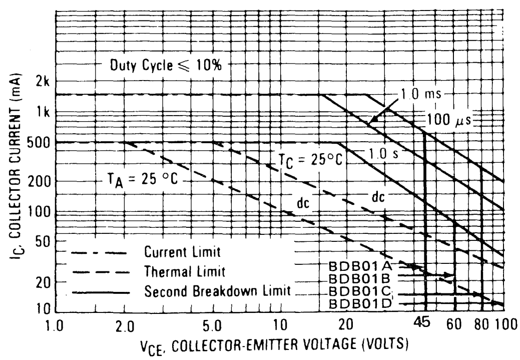
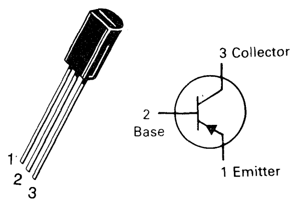


FIGURE 7 – ACTIVE REGION-SAFE OPERATING AREA



BDB02C,D

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BDB02C	BDB02D	Unit
Collector-Emitter Voltage	V_{CEO}	−80	−100	Vdc
Collector-Base Voltage	V_{CES}	−80	−100	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−0.5		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 Ambient	$R_{\theta JA}$	125	°c/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°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) BDB02C BDB02D	$V_{(BR)CEO}$	 −80 −100	 — —	Vdc
Collector Cutoff Current (V_{CB} = −80 V, I_E = 0) BDB02C (V_{CB} = −100 V, I_E = 0) BDB02D	I_{CBO}	 — —	 −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} = −1.0 V) (I_C = −500 mA, V_{CE} = −2.0 V)	h_{FE}	 40 25	 400 —	—
Collector-Emitter Saturation Voltage* (I_C = −1000 mA, I_B = −100 mA)	$V_{CE(sat)}$	—	−0.7	Vdc
Collector-Emitter On Voltage* (I_C = −1000 mA, V_{CE} = −1.0 V)	$V_{BE(on)}$	—	−1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = −200 mA, V_{CE} = −5.0 V, f = 20 MHz	f_T	50	—	MHz
Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz	C_{ob}	—	30	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

2

FIGURE 1 — D.C. CURRENT GAIN

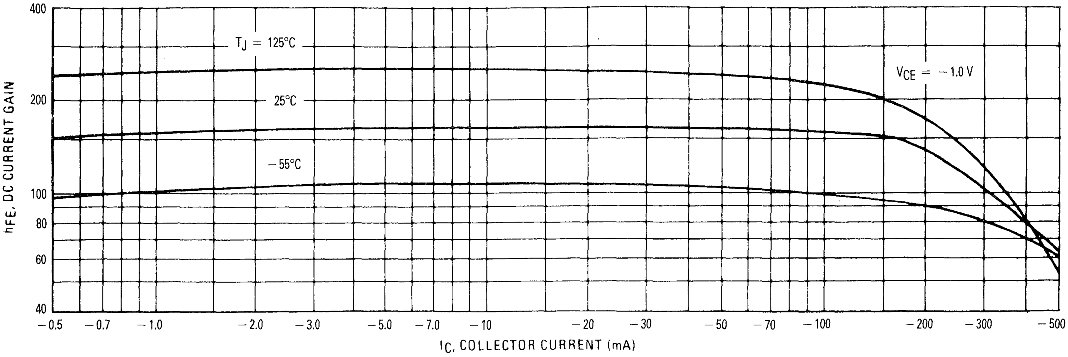


FIGURE 2 — COLLECTOR SATURATION REGION

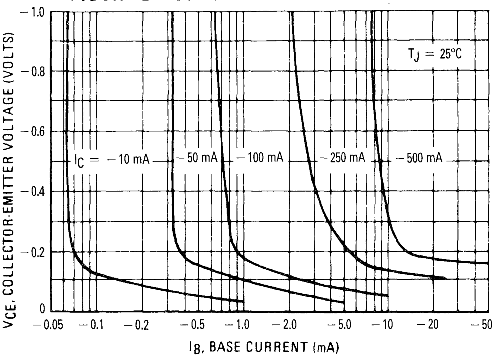


FIGURE 3 — ON VOLTAGES

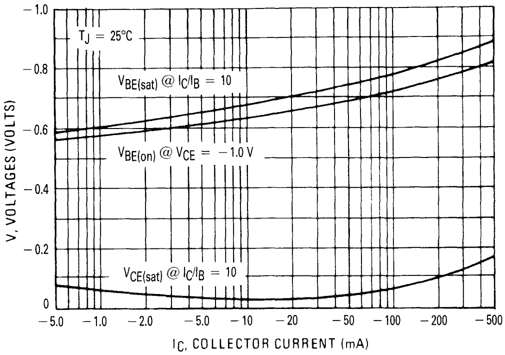


FIGURE 4 — BASE-EMITTER TEMPERATURE COEFFICIENT

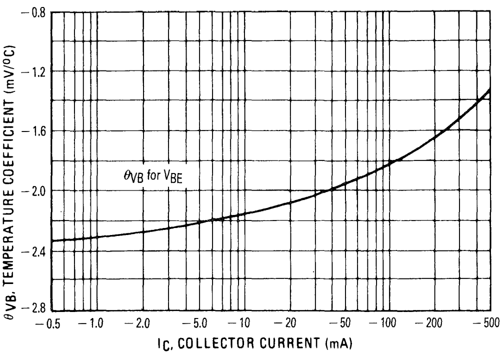


FIGURE 5 — CAPACITANCE

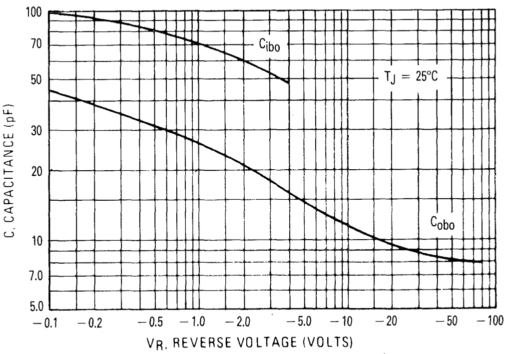


FIGURE 6 — CURRENT GAIN-BANDWIDTH PRODUCT

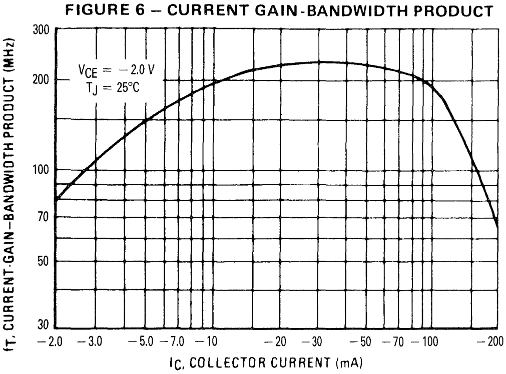
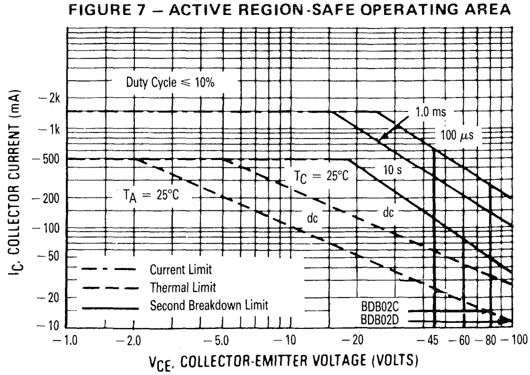
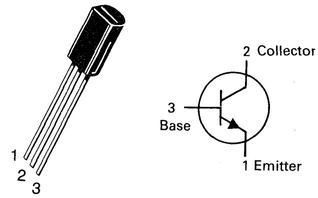


FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



BDC01D

CASE 29-05, STYLE 14
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSW05 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BDC01D	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	0.5	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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

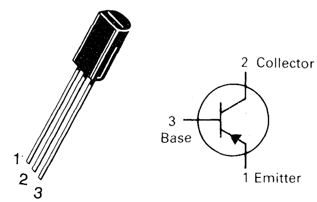
ELECTRICAL CHARACTERISTICS ($T_A = 25°c$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage ($I_C = 10$ mA, $I_B = 0$)	$V_{(BR)CEO}$	100	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ V, $I_E = 0$)	I_{CBO}	—	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, $V_{CE} = 1.0$ V) ($I_C = 500$ mA, $V_{CE} = 2.0$ V)	h_{FE}	 40 25	 400 —	—
Collector-Emitter Saturation Voltage* ($I_C = 1000$ mA, $I_B = 100$ mA)	$V_{CE(sat)}$	—	0.7	Vdc
Collector-Emitter On Voltage* ($I_C = 1000$ mA, $V_{CE} = 1.0$ V)	$V_{BE(on)}$	—	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product ($I_C = 200$ mA, $V_{CE} = 5.0$ V, f = 20 MHz	f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10$ V, $I_E = 0$, f = 1.0 MHz)	C_{ob}	—	30	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

BDC02D

CASE 29-05, STYLE 14
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPSW55 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	BDC02D	Unit
Collector-Emitter Voltage	V_{CEO}	−100	Vdc
Collector-Base Voltage	V_{CBO}	−100	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−0.5	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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

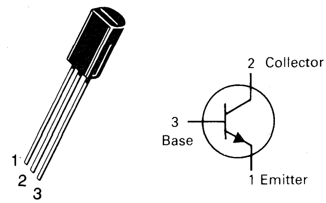
ELECTRICAL CHARACTERISTICS (T_A = 25°c unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage (I_C = −10 mA, I_B = 0)	$V_{(BR)CEO}$	−100	—	Vdc
Collector Cutoff Current (V_{CB} = −100 V, I_E = 0)	I_{CBO}	—	−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} = −1.0 V) (I_C = −500 mA, V_{CE} = −2.0 V)	h_{FE}	 40 25	 400 —	—
Collector-Emitter Saturation Voltage* (I_C = −1000 mA, I_B = −100 mA)	$V_{CE(sat)}$	—	−0.7	Vdc
Collector-Emitter On Voltage* (I_C = −1000 mA, V_{CE} = −1.0 V)	$V_{BE(on)}$	—	−1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = −200 mA, V_{CE} = −5.0 V, f = 20 MHz	f_T	50	—	MHz
Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	30	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

BDC05

CASE 29-05, STYLE 14
TO-92 (TO-226AE)



ONE WATT
HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSW42 for graphs.

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	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 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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

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

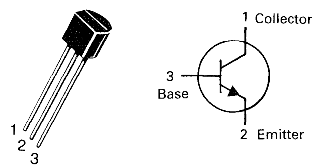
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V_{EB} = 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	—	—
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 = 20 MHz	f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}	—	2.8	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

2

BF199

CASE 29-04, STYLE 21
TO-92 (TO-226AA)



RF TRANSISTOR

NPN SILICON

Refer to BF240 for graphs.

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	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

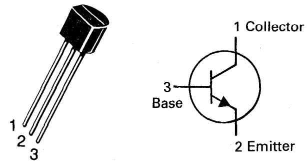
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

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

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	$V_{(BR)CEO}$	25			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 = 7 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	85		
Base-Emitter On Voltage (I_C = 7 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$		770	900	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain−Bandwidth Product (2) (I_C = 5 mAdc, 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 29-04, 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 Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

Refer to BF240 for graphs.

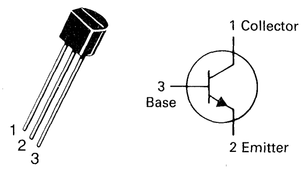
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

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) T_A = 25°C	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 = 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

2

BF240

CASE 29-04, STYLE 21
TO-92 (TO-226AA)



AM/FM 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}	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 Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

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 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)	h_{FE}	65		220	—
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	0.65	0.70	0.74	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain−Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T		600		MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}		0.28	0.34	pF

(1) Pulse test: Pulse Width ≦ 300 μs. Duty cycle ≦ 2.0%.

FIGURE 1 — CURRENT GAIN-BANDWIDTH PRODUCT

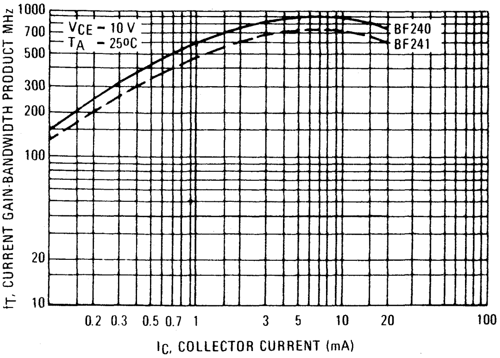


FIGURE 2 — CAPACITANCES

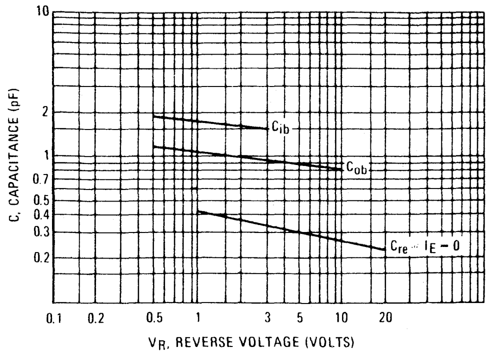


FIGURE 3 — DC CURRENT GAIN

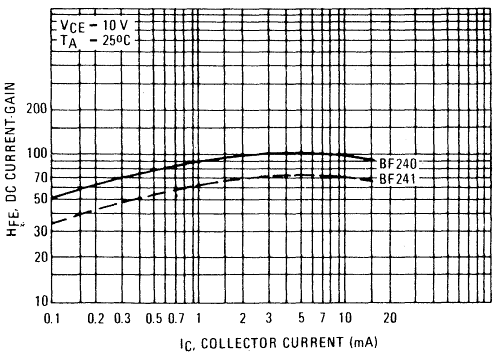


FIGURE 4 — b11e

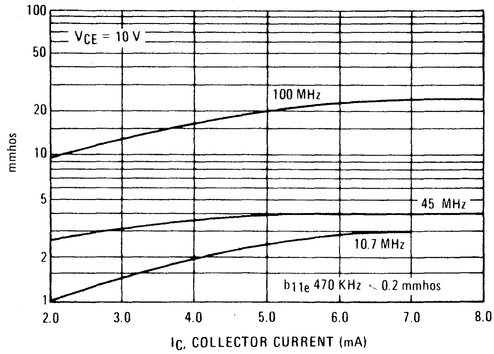


FIGURE 5 — b21e

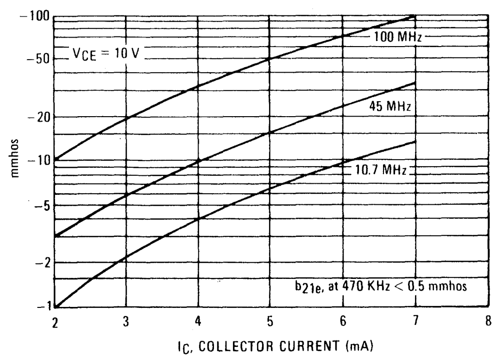
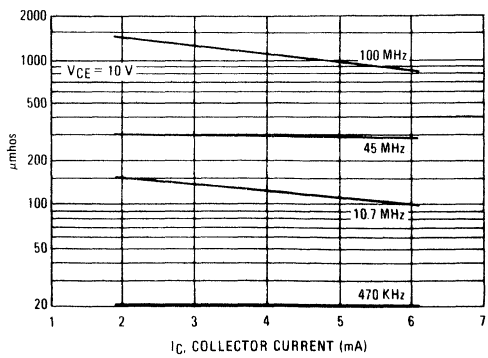


FIGURE 6 — b22e (boe)



2

FIGURE 7 — g11e (gie)

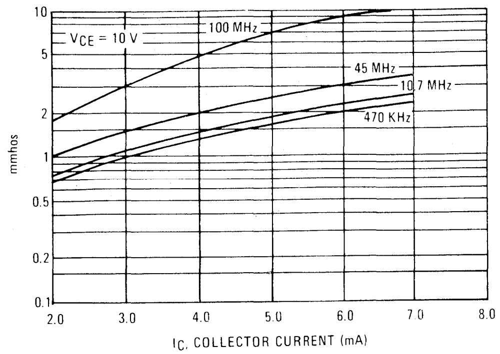


FIGURE 8 — g21e (Yfe)

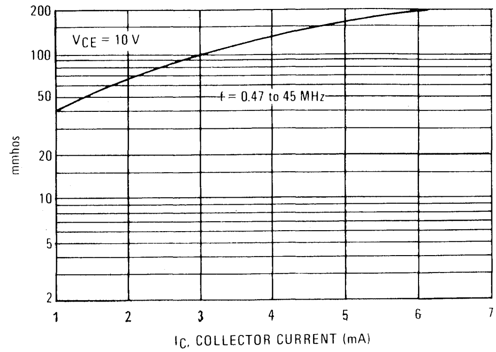
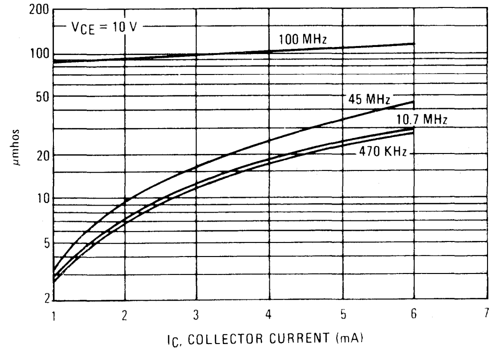
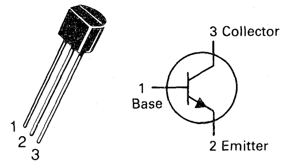


FIGURE 9 — g22e (goe)



BF374

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



VHF TRANSISTOR

NPN SILICON

2

Refer to MPSH10 for graphs.

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
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 Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°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)	$V_{(BR)CEO}$	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		250	
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_bC_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°C unless otherwise noted)

TYPICAL ADMITTANCE PARAMETERS (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, frequency as stated)

Symbol	f = 10.7 MHz	f = 30 MHz	f = 100 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

2

FIGURE 1 — INPUT ADMITTANCE
(Output short circuit)

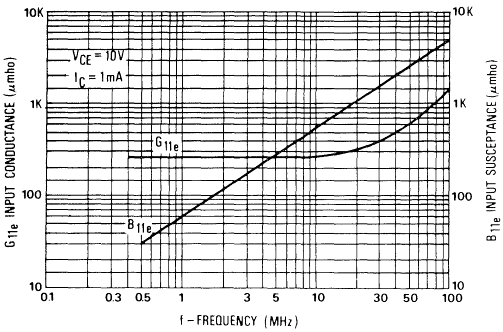


FIGURE 2 — OUTPUT ADMITTANCE
(Input short circuit)

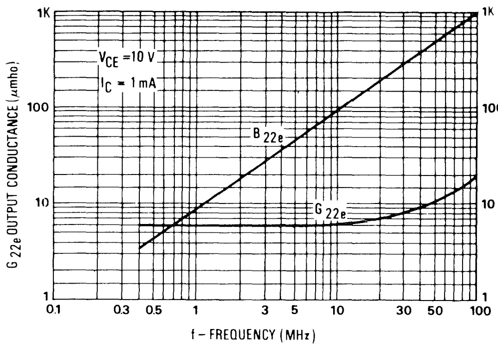


FIGURE 3 — FORWARD TRANSFER ADMITTANCE
(Output short circuit)

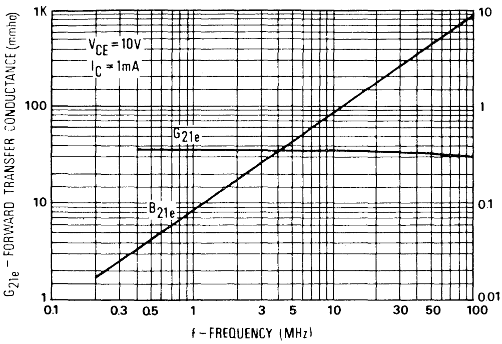
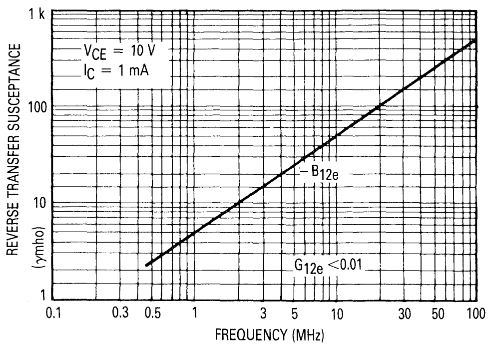
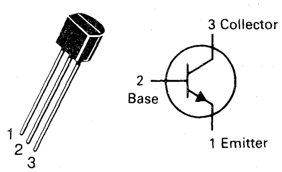


FIGURE 4 — REVERSE TRANSFER ADMITTANCE
(Input short circuit)



BF391
thru
BF393

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

2

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 @ $T_A = 25°C$ 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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

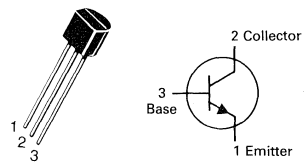
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0$ mAdc, $I_B = 0$)	BF391 BF392 BF393	$V_{(BR)CEO}$	200 250 300	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BF391 BF392 BF393	$V_{(BR)CBO}$	200 250 300	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	BF391 BF392 BF393	$V_{(BR)EBO}$	6.0 6.0 6.0	— — —	Vdc
Collector Cutoff Current ($V_{CB} = 160$ Vdc, $I_E = 0$) ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 200$ Vdc, $I_E = 0$)	BF391 BF392 BF393	I_{CBO}	— — —	0.1 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$) ($V_{EB} = 6.0$ Vdc, $I_C = 0$) ($V_{EB} = 6.0$ Vdc, $I_C = 0$)	BF391 BF392 BF393	I_{EBO}	— — —	0.1 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ 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	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 ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Common Emitter Feedback Capacitance ($V_{CB} = 60$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{re}		2.0	pF

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

BF420
BF422

CASE 29-04, STYLE 14
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

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

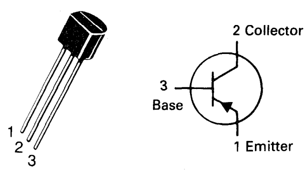
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)	BF420 BF422	$V_{(BR)CEO}$	300 250	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BF420 BF422	$V_{(BR)CBO}$	300 250	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BF420 BF422	$V_{(BR)EBO}$	5.0 5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	BF420 BF422	I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	BF420 BF422	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 25 mAdc, V_{CE} = 20 Vdc)	BF420 BF422	h_{FE}	50 50	— —	—
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 mA, I_B = 2.0 mA)		$V_{BE(sat)}$		2.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	—	MHz
Common Emitter Feedback Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		1.6	pF

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

BF421
BF423

CASE 29-04, 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_{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	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

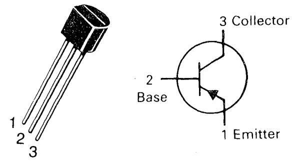
ELECTRICAL CHARACTERISTICS T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = −1.0 mAdc, I_B = 0)	BF421 BF423	$V_{(BR)CEO}$	−300 −250	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	BF421 BF423	$V_{(BR)CBO}$	−300 −250	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	BF421 BF423	$V_{(BR)EBO}$	−5.0 −5.0	— —	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc, I_E = 0)	BF421 BF423	I_{CBO}	— —	−0.01 —	μAdc
Emitter Cutoff Current (V_{EB} = −5.0 Vdc, I_C = 0)	BF421 BF423	I_{EBO}	— —	−100 —	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −25 mA, V_{CE} = −20 Vdc)	BF421 BF423	h_{FE}	50 50	— —	—
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 mA, I_B = −2.0 mA)		$V_{BE(sat)}$	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 20 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%

BF492
BF493

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	BF492	BF493	Unit
Collector-Emitter Voltage	V_{CEO}	−250	−300	Vdc
Collector-Base Voltage	V_{CBO}	−250	−300	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	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

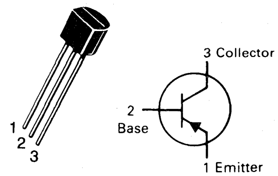
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = −1.0 mAdc, I_B = 0)	 BF492 BF493	$V_{(BR)CEO}$	 −250 −300	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	 BF492 BF493	$V_{(BR)CBO}$	 −250 −300	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	 BF492 BF493	$V_{(BR)EBO}$	 −6.0 −6.0	 — —	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc, I_E = 0) (V_{CB} = −200 Vdc, I_E = 0)	 BF492 BF493	I_{CBO}	 — —	 −0.1 −0.1	μAdc
Emitter Cutoff Current (V_{EB} = −6.0 Vdc, I_C = 0) (V_{EB} = −6.0 Vdc, I_C = 0)	 BF492 BF493	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)	 Both Types Both Types	h_{FE}	 25 40	 — —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{CE(sat)}$	—	−2.0	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 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%.

BF493S

CASE 29-04, 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°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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

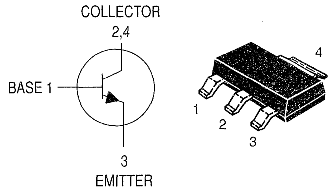
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−350	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−6.0	—	Vdc
Collector Cutoff Current (V_{CE} = −250 Vdc)	I_{CES}	—	−10	nAdc
Emitter Cutoff Current (V_{EB} = −6.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = −250 Vdc, I_E = 0, T_A = 25°C) (V_{CB} = −250 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 −0.005 −1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc)	h_{FE}	 25 40	 — —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)	$V_{CE(sat)}$	—	−2.0	Vdc
Base-Emitter On 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} = −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%.

BF720T1★

CASE 318E-04, STYLE 1
(TO-261AA)



SOT-223 PACKAGE
NPN SILICON
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Collector-Emitter Voltage	V_{CER}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current	I_C	100	mAdc
Total Power Dissipation up to T_A = 25°C	P_D	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

DC

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

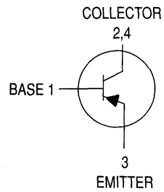
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

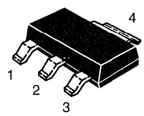
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, R_{BE} = 2.7 kΩ)	$V_{(BR)CER}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	10	nAdc
Collector-Emitter Cutoff Current	I_{CER}			
(V_{CE} = 250 Vdc, R_{BE} = 2.7 kΩ)		—	50	nAdc
(V_{CE} = 200 Vdc, R_{BE} = 2.7 kΩ, T_J = 150°C)		—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 25 mAdc, V_{CE} = 20 Vdc)	h_{FE}	50	—	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	0.6	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 35 MHz)	f_T	60	—	MHz
Feedback Capacitance (V_{CE} = 30 Vdc, I_C = 0, f = 1.0 MHz)	C_{re}	—	1.6	pF

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

BF721T1★

CASE 318E-04, STYLE 1
(TO-261AA)





SOT-223 PACKAGE
PNP SILICON
TRANSISTOR
SURFACE MOUNT

★**This is a Motorola designated preferred device.**

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	– 300	Vdc
Collector-Base Voltage	V_{CBO}	– 300	Vdc
Collector-Emitter Voltage	V_{CER}	– 300	Vdc
Emitter-Base Voltage	V_{EBO}	– 5.0	Vdc
Collector Current	I_C	– 100	mAdc
Total Power Dissipation up to T_A = 25°C*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

DF

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

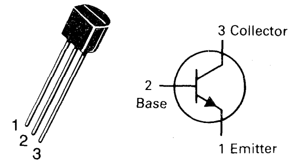
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = – 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	– 300	—	Vdc
Collector-Base Breakdown Voltage (I_C = – 100 µAdc, I_E = 0)	$V_{(BR)CBO}$	– 300	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = – 100 µAdc, R_{BE} = 2.7 kΩ)	$V_{(BR)CER}$	– 300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = – 10 µAdc, I_C = 0)	$V_{(BR)EBO}$	– 5.0	—	Vdc
Collector-Base Cutoff Current (V_{CB} = – 200 Vdc, I_E = 0)	I_{CBO}	—	– 10	nAdc
Collector-Emitter Cutoff Current	I_{CER}			
(V_{CE} = – 250 Vdc, R_{BE} = 2.7 kΩ)		—	– 50	nAdc
(V_{CE} = – 200 Vdc, R_{BE} = 2.7 kΩ, T_J = 150°C)		—	– 10	µAdc
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = – 25 mAdc, V_{CE} = – 20 Vdc)	h_{FE}	50	—	—
Collector-Emitter Saturation Voltage (I_C = – 30 mAdc, I_B = – 5.0 mAdc)	$V_{CE(sat)}$	—	– 0.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = – 10 Vdc, I_C = – 10 mAdc, f = 35 MHz)	f_T	60	—	MHz
Feedback Capacitance (V_{CE} = – 30 Vdc, I_C = 0, f = 1.0 MHz)	C_{re}	—	1.6	pF

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

BF844

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSA44 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	400	Vdc
Collector-Base Voltage	V_{CBO}	450	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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, $I_B = 0$)	$V_{(BR)CEO}$	400	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	450	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	450	—	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, $I_E = 0$)	I_{CBO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CE} = 400$ Vdc, $V_{BE} = 0$)	I_{CES}	—	500	nAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	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)	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)	$V_{CE(sat)}$	 — — —	 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 ≦ 2.0%.

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

Characteristic	Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS				
High Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	$\|h_{fe}\|$	1.0	—	
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	110	pF
Turn-On Time (V_{CC} = 150 Vdc, $V_{BE(off)}$ = 4.0 V, I_C = 30 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	0.6	μs
Turn-Off Time (V_{CC} = 150 Vdc, I_C = 30 mAdc, I_{B1} = I_{B2} = 3.0 mAdc)	t_{off}	—	10	μs

2

FIGURE 1 — DC CURRENT GAIN

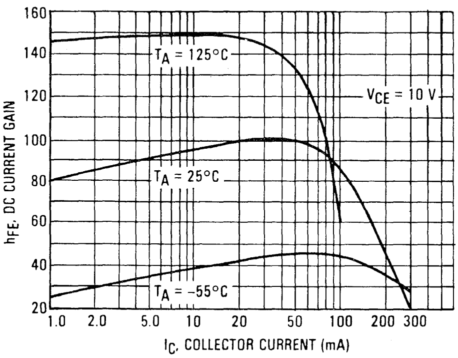
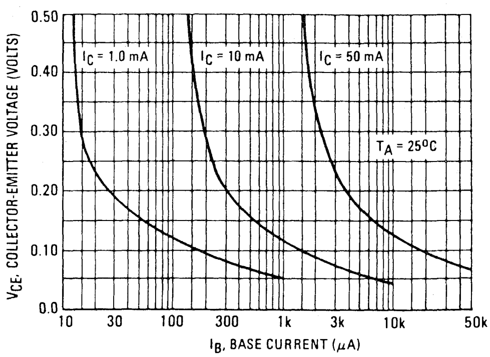
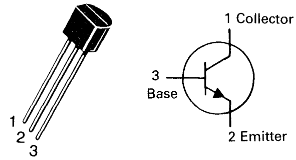


FIGURE 2 — COLLECTOR SATURATION REGION



BF959

CASE 29-04, 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	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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

2

FIGURE 1 – Hfe AT 10 V

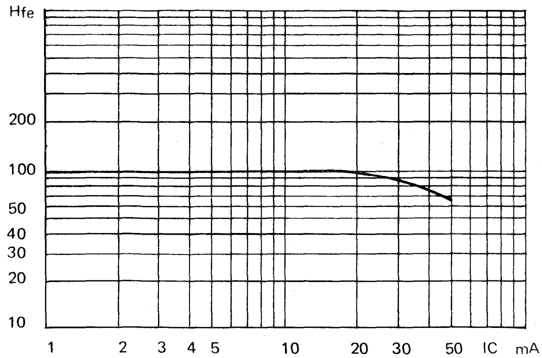


FIGURE 2 – VCE Sat AT IC/IB = 10

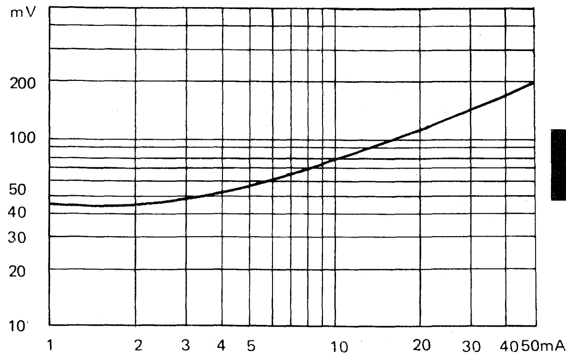


FIGURE 3 – CURRENT-GAIN – BANDWIDTH-PRODUCT

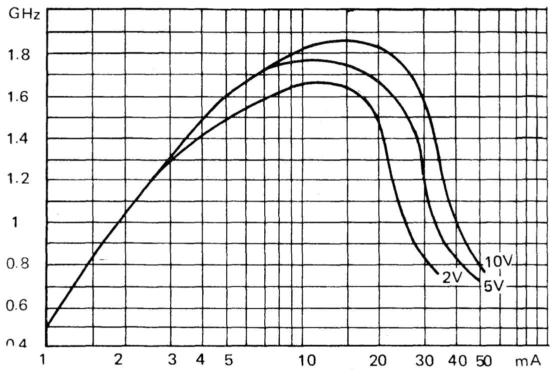


FIGURE 4 – CAPACITANCES

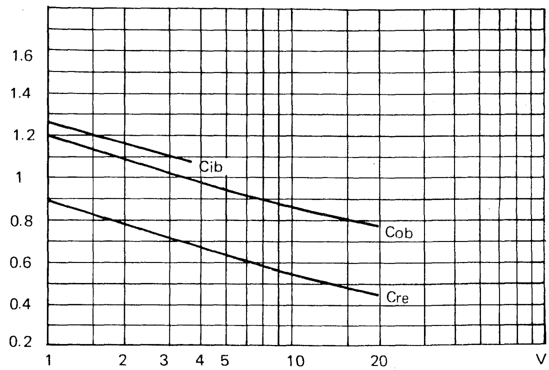


FIGURE 5 – INPUT IMPEDANCE AT 30 MHz

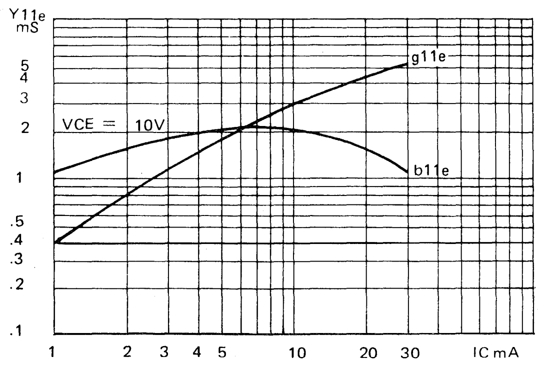
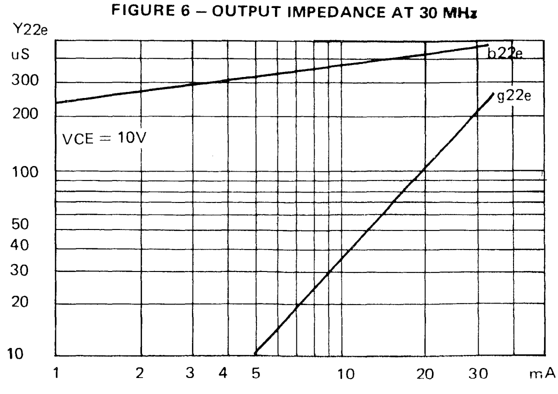
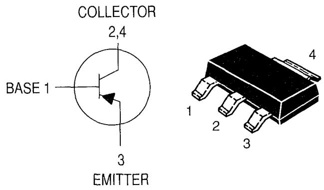


FIGURE 6 – OUTPUT IMPEDANCE AT 30 MHz



BSP16T1★

CASE 318E-04, STYLE 1
(TO-261AA)



SOT-223 PACKAGE
PNP SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	– 300	Vdc
Collector-Base Voltage	V_{CBO}	– 350	Vdc
Emitter-Base Voltage	V_{EBO}	– 6.0	Vdc
Collector Current	I_C	– 1000	mAdc
Base Current	I_B	– 500	mAdc
Total Power Dissipation, T_A = 25°C*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

BT2

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = – 50 mAdc, I_B = 0, L = 25 mH)	$V_{(BR)CEO}$	– 300	—	Vdc
Collector-Base Breakdown Voltage (I_C = – 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	– 300	—	Vdc
Collector-Emitter Cutoff Current (V_{CE} = – 250 Vdc, I_B = 0)	I_{CES}	—	– 50	μAdc
Collector-Base Cutoff Current (V_{CB} = – 280 Vdc, I_E = 0)	I_{CBO}	—	– 1.0	μAdc
Emitter-Base Cutoff Current (V_{EB} = – 6.0 Vdc, I_C = 0)	I_{EBO}	—	– 20	μAdc
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = – 10 Vdc, I_C = – 50 mAdc)	h_{FE}	30	120	—
Collector-Emitter Saturation Voltage (I_C = – 50 mAdc, I_B = – 5.0 mAdc)	$V_{CE(sat)}$	—	– 2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = – 10 Vdc, I_C = – 10 mAdc, f = 30 MHz)	f_T	15	—	MHz
Collector-Base Capacitance (V_{CB} = – 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	pF

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

NPN Small-Signal Darlington Transistor

BSP52T1

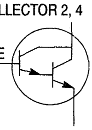
Motorola Preferred Device

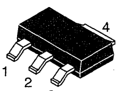
2

This NPN small signal darlington transistor is designed for use in switching applications, such as print hammer, relay, solenoid and lamp drivers. The device is housed in the SOT-223 package, which is designed for medium power surface mount applications.

- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use BSP52T1 to order the 7 inch/1000 unit reel.
  Use BSP52T3 to order the 13 inch/4000 unit reel.
- PNP Complement is BSP62T1

MEDIUM POWER NPN SILICON DARLINGTON TRANSISTOR SURFACE MOUNT





CASE 318E-04, STYLE 1
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Base Voltage	V_{CBO}	90	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

AS3

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a FR-4 glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.0625 in.; mounting pad for the collector lead = 0.93 sq. in.

Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

2

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

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0)	$V_{(BR)CBO}$	90	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0)	I_{CES}	—	10	µAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	10	µAdc
ON CHARACTERISTICS (1)				
DC Current Gain	h_{FE}			—
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		1000	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		2000	—	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	1.3	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	—	1.9	Vdc

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

PNP Small-Signal Darlington Transistor

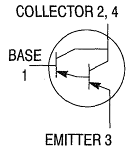
BSP62T1

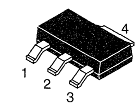
Motorola Preferred Device

This PNP small signal darlington transistor is designed for use in switching applications, such as print hammer, relay, solenoid and lamp drivers. The device is housed in the SOT-223 package, which is designed for medium power surface mount applications.

- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use BSP62T1 to order the 7 inch/1000 unit reel.
  Use BSP62T3 to order the 13 inch/4000 unit reel.
- NPN Complement is BSP52T1

MEDIUM POWER PNP SILICON DARLINGTON TRANSISTOR SURFACE MOUNT





CASE 318E-04, STYLE 1
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Base Voltage	V_{CBO}	90	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

BS3

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a FR-4 glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.0625 in.; mounting pad for the collector lead = 0.93 sq. in.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

2

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

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	90	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0)	I_{CBO}	—	10	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain	h_{FE}			—
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		1000	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		2000	—	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	1.3	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	—	1.9	Vdc

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

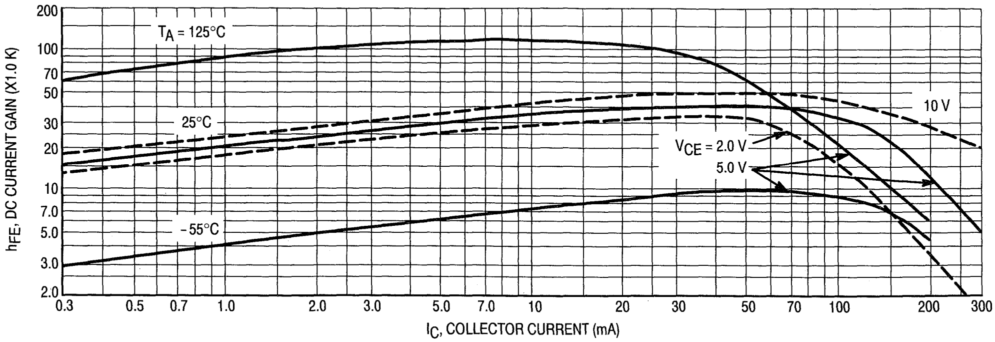


Figure 1. DC Current Gain

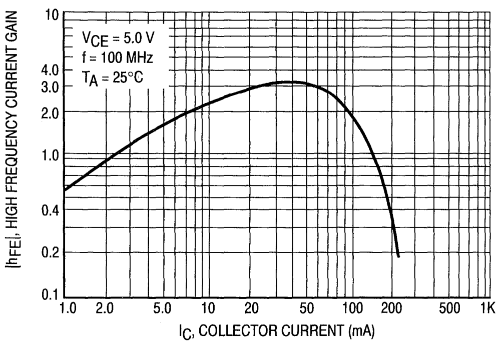


Figure 2. High Frequency Current Gain

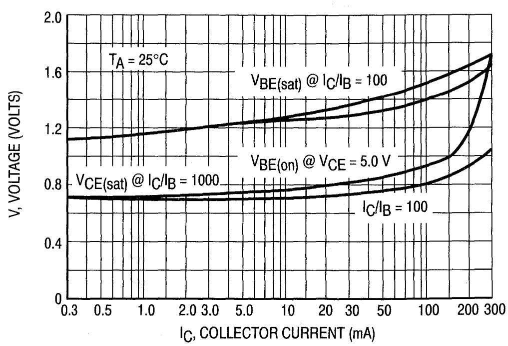


Figure 3. "On" Voltage

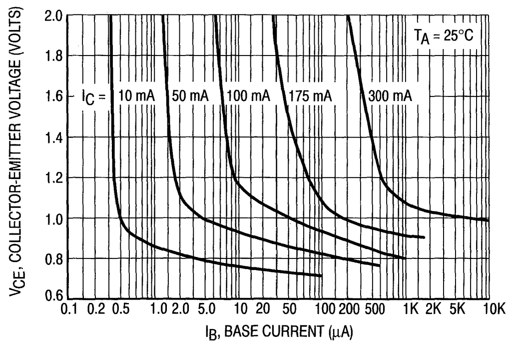


Figure 4. Collector Saturation Region

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−100	Vdc
Collector-Emitter Voltage R_{BE} = 10 kΩ	V_{CER}	−110	Vdc
Collector Current — Continuous	I_C	−100	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

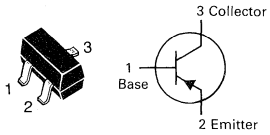
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BSS63LT1 = T1

BSS63LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTOR

PNP SILICON

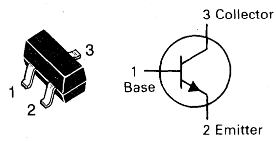
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc)	$V_{(BR)CEO}$	−100	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −10 μAdc, I_E = 0, R_{BE} = 10 kΩ)	$V_{(BR)CER}$	−110	—	—	Vdc
Collector-Base Breakdown Voltage (I_E = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−110	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc)	$V_{(BR)EBO}$	−6.0	—	—	Vdc
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 = 20 MHz)	f_T	50	95	—	MHz
Case Capacitance (I_E = I_C = 0, V_{CB} = −10 Vdc, f = 1.0 MHz)	C_C	—	—	5.0	pF

2

BSS64LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



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 FR-5 Board,* $T_A = 25°C$	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

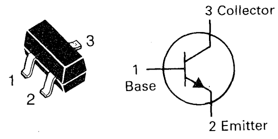
BSS64LT1 = AM

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 4.0$ mA)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu A$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current	I_{CBO}			μA
($V_{CE} = 90$ V)		—	0.1	
($T_A = 150°C$)		—	500	
Emitter Cutoff Current ($V_{EB} = 4.0V$)	I_{EBO}	—	200	nA
ON CHARACTERISTICS				
DC Current Gain ($V_{CE} = 1.0$ V, $I_C = 10$ mA)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
($I_C = 4.0$ mA, $I_B = 400\ \mu A$)		—	0.15	
($I_C = 50$ mA, $I_B = 15$ mA)		—	0.2	
Forward Base-Emitter Voltage	$V_{BE(sat)}$	—	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mA, $V_{CE} = 10$ V, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)	C_{ob}	—	5.0	pF

BSV52LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BSV52LT1 = B2

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)	$V_{(BR)CEO}$	12	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	 — —	 100 5.0	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (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)	h_{FE}	 25 40 25	 — 120 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 300 μAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — — —	 300 250 400	mVdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 700 —	 850 1200	mVdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	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, f = 1.0 MHz)	C_{ibo}	—	4.5	pF
SWITCHING CHARACTERISTICS				
Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	t_s	—	13	ns
Turn-On Time (V_{BE} = 1.5 Vdc, I_C = 10 mAdc, I_B = 3.0 mAdc)	t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mAdc, I_B = 3.0 mAdc)	t_{off}	—	18	ns

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}	−25	Vdc
Collector Current — Continuous	I_C	−150	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

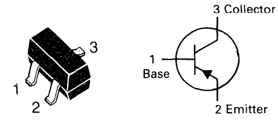
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT404ALT1 = 2N

MMBT404ALT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



CHOPPER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

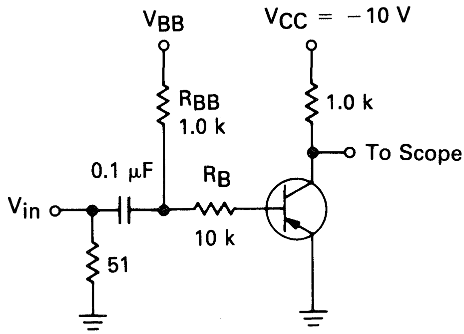
2

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)	$V_{(BR)CEO}$	−35	—	—	Vdc
Collector-Emitter 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)	$V_{(BR)EBO}$	−25	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −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}	100	—	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	Vdc
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	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = −6.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	20	pF
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

2

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 $I_{B1} = I_{B2}$

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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

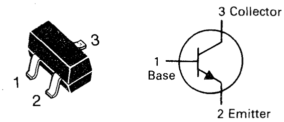
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT918LT1 = M3B

MMBT918LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



VHF/UHF TRANSISTOR

NPN SILICON

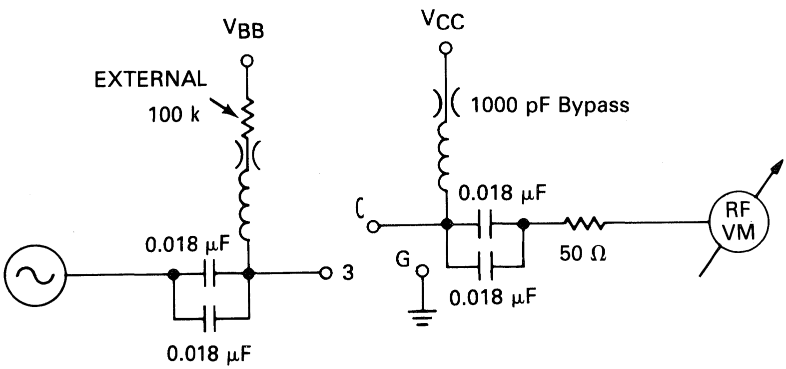
2

ELECTRICAL CHARACTERISTICS (T_A = 25°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

2

FIGURE 1 — NF, Gpe MEASUREMENT CIRCUIT 20-200

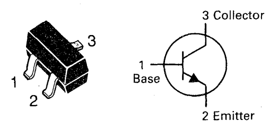


NF Test Conditions
I_C = 1.0 mA
V_{CE} = 6.0 Volts
R_S = 50 Ω
f = 60 MHz

G_{pe} Test Conditions
I_C = 6.0 mA
V_{CE} = 12 Volts
f = 200 MHz

MMBT2222LT1
MMBT2222ALT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MPS2222 for graphs.

2

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT2222LT1 = M1B; MMBT2222ALT1 = 1P

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)	MMBT2222 MMBT2222A	$V_{(BR)CEO}$	30 40	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MMBT2222 MMBT2222A	$V_{(BR)CBO}$	60 75	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, 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) (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)	 MMBT2222 MMBT2222A MMBT2222 MMBT2222A	I_{CBO}	 — — — —	 0.01 0.01 10 10	μAdc
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°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) (I_C = 500 mAdc, I_B = 50 mAdc)	 MMBT2222 MMBT2222A MMBTS2222 MMBT2222A	$V_{CE(sat)}$	 — — — —	 0.4 0.3 1.6 1.0	Vdc

Note: "LT1" must be used when ordering SOT-23 devices.

2

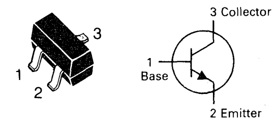
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MMBT2222		—	1.3	
	MMBT2222A		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	MMBT2222		—	2.6	
	MMBT2222A		—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMBT2222		250	—	
	MMBT2222A		300	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MMBT2222		—	30	
	MMBT2222A		—	25	
Input Impedance		h_{ie}			kΩ
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		25	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	MMBT2222A	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	MMBT2222A	NF	—	4.0	dB
SWITCHING CHARACTERISTICS MMBT2222A only					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	10	ns
Rise Time		t_r	—	25	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	—	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.

MMBT2369LT1
MMBT2369ALT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N2369 in Section 3 for graphs.

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	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT2369LT1 = M1J MMBT2369ALT1 = 1JA

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		I_{CBO}				μAdc
(V_{CB} = 20 Vdc, I_E = 0)			—	—	0.4	
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)			—	—	30	
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	MMBT2369A	I_{CES}	—	—	0.4	μAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MMBT2369		40	—	120	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MMBT2369A		—	—	120	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc)	MMBT2369A		40	—	—	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = −55°C)	MMBT2369A		20	—	—	
(I_C = 30 mAdc, V_{CE} = 0.4 Vdc)	MMBT2369A		30	—	—	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	MMBT2369		20	—	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MMBT2369A		20	—	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MMBT2369		—	—	0.25	
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MMBT2369A		—	—	0.20	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)	MMBT2369A		—	—	0.30	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	MMBT2369A		—	—	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	MMBT2369A		—	—	0.50	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MMBT2369,A		0.7	—	0.85	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = −55°C)	MMBT2369A		—	—	1.02	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	MMBT2369A		—	—	1.15	
(I_C = 100 mAdc, I_B = 10 mAdc)	MMBT2369A		—	—	1.60	

2

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

Characteristic	Symbol	Min	Typ	Max	Unit
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)	t_s	—	5.0	13	ns
Turn-On Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	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)	t_{off}	—	10	18	ns

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

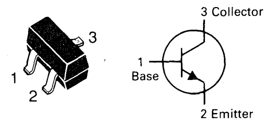
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT2484LT1 = 1U

MMBT2484LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



LOW NOISE TRANSISTOR

NPN SILICON

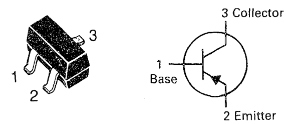
Refer to MPSA18 for graphs.

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)	$V_{(BR)CEO}$	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_{EB} = 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 = 1 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	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

MMBT2907LT1
MMBT2907ALT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to MPS2907 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MMBT2907	MMBT2907A	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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT2907LT1 = M2B MMBT2907ALT1 = 2F

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)	MMBT2907 MMBT2907A	$V_{(BR)CEO}$	−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)	MMBT2907 MMBT2907A	I_{CBO}	— —	−0.020 −0.010	μAdc
(V_{CB} = −50 Vdc, I_E = 0, T_A = 125°C)	MMBT2907 MMBT2907A		— —	−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	MMBT2907 MMBT2907A	h_{FE}	35 75	— —	—
(I_C = −1.0 mAdc, V_{CE} = −10 Vdc)	MMBT2907 MMBT2907A		50 100	— —	
(I_C = −10 mAdc, V_{CE} = −10 Vdc)	MMBT2907 MMBT2907A		75 100	— —	
(I_C = −150 mAdc, V_{CE} = −10 Vdc)(1)	MMBT2907 MMBT2907A		100	300	
(I_C = −500 mAdc, V_{CE} = −10 Vdc)(1)	MMBT2907 MMBT2907A		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

Note: "LT1" must be used when ordering SOT-23 devices.

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

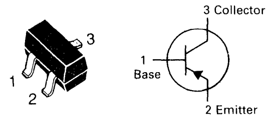
Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1),(2) (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc)	t_{on}	—	45	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-On Time	(V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = −15 mAdc)	t_{off}	—	100	ns
Delay Time		t_s	—	80	ns
Rise Time		t_f	—	30	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.

2

MMBT3640LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to MPS3640 for graphs.

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 CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT3640LT1 = 2J

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)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{CEO(sus)}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0) (V_{CE} = −6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	— —	−0.01 −1.0	μAdc
Base Current (V_{CE} = −6.0 Vdc, V_{EB} = 0)	I_B	—	−10	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = −10 mAdc, V_{CE} = −0.3 Vdc) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc	h_{FE}	30 20	120 —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc, T_A = 65°C)	$V_{CE(sat)}$	— — —	−0.2 −0.6 −0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 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 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{EB(off)}$ = −1.9 Vdc, I_{B1} = −5.0 mAdc)	t_d	—	10	ns
Rise Time	t_r	—	30	ns
Storage Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc)	t_s	—	20	ns
Fall Time	t_f	—	12	ns
Turn-On Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{EB(off)}$ = −1.9 Vdc, I_{B1} = −5.0 mAdc) (V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = −0.5 mAdc)	t_{on}	— —	25 60	ns
Turn-Off Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{EB(off)}$ = −1.9 V, I_{B1} = I_{B2} = −5.0 mAdc) (V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −0.5 mAdc)	t_{off}	—	35 75	ns

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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

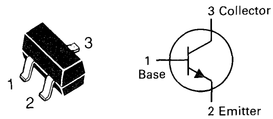
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT3904LT1 = 1AM

MMBT3904LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N3903 for graphs.

2

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 = 10 μAdc, I_E = 0)	$V_{(BR)CEO}$	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(1)				
DC Current Gain(1) (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}	 40 70 100 60 30	 — — 300 — —	—
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)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.0	10	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.5	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—

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

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

Characteristic	Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)	NF	—	5.0	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	—	200	ns
Fall Time		t_f	—	50	

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

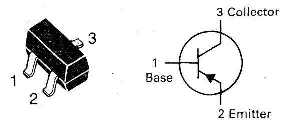
DEVICE MARKING

MMBT3906LT1 = 2A

MMBT3906LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)

2



GENERAL PURPOSE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3905 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)	$V_{(BR)CEO}$	−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_{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(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 = 1.0 MHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	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	—

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

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{oe}	3.0	60	μmhos
Noise Figure (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 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 ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

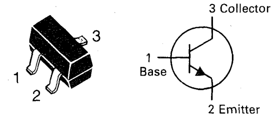
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT4401LT1 = 2X

MMBT4401LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N4401 for graphs.

2

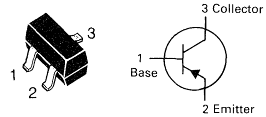
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

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) (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)	h_{FE}	20 40 80 100 40	— — — 300 —	—
Collector-Emitter Saturation Voltage	(I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	— —	0.4 0.75	Vdc
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	250	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	6.5	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	1.0	15	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	40	500	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	30	μmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, V_{EB} = 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 ≤ 2.0%.

MMBT4403LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

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 CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT4403LT1 = 2T

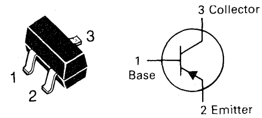
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

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)		$V_{(BR)CBO}$	−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_{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					
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 = 1.0 MHz)		C_{cb}	—	8.5	pF
Emitter-Base Capacitance (V_{BE} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		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	X 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_{EB} = −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 ≤ 2.0%.

MMBT5087LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



LOW NOISE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N5086 for graphs.

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 CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT5087LT1 = 2Q

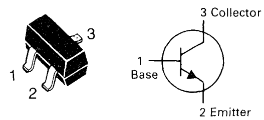
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−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) (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	h_{FE}	 250 250 250	 800 — —	—
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 = 1.0 MHz)	C_{obo}	—	4.0	pF
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)	h_{fe}	250	900	—
Noise Figure (I_C = −20 mAdc, V_{CE} = −5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz) (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, R_S = 3.0 kΩ, f = 1.0 kHz)	NF	 — —	 2.0 2.0	dB

2

MMBT5088LT1
MMBT5089LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



LOW NOISE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value MMBT5088	Value MMBT5089	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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT5088LT1 = 1Q; MMBT5089LT1 = 1R

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)	MMBT5088 MMBT5089	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MMBT5088 MMBT5089	$V_{(BR)CBO}$	35 30	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0)	MMBT5088 MMBT5089	I_{CBO}	— —	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0) ($V_{EB(off)}$ = 4.5 Vdc, I_C = 0)	MMBT5088 MMBT5089	I_{EBO}	— —	50 100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089	h_{FE}	300 400	900 1200	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089		350 450	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089		300 400	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 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)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz emitter guarded)		C_{cb}	—	4.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz collector guarded)		C_{eb}	—	10	pF
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	MMBT5088 MMBT5089	h_{fe}	350 450	1400 1800	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz)	MMBT5088 MMBT5089	NF	— —	3.0 2.0	dB

Note: "LT1" must be used when ordering SOT-23 devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−150	Vdc
Collector-Base Voltage	V_{CBO}	−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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

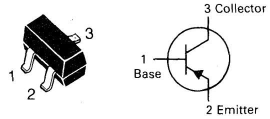
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT5401LT1 = 2L

MMBT5401LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N5401 for graphs.

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)	$V_{(BR)CEO}$	−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} = −120 Vdc, I_E = 0) (V_{CB} = −120 Vdc, I_E = 0, T_A = 100°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 = 1.0 kHz)	NF	—	8.0	dB

2

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

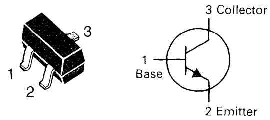
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT5550LT1 = M1F; MMBT5551LT1 = G1

MMBT5550LT1
MMBT5551LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N5550 for graphs.

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)	MMBT5550 MMBT5551	$V_{(BR)CEO}$	140 160	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MMBT5550 MMBT5551	$V_{(BR)CBO}$	160 180	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, 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°C) (V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	 MMBT5550 MMBT5551 MMBT5550 MMBT5551	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) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 MMBT5550 MMBT5551 MMBT5550 MMBT5551 MMBT5550 MMBT5551	h_{FE}	 60 80 60 80 20 30	 — — 250 250 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types MMBT5550 MMBT5551	$V_{CE(sat)}$	 — — —	 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 MMBT5550 MMBT5551	$V_{BE(sat)}$	 — — —	 1.0 1.2 1.0	Vdc

(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
Note: "LT1" must be used when ordering SOT-23 devices.

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 FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$ Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

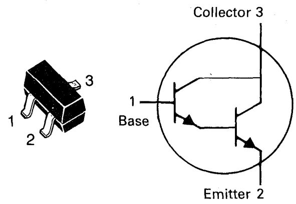
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT6427LT1 = 1V

MMBT6427LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DARLINGTON TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N6426 for graphs.

2

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $V_{BE} = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CE} = 25$ Vdc, $I_B = 0$)	I_{CES}	—	1.0	μAdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ 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 ($V_{EB} = 0.5$, $I_C = 0$, 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)	NF	—	10	dB

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

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

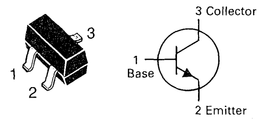
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

MMBT6428LT1
MMBT6429LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MPSA18 for graphs.

DEVICE MARKING

MMBT6428LT1 = 1KM; MMBT6429LT1 = 1L

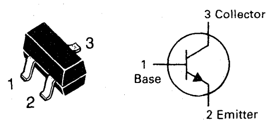
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$			Vdc
(I_C = 1.0 mAdc, I_B = 0)	MMBT6428		50	—	
(I_C = 1.0 mAdc, I_B = 0)	MMBT6429		45	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 0.1 mAdc, I_E = 0)	MMBT6428		60	—	
(I_C = 0.1 mAdc, I_E = 0)	MMBT6429		55	—	
Collector Cutoff Current (V_{CE} = 30 Vdc)		I_{CES}	—	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		h_{FE}			—
(I_C = 0.01 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	—	
	MMBT6429		500	—	
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	650	
	MMBT6429		500	1250	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	—	
	MMBT6429		500	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	—	
	MMBT6429		500	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)			—	0.2	
(I_C = 100 mAdc, I_B = 5.0 mAdc)			—	0.6	
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

Note: "LT1" must be used when ordering SOT-23 devices.

MMBT6517LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N6517 for graphs.

2

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT6517LT1 = 1Z

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)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 250 V)	I_{CBO}	—	50	nA
Emitter Cutoff Current (V_{EB} = 5.0 V)	I_{EBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 1.0 mA, V_{CE} = 10 V)		20	—	
(I_C = 10 mA, V_{CE} = 10 V)		30	—	
(I_C = 30 mA, V_{CE} = 10 V)		30	200	
(I_C = 50 mA, V_{CE} = 10 V)		20	200	
(I_C = 100 mA, V_{CE} = 10 V)		15	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$*			Vdc
(I_C = 10 mA, I_B = 1.0 mA)		—	0.30	
(I_C = 20 mA, I_B = 2.0 mA)		—	0.35	
(I_C = 30 mA, I_B = 3.0 mA)		—	0.50	
(I_C = 50 mA, I_B = 5.0 mA)		—	1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mA, I_B = 1.0 mA)		—	0.75	
(I_C = 20 mA, I_B = 2.0 mA)		—	0.85	
(I_C = 30 mA, I_B = 3.0 mA)		—	0.90	
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 10 V)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 20 V, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = 20 V, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)	C_{eb}	—	80	pF

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2

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	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$ Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

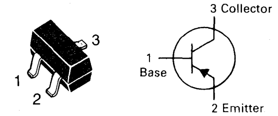
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT6520LT1 = 2Z

MMBT6520LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N6520 for graphs.

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)	$V_{(BR)CEO}$	−350	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μA)	$V_{(BR)CBO}$	−350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μA)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −250 V)	I_{CBO}	—	−50	nA
Emitter Cutoff Current (V_{EB} = −4.0 V)	I_{EBO}	—	−50	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mA, V_{CE} = −10 V) (I_C = −10 mA, V_{CE} = −10 V) (I_C = −30 mA, V_{CE} = −10 V) (I_C = −50 mA, V_{CE} = −10 V) (I_C = −100 mA, V_{CE} = −10 V)	h_{FE}	 20 30 30 20 15	 — — 200 200 —	—
Collector-Emitter Saturation Voltage (I_C = −10 mA, I_B = −1.0 mA) (I_C = −20 mA, I_B = −2.0 mA) (I_C = −30 mA, I_B = −3.0 mA) (I_C = −50 mA, I_B = −5.0 mA)	$V_{CE(sat)}$	 — — — —	 −0.30 −0.35 −0.50 −1.0	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mA, I_B = −1.0 mA) (I_C = −20 mA, I_B = −2.0 mA) (I_C = −30 mA, I_B = −3.0 mA)	$V_{BE(sat)}$	 — — —	 −0.75 −0.85 −0.90	Vdc
Base-Emitter On Voltage (I_C = −100 mA, V_{CE} = −10 V)	$V_{BE(on)}$	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mA, V_{CE} = −20 V, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = −20 V, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = −0.5 V, f = 1.0 MHz)	C_{eb}	—	100	pF

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−80	V
Collector-Base Voltage	V_{CBO}	−80	V
Emitter-Base Voltage	V_{EBO}	−5.0	V
Collector Current — Continuous	I_C	−500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

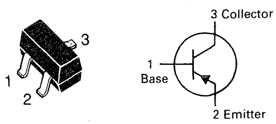
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT8599LT1 = 2W

MMBT8599LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N4125 for graphs.

2

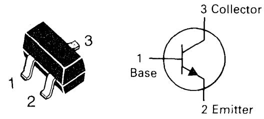
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_E = 0)	$V_{(BR)CEO}$	−80	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −80 Vdc, I_E = 0)	I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = −1.0 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}	 100 100 75	 300 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −100 mAdc, I_B = −10 mAdc) (I_C = −100 mAdc, I_B = −5.0 mAdc)	$V_{CE(sat)}$	 — —	 −0.3 −0.4	Vdc
Base-Emitter On Voltage(1) (I_C = −10 mAdc, V_{CE} = 5.0 V)	$V_{BE(on)}$	−0.6	−0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	150	—	MHz
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	30	pF
Collector-Base Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	4.5	pF

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

MMBTA05LT1
MMBTA06LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DRIVER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MMBTA05	MMBTA06	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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA05LT1 = 1H; MMBTA06LT1 = 1GM

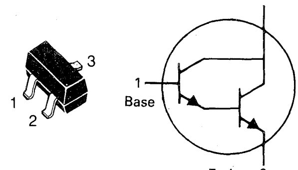
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MMBTA05 MMBTA06	$V_{(BR)CEO}$	 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_{CES}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MMBTA05 MMBTA06	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}	 100 100	 — —	—
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 = 10 mA, V_{CE} = 2.0 V, f = 100 MHz)		f_T	100	—	MHz

(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.
Note: "LT1" must be used when ordering SOT-23 devices.

MMBTA13LT1
MMBTA14LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DARLINGTON AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N6426 for graphs.

2

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 FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$ Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA13LT1 = 1M; MMBTA14LT1 = 1N

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

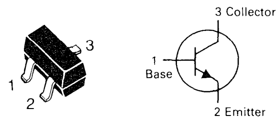
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBTA13		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

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.
Note: "LT1" must be used when ordering SOT-23 devices.

2

MMBTA20LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE AMPLIFIER

NPN SILICON

Refer to MPS3904 for graphs.

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 FR-5 Board,* $T_A = 25°C$	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

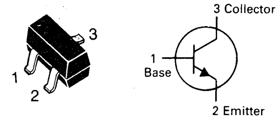
MMBTA20LT1 = 1C

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, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	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 = 1.0 MHz)	C_{obo}	—	4.0	pF

MMBTA42LT1★
MMBTA43LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MMBTA42	MMBTA43	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 FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$ Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA42LT1 = 1D; MMBTA43LT1 = M1E

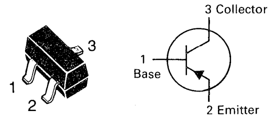
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

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	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MMBTA42 MMBTA43	$V_{(BR)CBO}$	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, $I_E = 0$)	MMBTA42 MMBTA43	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0$ Vdc, $I_C = 0$) ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	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	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)	MMBTA42 MMBTA43	C_{cb}	— —	3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
Note: "LT1" must be used when ordering SOT-23 devices.

MMBTA55LT1
MMBTA56LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DRIVER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA55LT1 = 2H; MMBTA56LT1 = 2GM

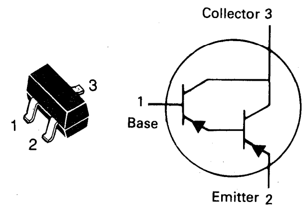
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	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_{CES}	—	−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}	100 100	— —	—
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

(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.
Note: "LT1" must be used when ordering SOT-23 devices.

MMBTA63LT1
MMBTA64LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DARLINGTON TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA63LT1 = 2U; MMBTA64LT1 = 2V

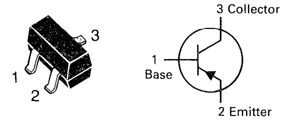
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc)		$V_{(BR)CES}$	−30	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc)		I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −10 Vdc)		I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			—
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	MMBTA63		5,000	—	
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	MMBTA64		10,000	—	
(I_C = −100 mAdc, V_{CE} = −5.0 Vdc)	MMBTA63		10,000	—	
(I_C = −100 mAdc, V_{CE} = −5.0 Vdc)	MMBTA64		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)		$V_{BE(on)}$	—	−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

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
Note: "LT1" must be used when ordering SOT-23 devices.

MMBTA70LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AA)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA70LT1 = M2C

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)	$V_{(BR)CEO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, 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 = 1.0 MHz)	C_{obo}	—	4.0	pF

MAXIMUM RATINGS

Rating	Symbol	MMBTA92	MMBTA93	Unit
Collector-Emitter Voltage	V_{CEO}	−300	−200	Vdc
Collector-Base Voltage	V_{CBO}	−300	−200	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	−5.0	Vdc
Collector Current — Continuous	I_C	−500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$ Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

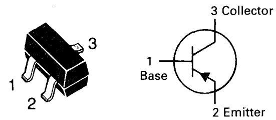
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA92LT1 = 2D; MMBTA93LT1 = 2E

MMBTA92LT1★
MMBTA93LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to MPSA92 for graphs.

2

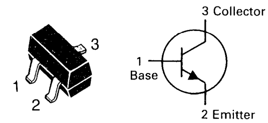
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = -1.0$ mAdc, $I_B = 0$)	MMBTA92 MMBTA93	$V_{(BR)CEO}$	−300 −200	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = -100$ μAdc, $I_E = 0$)	MMBTA92 MMBTA93	$V_{(BR)CBO}$	−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, $I_E = 0$)	MMBTA92 MMBTA93	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 MMBTA92 MMBTA93	h_{FE}	25 40 25 25	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = -20$ mAdc, $I_B = -2.0$ mAdc)	MMBTA92 MMBTA93	$V_{CE(sat)}$	— —	−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)	MMBTA92 MMBTA93	C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
Note: "LT1" must be used when ordering SOT-23 devices.

MMBTH10LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



VHF/UHF TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MPSH10 for graphs.

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTH10LT1 = 3EM

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)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 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 = 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}	—	0.65	pF
Collector Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$rb'C_c$	—	9.0	ps

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	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

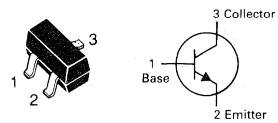
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTH24LT1 = M3A

MMBTH24LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



VHF MIXER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

2

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

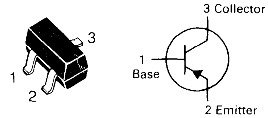
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	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	0.45	pF
Conversion Gain	—				dB
(213 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)	C_G	19	24	—	
(60 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)		24	29	—	

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

- Designed for UHF/VHF Amplifier Applications
- High Current Gain Bandwidth Product
  f_T = 2000 MHz Min @ 10 mA

MMBTH69LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



UHF/VHF TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

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}	−4.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTH69LT1 = M3J

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 = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc)	h_{FE}	30	—	300	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	2000	—	—	MHz
Collector-Base Capacitance (V_{CE} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{rb}	—	—	0.35	pF

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

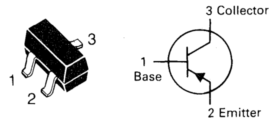
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTH81LT1 = 3D

MMBTH81LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



UHF/VHF TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

2

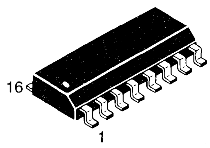
ELECTRICAL CHARACTERISTICS (T_A = 25°c unless otherwise noted.)

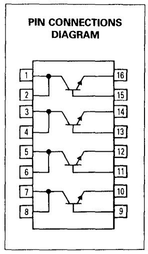
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 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 = −5.0 mAdc, V_{CE} = −10 Vdc)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage (I_C = −5.0 mAdc, I_B = −0.5 mAdc)	$V_{CE(sat)}$	—	—	−0.5	Vdc
Base-Emitter On Voltage (I_C = −5.0 mAdc, V_{CE} = −10 Vdc)	$V_{BE(on)}$	—	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −5.0 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance (I_B = 0, V_{CB} = −10 Vdc, f = 1.0 MHz)	C_{ce}	—	—	0.65	pF

2

MMPQ2222,A★

CASE 751B-04, STYLE 4
SO-16





QUAD GENERAL-PURPOSE TRANSISTORS

NPN SILICON

★MMPQ2222A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MMPQ2222	MMPQ2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.52 4.2	1.0 8.0	Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.8 6.4	2.4 19.2	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
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MMPQ2222 MMPQ2222A	$V_{(BR)CEO}$	30 40	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MMPQ2222 MMPQ2222A	$V_{(BR)CBO}$	60 75	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, 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)	 MMPQ2222 MMPQ2222A	I_{CBO}	 — —	 — —	 50 10	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	MMPQ2222 MMPQ2222A	I_{EBO}	— —	— —	50 10	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 100 μA, V_{CE} = 10 V) (I_C = 1.0 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V) (I_C = 150 mA, V_{CE} = 10 V) (I_C = 300 mA, V_{CE} = 10 V) (I_C = 500 mA, V_{CE} = 10 V) (I_C = 150 mA, V_{CE} = 1.0 V)	 MMPQ2222A MMPQ2222A MMPQ2222 MMPQ2222A MMPQ2222 MMPQ2222A MMPQ2222 MMPQ2222A MMPQ2222A	h_{FE}	 35 50 75 75 100 100 30 40 50	 — — — — — — — — —	 — — — — — 300 — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 MMPQ2222 MMPQ2222A MMPQ2222 MMPQ2222A	$V_{CE(sat)}$	 — — — —	 — — — —	 0.4 0.3 1.6 1.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 MMPQ2222 MMPQ2222A MMPQ2222 MMPQ2222A	$V_{BE(sat)}$	 — — — —	 — — — —	 1.3 1.2 2.6 2.0	Vdc

ELECTRICAL CHARACTERISTICS (Continued)

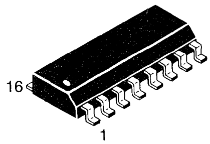
Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	4.5	—	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	17	—	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%.

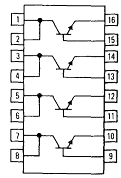
2

MMPQ2369★

CASE 751B-04, STYLE 4
SO-16



PIN CONNECTIONS DIAGRAM



QUAD SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

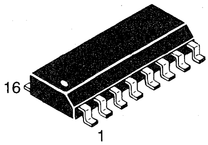
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

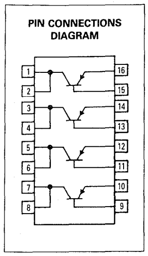
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5 —	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.4	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 20	 — —	 — —	—
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
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	450	550	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	2.5	4.0	pF
Input Capacitance V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	3.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 3.0 Vdc, ($V_{EB(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	9.0	—	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	—	15	—	ns

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

MMPQ2907,A★

CASE 751B-04, STYLE 4
SO-16





QUAD GENERAL PURPOSE TRANSISTORS

PNP SILICON

★MMPQ2907A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MMPQ2907	MMPQ2907A	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CB}	−60		Vdc
Emitter-Base Voltage	V_{EB}	−5.0		Vdc
Collector Current — Continuous	I_C	−600		mAdc

		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.52 4.2	1.0 8.0	Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.8 6.4	2.4 19.2	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
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	MMPQ2907 MMPQ2907A	$V_{(BR)CEO}$	−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} = −30 Vdc, I_E = 0) (V_{CB} = −50 Vdc, I_E = 0)	 MMPQ2907 MMPQ2907A	I_{CBO}	 — —	 — —	 −50 −10	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	—	−50	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = −100 μAdc, V_{CE} = −10 V) (I_C = −1.0 mAdc, V_{CE} = −10 V) (I_C = −10 mAdc, V_{CE} = −10 V) (I_C = −150 mAdc, V_{CE} = −10 V) (I_C = −300 mAdc, V_{CE} = −10 V) (I_C = −500 mAdc, V_{CE} = −10 V)	 MMPQ2907A MMPQ2907A MMPQ2907/2907A MMPQ2907/2907A MMPQ2907/2907A MMPQ2907/2907A	h_{FE}	 75 100 75/100 100 30/50 50	 — — — — — —	 — — — 300 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −300 mAdc, I_B = −30 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)	 MMPQ2907 MMPQ2907 MMPQ2907	$V_{CE(sat)}$	 — — —	 — — —	 −0.4 −1.6 −1.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −300 mAdc, I_B = −30 mAdc) (I_C = −500 mAdc, I_B = −15 mAdc)	 MMPQ2907 MMPQ2907 MMPQ2907A	$V_{BE(sat)}$	 — — —	 — — —	 −1.3 −2.6 −2.6	Vdc

2

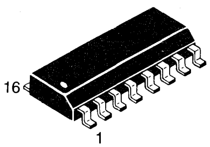
ELECTRICAL CHARACTERISTICS (Continued)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	6.0	—	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	20	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc)	t_{on}	—	30	—	ns
Turn-Off Time (V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = −15 mAdc)	t_{off}	—	100	—	ns

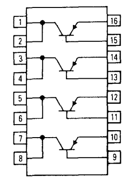
(1) Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle = 2.0%.

MMPQ3467★

CASE 751B-04, STYLE 4
SO-16



PIN CONNECTIONS DIAGRAM



QUAD MEMORY DRIVER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CB}	−40	Vdc
Emitter-Base Voltage	V_{EB}	−5.0	Vdc
Collector Current — Continuous	I_C	−1.0	Adc

		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.52 4.2	1.2 9.6	Watts mW/°C
Power Dissipation @ T_C = 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

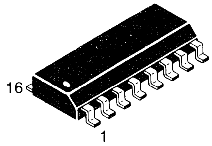
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

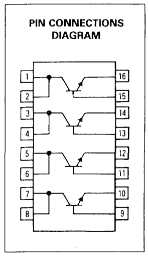
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0 —	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)	I_{CBO}	—	—	−200	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	—	−200	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = −500 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage(1) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{CE(sat)}$	—	−0.23	−0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{BE(sat)}$	—	−0.9	−1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	—	190	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	10	—	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	55	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = −500 mAdc, I_{B1} = −50 mAdc)	t_{on}	—	20	—	ns
Turn-Off Time (I_C = −500 mAdc, I_{B1} = I_{B2} = −50 mAdc)	t_{off}	—	60	—	ns

2

MMPQ3725★

CASE 751B-04, STYLE 4
SO-16





QUAD CORE DRIVER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C
		Each Transistor	**Four Transistors Equal Power**	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.8	1.4 11.2	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	2.5 2.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

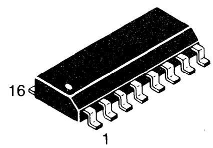
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

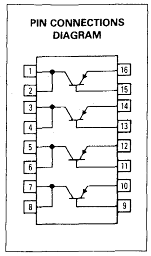
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0 —	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 35 25	 75 45	 200 —	—
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
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	—	275	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	5.1	—	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	62	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = −3.8 Vdc)	t_{on}	—	20	—	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	50	—	ns

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

MMPQ3799★

CASE 751B-04, STYLE 4
SO-16





2

QUAD AMPLIFIER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−60	Vdc
Collector-Base Voltage	V_{CB}	−60	Vdc
Emitter-Base Voltage	V_{EB}	−5.0	Vdc
Collector Current — Continuous	I_C	−200	mAdc

		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.66 5.3	1.92 15.4	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.)

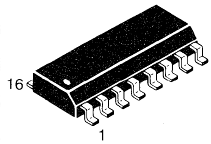
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−60	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0)	I_{CBO}	—	—	−10	nAdc
Emitter Cutoff Current (V_{EB} = −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) (I_C = −100 μAdc, V_{CE} = −5.0 Vdc) (I_C = −500 μAdc, V_{CE} = −5.0 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	h_{FE}	 225 300 300 250	 — — — —	 — — — —	—
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
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	60	250	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	2.1	4.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	5.5	8.0	pF
Noise Figure (I_C = −100 μAdc, V_{CE} = −10 Vdc, R_S = 3.0 kohms, f = 1.0 kHz)	NF	—	1.5	—	dB

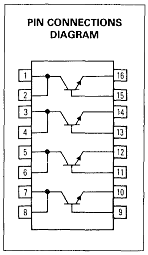
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MMPQ3904★

CASE 751B-04, STYLE 4
SO-16





QUAD AMPLIFIER/SWITCH TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

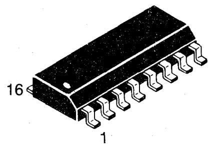
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

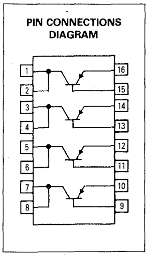
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	6.0 —	— —	— —	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ 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
DYNAMIC 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 = 1.0 MHz)	C_{ob}	—	2.0	4.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ib}	—	4.0	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_C = 10$ Vdc, $V_{BE(off)} = -0.5$ 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%.

MMPQ3906★

CASE 751B-04, STYLE 4
SO-16





QUAD AMPLIFIER/SWITCH TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	−40		Vdc
Collector-Base Voltage	V_{CB}	−40		Vdc
Emitter-Base Voltage	V_{EB}	−5.0		Vdc
Collector Current — Continuous	I_C	−200		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.66 5.3	1.92 15.4	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.)

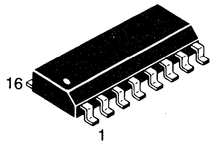
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
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(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}	 40 60 75	 160 180 200	 — — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−0.1	−0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{BE(sat)}$	—	−0.65	−0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	200	250	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	3.3	4.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	4.8	10	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = −10 mAdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = −1.0 mAdc)	t_{on}	—	43	—	ns
Turn-Off Time (I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	155	—	ns

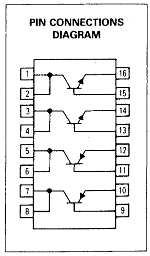
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MMPQ6700★

CASE 751B-04, STYLE 4
SO-16





QUAD COMPLEMENTARY PAIR TRANSISTOR

PNP(2)/NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

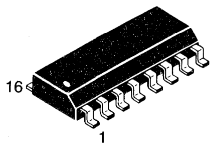
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

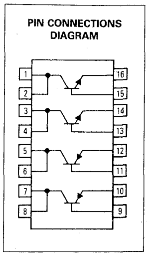
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	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(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 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
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (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 = 1.0 MHz)	C_{ob}	—	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) PNP NPN	C_{ib}	 — —	 10 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

MMPQ6842

CASE 751B-04, STYLE 4
SO-16





QUAD MPU CLOCK BUFFER TRANSISTOR

PNP(2)/NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

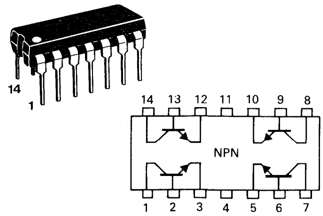
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ µAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ µAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ 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(1)					
DC Current Gain ($I_C = 0.5$ 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 ($I_C = 0.5$ mAdc, $I_B = 0.05$ mAdc, $0°C \leq T \leq 70°C$)	$V_{CE(sat)}$	—	0.05	0.15	Vdc
Base-Emitter Saturation Voltage ($I_C = 0.5$ mAdc, $I_B = 0.05$ mAdc)	$V_{BE(sat)}$	—	0.65	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	—	3.0	4.5	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz) PNP NPN	C_{ib}	 — —	 5.0 4.0	 10 8.0	pF
SWITCHING CHARACTERISTICS ($T_A = 25°C$, $V_{CC} = 5.0$ 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

(1) Pulse Test: Pulse Width ≤ 300 µs Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

2

MPQ2222,A★



CASE 646-06, STYLE 1
TO-116

QUAD GENERAL PURPOSE TRANSISTORS

NPN SILICON

★MPQ2222A is a Motorola designated preferred device.

Refer to MD2218 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ2222	MPQ2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	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	P_D	0.65 5.2	1.9 15.2	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	$R_{\theta JA}$	66	°C/W

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$			Vdc
(I_C = 10 mAdc, I_B = 0)	MPQ2222		40	—	
	MPQ2222A		40	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 10 μAdc, I_E = 0)	MPQ2222		60	—	
	MPQ2222A		75	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)	MPQ2222		5.0	—	
	MPQ2222A		6.0	—	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 50 Vdc, I_E = 0)	MPQ2222		—	50	
(V_{CB} = 60 Vdc, I_E = 0)	MPQ2222A		—	10	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 3.0 Vdc, I_C = 0)	MPQ2222		—	50	
	MPQ2222A		—	10	
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPQ2222A		35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MPQ2222A		50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPQ2222,A		75	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MPQ2222,A		100	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MPQ2222		30	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MPQ2222A		40	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MPQ2222		—	0.4	
	MPQ2222A		—	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)	MPQ2222		—	1.6	
(I_C = 500 mA, I_B = 50 mA)	MPQ2222A		—	1.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MPQ2222		—	1.3	
	MPQ2222A		0.6	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	MPQ2222		—	2.6	
(I_C = 500 mA, I_B = 50 mA)	MPQ2222A		—	2.0	

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

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	—	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
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	MPQ2222A	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	MPQ2222A	t_{off}	—	285	ns

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

2

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

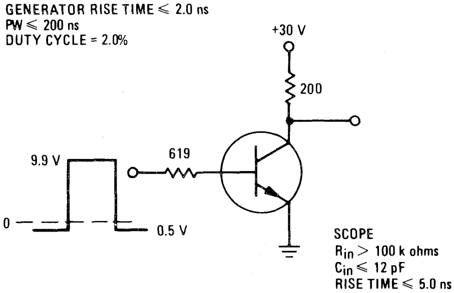
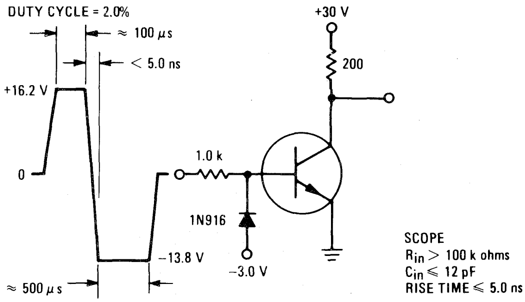


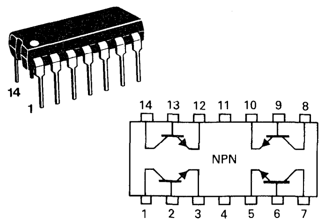
FIGURE 2 — STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



2

MPQ2369★

CASE 646-06, STYLE 1
TO-116



QUAD SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MD2369 for graphs.

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}	4.5		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 5.0	1.5 15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +125		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	83	°C/W

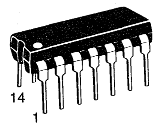
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

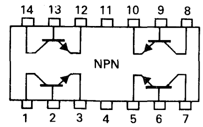
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.4	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	40 20	— —	— —	—
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 (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	450	550	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	2.5	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 3.0 Vdc, V_{BE} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	9.0	—	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	—	15	—	ns

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

MPQ2483
MPQ2484★

CASE 646-06, STYLE 1
TO-116





QUAD AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

2

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 Effective, 4 Die	151 52	250 134	°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(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_{EB} = 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)	 MPQ2483 MPQ2484	h_{FE}	 100 200	 — —	 — —	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483 MPQ2484		150 300	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483 MPQ2484		150 300	— —	— —	
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

2

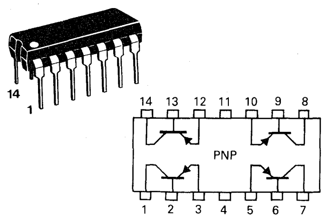
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	4.0	8.0	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.8	6.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz, BW = 10 kHz) MPQ2483	NF	—	3.0	—	dB
MPQ2484		—	2.0	—	

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

MPQ2906
MPQ2907,A★

CASE 646-06, STYLE 1
TO-116



QUAD
GENERAL PURPOSE
TRANSISTORS
PNP SILICON

2

★MPQ2907A is a Motorola designated preferred device.

Refer to MD2905 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ2906 MPQ2907	MPQ2907A	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
		Each Transistor	**Total Device**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.65 6.5	1.9 19	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +125		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	66	°C/W

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$			Vdc
(I_C = −10 mAdc, I_B = 0)	MPQ2906, MPQ2907		−40	—	
	MPQ2907A		−60	—	
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		I_{CBO}	—	−50	nAdc
(V_{CB} = −30 Vdc, I_E = 0)	MPQ2906, MPQ2907				
(V_{CB} = −50 Vdc, I_E = 0)	MPQ2907A				
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_E = 0)	MPQ2906,7 Only	I_{EBO}	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
(I_C = −100 μAdc, V_{CE} = −10 Vdc)	MPQ2907A		75	—	
(I_C = −1.0 mAdc, V_{CE} = −10 Vdc)	MPQ2907A		100	—	
(I_C = −10 mAdc, V_{CE} = −10 Vdc)	MPQ2906		35	—	
	MPQ2907		75	—	
(I_C = −10 mAdc, V_{CE} = −10 Vdc)	MPQ2907A		100	—	
(I_C = −150 mAdc, V_{CE} = −10 Vdc)	MPQ2907A		100	300	
(I_C = −150 mAdc, V_{CE} = −10 Vdc)	MPQ2906		40	—	
	MPQ2907		100	—	
(I_C = −300 mAdc, V_{CE} = −10 Vdc)	MPQ2906		20	—	
	MPQ2907		30	—	
(I_C = −500 mAdc, V_{CE} = −10 Vdc)	MPQ2907A		50	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = −150 mAdc, I_B = −15 mAdc)			—	−0.4	
(I_C = −300 mAdc, I_B = −30 mAdc)	MPQ2906, MPQ2907		—	−1.6	
(I_C = −500 mA, I_B = −500 mA)	MPQ2907A		—	−1.6	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = −150 mAdc, I_B = −15 mAdc)	MPQ2906, MPQ2907		—	−1.3	
(I_C = −300 mAdc, I_B = −30 mAdc)	MPQ2906, MPQ2907		—	−2.6	
(I_C = −500 mA, I_B = −50 mA)	MPQ2907A		—	−2.6	

2

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

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance, (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance, (V_{EB} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = 15 mAdc) MPQ2907A Only	t_{on}	—	45	ns
Turn-Off Time (V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = 15 mAdc) MPQ2907A Only	t_{off}	—	180	ns

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

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

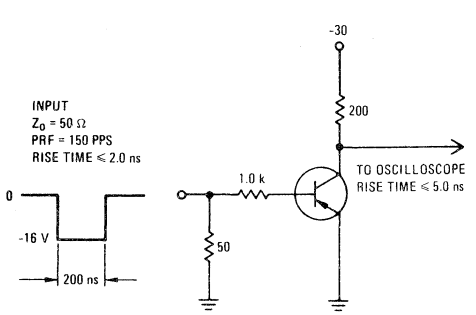
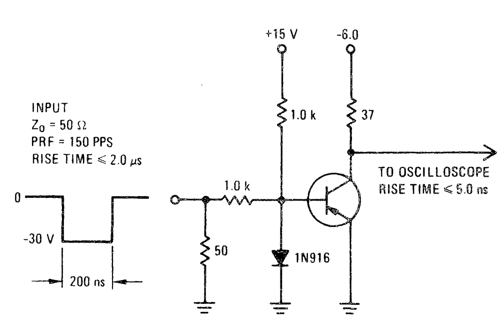


FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	−40		Vdc
Collector-Base Voltage	V_{CBO}	−40		Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	650 5.2	1500 12	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

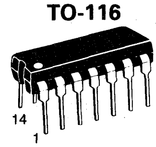
(1) Second Breakdown occurs at power levels greater than 2 times the power dissipation rating.

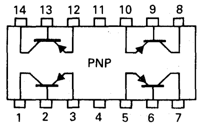
THERMAL CHARACTERISTICS

Characteristic		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	100 39	193 83.2	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	45 5.0	55 10	% %

MPQ3467★

CASE 646-06, STYLE 1
TO-116





QUAD
MEMORY DRIVER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3467 in Section 3 for graphs.

2

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

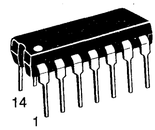
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)	I_{CBO}	—	—	−200	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	—	−200	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = −500 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	−20	—	—	—
Collector-Emitter Saturation Voltage(2) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{CE(sat)}$	—	−0.23	−0.5	Vdc
Base-Emitter Saturation Voltage(2) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{BE(sat)}$	—	−0.90	−1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	125	190	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	10	25	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = −500 mAdc, I_{B1} = −50 mAdc)	t_{on}	—	—	40	ns
Turn-Off Time (I_C = −500 mAdc, I_{B1} = I_{B2} = −50 mAdc)	t_{off}	—	—	90	ns

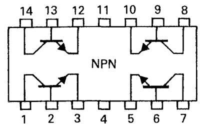
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPQ3725★

CASE 646-06, STYLE 1
TO-116





QUAD CORE DRIVER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MM3725 in Section 3 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Emitter Voltage	V_{CES}	60		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)	$R_{\theta JA}$	125	50	°C/W

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

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

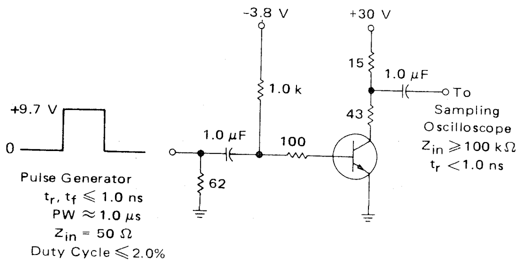
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	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) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 35 25	 75 45	 200 —	—
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	275	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	5.1	10	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	62	80	pF

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

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

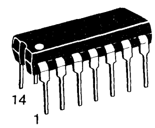
Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = −3.8 Vdc)	t_{on}	—	20	35	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	50	60	ns

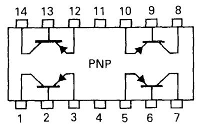
FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



MPQ3762

CASE 646-06, STYLE 1
TO-116





QUAD MEMORY DRIVER TRANSISTOR

PNP SILICON

Refer to 2N3467 in Section 3 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	−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) $R_{\theta JA}$ 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)	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	h_{FE}				—
(I_C = −150 mAdc, V_{CE} = −1.0 Vdc)		35	70	—	
(I_C = −500 mAdc, V_{CE} = −2.0 Vdc)		30	65	—	
(I_C = −1.0 Adc, V_{CE} = −2.0 Vdc)		20	35	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = −500 mAdc, I_B = −50 mAdc)		—	−0.3	−0.55	
(I_C = −1.0 Adc, I_B = −100 mAdc)		—	−0.6	−0.9	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = −500 mAdc, I_B = −50 mAdc)		—	−0.9	−1.25	
(I_C = −1.0 Adc, I_B = −100 mAdc)		—	−1.0	−1.4	
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 = 1.0 MHz)	C_{obo}	—	9.0	15	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	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%.

EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON

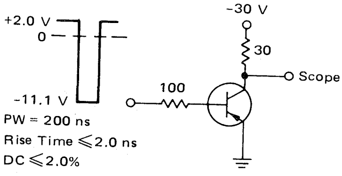
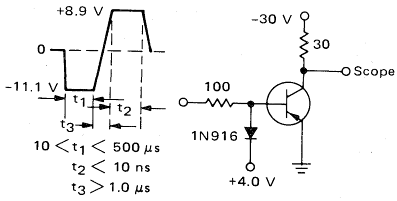


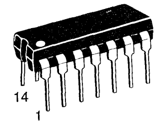
FIGURE 2 – TURN-OFF

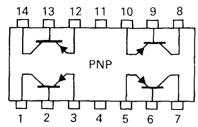


2

MPQ3798
MPQ3799★

CASE 646-06, STYLE 1
TO-116





QUAD AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3810 for graphs.

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		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ 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	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	MPQ3798 MPQ3799	$V_{(BR)CEO}$	−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_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	—	−20	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	MPQ3798 MPQ3799		100 225	— —	— —	
(I_C = −100 μAdc, V_{CE} = −5.0 Vdc)	MPQ3798 MPQ3799		150 300	— —	— —	
(I_C = −500 μAdc, V_{CE} = −5.0 Vdc)	MPQ3798 MPQ3799		150 300	— —	— —	
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	MPQ3798 MPQ3799		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

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

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	60	250	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	2.1	4.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	5.5	8.0	pF
Noise Figure (I_C = −100 μAdc, V_{CE} = −10 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz) MPQ3798	NF	—	2.5	—	dB
MPQ3799		—	1.5	—	

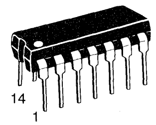
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

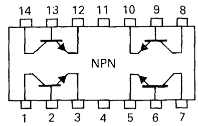
2

2

MPQ3904★

CASE 646-06, STYLE 1
TO-116





QUAD AMPLIFIER SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N3904 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}	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	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	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_{EB} = 40 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		30	90	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		50	160	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		75	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 = 1.0 MHz)	C_{obo}	—	2.0	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	4.0	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 10 mAdc, $V_{BE(off)}$ = −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

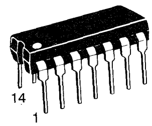
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

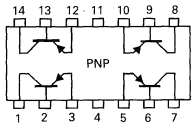
MAXIMUM RATINGS

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 @ $T_A = 25°C$ 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

MPQ3906★

CASE 646-06, STYLE 1
TO-116





QUAD
AMPLIFIER SWITCHING
TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3906 for graphs.

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	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, $I_E = 0$)	$V_{(BR)CBO}$	−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(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}	 40 60 75	 160 180 200	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = -10$ mAdc, $I_B = -1.0$ mAdc)	$V_{CE(sat)}$	—	−0.1	−0.25	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	200	250	—	MHz
Output Capacitance ($V_{CB} = -5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	3.3	4.5	pF
Input Capacitance ($V_{EB} = -0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	4.8	10	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_C = -10$ mAdc, $V_{BE(off)} = 0.5$ Vdc, $I_{B1} = -1.0$ mAdc)	t_{on}	—	43	—	ns
Turn-Off Time ($I_C = -10$ mAdc, $I_{B1} = I_{B2} = -1.0$ mAdc)	t_{off}	—	155	—	ns

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

2

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

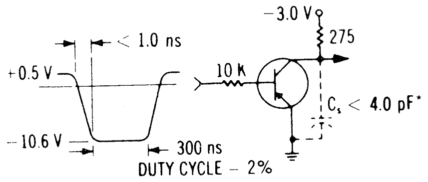
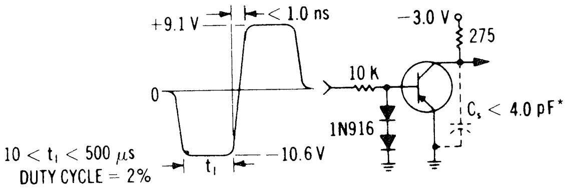


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

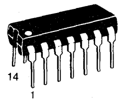
MAXIMUM RATINGS

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°C(1) MPQ6001, MPQ6002, MPQ6501, MPQ6502	P_D	0.65	1.25	Watts
Derate above 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502		5.18	10	mW/°C
Total Device Dissipation @ T_C = 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502	P_D	1.0	3.0	Watts
Derate above 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502		8.0	24	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

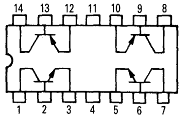
MPQ6001 MPQ6002★ MPQ6501 MPQ6502★

STYLE 1 TYPE A — **STYLE 1 TYPE B**

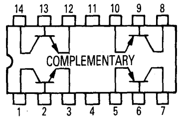
CASE 646-06
TO-116



TYPE A



TYPE B



QUAD COMPLEMENTARY PAIR TRANSISTORS

NPN/PNP(1) SILICON

★These are Motorola designated preferred devices.

2

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance				°C/W
Each Die	MPQ6001, MPQ6002, MPQ6501, MPQ6502	125	193	
Effective, 4 Die	MPQ6001, MPQ6002, MPQ6501, MPQ6502	41.6	100	
Coupling Factors				%
Q1–Q4 or Q2–Q3	MPQ6001, MPQ6002, MPQ6501, MPQ6502	30	60	
Q1–Q2 or Q3–Q4	MPQ6001, MPQ6002, MPQ6501, MPQ6502	20	24	

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)		$V_{(BR)CBO}$	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}	—	—	30	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		25	—	—	
	MPQ6002, MPQ6502		50	—	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		35	—	—	
	MPQ6002, MPQ6502		75	—	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		40	—	—	
	MPQ6002, MPQ6502		100	—	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		20	—	—	
	MPQ6002, MPQ6502		30	—	—	

(1) Voltage and Current are negative for PNP Transistors.

2

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

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage(2)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	1.4	
Base-Emitter Saturation Voltage(2)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	2.0	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	350	—	MHz
Output Capacitance		C_{obo}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	PNP		—	6.0	8.0	
	NPN		—	4.5	8.0	
Input Capacitance		C_{ibo}				pF
(V_{EB} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)	PNP		—	20	30	
	NPN		—	17	30	
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, V_{EB} = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc, Figure 1)		t_{on}	—	30	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 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 ≤ 300 μs, Duty Cycle ≤ 2.0%.

NPN DATA

FIGURE 1 — NORMALIZED DC CURRENT GAIN

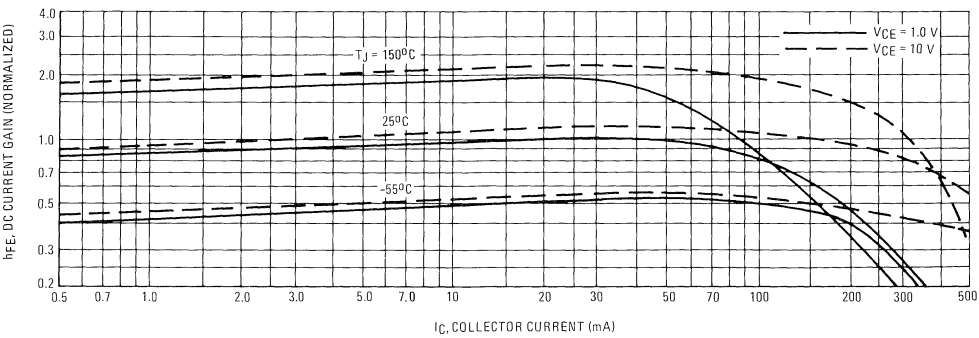


FIGURE 2 — "ON" VOLTAGES

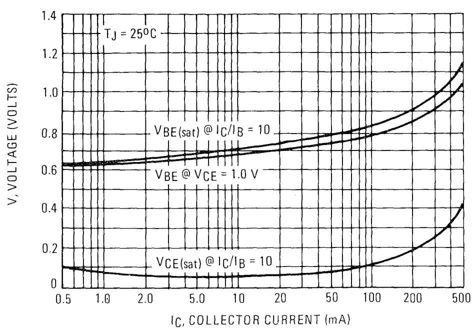
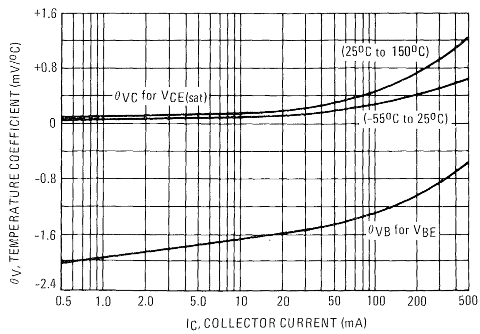


FIGURE 3 — TEMPERATURE COEFFICIENTS



NOISE FIGURE
(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 4 — FREQUENCY EFFECTS

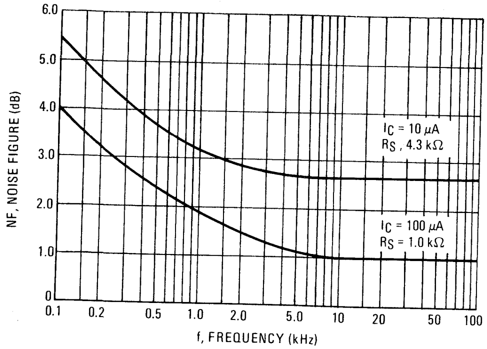
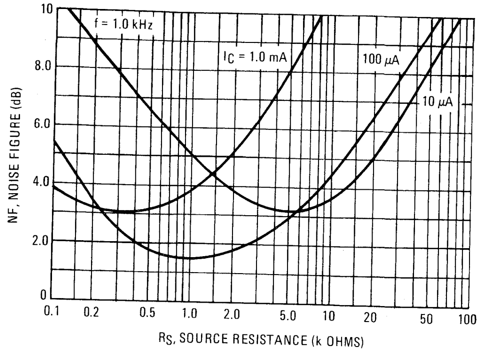


FIGURE 5 — SOURCE RESISTANCE EFFECTS



2

MAXIMUM RATINGS

Rating	Symbol	MPQ6100A MPQ6600A1		Unit
Collector-Emitter Voltage	V_{CEO}	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°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	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

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)	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	%

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

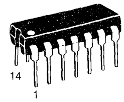
MPQ6100A

STYLE 1
TYPE A

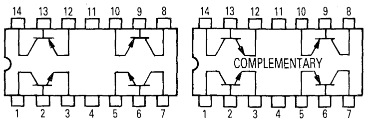
MPQ6600A1★

STYLE 1
TYPE B

CASE 646-06
TO-116



TYPE A **TYPE B**



QUAD COMPLEMENTARY PAIR TRANSISTORS

NPN/PNP(1) SILICON

★This is a Motorola designated preferred device.

Refer to 2N3799 in Section 3 for PNP Curves.

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)	MPQ6100A,6600A1	$V_{(BR)CEO}$	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(2)						
DC Current Gain		h_{FE}				—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MPQ6100A,6600A1		100	—	—	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MPQ6100A,6600A1		150	—	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100A,6600A1		150	—	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100A,6600A1		125	—	—	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	—	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	PNP	C_{obo}	—	1.2	4.0	pF
	NPN		—	1.8	4.0	

2

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

Characteristic	Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) PNP NPN	C_{ibo}	 — —	 — —	 8.0 8.0	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz, BW = 10 kHz)	NF	—	4.0	—	dB
MATCHING CHARACTERISTICS (MPQ6600A1 ONLY)					
DC Current Gain Ratio (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	h_{FE1}/h_{FE2}	0.8	—	1.0	—
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	$\|V_{BE1}-V_{BE2}\|$	—	—	20	mVdc

(1) Voltage and Current are negative for PNP Transistors.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

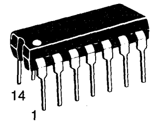
MAXIMUM RATINGS

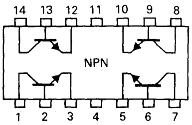
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Die	Four Die Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	500 4.0	900 7.2	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.

MPQ6426

CASE 646-06, STYLE 1
TO-116





QUAD DARLINGTON TRANSISTOR

NPN SILICON

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
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 = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	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_{EB} = 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 = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	15	pF

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

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 1 – NOISE VOLTAGE

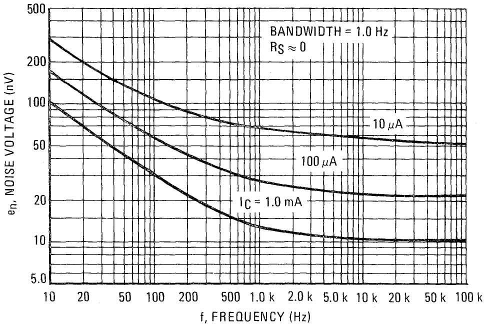


FIGURE 2 – NOISE CURRENT

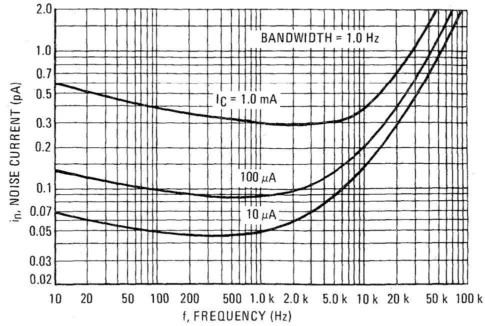


FIGURE 3 – TOTAL WIDEBAND NOISE VOLTAGE

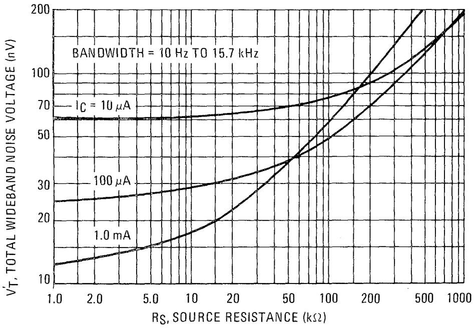
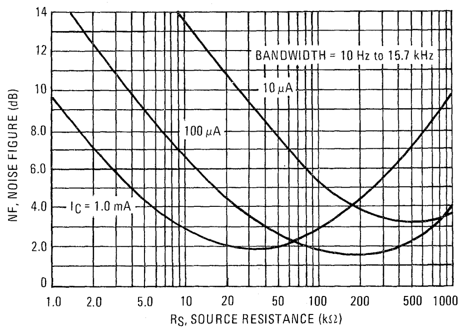


FIGURE 4 – WIDEBAND NOISE FIGURE



DYNAMIC CHARACTERISTICS

FIGURE 5 – CAPACITANCE

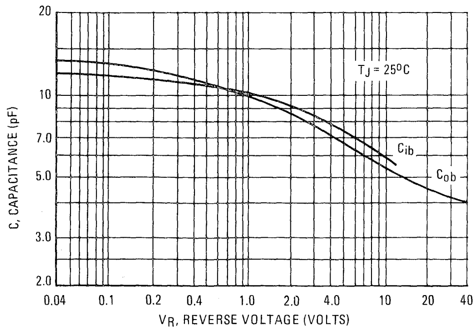
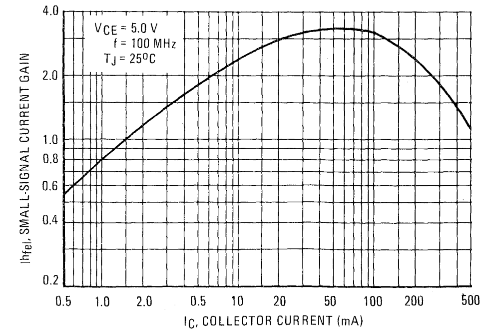


FIGURE 6 – HIGH FREQUENCY CURRENT GAIN



MPQ6501, MPQ6502 For Specifications, See MPQ6001 Data
MPQ6600A1 For Specifications, See MPQ6100A Data

2

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.

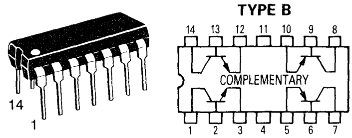
THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die 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	% %

MPQ6700★

CASE 646-06, STYLE 1
TO-116
TYPE B

TYPE B



QUAD COMPLEMENTARY PAIR TRANSISTOR

NPN/PNP(2) SILICON

★This is a Motorola designated preferred device.

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)		$V_{(BR)CBO}$	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(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 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(1) (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 = 1.0 MHz)		C_{obo}	—	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	 PNP NPN	C_{ibo}	 — —	 10 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

NPN   PNP

FIGURE 1 — DC CURRENT GAIN

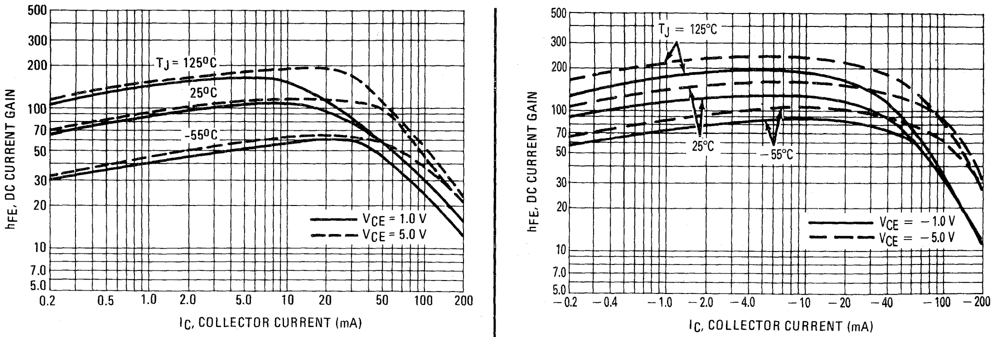


FIGURE 2 — "ON" VOLTAGE

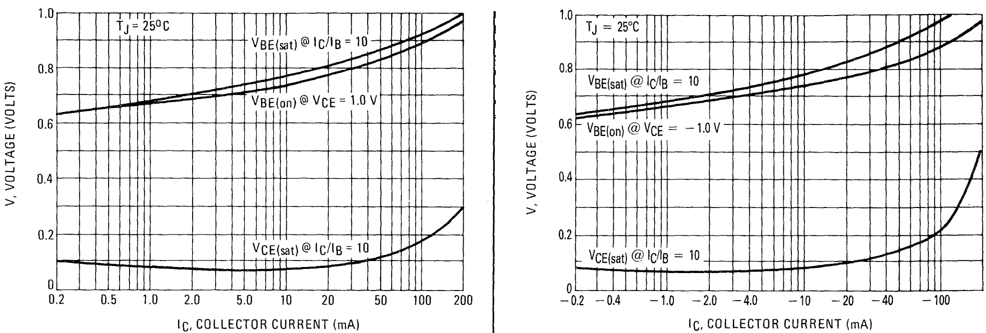
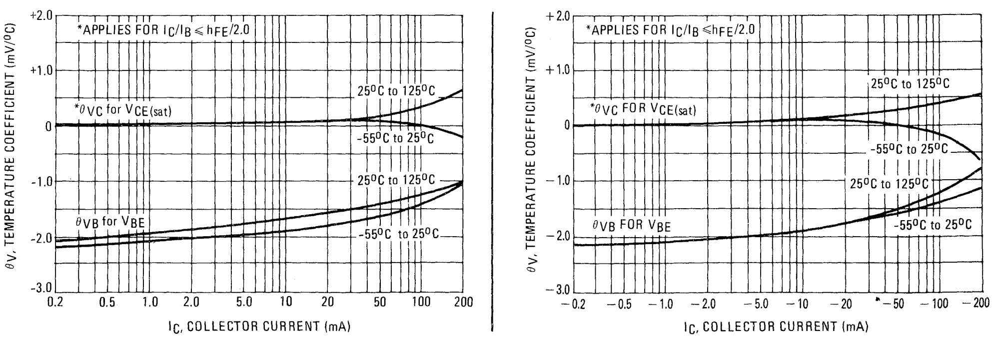


FIGURE 3 — TEMPERATURE COEFFICIENTS



2

NPN | PNP

FIGURE 4 — COLLECTOR SATURATION REGION

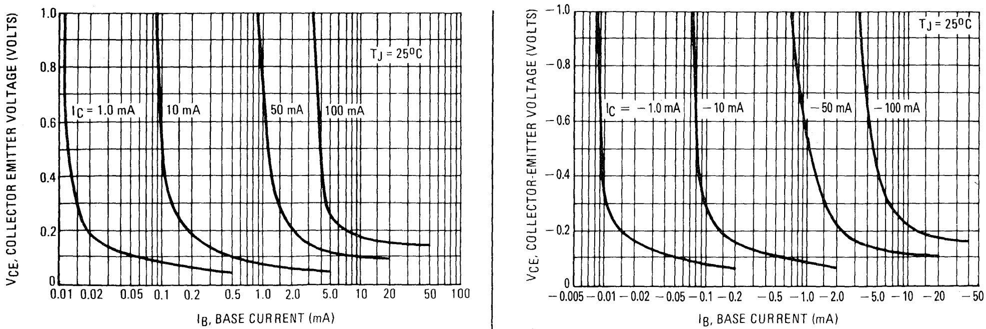


FIGURE 5 — TURN-ON TIME

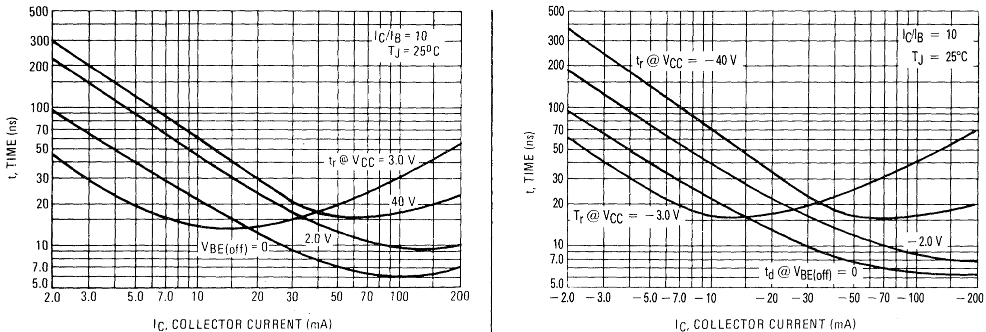
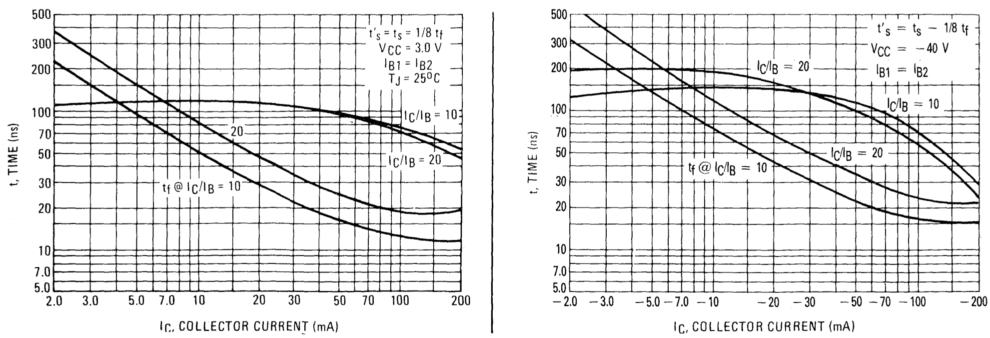


FIGURE 6 — TURN-OFF TIME



NPN PNP

FIGURE 7 — CURRENT-GAIN — BANDWIDTH PRODUCT

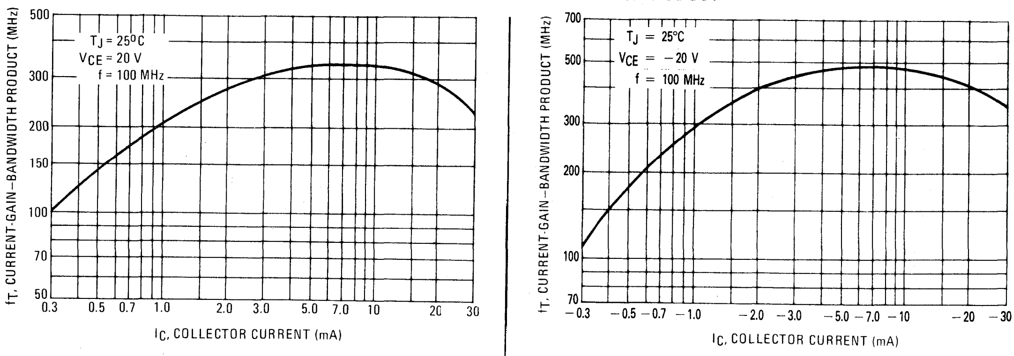
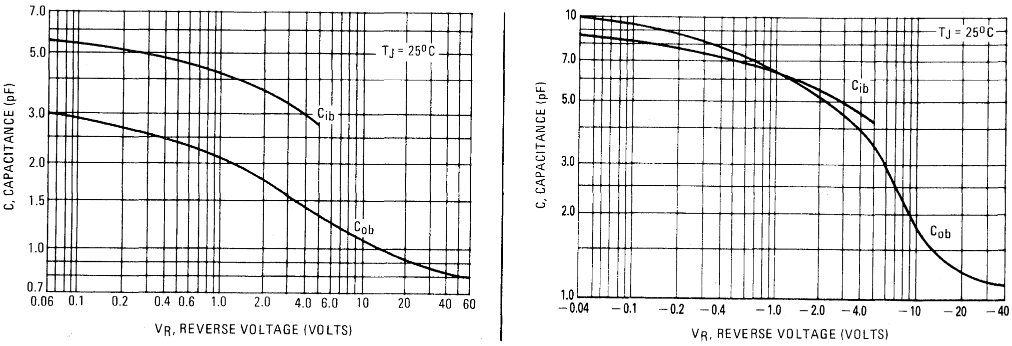


FIGURE 8 — CAPACITANCE



2

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°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.

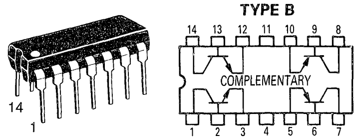
THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die 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	% %

MPQ6842

CASE 646-06, STYLE 1
TO-116
TYPE B

TYPE B



QUAD COMPLEMENTARY PAIR TRANSISTOR

NPN/PNP(2) 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)	$V_{(BR)CEO}$	30	—	—	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)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 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(1)					
DC Current Gain (I_C = 0.5 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 = 0.5 mAdc, I_B = 0.05 mAdc, 0°C ≤ T ≤ 70°C)	$V_{CE(sat)}$	—	0.05	0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 0.5 mAdc, I_B = 0.05 mAdc)	$V_{BE(sat)}$	—	0.65	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz	C_{obo}	—	3.0	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz PNP NPN	C_{ibo}	— —	5.0 4.0	10 8.0	pF
SWITCHING CHARACTERISTICS (T_A = 25°C, V_{CC} = 5.0 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

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

MPQ6842

NPN | PNP

FIGURE 1 — DC CURRENT GAIN

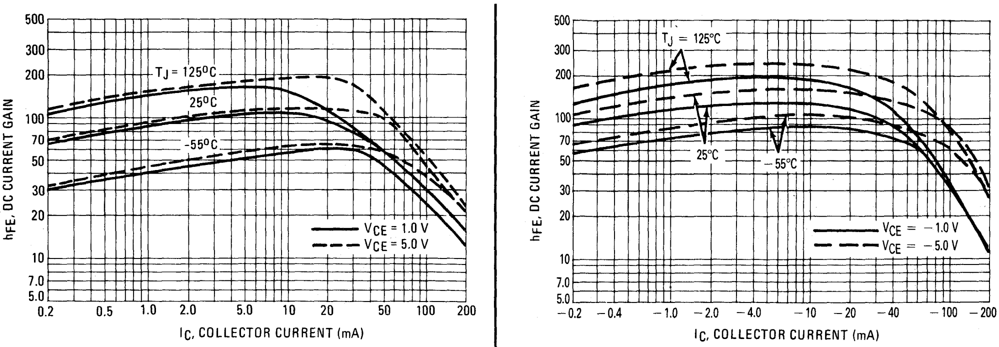


FIGURE 2 — "ON" VOLTAGE

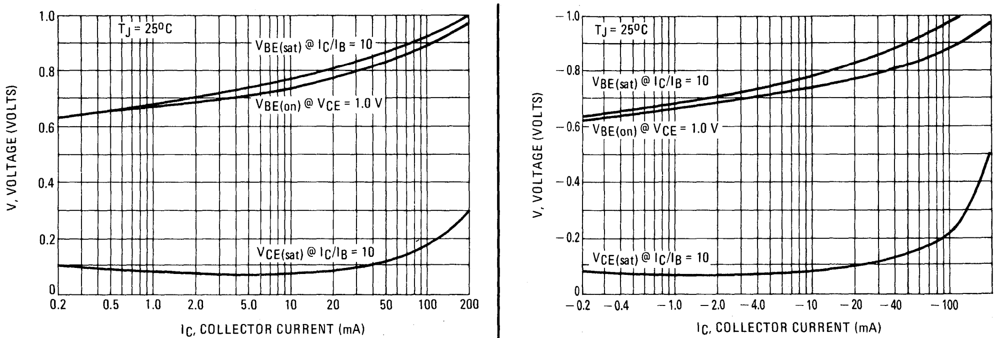
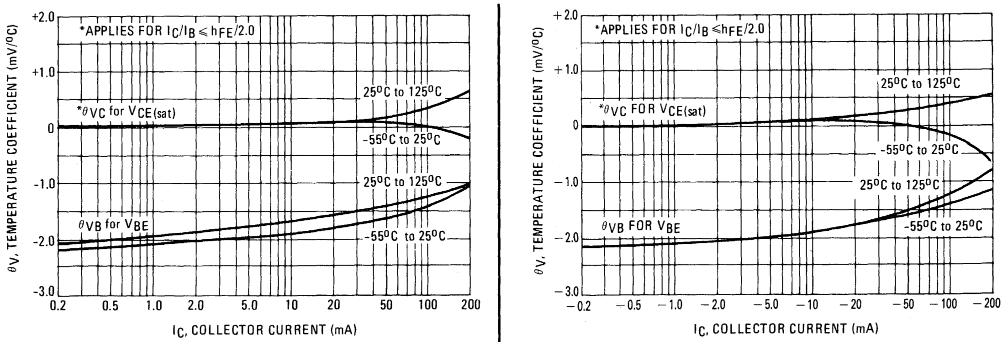


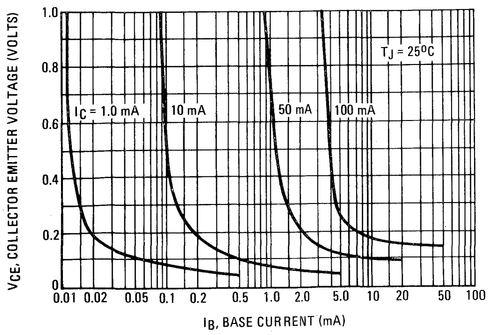
FIGURE 3 — TEMPERATURE COEFFICIENTS



2

FIGURE 4 — COLLECTOR SATURATION REGION

NPN



PNP

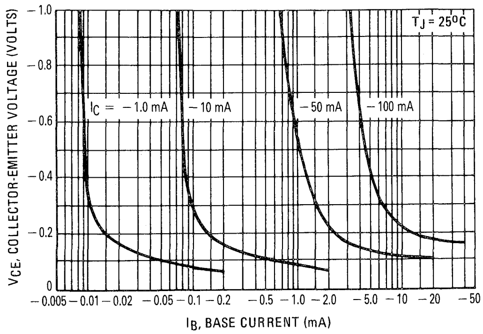
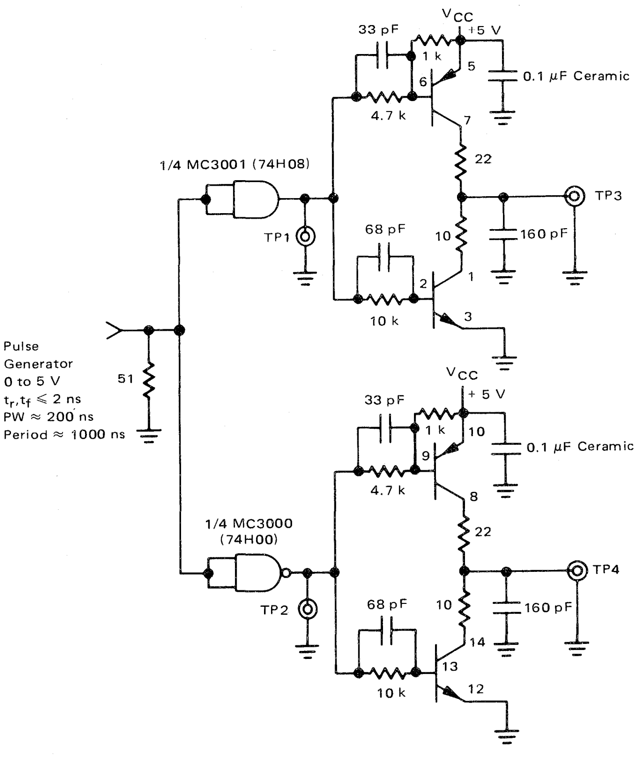
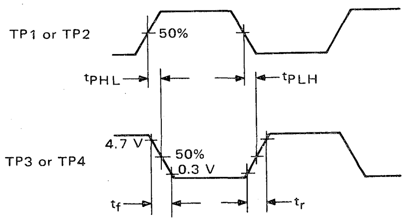


FIGURE 5 — SWITCHING TIMES TEST CIRCUIT AND WAVEFORMS



NOTES:

1. Unless otherwise noted, all resistors carbon composition ¼ 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.



MAXIMUM RATINGS

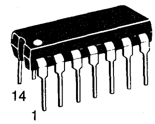
Rating	Symbol	MPQ7041	MPQ7042	MPQ7043	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	500			mAdc
		Each Die	**Four Die Equal Power**		
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 750 5.98	 1700 13.6		 mW mW/°C
Total Device Dissipation @ T_A = 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

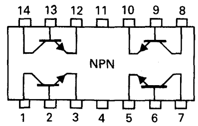
THERMAL CHARACTERISTICS

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	%

MPQ7041
MPQ7042
MPQ7043★

CASE 646-06, STYLE 1
TO-116





QUAD
AMPLIFIER TRANSISTORS
NPN SILICON

★**This is a Motorola designated preferred device.**

Refer to MPQ7051 for graphs.

2

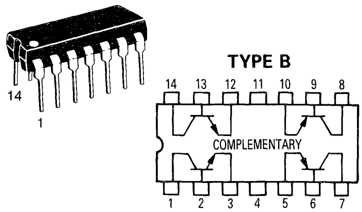
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	 MPQ7041 MPQ7042 MPQ7043	$V_{(BR)CEO}$	 150 200 250	 — — —	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPQ7041 MPQ7042 MPQ7043	$V_{(BR)CBO}$	 150 200 250	 — — —	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 150 Vdc, I_E = 0) (V_{CB} = 180 Vdc, I_E = 0)	 MPQ7041 MPQ7042 MPQ7043	I_{CBO}	 — — —	 — — —	 100 100 100	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 40 40	 45 60 80	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	—	0.3	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	80	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	2.5	5.0	pF
Input Capacitance (V_{EB} = 3.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	40	50	pF

MPQ7051★

CASE 646-06, TYPE B
TO-116

TYPE B



QUAD COMPLEMENTARY PAIR TRANSISTOR

NPN/PNP(1) SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	150		Vdc
Collector-Base Voltage	V_{CBO}	150		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°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	Max	Unit
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)	$V_{(BR)CBO}$	150	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0)	I_{CBO}	—	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	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
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) NPN PNP	C_{ibo}	— —	50 75	pF

(1) Voltage and current are negative for PNP transistors.

2

DC CHARACTERISTICS

NPN | **PNP**

FIGURE 1 — DC CURRENT GAIN

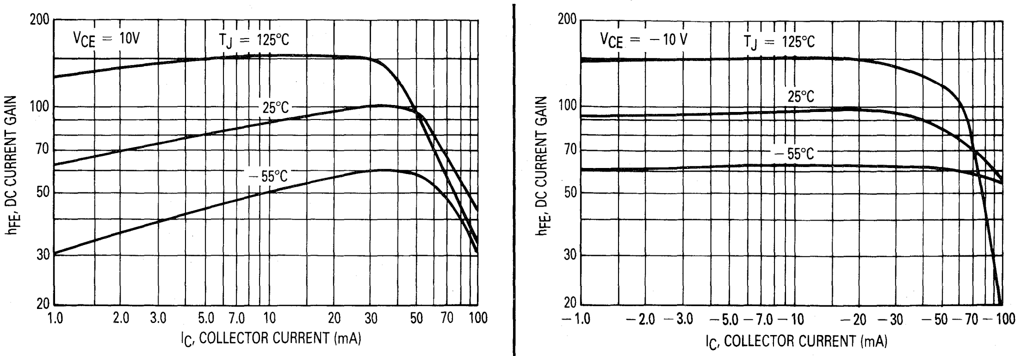


FIGURE 2 — "ON" VOLTAGES

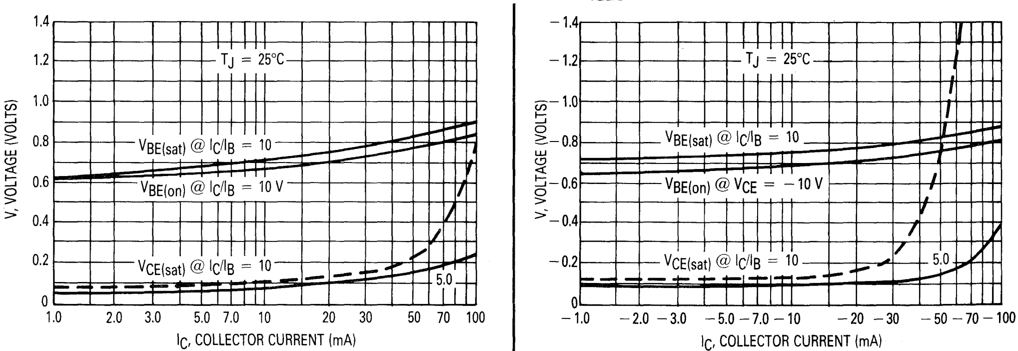
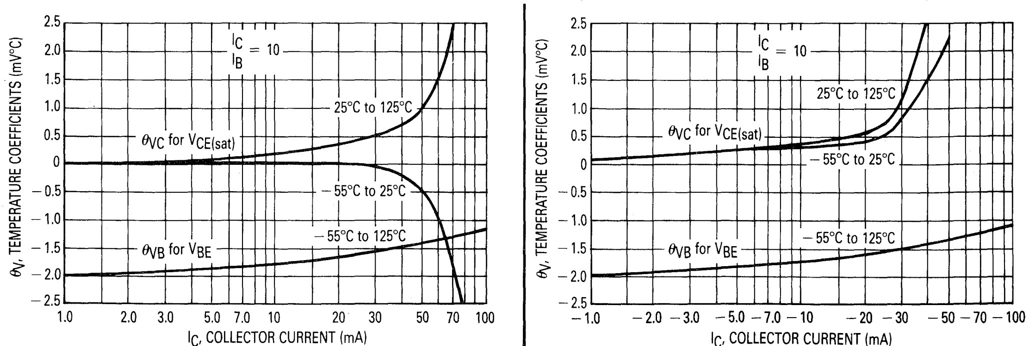
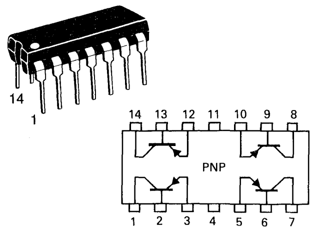


FIGURE 3 — TEMPERATURE COEFFICIENTS



MPQ7091
MPQ7093★

CASE 646-06, STYLE 1
TO-116



QUAD AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to MPQ7051 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ7091	MPQ7093	Unit
Collector-Emitter Voltage	V_{CEO}	−150	−250	Vdc
Collector-Base Voltage	V_{CBO}	−150	−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°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

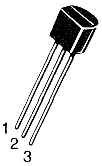
Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	 MPQ7091 MPQ7093	$V_{(BR)CEO}$	 −150 −250	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	 MPQ7091 MPQ7093	$V_{(BR)CBO}$	 −150 −250	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −120 Vdc, I_E = 0)	 MPQ7091 MPQ7093	I_{CBO}	 — —	 — —	 −250 −250	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 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	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{BE(sat)}$	—	−0.7	−0.9	Vdc
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

MPS404A★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



CHOPPER TRANSISTOR
PNP SILICON

★This is a Motorola designated preferred device.

2

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}	−25	Vdc
Collector Current — Continuous	I_C	−150	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	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−35	—	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)	$V_{(BR)EBO}$	−25	—	Vdc
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	Vdc
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	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Common-Base Cutoff Frequency (I_C = −1.0 mAdc, V_{CB} = 6.0 Vdc)	f_{ob}	4.0	—	MHz
Output Capacitance (V_{CB} = −6.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	20	pF

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

2

FIGURE 1 — COLLECTOR-EMITTER VOLTAGE

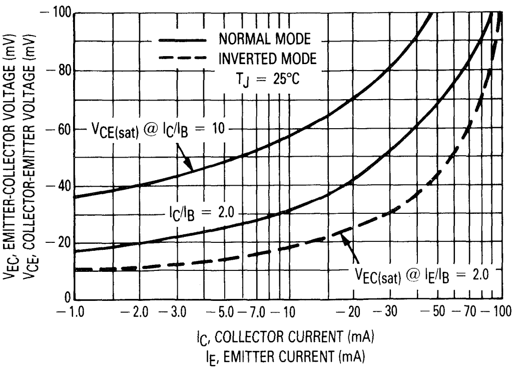
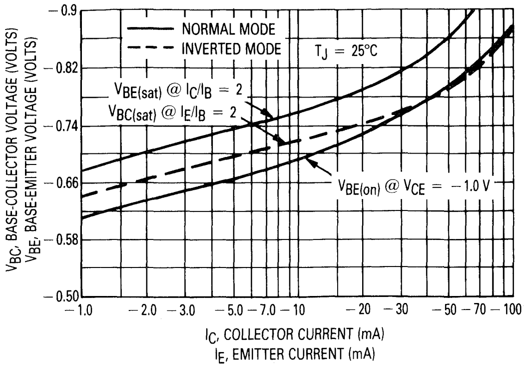


FIGURE 2 — BASE "ON" VOLTAGE



NORMAL MODE

FIGURE 3 — DC CURRENT GAIN @ V_{CE} = −0.15 Vdc

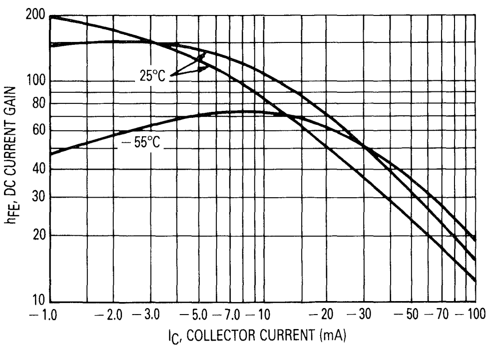
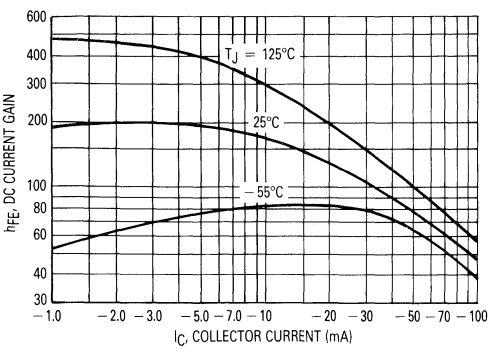


FIGURE 5 — DC CURRENT GAIN @ V_{CE} = −1.0 Vdc



INVERTED MODE

FIGURE 4 — DC CURRENT GAIN @ V_{EC} = −0.15 Vdc

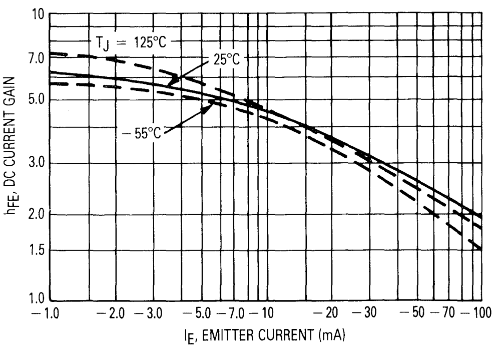


FIGURE 6 — DC CURRENT GAIN @ V_{EC} = −1.0 Vdc

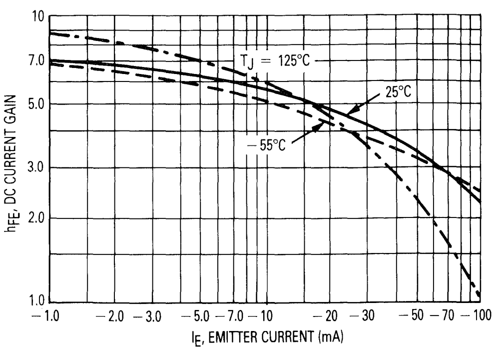


FIGURE 7 — COLLECTOR SATURATION REGION

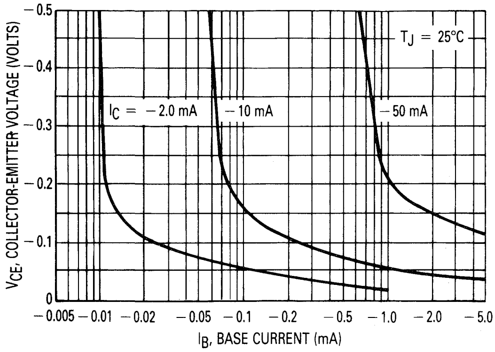


FIGURE 8 — EMITTER SATURATION REGION

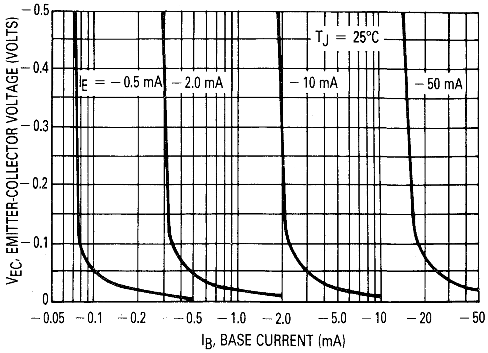


FIGURE 9 — EMITTER-COLLECTOR "ON" RESISTANCE

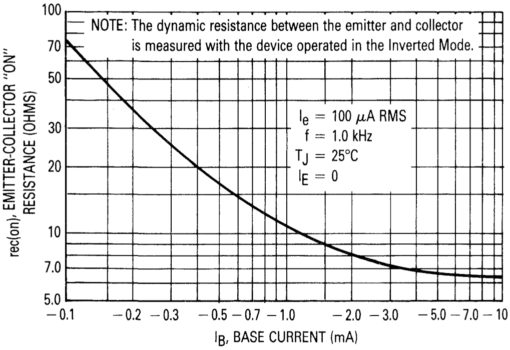


FIGURE 10 — CAPACITANCE

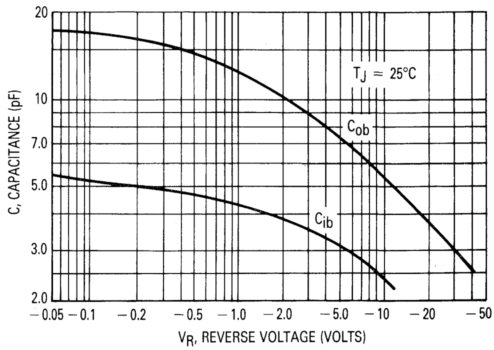


FIGURE 11 — TURN-ON TIME

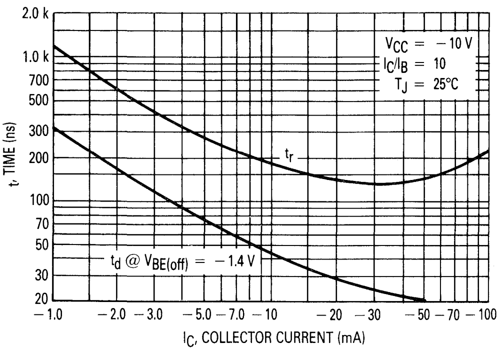
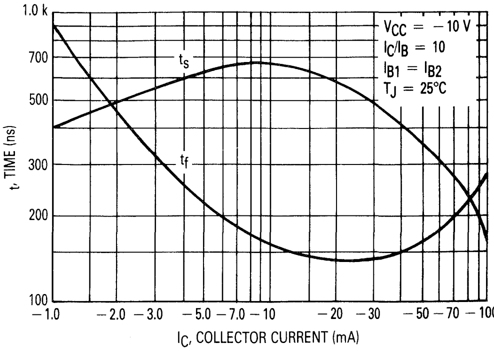
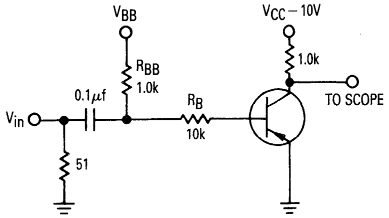


FIGURE 12 — TURN-OFF TIME



2

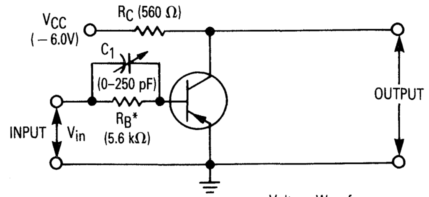
FIGURE 13 — SWITCHING TIME TEST CIRCUIT

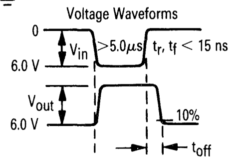


	V_{in} (Volts)	V_{BB} (Volts)
t_{on}, t_d and t_r	– 12	+ 1.4
t_{off}, t_s and t_f	+ 20.6	– 11.6

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





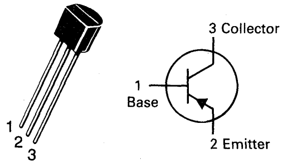
MEASUREMENT PROCEDURE

C_1 is increased until the t_{off} time of the output waveform is decreased to 0.2 μs, Q_S is then calculated by $Q_S = C_1 V_{in}$.

Q_{S3} or Q_{S7} by B-Line Electronics or equivalent may also be used.

MPS536

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



HIGH FREQUENCY TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPS536	Unit
Collector-Emitter Voltage	V_{CEO}	−10	Vdc
Collector-Base Voltage	V_{CBO}	−15	Vdc
Emitter-Base Voltage	V_{EBO}	−4.5	Vdc
Collector Current — Continuous	I_C	−30	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

*Free air

ELECTRICAL CHARACTERISTICS (T_C = 25°C *For both package types unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −2.0 mA, I_B = 0)	$V_{(BR)CEO}$	−10	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μA, I_E = 0)	$V_{(BR)CBO}$	−15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μA, 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 = −20 mA, V_{CE} = −5.0 V)	h_{FE}	20	—	200	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −20 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance (V_{CB} = −5.0 Vdc, I_F = 0, f = 1.0 MHz)	C_{cb}	—	0.8	1.2	pF
FUNCTIONAL TESTS					
Gain @ Noise Figure (I_C = −10 mAdc, V_{CE} = −5.0 Vdc) f = 500 MHz f = 1.0 GHz	G_{NF}	 — —	 14 8.0	 — —	dB
Noise Figure (I_C = −10 mAdc, V_{CE} = −5.0 Vdc f = 500 MHz f = 1.0 GHz	NF	 — —	 4.5 6.0	 — —	dB

2

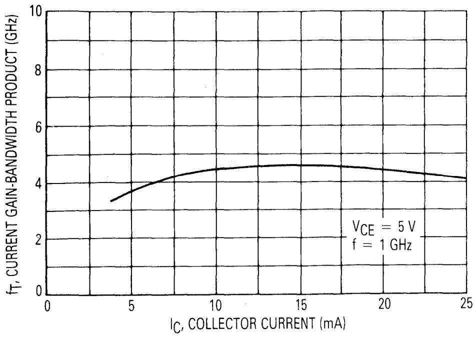


Figure 1. Current Gain-Bandwidth Product versus Collector Current

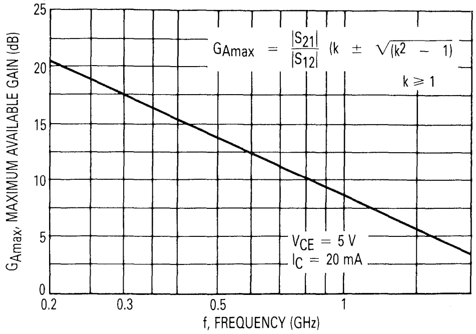


Figure 2. Maximum Available Gain (G_{Amax}) versus Frequency

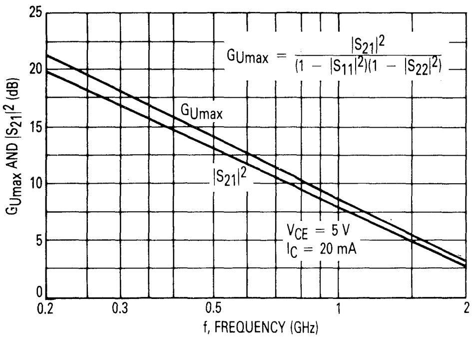


Figure 3. Maximum Unilateral Gain (G_{Umax}) and Insertion Gain ($|S_{21}|^2$) versus Frequency

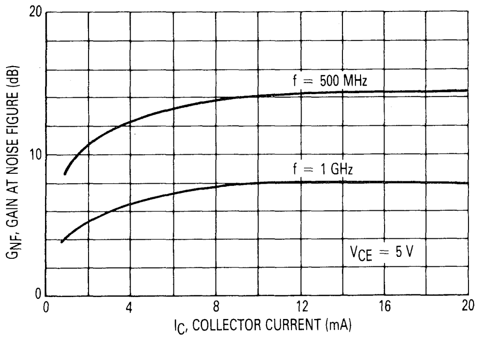


Figure 4. Gain at Noise Figure versus Collector Current

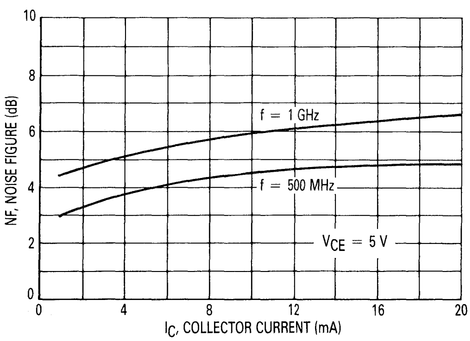


Figure 5. Noise Figure versus Collector Current

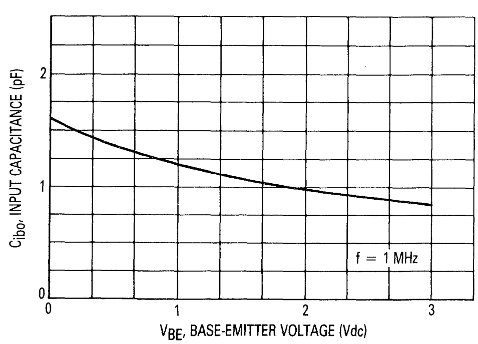


Figure 6. Input Capacitance versus Emitter-Base Voltage

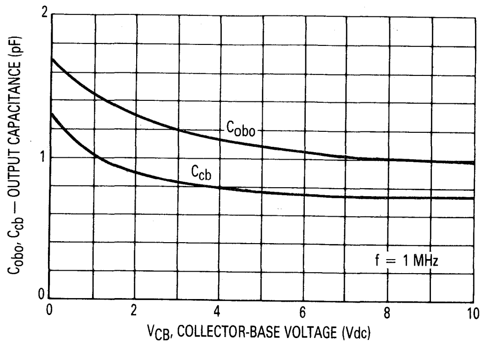
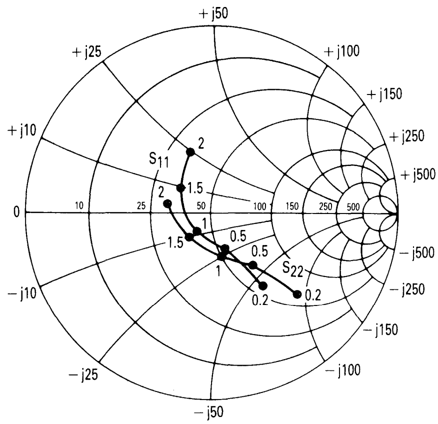
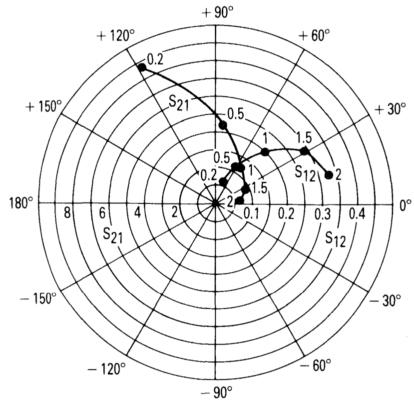


Figure 7. Output Capacitance versus Collector-Base Voltage

INPUT/OUTPUT REFLECTION COEFFICIENT versus FREQUENCY V_{CE} = 10 V, I_C = 10 mA



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY V_{CE} = 10 V, I_C = 10 mA



COMMON EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
10	5	200	0.60	−43	6.60	125	0.07	68	0.71	−35
		500	0.30	−60	3.64	87	0.14	57	0.47	−43
		1000	0.17	−103	2.11	56	0.22	43	0.32	−69
		1500	0.15	156	1.70	28	0.30	28	0.22	−112
		2000	0.28	110	1.29	2	0.33	13	0.25	−174
	10	200	0.48	−52	8.78	118	0.06	69	0.62	−42
		500	0.21	−66	4.31	84	0.12	60	0.37	−46
		1000	0.12	−122	2.40	54	0.20	47	0.24	−73
		1500	0.18	138	1.90	29	0.29	31	0.16	−126
		2000	0.32	104	1.41	4	0.33	16	0.23	170
	20	200	0.38	−59	10.21	112	0.06	70	0.54	−46
		500	0.14	−76	4.72	81	0.12	63	0.30	−47
		1000	0.11	−144	2.58	53	0.20	49	0.19	−74
		1500	0.22	132	1.99	28	0.29	34	0.12	−139
		2000	0.35	103	1.46	4	0.33	19	0.22	161

2

MAXIMUM RATINGS

Rating	Symbol	MPS650 MPS750	MPS651 MPS751	Unit
Collector-Emitter Voltage	V_{CE}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Power 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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

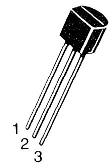
NPN

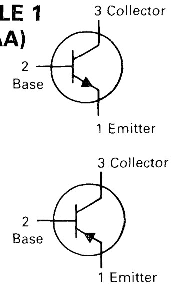
MPS650, MPS651★

PNP(3)

MPS750, MPS751★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)





AMPLIFIER TRANSISTORS

★These are Motorola designated preferred devices.

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MPS650, MPS750 MPS651, MPS751	$V_{(BR)CEO}$	40 60	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS650, MPS750 MPS651, MPS751	$V_{(BR)CBO}$	60 80	— —	Vdc
Emitter-Base Breakdown Voltage (I_C = 0, I_E = 10 μAdc)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	MPS650, MPS750 MPS651, MPS751	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 V, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 50 mA, V_{CE} = 2.0 V) (I_C = 500 mA, V_{CE} = 2.0 V) (I_C = 1.0 A, V_{CE} = 2.0 V) (I_C = 2.0 A, V_{CE} = 2.0 V)		h_{FE}	75 75 75 40	— — — —	—
Collector-Emitter Saturation Voltage (I_C = 2.0 A, I_B = 200 mA) (I_C = 1.0 A, I_B = 100 mA)		$V_{CE(sat)}$	— —	0.5 0.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 A, V_{CE} = 2.0 V)		$V_{BE(on)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 A, I_B = 100 mA)		$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	75	—	MHz

(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.
(3) Voltage and current are negative for PNP transistors.

FIGURE 1 — MPS650, MPS651
TYPICAL DC CURRENT GAIN
NPN

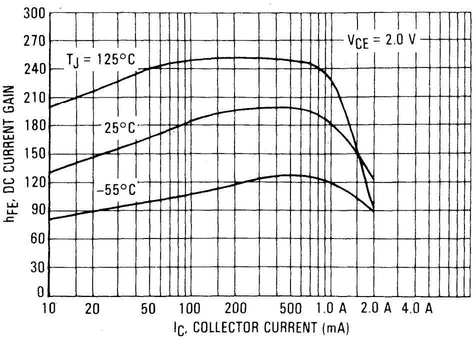


FIGURE 2 — MPS750, MPS751
TYPICAL DC CURRENT GAIN
PNP

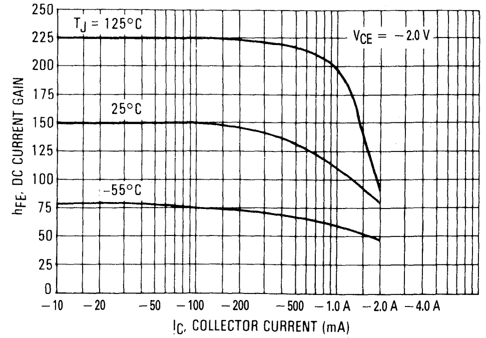


FIGURE 3 — MPS650, MPS651
ON VOLTAGES
NPN

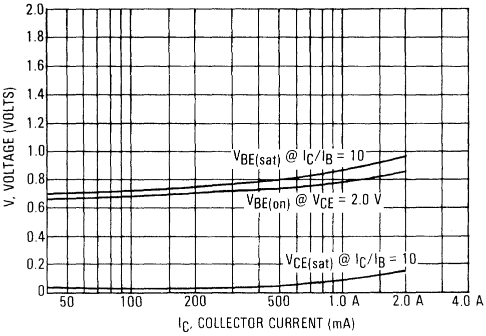


FIGURE 4 — MPS750, MPS751
ON VOLTAGES
PNP

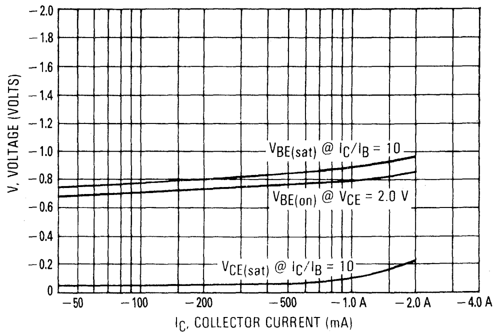


FIGURE 5 — MPS650, MPS651
COLLECTOR SATURATION REGION
NPN

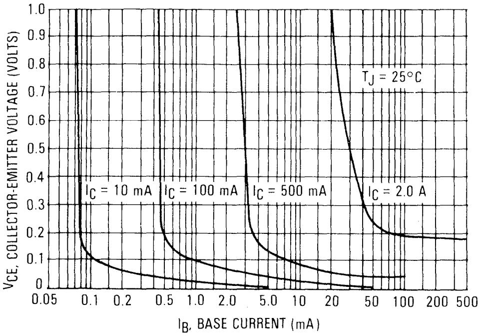
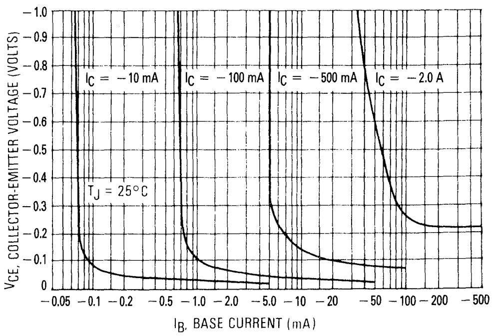


FIGURE 6 — MPS750, MPS751
COLLECTOR SATURATION REGION
PNP



2

FIGURE 7 — MPS650, MPS651 SOA,
SAFE OPERATING AREA

NPN

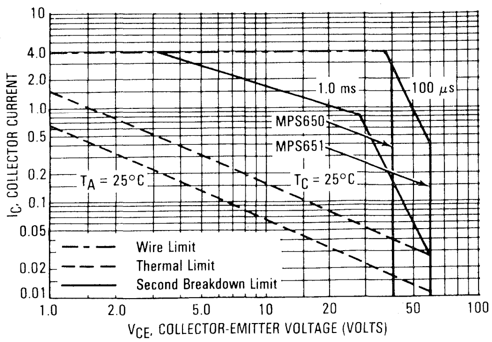
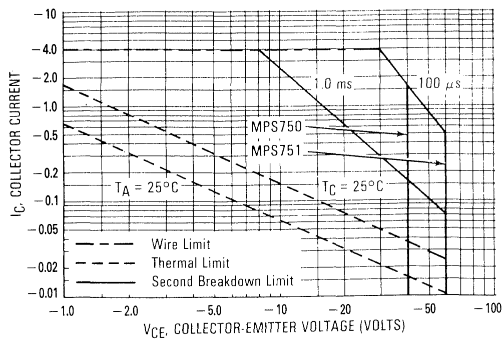


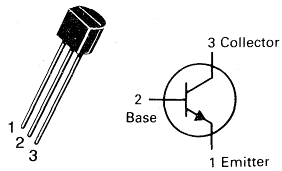
FIGURE 8 — MPS750, MPS751 SOA,
SAFE OPERATING AREA

PNP



MPS918★
MPS3563

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON
★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPS918	MPS3563	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CBO}	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	2.0	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	0.85 6.8		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 Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	147	°C/W

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 3.0 mAdc, I_B = 0)	MPS918 MPS3563	$V_{(BR)CEO}$	15 12	— —	Vdc
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	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPS918 MPS3563	$V_{(BR)EBO}$	3.0 2.0	— —	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, 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 Vdc) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	MPS918 MPS3563	h_{FE}	20 20	— 200	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS918	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS918	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS918 MPS3563	f_T	600 600	— 1500	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) (V_{CB} = 10 Vdc, 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 Vdc, I_C = 0, f = 1.0 MHz)	MPS918	C_{ibo}	—	2.0	pF
Small-Signal Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3563	h_{fe}	20	250	—
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 ohms, f = 60 MHz)	MPS918	NF	—	6.0	dB

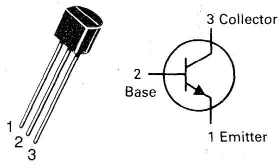
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

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

Characteristic		Symbol	Min	Max	Unit
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain		G_{pe}			dB
(I_C = 6.0 mAdc, V_{CB} = 12 Vdc, f = 200 MHz)	MPS918		15	—	
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz) ($G_{fd} + G_{re} < -20$ dB)	MPS3563		14	—	
Power Output (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, f = 500 MHz)	MPS918	P_{out}	30	—	mW
Oscillator Collector Efficiency (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, P_{out} = 30 mW, f = 500 MHz)	MPS918	η	25	—	%

MPS2222,A★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



2

GENERAL PURPOSE TRANSISTORS

NPN SILICON

★MPS2222A is a Motorola designated preferred device.

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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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, $I_B = 0$)	 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

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

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MPS2222		—	1.3	
	MPS2222A		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	MPS2222		—	2.6	
	MPS2222A		—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MPS2222		250	—	
	MPS2222A		300	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS2222		—	30	
	MPS2222A		—	25	
Input Impedance		h_{ie}			kΩ
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			$X\ 10^{-4}$
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		25	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	MPS2222A	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	MPS2222A	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	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_s	—	225	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.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

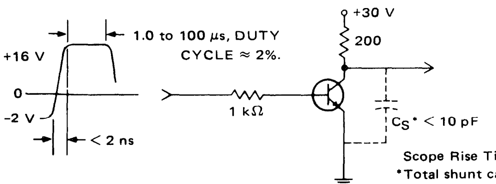
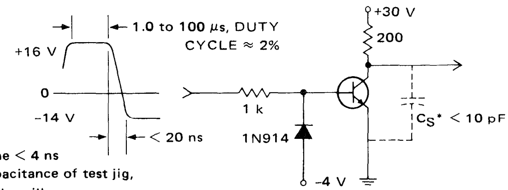


FIGURE 2 — TURN-OFF TIME



Scope Rise Time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

FIGURE 3 — DC CURRENT GAIN

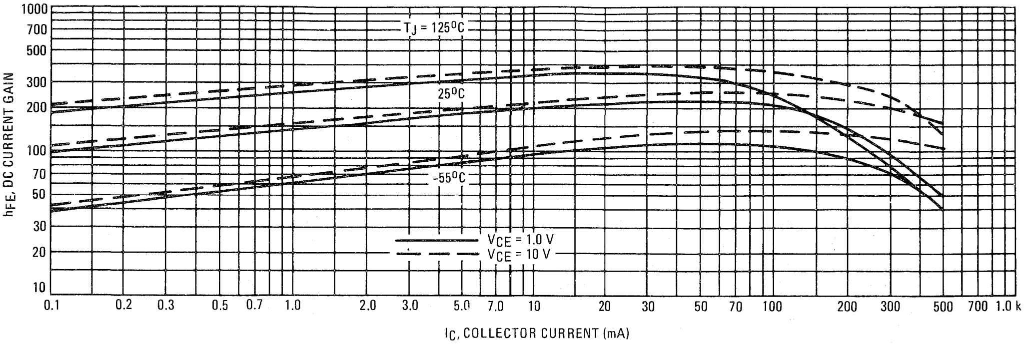


FIGURE 4 — COLLECTOR SATURATION REGION

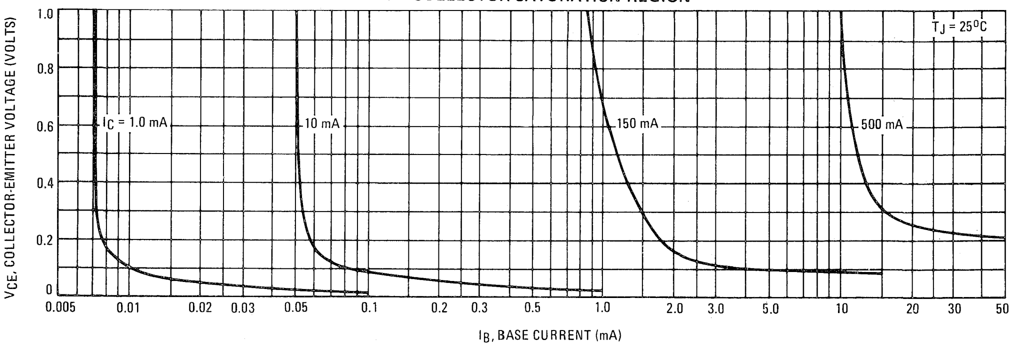


FIGURE 5 — TURN-ON TIME

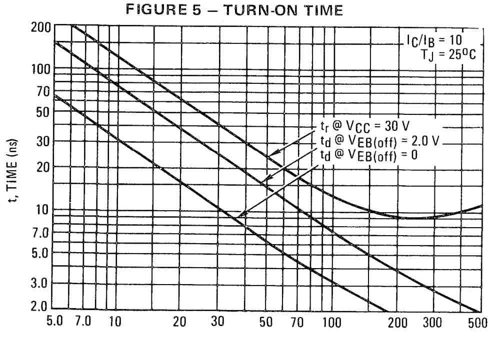
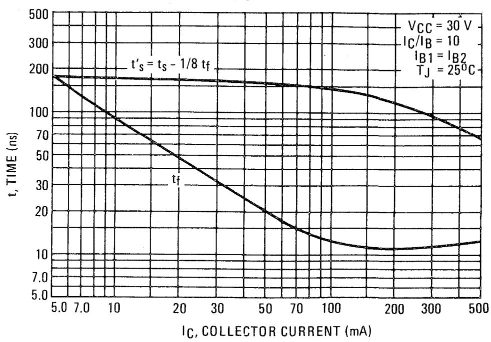


FIGURE 6 — TURN-OFF TIME



2

FIGURE 7 — FREQUENCY EFFECTS

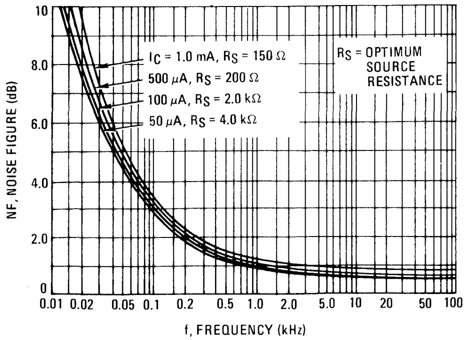


FIGURE 8 — SOURCE RESISTANCE EFFECTS

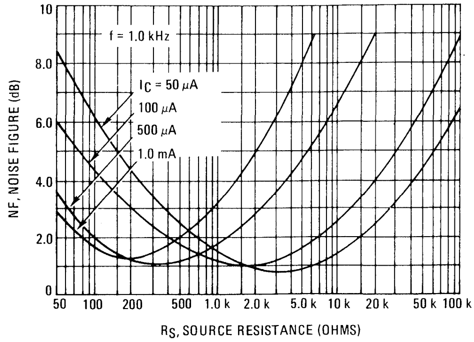


FIGURE 9 — CAPACITANCES

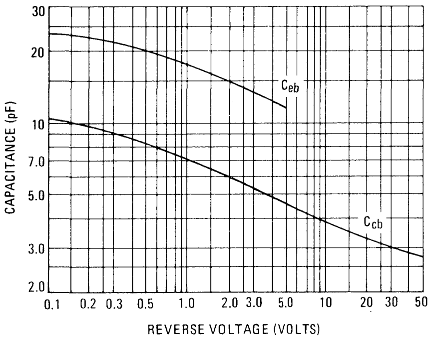


FIGURE 10 — CURRENT-GAIN BANDWIDTH PRODUCT

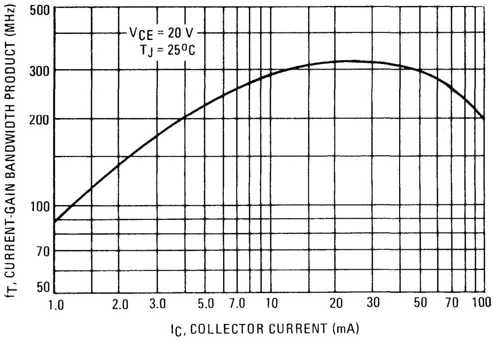


FIGURE 11 — "ON" VOLTAGES

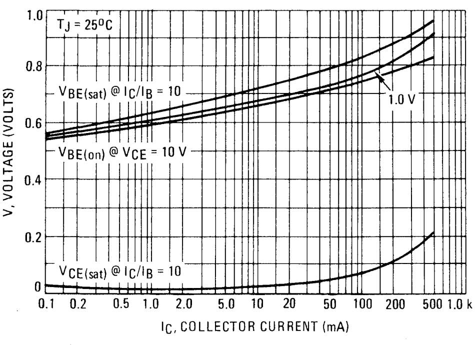
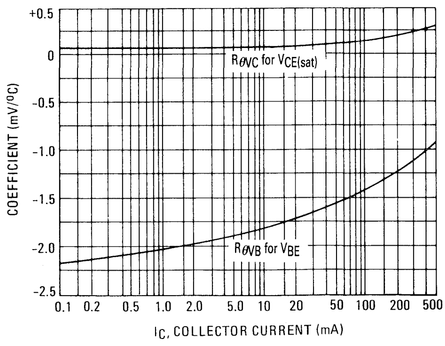
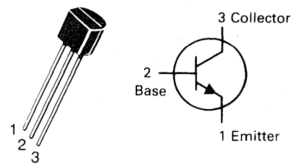


FIGURE 12 — TEMPERATURE COEFFICIENTS



MPS2369,A★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTORS

NPN SILICON

★MPS2369A is a Motorola designated preferred device.

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	200	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	$R_{\theta JA}$	200	°C/W

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, $I_B = 0$)	MPS2369A	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $V_{BE} = 0$)	MPS2369,A	$V_{(BR)CES}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	MPS2369,A	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	MPS2369,A	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 125°C$)	 MPS2369,A	I_{CBO}	 — —	 — —	 0.4 30	μAdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$)	MPS2369,A	I_{CES}	—	—	0.4	μAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ V)	MPS2369A		—	—	120	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)	MPS2369		20	—	—	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS2369		40	—	120	
($I_C = 10$ mAdc, $V_{CE} = 0.35$ Vdc)	MPS2369A		40	—	—	
($I_C = 10$ mAdc, $V_{CE} = 0.35$ Vdc, $T_A = -55°C$)	MPS2369A		20	—	—	
($I_C = 30$ mAdc, $V_{CE} = 0.4$ Vdc)	MPS2369A		30	—	—	
($I_C = 100$ mAdc, $V_{CE} = 2.0$ Vdc)	MPS2369		20	—	—	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS2369A		20	—	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	MPS2369		—	—	0.25	
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	MPS2369A		—	—	0.20	
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc, $T_A = +125°C$)	MPS2369A		—	—	0.30	
($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	MPS2369A		—	—	0.25	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)	MPS2369A		—	—	0.50	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	MPS2369		0.7	—	0.85	
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc, $T_A = +125°C$)	MPS2369A		0.5	—	—	
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc, $T_A = -55°C$)	MPS2369A		—	—	1.02	
($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	MPS2369A		—	—	1.15	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)	MPS2369A		—	—	1.60	

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

2

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

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	MPS2369,A	C_{obo}	—	—	4.0	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS2369,A	h_{fe}	5.0	—	—	—
SWITCHING CHARACTERISTICS						
Storage Time (I_{B1} = I_{B2} = I_C = 10 mAdc) (Figure 3)	MPS2369,A	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)	MPS2369,A	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)	MPS2369,A	t_{off}	—	10	18	ns

FIGURE 1 — t_{on} CIRCUIT

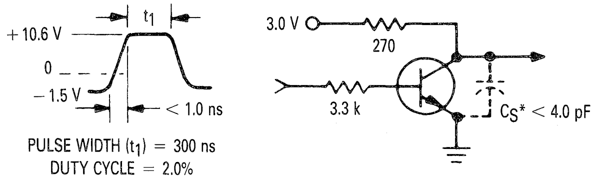


FIGURE 2 — t_{off} CIRCUIT

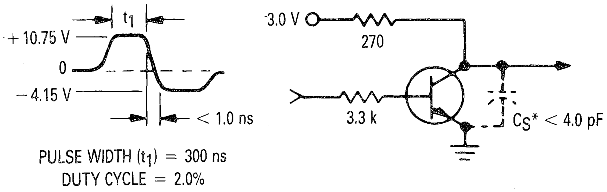
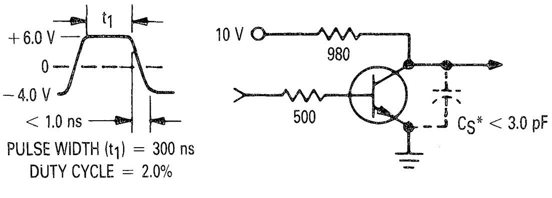


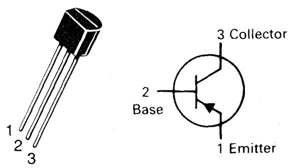
FIGURE 3 — STORAGE TEST CIRCUIT



*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS.

MPS2907,A★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★MPS2907A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPS2907	MPS2907A	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 @ 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}	−500 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

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)	 MPS2907 MPS2907A	$V_{(BR)CEO}$	 −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) (V_{CB} = −50 Vdc, I_E = 0, T_A = 150°C)	 MPS2907 MPS2907A MPS2907 MPS2907A	I_{CBO}	 — — — —	 −0.020 −0.010 −20 −10	μAdc
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) (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc) (I_C = −150 mAdc, V_{CE} = −10 Vdc)(1) (I_C = −500 mAdc, V_{CE} = −10 Vdc)(1)	 MPS2907 MPS2907A MPS2907 MPS2907A MPS2907 MPS2907A MPS2907, MPS2907A MPS2907 MPS2907A	h_{FE}	 35 75 50 100 75 100 100 30 50	 — — — — — — 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 −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

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 = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc) (Figures 1 and 5)	t_{on}	—	45	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-Off Time	(V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_{off}	—	100	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	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.

FIGURE 1 — DELAY AND RISE TIME TEST CIRCUIT

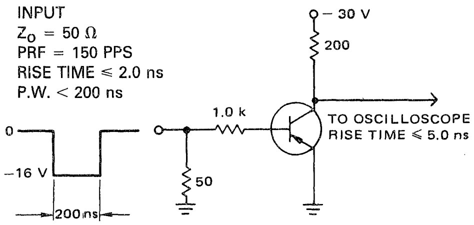
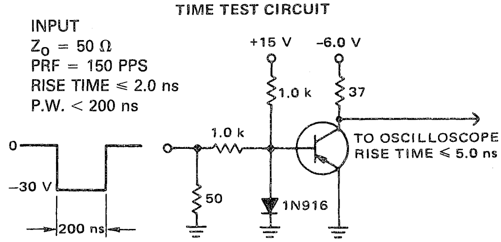


FIGURE 2 — STORAGE AND FALL TIME TEST CIRCUIT



TYPICAL CHARACTERISTICS

FIGURE 3 — DC CURRENT GAIN

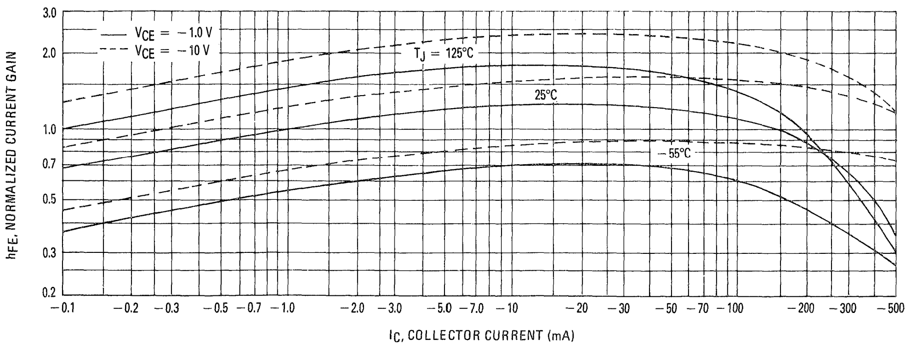


FIGURE 4 — COLLECTOR SATURATION REGION

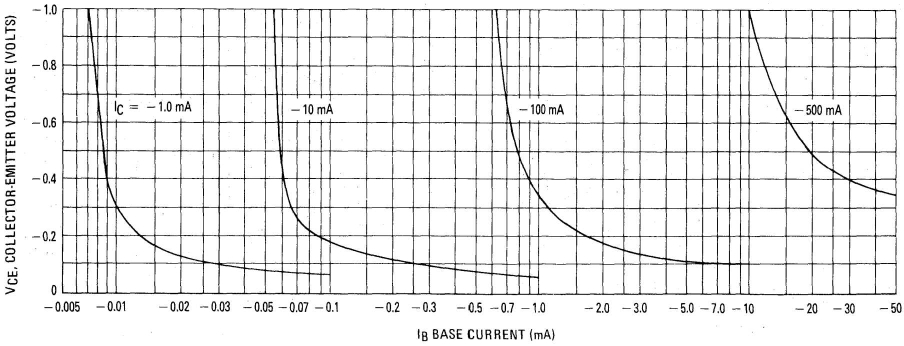


FIGURE 5 — TURN-ON TIME

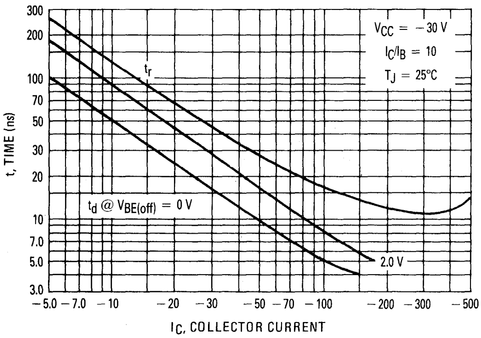
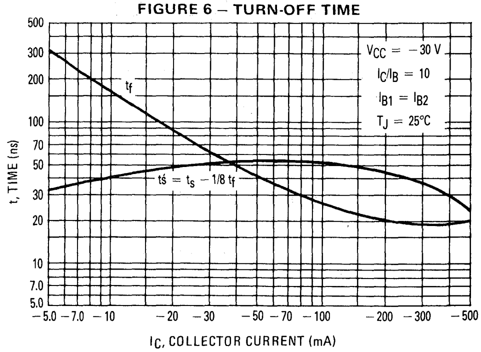


FIGURE 6 — TURN-OFF TIME



TYPICAL SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 7 — FREQUENCY EFFECTS

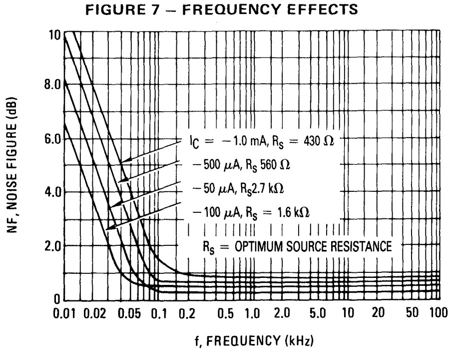
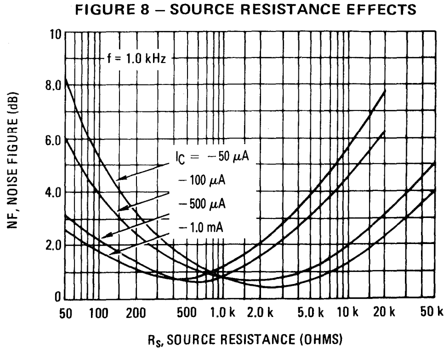


FIGURE 8 — SOURCE RESISTANCE EFFECTS



2

FIGURE 9 — CAPACITANCES

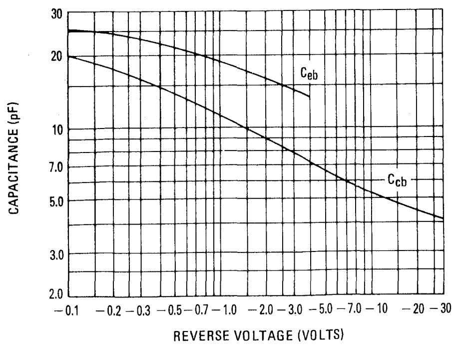


FIGURE 10 — CURRENT-GAIN — BANDWIDTH PRODUCT

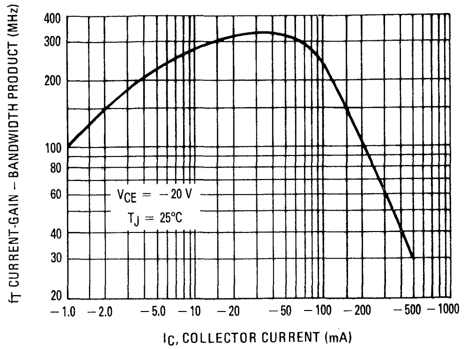


FIGURE 11 — "ON" VOLTAGE

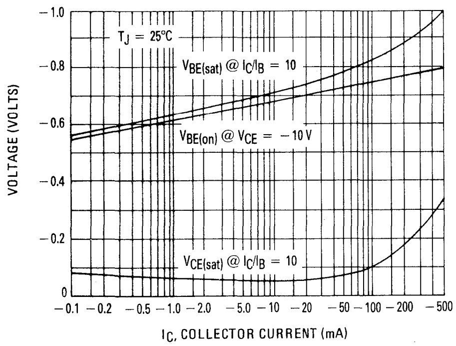
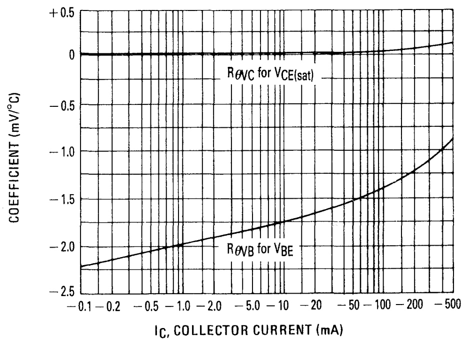
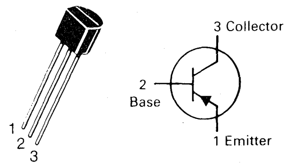


FIGURE 12 — TEMPERATURE COEFFICIENTS



MPS3638, A

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTORS

PNP SILICON

Refer to 2N4402 for graphs.

2

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}	−4.0	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	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	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1)$R_{\theta JA}$ 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 (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)	 MPS3638A	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

2

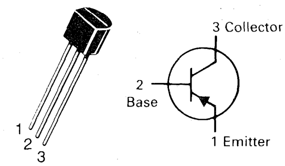
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = −3.0 Vdc, I_C = −50 mAdc, f = 100 MHz)	MPS3638 MPS3638A	f_T	100 150	— —	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	MPS3638 MPS3638A	C_{obo}	— —	20 10	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS3638 MPS3638A	C_{ibo}	— —	65 25	pF
Input Impedance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{ie}	—	2000	Ohms
Voltage Feedback Ratio (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	MPS3638 MPS3638A	h_{re}	— —	26 15	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	MPS3638 MPS3638A	h_{fe}	25 100	— —	—
Output Admittance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{oe}	—	1.2	mmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −10 Vdc, I_C = −300 mAdc, I_{B1} = −30 mAdc)	t_d	—	20	ns
Rise Time		t_r	—	70	ns
Storage Time	(V_{CC} = −10 Vdc, I_C = −300 mAdc, I_{B1} = −30 mAdc, I_{B2} = −30 mAdc)	t_s	—	140	ns
Fall Time		t_f	—	70	ns
Turn-On Time	(I_C = −300 mAdc, I_{B1} = −30 mAdc)	t_{on}	—	75	ns
Turn-Off Time	(I_C = −300 mAdc, I_{B1} = −30 mAdc, I_{B2} = 30 mAdc)	t_{off}	—	170	ns

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

MPS3640

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTOR

PNP SILICON

2

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°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derante 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

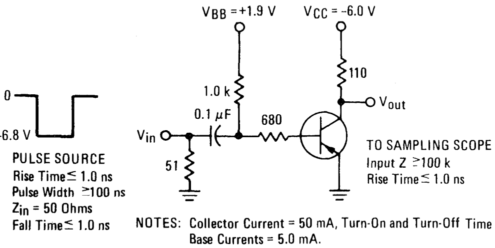
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{CEO(sus)}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0) (V_{CE} = −6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	— —	−0.01 −1.0	μAdc
Base Current — (V_{CE} = −6.0 Vdc, V_{EB} = 0)	I_B	—	−10	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = −10 mAdc, V_{CE} = −0.3 Vdc) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	30 20	120 —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc, T_A = 65°C)	$V_{CE(sat)}$	 — — —	 −0.2 −0.6 −0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	−0.75 −0.75 —	−0.95 −1.0 −1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{BE(off)}$ = −1.9 Vdc, I_{B1} = −5.0 mAdc)	t_d	—	10	ns
Rise Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{BE(off)}$ = −1.9 Vdc, I_{B1} = −5.0 mAdc)	t_r	—	30	ns
Storage Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc)	t_s	—	20	ns
Fall Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc)	t_f	—	12	ns
Turn-On Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = −5.0 mAdc) (V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = −0.5 mAdc)	t_{on}	 — —	 25 60	ns
Turn-Off Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc) (V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −0.5 mAdc)	t_{off}	— —	 35 75	ns

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

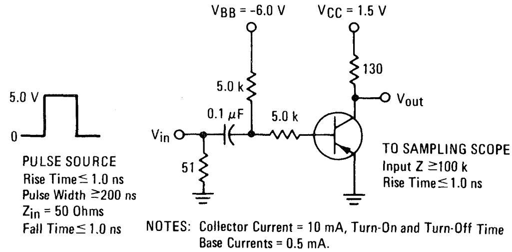
2

FIGURE 1



NOTES: Collector Current = 50 mA, Turn-On and Turn-Off Time Base Currents = 5.0 mA.

FIGURE 2



NOTES: Collector Current = 10 mA, Turn-On and Turn-Off Time Base Currents = 0.5 mA.

FIGURE 3 – DC CURRENT GAIN

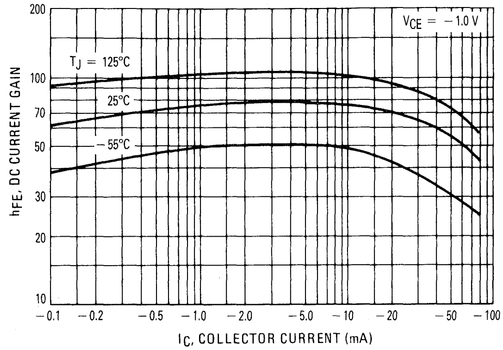


FIGURE 4 – "ON" VOLTAGES

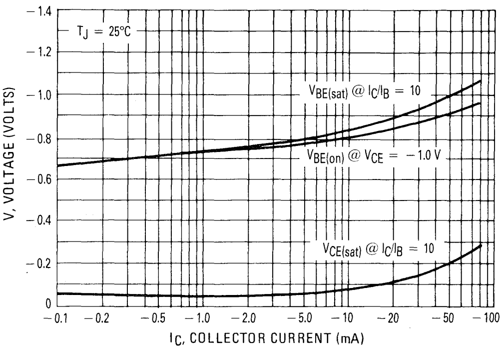


FIGURE 5 – COLLECTOR SATURATION REGION

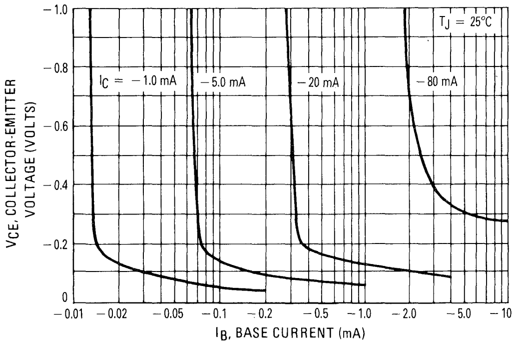


FIGURE 6 – TEMPERATURE COEFFICIENTS

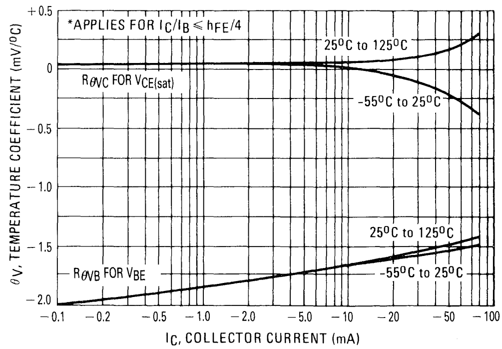


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

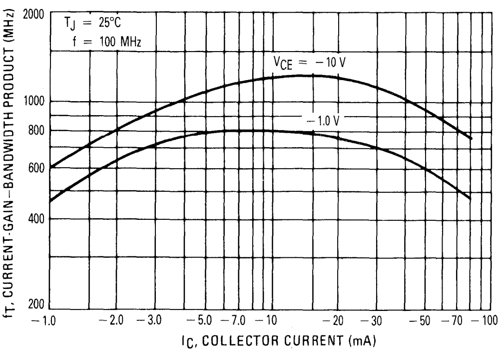
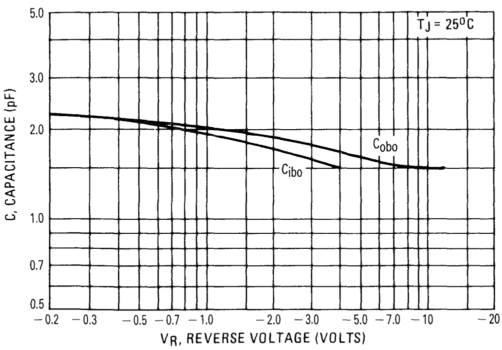


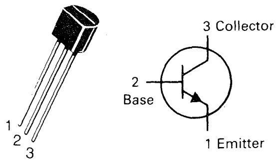
FIGURE 8 – CAPACITANCE



2

MPS3646★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N4264 for graphs.

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	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

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)	$V_{(BR)CES}$	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_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	9.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = 10 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%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

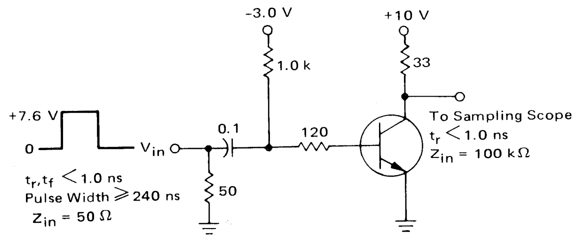
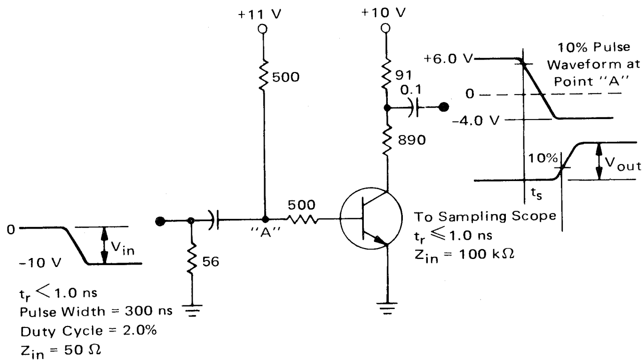
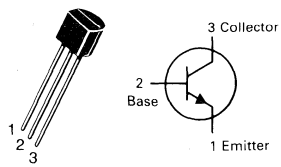


FIGURE 2 – CHARGE STORAGE TIME TEST CIRCUIT



MPS3866

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

2

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_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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

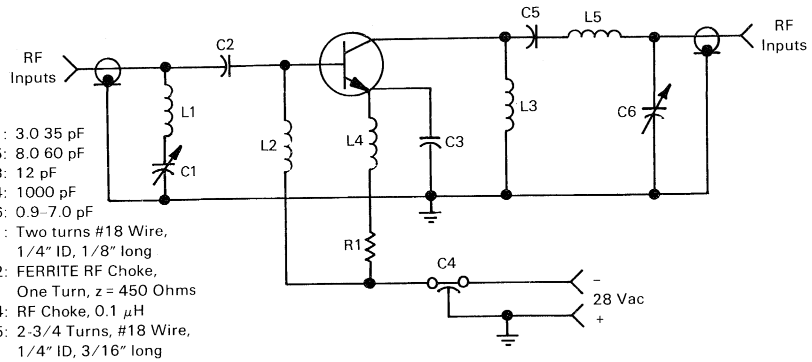
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ω)	$V_{CER(sus)}$	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 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CES}	—	0.02	mAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = −1.5 Vdc (Rev.), T_C = 150°C) (V_{CE} = 55 Vdc, V_{EB} = −1.5 Vdc (Rev.)	I_{CEX}	 — —	 5.0 0.1	mAdc
Emitter Cutoff Current (V_{EB} = 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)(1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 5.0 10	 — 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)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	pF
FUNCTIONAL TEST				
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	—	%

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

2

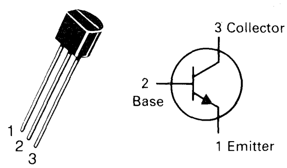
FIGURE 1 — 400 MHz TEST CIRCUIT SCHEMATIC



C1: 3.0 35 pF
C2, C5: 8.0 60 pF
C3: 12 pF
C4: 1000 pF
C6: 0.9–7.0 pF
L1: Two turns #18 Wire, 1/4″ ID, 1/8″ long
L2: FERRITE RF Choke, One Turn, z = 450 Ohms
L3, L4: RF Choke, 0.1 μH
L5: 2-3/4 Turns, #18 Wire, 1/4″ ID, 3/16″ long
R1: 5.6 Ohms

MPS3904

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

2

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	100	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	450	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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)	$V_{(BR)CEO}$	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_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{CEX}	—	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{BL}	—	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}	 40 70 100 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)	$V_{CE(sat)}$	 — —	 0.2 0.3	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 1.1	Vdc

2

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 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.0	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}	0.5	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	NF	—	5.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	50	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_s	—	900	ns
Fall Time		t_f	—	90	ns

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

EQUIVALENT SWITCHING TIME TEST CIRCUITS

FIGURE 1 – TURN-ON TIME

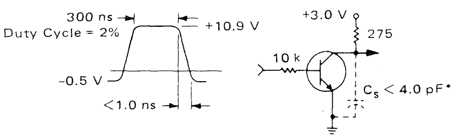
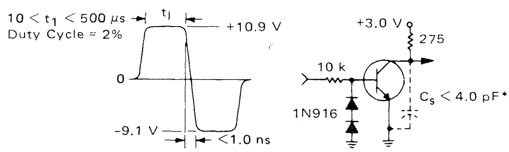


FIGURE 2 – TURN-OFF TIME



*Total shunt capacitance of test jig and connectors

TYPICAL NOISE CHARACTERISTICS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 3 – NOISE VOLTAGE

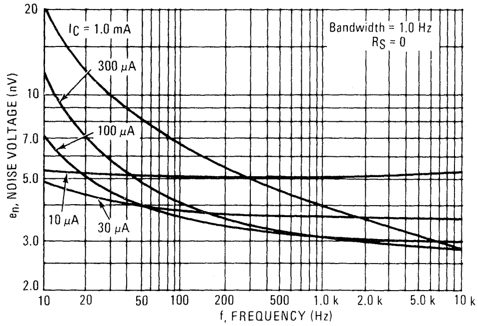
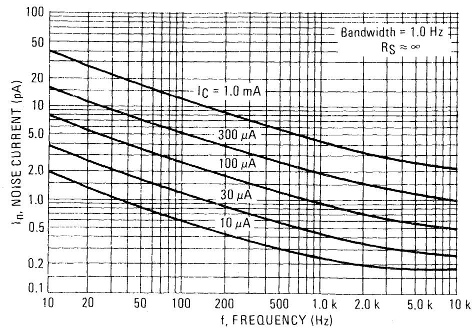


FIGURE 4 – NOISE CURRENT



NOISE FIGURE CONTOURS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 5 – NARROW BAND, 100 Hz

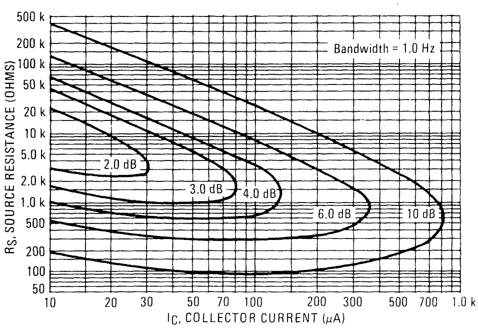


FIGURE 6 – NARROW BAND, 1.0 kHz

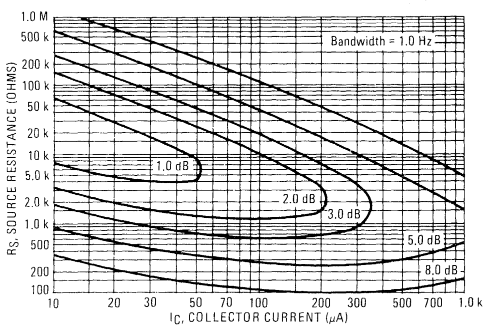
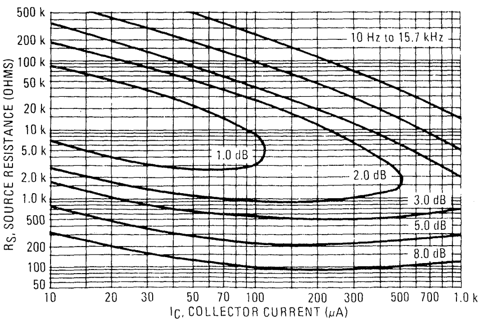


FIGURE 7 – WIDEBAND



Noise Figure is Defined as:

$$NF = 20\log_{10}\left(\frac{e_n^2 + 4KTR_S + I_n^2 R_S^2}{4KTR_S}\right)^{1/2}$$

e_n = Noise Voltage of the Transistor referred to the input. (Figure 3)
I_n = Noise Current of the transistor referred to the input (Figure 4)
K = Boltzman's Constant (1.38×10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

FIGURE 8 – DC CURRENT GAIN

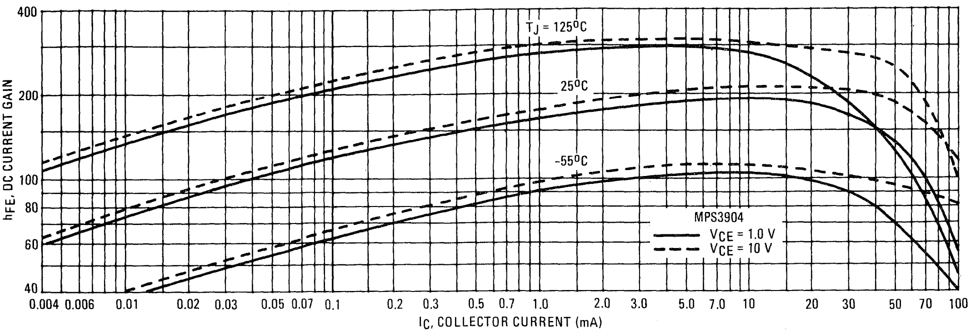


FIGURE 9 – COLLECTOR SATURATION REGION

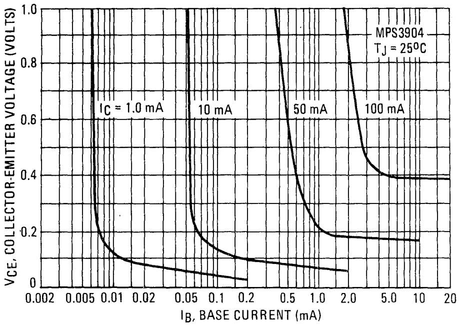


FIGURE 10 – COLLECTOR CHARACTERISTICS

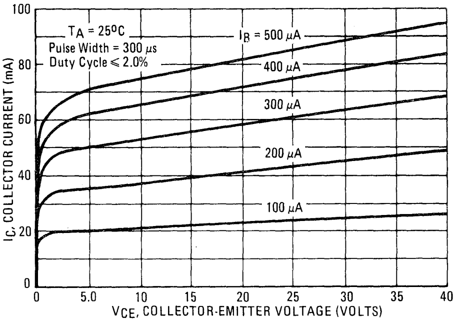


FIGURE 11 – "ON" VOLTAGES

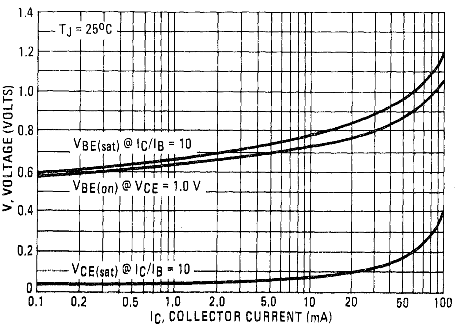
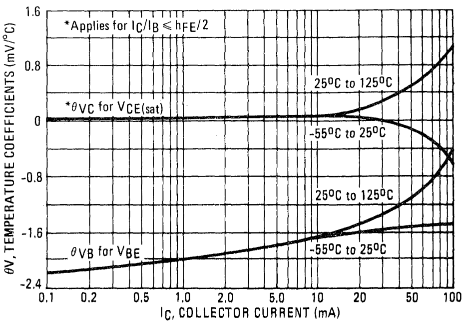


FIGURE 12 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 13 – TURN-ON TIME

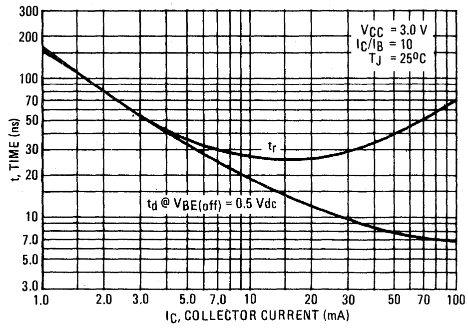


FIGURE 14 – TURN-OFF TIME

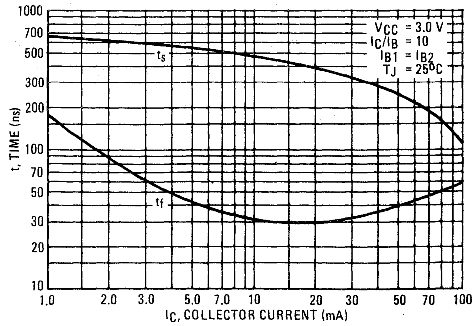


FIGURE 15 – CURRENT-GAIN – BANDWIDTH PRODUCT

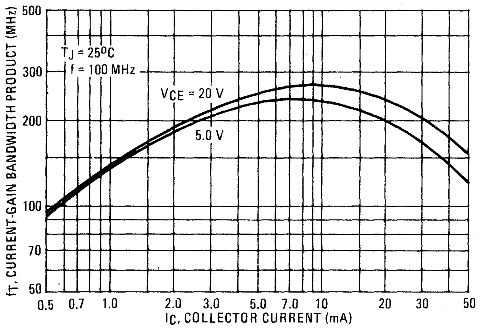


FIGURE 16 – CAPACITANCE

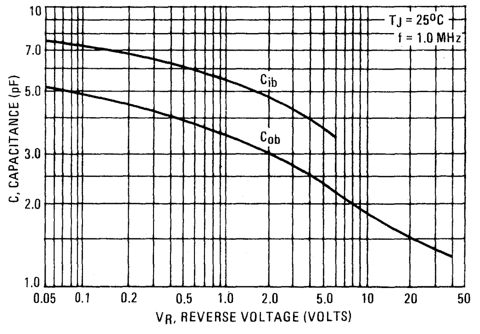


FIGURE 17 – INPUT IMPEDANCE

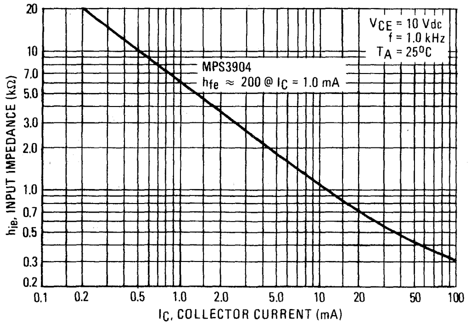
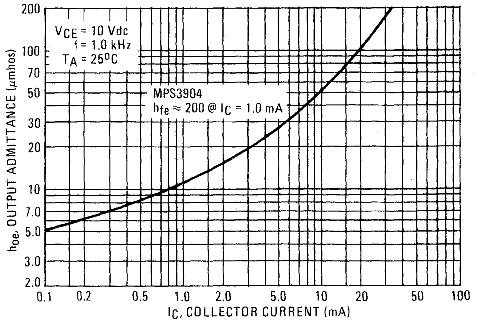


FIGURE 18 – OUTPUT ADMITTANCE



2

FIGURE 19 – THERMAL RESPONSE

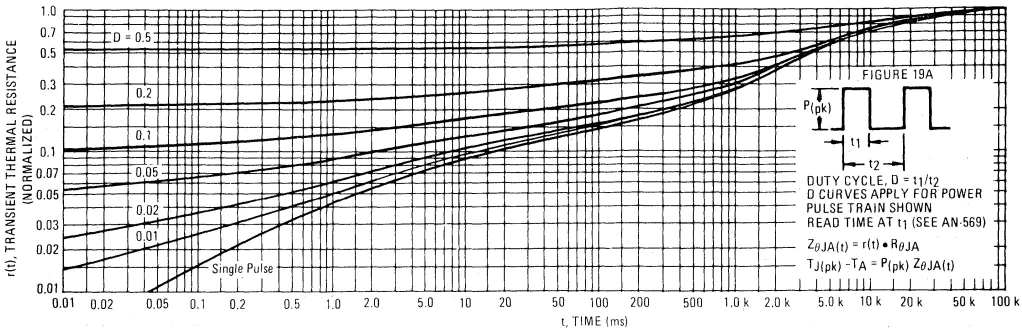
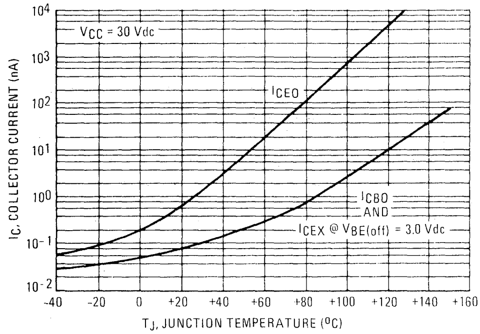


FIGURE 19A



DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19A. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 19 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 19 by the steady state value $R_{\theta JA}$.

Example:

The MPS3904 is dissipating 2.0 watts peak under the following conditions:

t_1 = 1.0 ms, t_2 = 5.0 ms. (D = 0.2)

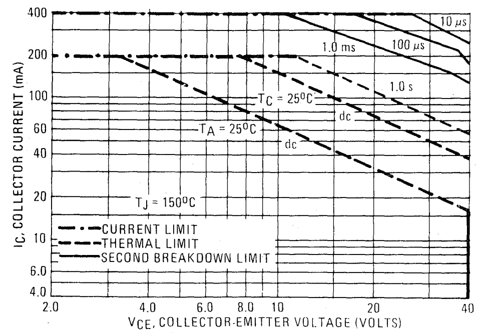
Using Figure 19 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

The peak rise in junction temperature is therefore

$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C$.

For more information, see AN-569.

FIGURE 20

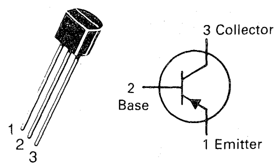


The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 20 is based upon $T_{J(pk)} = 150°C$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 19. At high case or ambient temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown.

MPS3906

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 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	Vdc
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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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)	$V_{(BR)CEO}$	−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_{CE} = −30 Vdc, $V_{EB(off)}$ = −3.0 Vdc)	I_{CEX}	—	−50	nAdc
Base Cutoff Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −3.0 Vdc)	I_{BL}	—	−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 V, f = 100 MHz)	f_T	250	—	MHz

2

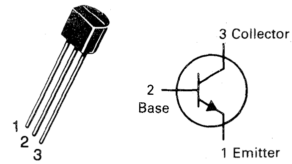
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	10	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}	1.0	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	—
Output Admittance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{oe}	3.0	60	μmhos
Noise Figure (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)		NF	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −3.0 Vdc, $V_{BE(off)}$ = +0.5 Vdc, I_C = −10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	50	ns
Storage Time	(V_{CC} = −3.0 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_s	—	600	ns
Fall Time		t_f	—	90	ns

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

MPS4123
MPS4124

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPS4123	MPS4124	Unit
Collector-Emitter Voltage	V_{CE}	30	25	Vdc
Collector-Base Voltage	V_{CB}	40	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

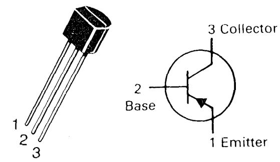
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mA, I_B = 0)	MPS4123 MPS4124	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)	MPS4123 MPS4124	$V_{(BR)CBO}$	40 30	— —	Vdc
Emitter-Base Breakdown Voltage (I_C = 0, I_E = 10 μA)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 V, I_E = 0)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 V, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mA, V_{CE} = 1.0 V) (I_C = 50 mA, V_{CE} = 1.0 V)	 MPS4123 MPS4124 MPS4123 MPS4124	h_{FE}	 50 120 25 60	 150 360 — —	—
Collector-Emitter Saturation Voltage (I_C = 50 mA, I_B = 5.0 mA)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mA, I_B = 5.0 mA)		$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 20 V, f = 100 MHz)	MPS4123 MPS4124	f_T	100 170	— —	MHz
Output Capacitance (V_{CB} = 5.0 V, I_E = 0, f = 1.0 MHz)		C_{ob}	—	4.0	pF
Input Capacitance (V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz)	MPS4123 MPS4124	C_{ib}	— —	14 13.5	pF
Small-Signal Current Gain (I_C = 2.0 mA, V_{CE} = 1.0 V, f = 1.0 kHz)	MPS4123 MPS4124	h_{fe}	50 120	200 480	—
Noise Figure (I_C = 100 μA, V_{CE} = 5.0 V, R_S = 1.0 kΩ, f = 1.0 kHz)	 MPS4123 MPS4124	NF	 — —	 6.0 5.0	dB

2

MPS4125
MPS4126

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS4125	MPS4126	Unit
Collector-Emitter Voltage	V_{CE}	−30	−25	Vdc
Collector-Base Voltage	V_{CB}	−10	−25	Vdc
Emitter-Base Voltage	V_{EB}	−4.0		Vdc
Collector Current — Continuous	I_C	−200		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

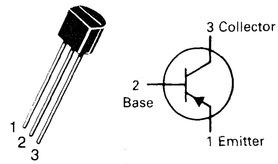
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −1.0 mA, I_B = 0)	MPS4125 MPS4126	$V_{(BR)CEO}$	−30 −25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μA, I_E = 0)	MPS4125 MPS4126	$V_{(BR)CBO}$	−30 −25	— —	Vdc
Emitter-Base Breakdown Voltage (I_C = 0, I_E = −10 μA)		$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −20 V, I_E = 0)		I_{CBO}	—	−50	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 V, I_C = 0)		I_{EBO}	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −2.0 mA, V_{CE} = −1.0 V) (I_C = −50 mA, V_{CE} = −1.0 V)	 MPS4125 MPS4126 MPS4125 MPS4126	h_{FE}	 50 120 25 60	 150 360 — —	—
Collector-Emitter Saturation Voltage (I_C = −50 mA, I_B = −5.0 mA)		$V_{CE(sat)}$	—	−0.4	Vdc
Base-Emitter Saturation Voltage (I_C = −50 mA, I_B = −5.0 mA)		$V_{BE(sat)}$	—	−0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product (I_C = −10 mA, V_{CE} = −20 V, f = 100 MHz)	MPS4125 MPS4126	f_T	150 170	— —	MHz
Output Capacitance (V_{CB} = −5.0 V, I_E = 0, f = 1.0 MHz)		C_{ob}	—	4.5	pF
Input Capacitance (V_{EB} = −0.5 V, I_C = 0, f = 1.0 MHz)	MPS4125 MPS4126	C_{ib}	— —	12 11.5	pF
Small-Signal Current Gain (I_C = −2.0 mA, V_{CE} = −1.0 V, f = 1.0 kHz)	MPS4125 MPS4126	h_{fe}	50 120	200 480	—
Noise Figure (I_C = −100 μA, V_{CE} = −5.0 V, R_S = 1.0 kΩ, f = 1.0 kHz)	 MPS4125 MPS4126	NF	 — —	 5.0 4.0	dB

2

MPS4250

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	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	I_C	—	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	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
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

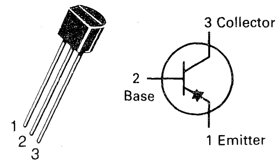
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −5.0 mA)	$V_{(BR)CES}$	−40	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = −5.0)	$V_{(BR)CEO(sus)}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μA)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μA)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −50 V) (V_{CB} = −40 V, T_A = 65°C)	I_{CBO}	 — —	 −10 −3.0	 nA μA
Emitter Cutoff Current (V_{EB} = −3.0 V)	I_{EBO}	—	−20	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mA, V_{CE} = −5.0 V) (I_C = −10 mA, V_{CE} = −5.0 V)	h_{FE}	 250 250	 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −10 mA, I_B = −0.5 mA)	$V_{CE(sat)}$	—	−0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −10 mA, I_B = −0.5 mA)	$V_{BE(sat)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = −5.0 V, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = −0.5 V, f = 1.0 MHz)	C_{ibo}	—	16	pF
Small-Signal Current Gain (I_C = −1.0 mA, V_{CE} = −5.0 V, f = 1.0 kHz) (I_C = −0.5 mA, V_{CE} = −5.0 V, f = 20 MHz)	h_{fe}	 250 2.0	 800 —	—
Noise Figure (I_C = −20 μA, V_{CE} = −5.0 V, R_S = 10 kΩ, f = 1.0 kHz, P_{BW} = 150 Hz) (I_C = −250 μA, V_{CE} = −5.0 V, R_S = 1.0 kΩ, f = 1.0 kHz, P_{BW} = 150 Hz)	NF	 — —	 2.0 2.0	dB

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

MPS4258

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTOR

PNP SILICON

Refer to MPS3640 for graphs.

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}	−4.5	Vdc
Collector Current — Continuous	I_C	−80	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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

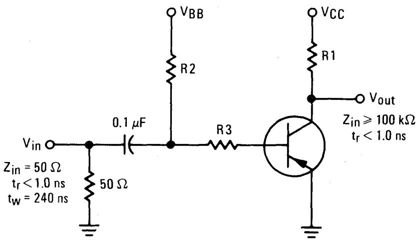
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = −3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	Vdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0) (V_{CE} = −6.0 Vdc, V_{BE} = 0, T_A = +65°C)	I_{CES}	 — —	 −0.01 −5.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −0.5 Vdc) (I_C = −10 mAdc, V_{CE} = −3.0 Vdc) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 15 30 30	 — 120 —	—
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 −0.5	Vdc
Base-Emitter On Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	 −0.75 —	 −0.95 −1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current Gain — Bandwidth Product(2) (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	700	—	MHz
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
Collector-Base Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	3.0	pF

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

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −1.5 Vdc, $V_{EB(off)}$ = 0, I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	15	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	(V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	20	ns
Storage Time		t_s	—	10	ns
Fall Time		t_f	—	20	ns
Storage Time (I_C ≈ −10 mAdc, I_{B1} ≈ −10 mAdc, I_{B2} ≈ 10 mAdc)		t_s	—	20	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.

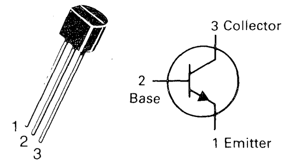
FIGURE 1 — SWITCHING TIME TEST CIRCUIT



	V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R1 Ohms	R2 Ohms	R3 Ohms	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	GND	-1.5	130	2.2 k	5 k	10	1.0	–
t_{off}	+9.8	-8.0	-1.5	130	2.2 k	5 k	10	1.0	1.0
t_s	+9.0	-10	-3.0	270	510	390	10	10	10

MPS5179★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

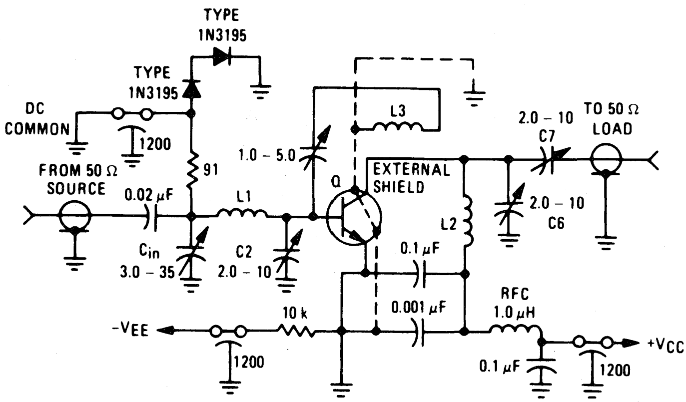
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°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°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 (See Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	—	5.0	dB
Common-Emitter Amplifier Power Gain (See Figure 1) (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}	15	—	dB

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

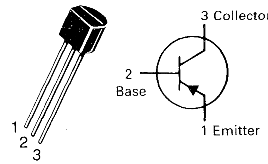
FIGURE 1 – 200 MHz AMPLIFIER POWER GAIN
AND NOISE FIGURE CIRCUIT



L1 1-3/4 Turns, #18 AWG, 0.5" L, 0.5" Diameter
L2 2 Turns, #16 AWG, 0.5" L, 0.5" Diameter
L3 2 Turns, #13 AWG, 0.25" L, 0.5" Diameter (Position 1/4" from L2)

MPS5771

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



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	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	Watts 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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −3.0 mA)(1)	$V_{(BR)CEO}$	−15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μA)	$V_{(BR)CES}$	−15	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μA)	$V_{(BR)CBO}$	−15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μA)	$V_{(BR)EBO}$	−4.5	—	Vdc
Collector Cutoff Current (V_{CB} = −8.0 Vdc)	I_{CBO}	—	−10	nA
Collector Cutoff Current (V_{CE} = −8.0 Vdc) (V_{CE} = −8.0 Vdc, T_A = 125°C)	I_{CES}	— —	−10 −5.0	nA μA
Emitter Cutoff Current (V_{EB} = −4.5 Vdc)	I_{EBO}	—	−1.0	μA
ON CHARACTERISTICS				
DC Current (I_C = −1.0 mA, V_{CE} = −0.5 Vdc)(1) (I_C = −10 mA, V_{CE} = −1.0 Vdc)(1) (I_C = −50 mA, V_{CE} = −1.0 Vdc)(1) (I_C = −10 mA, V_{CE} = −1.0 Vdc, T_A = −55°C)	h_{FE}	30 35 25 15	— 120 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −1.0 mA, I_B = −0.1 mA) (I_C = −10 mA, I_B = −1.0 mA) (I_C = −50 mA, I_B = −5.0 mA)	$V_{CE(sat)}$	 — — —	 −0.15 −0.18 −0.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −1.0 mA, I_B = −0.1 mA) (I_C = −10 mA, I_B = −1.0 mA) (I_C = −50 mA, I_B = −5.0 mA)	$V_{BE(sat)}$	— −0.75 —	−0.8 −0.95 −1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance (V_{CB} = −5.0 Vdc, f = 140 kHz, f = 1.0 MHz)	C_{cb}	—	3.0	pF
Emitter-Base Capacitance (V_{EB} = −0.5 Vdc, f = 140 kHz, f = 1.0 MHz)	C_{eb}	—	3.5	pF
Small-Signal Current Gain (I_C = −10 mA, V_{CE} = −10 Vdc, f = 100 MHz)	h_{fe}	8.5	—	—

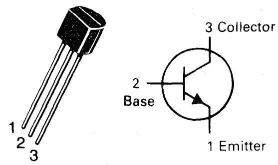
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Time	(V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_B = −1.0 mA)	t_{on}	—	15	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	(V_{CC} = −1.5 V, I_C = −10 mA, I_{B1} = I_{B2} = −1.0 mA)	t_{off}	—	20	ns
Fall Time		t_f	—	10	ns
Storage Time	(V_{CC} = −1.5 V, I_C = −10 mA, I_{B1} ≈ I_{B2} ≈ −10 mA)	t_s	—	20	ns

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

MPS6428

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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)	$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc)	I_{CES}	—	0.025	μA
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	0.01	μA
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.01	μA
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = 5.0 Vdc, 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 = 10 mAdc)	h_{FE}	 250 250 250 250	 — 650 — —	—
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 V, 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

2

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

Characteristic	Symbol	Min	Max	Unit
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	3.0	30	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	2.0	20	$X 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	200	800	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	50	μmhos

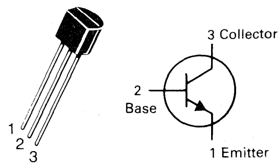
NOISE FIGURE/TOTAL NOISE VOLTAGE CHARACTERISTICS

	NF Max (1)	V_T Max (1)	NF Max (2)	V_T Max (2)	NF Max (3)	V_T Max (3)	Unit	
Noise Figure/Voltage (V_{CE} = 5.0 V, I_C = 0.1 mA, T_A = 25°C)	7.0	18.1	6.0	5700	3.5	4.3	dB	nV

(1) R_S = 10 kΩ, BW = 1.0 Hz, f = 100 Hz
(2) R_S = 50 kΩ, BW = 15.7 kHz, f = 10 Hz–10 kHz
(3) R_S = 500 Ω, BW = 1.0 Hz, f = 10 Hz

MPS6507

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

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}	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 Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ 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) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	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 ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 60°C$)	I_{CBO}	 — —	 — —	 50 1.0	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	75	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	700	800	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	1.25	2.5	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	h_{fe}	20	—	—	—

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

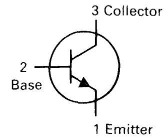
MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage MPS6520, MPS6521 MPS6523	V_{CEO}	 25 —	 — 25	Vdc
Collector-Base Voltage MPS6520, MPS6521 MPS6523	V_{CBO}	 40 —	 — 25	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	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

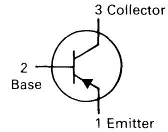
THERMAL CHARACTERISTICS

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

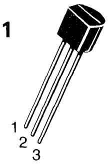
NPN MPS6520 MPS6521★



PNP(1) MPS6523



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

★This is a Motorola designated preferred device.

Refer to MPS3904 for NPN graphs.
Refer to 2N5086 for PNP graphs.

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

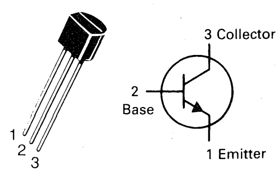
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)		$V_{(BR)CEO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0)	 MPS6520,MPS6521 MPS67523	I_{CBO}	 — —	 0.05 0.05	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	 MPS6520 MPS6521 MPS6520 MPS6521 MPS6523 MPS6523	h_{FE}	 100 150 200 300 150 300	 — — 400 600 — 600	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	—	3.0	dB

*Refer to 2N5086 for PNP graphs.
(1) Voltage and Current are negative for PNP Transistors.

MPS6530
MPS6531

CASE 29-04, STYLE 1
TO-92 (TO-226AA)

2



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to 2N4400 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}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625	mW
Junction Temperature	T_J, T_{stg}	150	°C

THERMAL CHARACTERISTICS

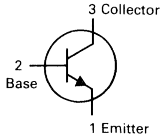
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	°C/mW

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

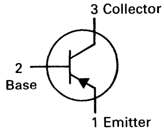
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_B = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
($V_{CB} = 40$ Vdc, $I_E = 0$)			—	0.05	
($V_{CB} = 40$ Vdc, $I_E = 0$, $T_A = 60°C$)			—	2.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS6530		30	—	
	MPS6531		60	—	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS6530		40	120	
	MPS6531		90	270	
($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	MPS6530		25	—	
	MPS6531		50	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
($I_C = 100$ mAdc, $I_B = 10$ mAdc)	MPS6530		—	0.5	
	MPS6531		—	0.3	
Base-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	5.0	pF

2

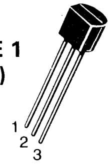
NPN MPS6560



PNP(2) MPS6562



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AUDIO TRANSISTORS

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	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 Ambient	$R_{\theta JA}$(1)	200	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/mW

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

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

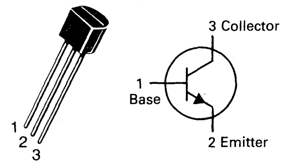
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)	I_{CES}	—	100	nAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
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 = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 35 50 50	 — — 200	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 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}	—	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

MPS6568A

CASE 29-04, STYLE 2
TO-92 (TO-226AA)

2



VHF TRANSISTOR

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

(1) $R_{\theta JA}$ 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 (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	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_C = 0)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	200	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	—	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	375	800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded)	C_{cb}	—	0.65	pF
Noise Figure (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	—	3.3	dB
FUNCTIONAL TEST				
Amplifier Power Gain (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz)	G_{pe}	20	27	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 200 MHz)	V_{AGC}	4.0	5.0	Vdc

2

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 OHMS, SEE FIGURES 9 AND 10

—— f = 45 MHz — — f = 200 MHz

FIGURE 1 — POWER GAIN

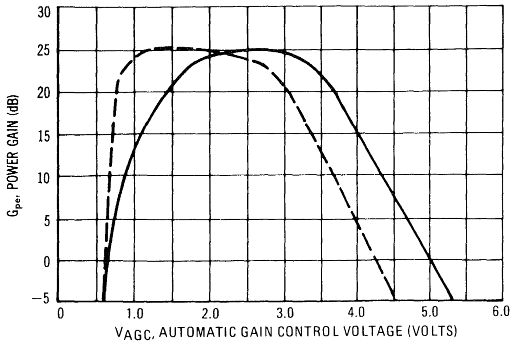


FIGURE 2 — NOISE FIGURE

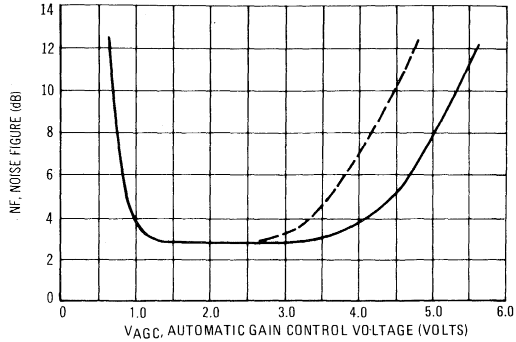
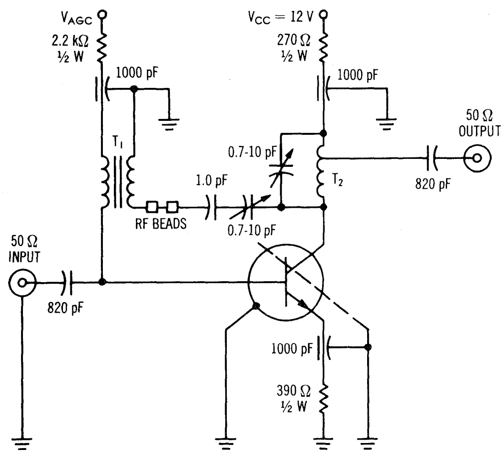
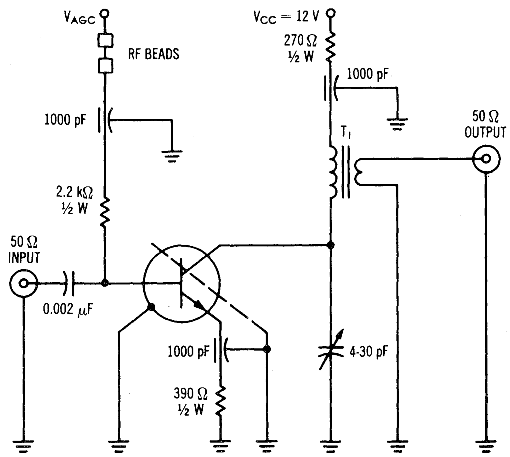


FIGURE 3 — 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



T_1 = FERRITE CORE INDIANA GEN. CORP. F-684
T_2 = 6 TURNS #16 BUSS WIRE, ID = ¼″, L = ¾″.

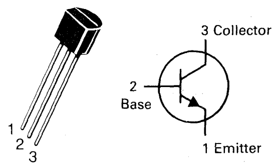
FIGURE 4 — 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



T_1 = TOROID 4:1 RATIO 8T-PRI 2T-SEC } #22 WIRE

MPS6571

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

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}	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	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

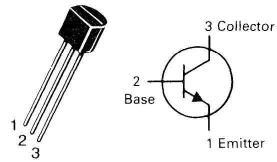
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

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 = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	h_{FE}	250	—	1000	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	—	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	175	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	4.5	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 100 Hz)	NF	—	1.2	—	dB

2

MPS6595★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	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	350 2.81	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8	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 Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ 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) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	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}	—	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 2.5$ Vdc, $I_C = 0$)	I_{EBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 25 20	 — —	 250 230	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	f_T	1200	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{cb}	—	—	1.3	pF

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

MAXIMUM RATINGS

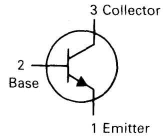
Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6601/6651 MPS6602/6652	V_{CEO}	 25 40	Vdc
Collector-Base Voltage MPS6601/6651 MPS6602/6652	V_{CBO}	 25 30	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	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

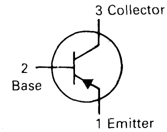
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

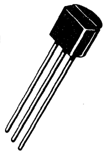
NPN
MPS6601
MPS6602★



PNP(1)
MPS6651
MPS6652★



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

★These are Motorola designated preferred devices.

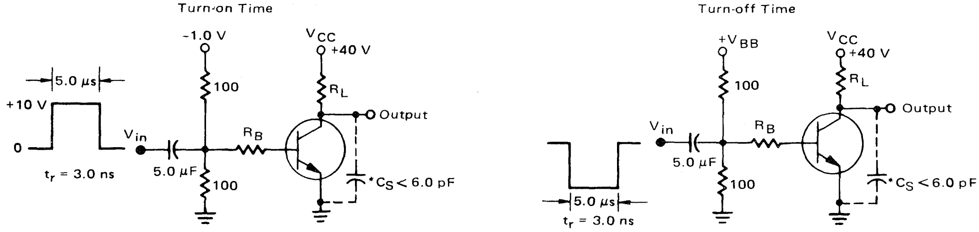
2

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)	 MPS6601/6651 MPS6602/6652	$V_{(BR)CEO}$	 25 40	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPS6601/6651 MPS6602/6652	$V_{(BR)CBO}$	 25 40	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0) (V_{CE} = 30 Vdc, I_B = 0)	 MPS6601/6651 MPS6602/6652	I_{CES}	 — —	 0.1 0.1	μAdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0)	 MPS6601/6651 MPS6602/6652	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 50 50 30	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 1000 mAdc, I_B = 100 mAdc)		$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50mAdc, 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}	—	30	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 40 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, t_p ≥ 300 ns Duty Cycle)	t_d	—	25	ns
Rise Time		t_r	—	30	ns
Storage Time		t_s	—	250	ns
Fall Time		t_f	—	50	ns

(1) Voltage and Current are negative for PNP Transistors.

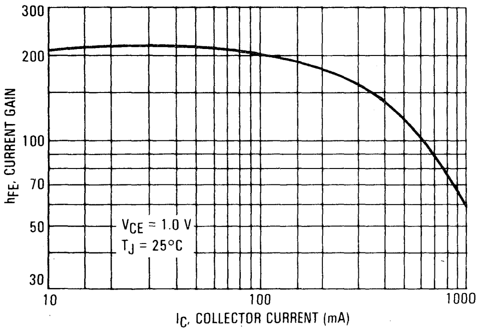
FIGURE 1 — SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

NPN

FIGURE 2 — MPS6601/6602 DC CURRENT GAIN



PNP

FIGURE 3 — MPS6651/6652 DC CURRENT GAIN

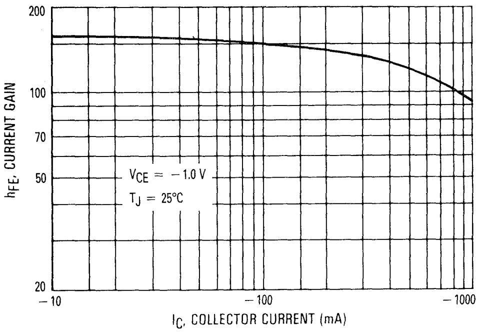


FIGURE 4 — CURRENT GAIN BANDWIDTH PRODUCT

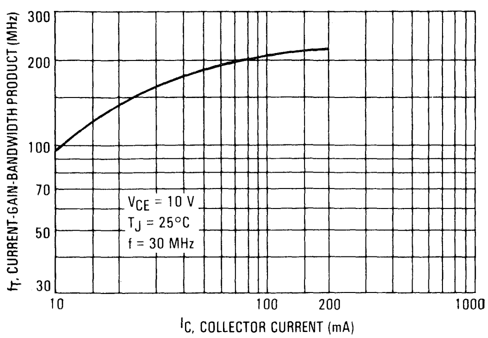
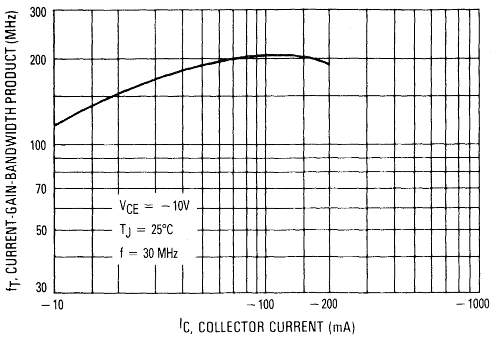


FIGURE 5 — CURRENT GAIN BANDWIDTH PRODUCT



2

FIGURE 6 — ON VOLTAGES

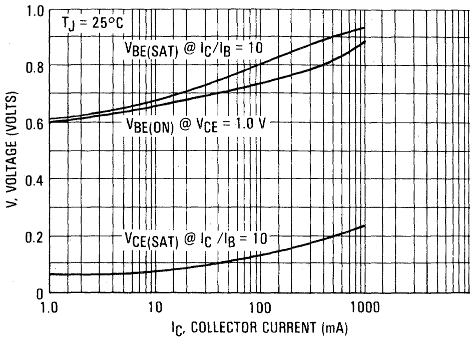
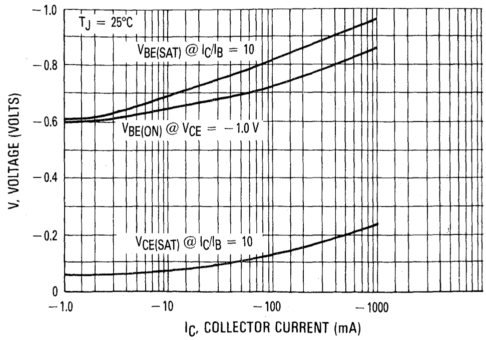
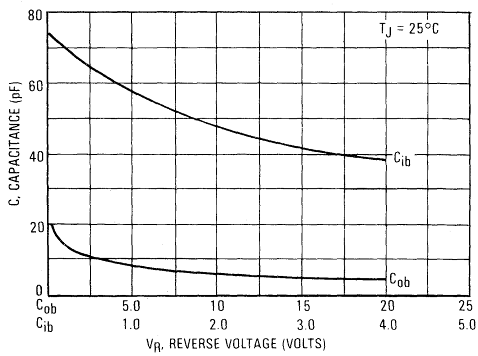


FIGURE 7 — ON VOLTAGES



NPN

FIGURE 8 — CAPACITANCE



PNP

FIGURE 9 — CAPACITANCE

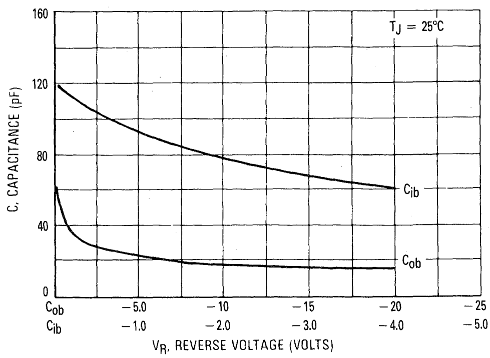


FIGURE 10 — MPS6601/6602 NOISE FIGURE

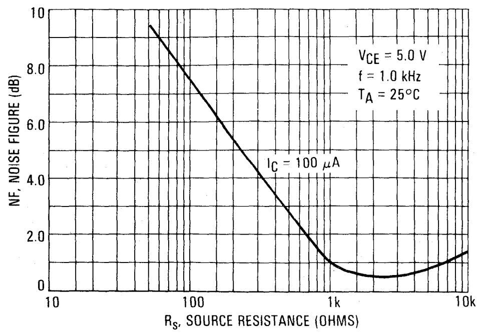
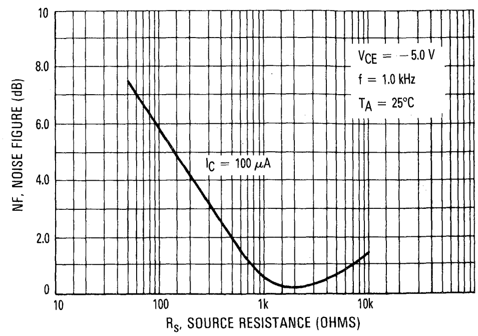


FIGURE 11 — MPS6651/6652 NOISE FIGURE



2

FIGURE 12 — MPS6601/6602 SWITCHING TIMES

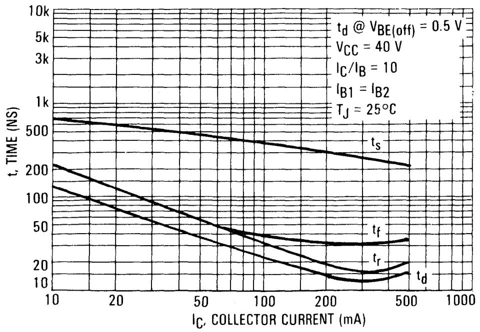
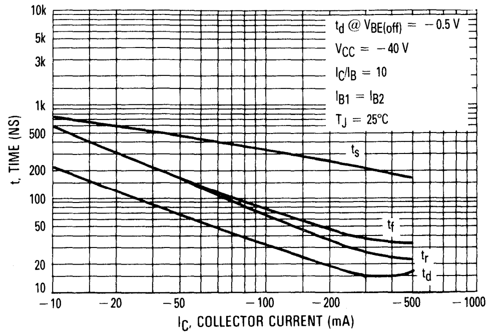
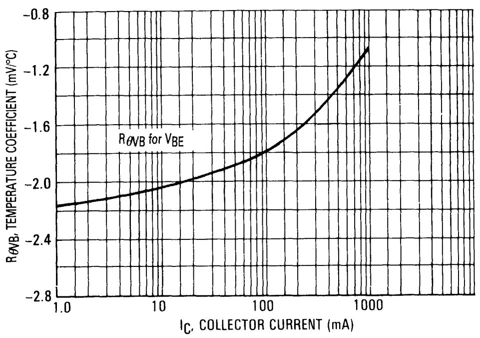


FIGURE 13 — MPS6651/6652 SWITCHING TIMES



NPN

FIGURE 14 — BASE-EMITTER TEMPERATURE COEFFICIENT



PNP

FIGURE 15 — BASE-EMITTER TEMPERATURE COEFFICIENT

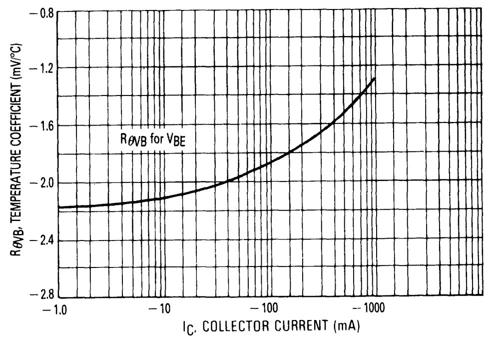


FIGURE 16 — SAFE OPERATING AREA

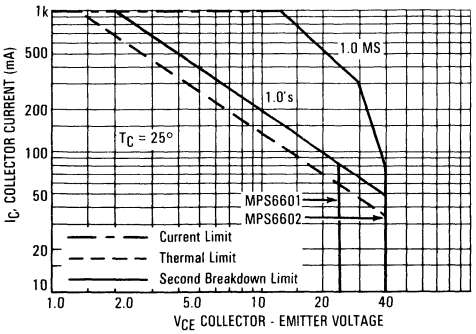


FIGURE 17 — SAFE OPERATING AREA

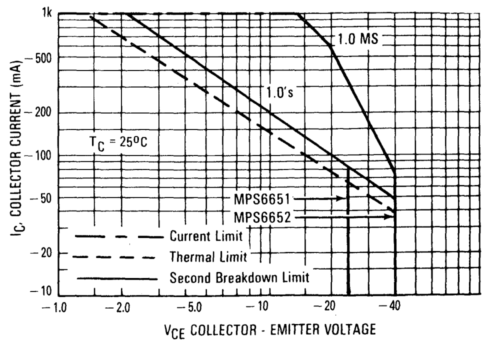


FIGURE 18 — MPS6601/6602 SATURATION REGION

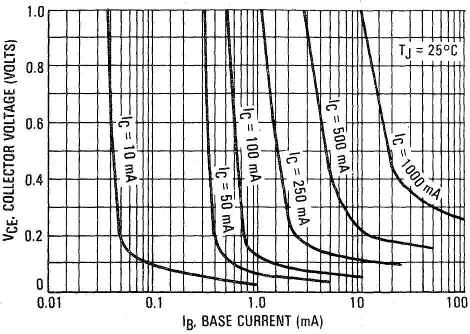


FIGURE 19 — MPS6651/6652 SATURATION REGION

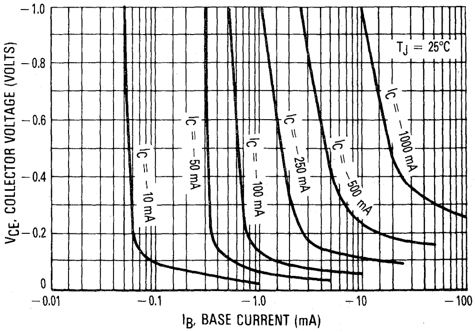
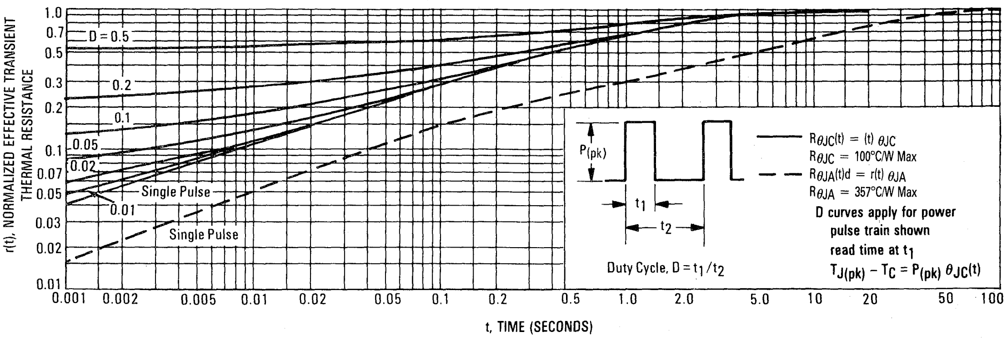


FIGURE 20 — THERMAL RESPONSE



2

MAXIMUM RATINGS

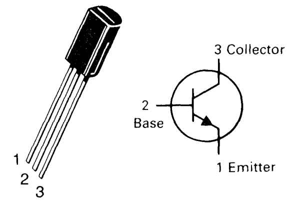
Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6714 MPS6715	V_{CEO}	30 40	Vdc
Collector-Base Voltage MPS6714 MPS6715	V_{CBO}	40 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

MPS6714
MPS6715

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MPSW01 for graphs.

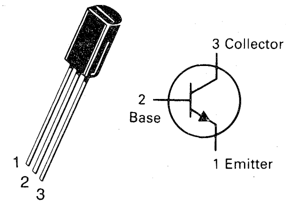
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MPS6714 MPS6715	$V_{(BR)CEO}$	30 40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPS6714 MPS6715	$V_{(BR)CBO}$	40 50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$)	MPS6714 MPS6715	I_{CBO}	— —	0.1 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 ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	60 50	— 250	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	30	pF
Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		h_{fe}	2.5	25	—

(1) Pulse Test: Pulse Width ≤ 30 μs, Duty Cycle ≤ 2.0%.

MPS6717

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSW05 for graphs.

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	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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

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

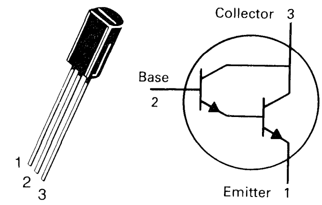
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 80 50	 — 250	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	30	pF
Small-Signal Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	h_{fe}	2.5	25	—

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

2

MPS6724
MPS6725

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT
DARLINGTON TRANSISTORS

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS6724	MPS6725	Unit
Collector-Emitter Voltage	V_{CES}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
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

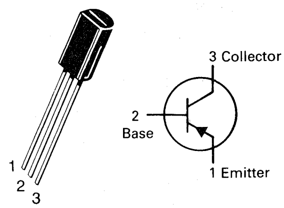
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

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, $I_B = 0$)	 MPS6724 MPS6725	$V_{(BR)CES}$	 40 50	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	 MPS6724 MPS6725	$V_{(BR)CBO}$	 50 60	 — —	 Vdc Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$)	 MPS6724 MPS6725	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 5.0$ Vdc)		h_{FE}	 25,000 4,000	 — 40,000	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	100	1000	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	10	pF

MPS6726
MPS6727

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

PNP SILICON

Refer to MPSW51 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6726 MPS6727	V_{CEO}	 −30 −40	Vdc
Collector-Base Voltage MPS6726 MPS6727	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 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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

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

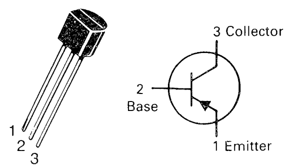
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −10 mAdc, I_B = 0)	 MPS6726 MPS6727	$V_{(BR)CEO}$	 −30 −40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	 MPS6726 MPS6727	$V_{(BR)CBO}$	 −40 −50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −40 Vdc, I_E = 0) (V_{CB} = −50 Vdc, I_E = 0)	 MPS6726 MPS6727	I_{CBO}	—	 −0.1 −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 = −100 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1000 mAdc, V_{CE} = −1.0 Vdc)		h_{FE}	 60 50	 — 250	—
Collector-Emitter Saturation Voltage (I_C = −1000 mAdc, I_B = −100 mAdc)		$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter On Voltage (I_C = −1000 mAdc, V_{CE} = −1.0 Vdc)		$V_{BE(on)}$	—	−1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	30	pF
Small-Signal Current Gain (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 20 MHz)		h_{fe}	2.5	25	—

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

2

MPS8093

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE 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	−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 = 60°C	P_D	450	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

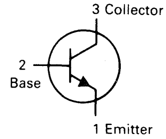
THERMAL CHARACTERISTICS

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

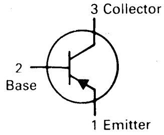
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −10 mAdc)	$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −20 V)	I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 V)	I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −50 mAdc, V_{CE} = −2.0 Vdc)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{CE(sat)}$	—	−0.25	Vdc
Base-Emitter On Voltage (I_C = −50 mAdc, V_{CE} = −2.0 V)	$V_{BE(on)}$	−0.6	−1.0	Vdc

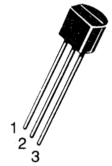
NPN
MPS8098
MPS8099★



PNP(2)
MPS8598
MPS8599★



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	MPS8098 MPS8598	MPS8099 MPS8599	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
		MPS8099	MPS8598 MPS8599	
Emitter-Base Voltage	V_{EBO}	6.0	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		Watts mW/°C
Operating 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

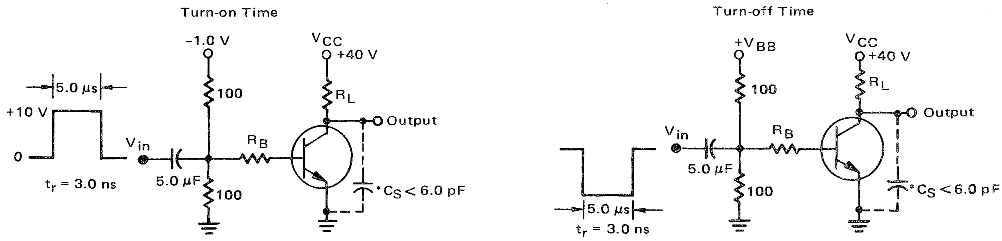
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 MPS8098, MPS8099 MPS8598, MPS8599	$V_{(BR)EBO}$	 6.0 5.0	 — —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CES}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MPS8098, MPS8598 MPS8099, MPS8599	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)	 MPS8098, MPS8099 MPS8598, MPS8599	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 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}	100 100 75	300 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	— —	0.4 0.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	 MPS8098, MPS8098 MPS8099, MPS8599	$V_{BE(on)}$	 0.5 0.6	 0.7 0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	150	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	 MPS8098, MPS8099 MPS8598, MPS8599	C_{obo}	 — —	 6.0 8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	 MPS8098, MPS8099 MPS8598, MPS8599	C_{ibo}	 — —	 25 30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

2

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

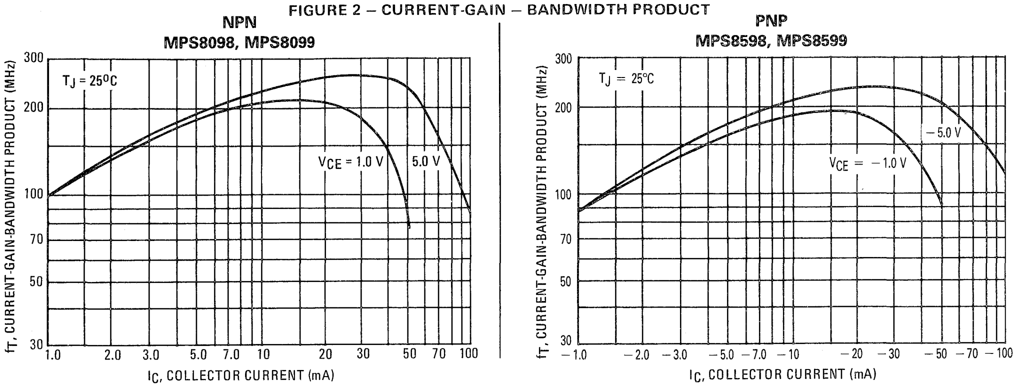


FIGURE 3 – CAPACITANCE

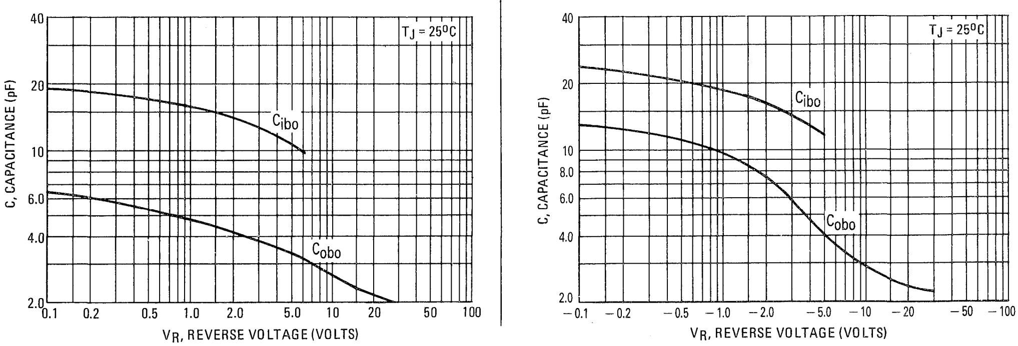


FIGURE 4 – SWITCHING TIMES

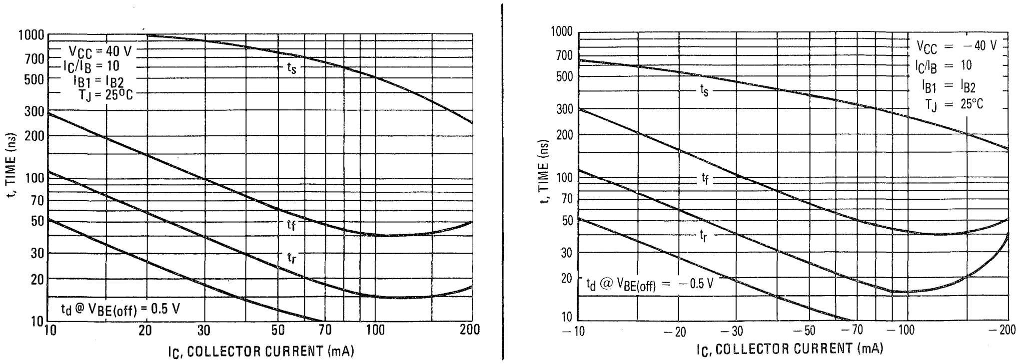
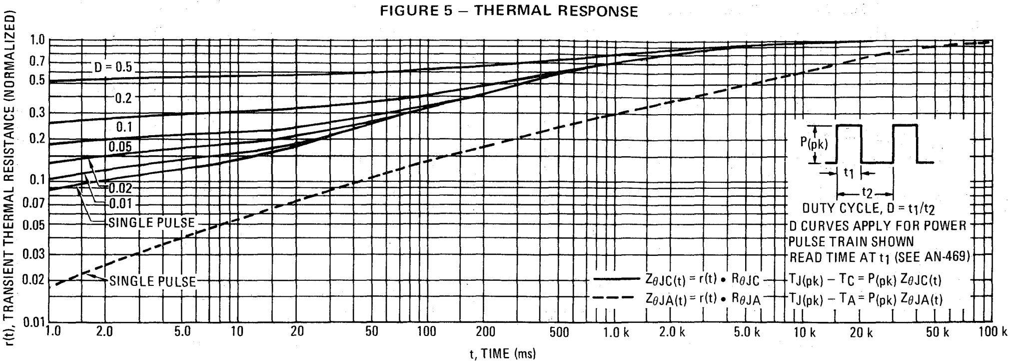


FIGURE 5 – THERMAL RESPONSE



2

FIGURE 6 — ACTIVE REGION, SAFE OPERATING AREA
MPS8098, MPS8099

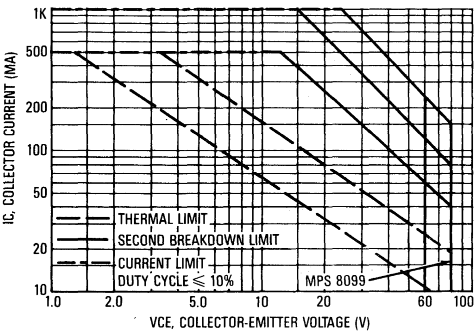
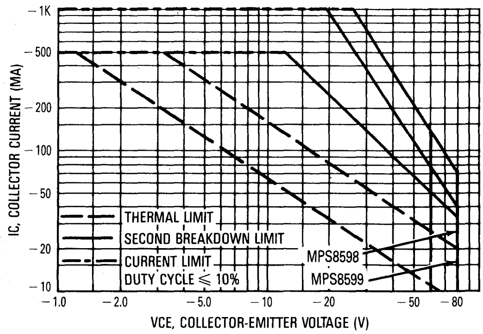
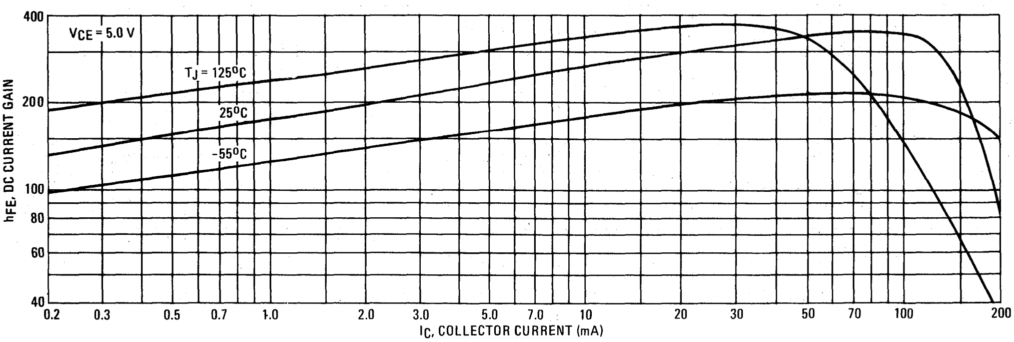


FIGURE 6 — ACTIVE REGION, SAFE OPERATING AREA
MPS8598, MPS8599



MPS8098, MPS8099

FIGURE 7 – DC CURRENT GAIN



2

FIGURE 8 – "ON" VOLTAGES

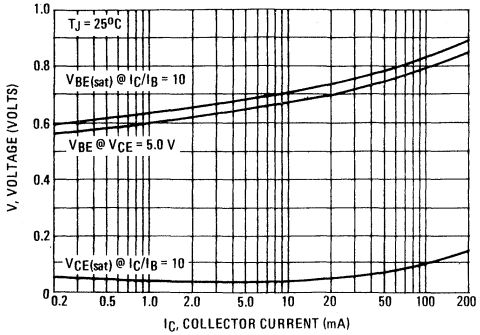


FIGURE 9 – COLLECTOR SATURATION REGION

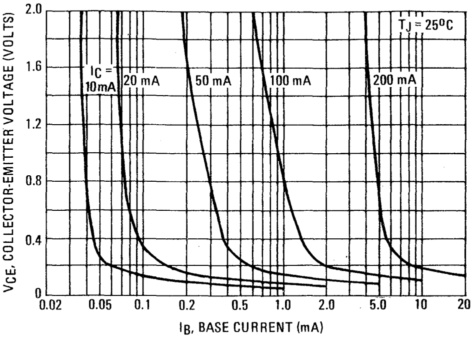
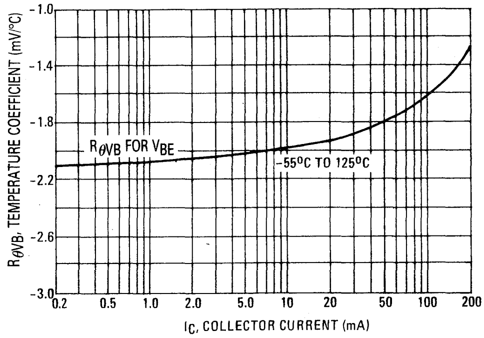
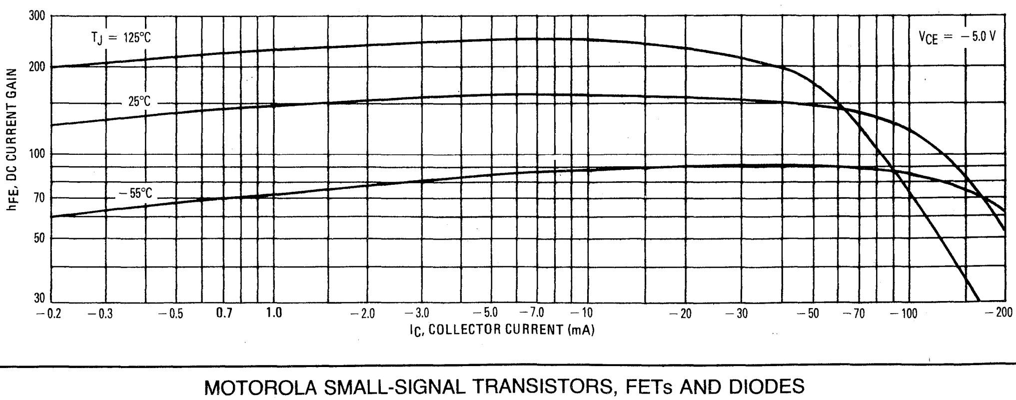


FIGURE 10 – BASE-EMITTER TEMPERATURE COEFFICIENT



MPS8598, MPS8599

FIGURE 11 – DC CURRENT GAIN



2

FIGURE 12 — "ON" VOLTAGES

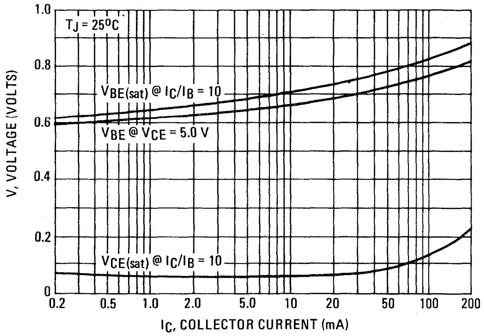


FIGURE 13 — COLLECTOR SATURATION REGION

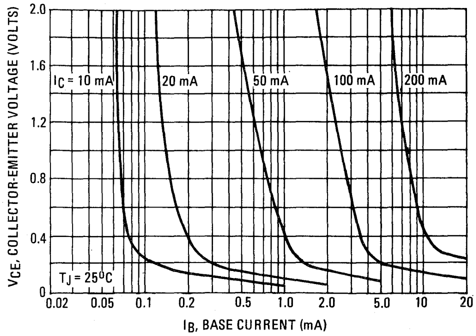
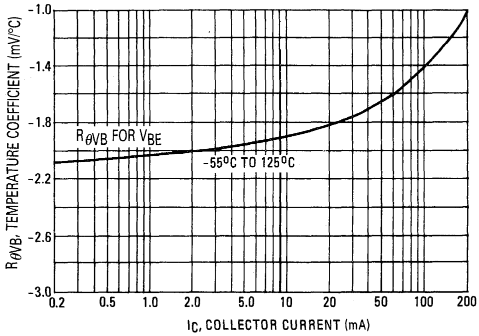
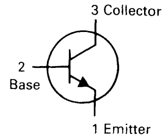


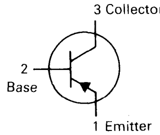
FIGURE 14 — BASE-EMITTER TEMPERATURE COEFFICIENT



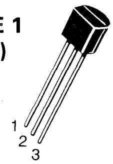
NPN MPSA05 MPSA06★



PNP[3] MPSA55 MPSA56★



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	MPSA05 MPSA55	MPSA06 MPSA56	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
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	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

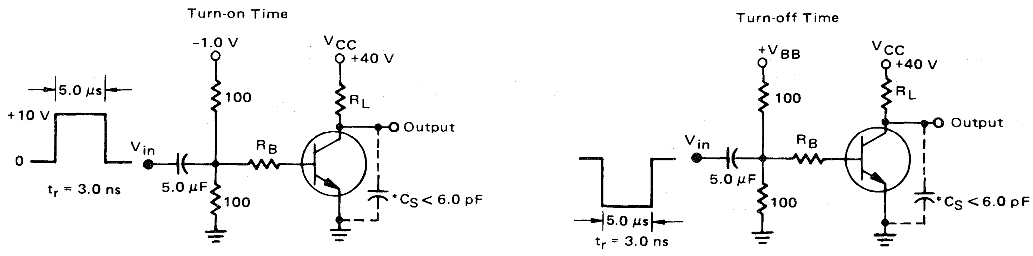
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MPSA05, MPSA55 MPSA06, MPSA56	$V_{(BR)CEO}$	 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_{CES}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MPSA05, MPSA55 MPSA06, MPSA56	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}	 100 100	 — —	—
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 = 10 mA, V_{CE} = 2.0 V, f = 100 MHz) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc, f = 100 MHz)	 MPSA05 MPSA06 MPSA55 MPSA56	f_T	 100 50	 — —	MHz

(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.
(3) Voltage and Current are negative for PNP Transistors.

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

2

FIGURE 2 — CURRENT-GAIN — BANDWIDTH PRODUCT

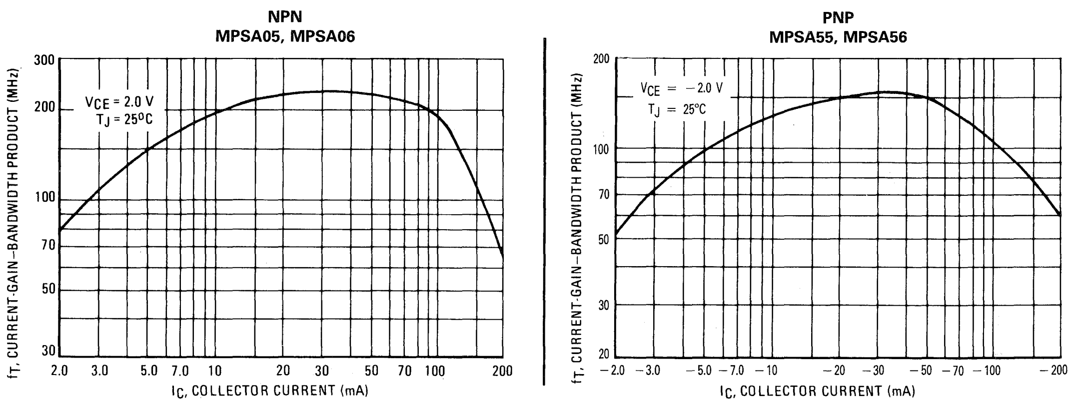
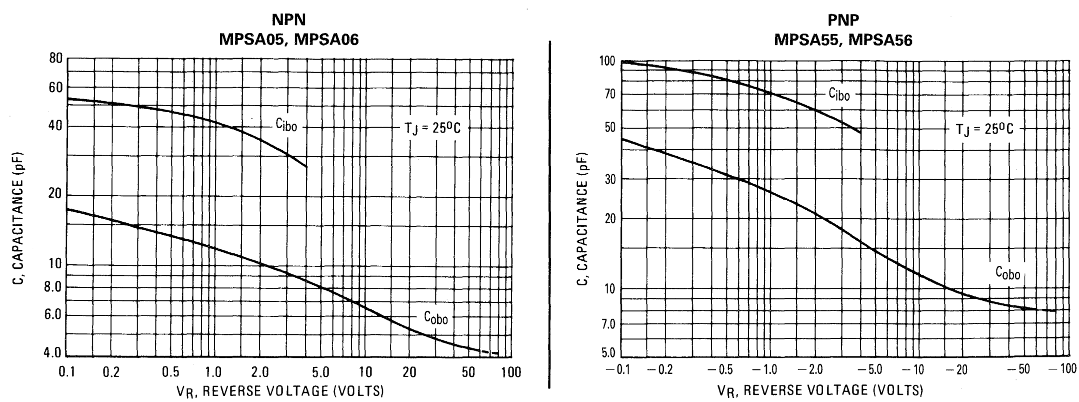


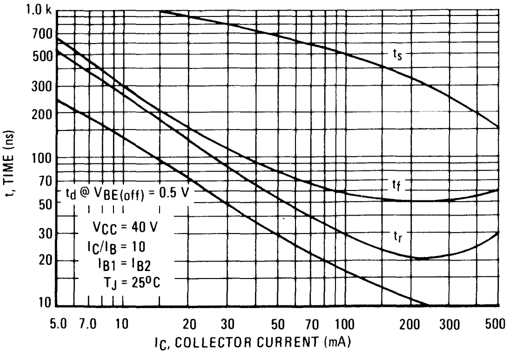
FIGURE 3 — CAPACITANCE



2

FIGURE 4 — SWITCHING TIME

NPN
MPSA05, MPSA06



PNP
MPSA55, MPSA56

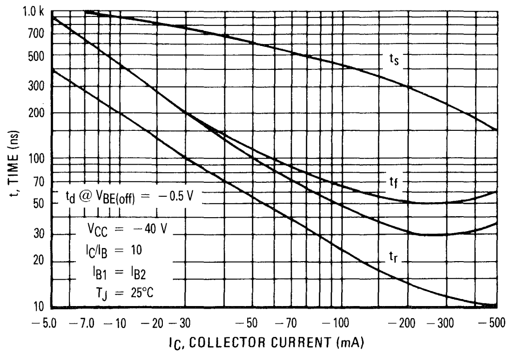


FIGURE 5 — THERMAL RESPONSE
MPSA05, MPSA06, MPSA55, MPSA56

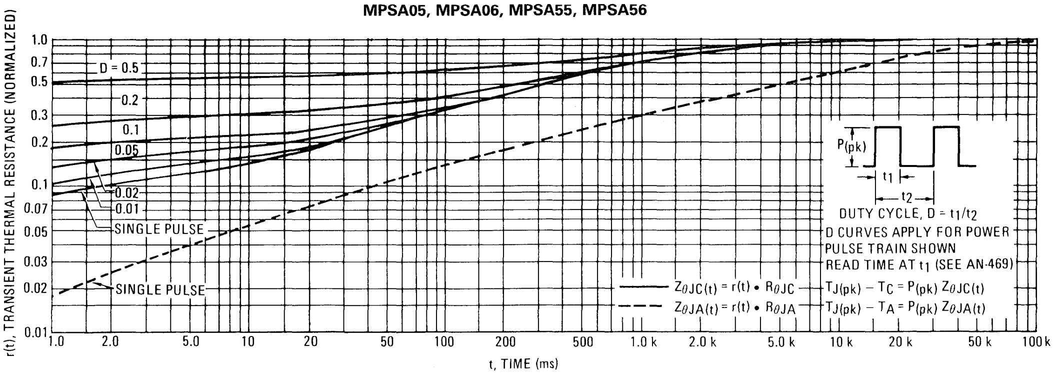
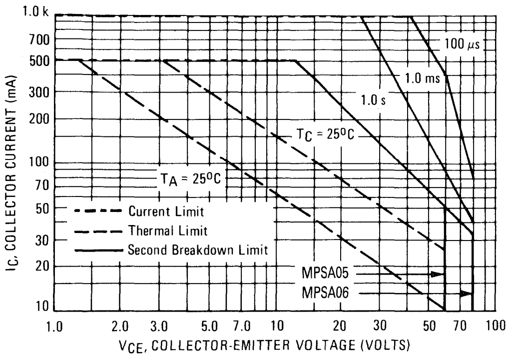
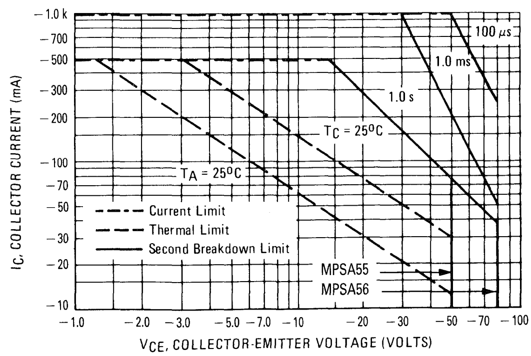


FIGURE 6 — ACTIVE — REGION SAFE OPERATING AREA

NPN
MPSA05, MPSA06



PNP
MPSA55, MPSA56



2

NPN
MPSA05, MPSA06

FIGURE 7 – DC CURRENT GAIN

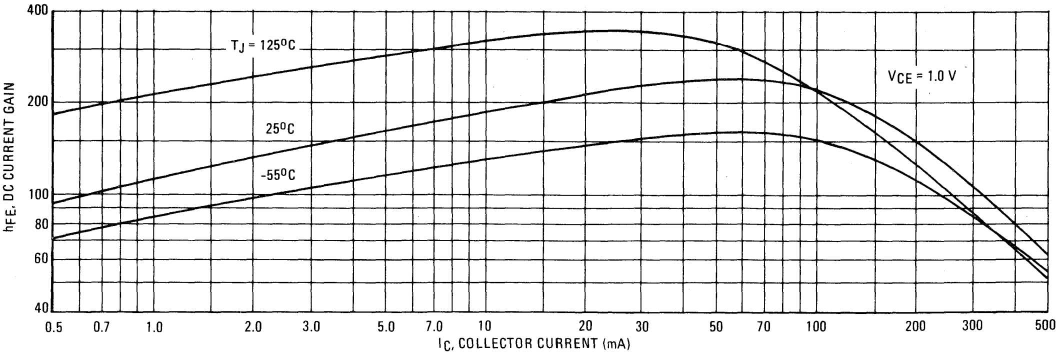


FIGURE 8 – "ON" VOLTAGES

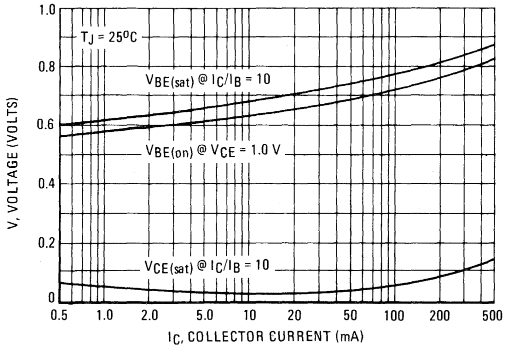


FIGURE 9 – COLLECTOR SATURATION REGION

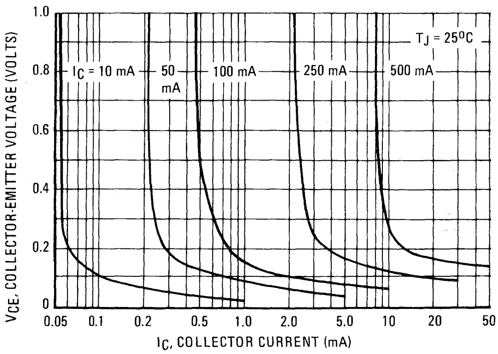
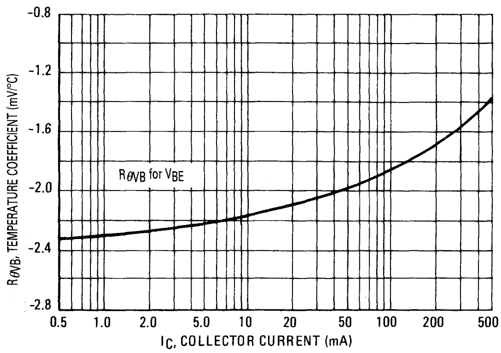


FIGURE 10 – BASE-EMITTER TEMPERATURE COEFFICIENT



2

PNP
MPSA55, MPSA56

FIGURE 11 – DC CURRENT GAIN

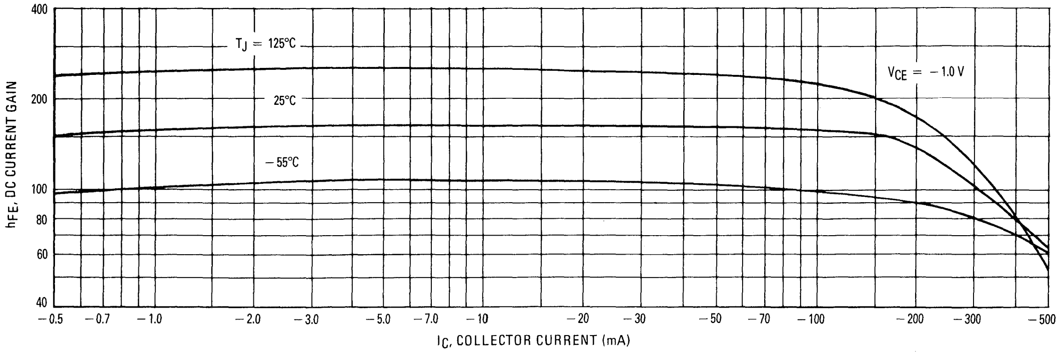


FIGURE 12 – "ON" VOLTAGES

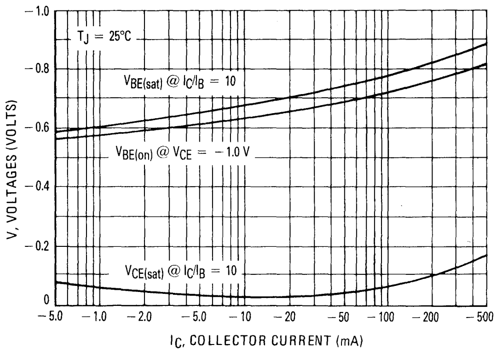


FIGURE 13 – COLLECTOR SATURATION REGION

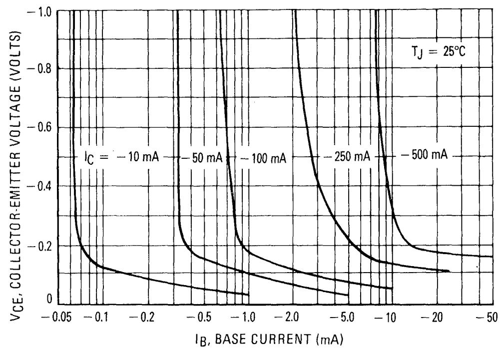
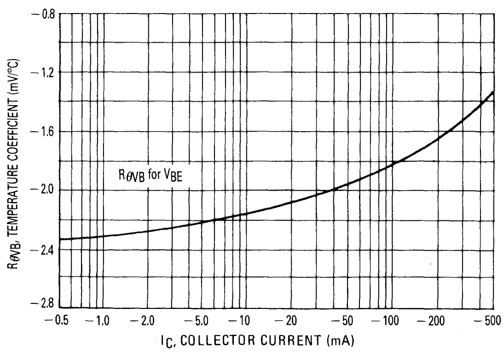
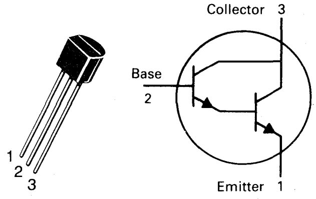


FIGURE 14 – BASE-EMITTER TEMPERATURE COEFFICIENT



MPSA13
MPSA14★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N6426 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
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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

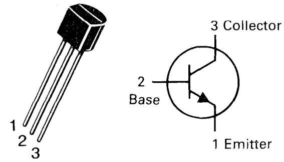
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_B = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
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

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2

MPSA16
MPSA17★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



CHOPPER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPS-A16	MPS-A17	Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	12	15	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

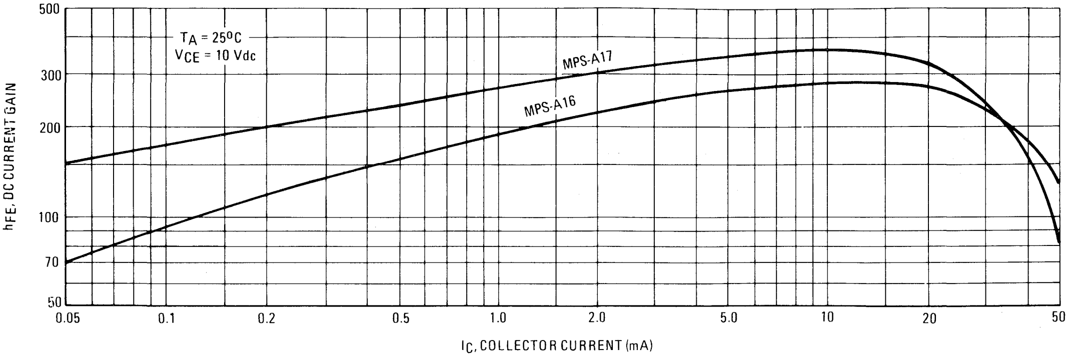
THERMAL CHARACTERISTICS

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

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	MPS-A16 MPS-A17	$V_{(BR)EBO}$	12 15	— —	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ 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)	MPS-A16 MPS-A17	f_T	100 80	— —	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	4.0	pF

FIGURE 1 — DC CURRENT GAIN



2

FIGURE 2 — SMALL SIGNAL CURRENT GAIN

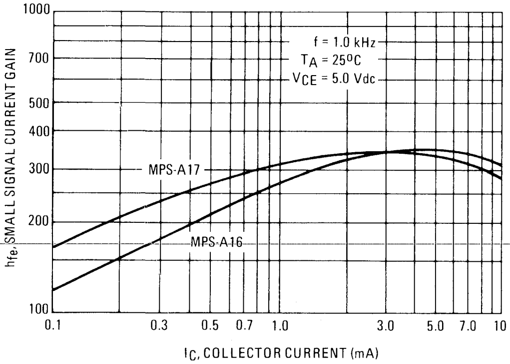


FIGURE 3 — SATURATION AND ON VOLTAGES

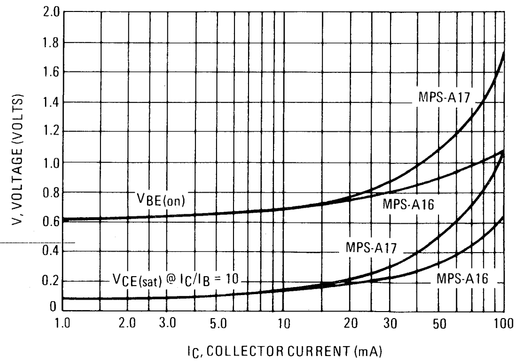


FIGURE 4 — CURRENT-GAIN—BANDWIDTH PRODUCT

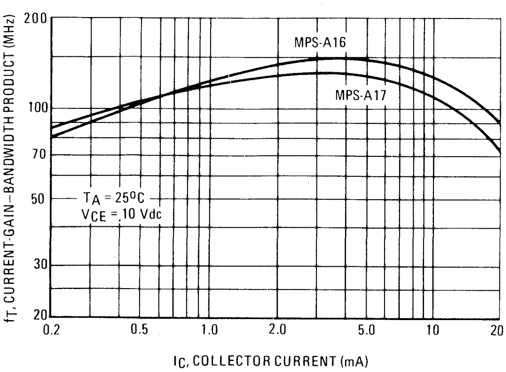
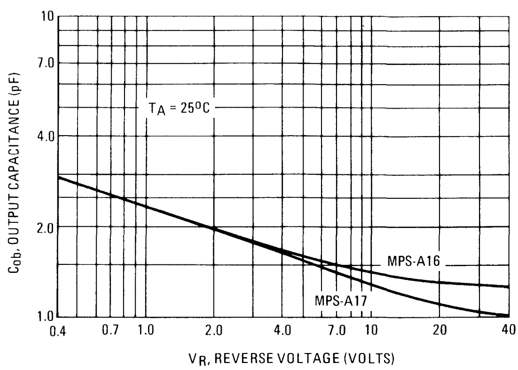


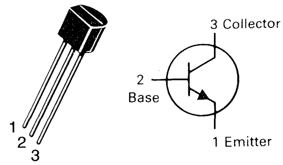
FIGURE 5 — OUTPUT CAPACITANCE



2

MPSA18★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



LOW NOISE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

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

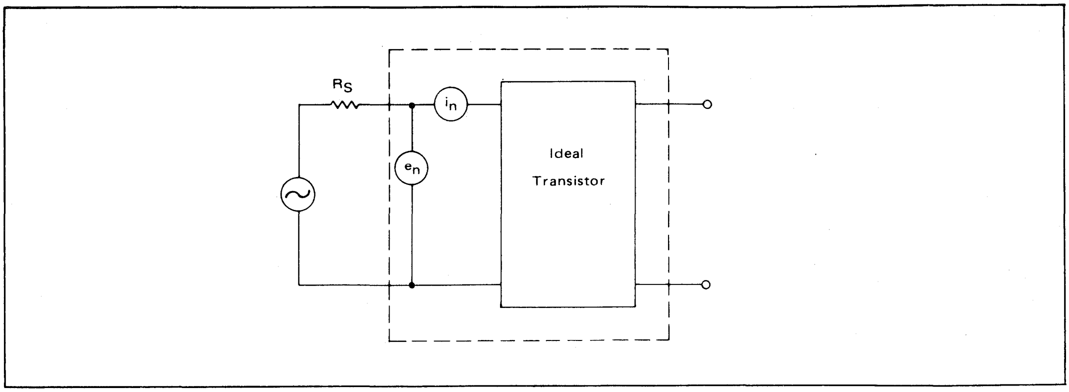
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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 = 1.0 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	—	$nV/\sqrt{Hz}$

(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 ≤ 2.0%.

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

FIGURE 2 – EFFECTS OF FREQUENCY

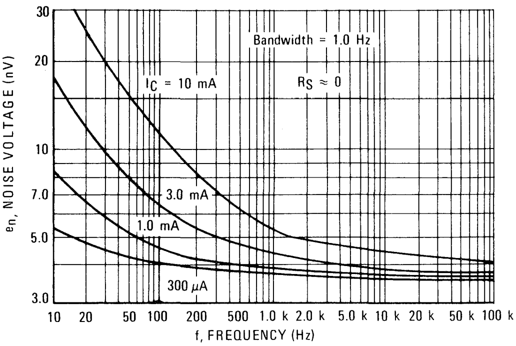


FIGURE 3 – EFFECTS OF COLLECTOR CURRENT

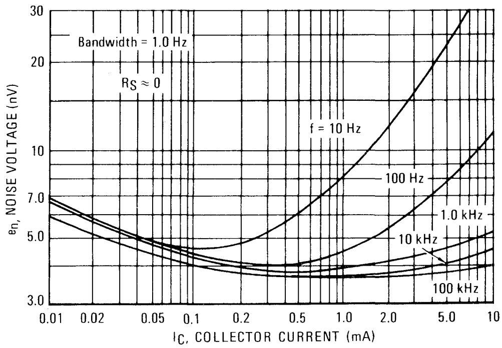


FIGURE 4 – NOISE CURRENT

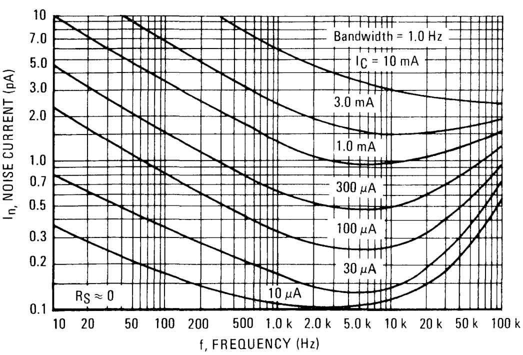
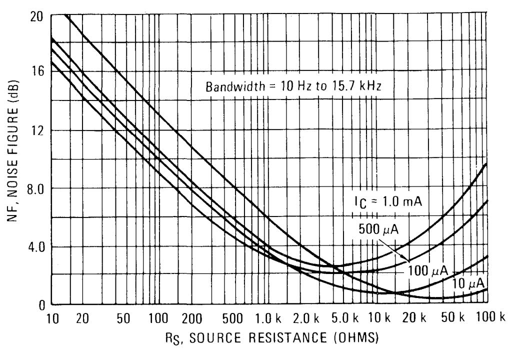


FIGURE 5 – WIDEBAND NOISE FIGURE



100 Hz NOISE DATA

FIGURE 6 – TOTAL NOISE VOLTAGE

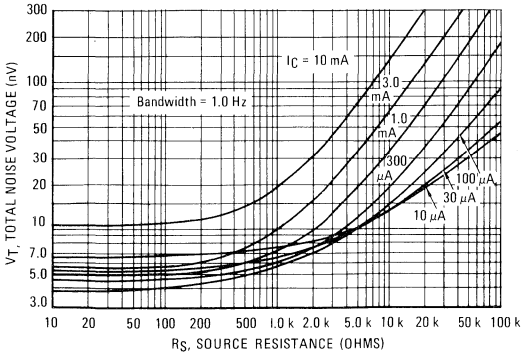


FIGURE 7 – NOISE FIGURE

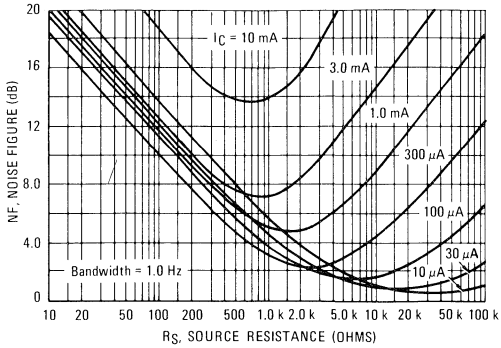


FIGURE 8 — DC CURRENT GAIN

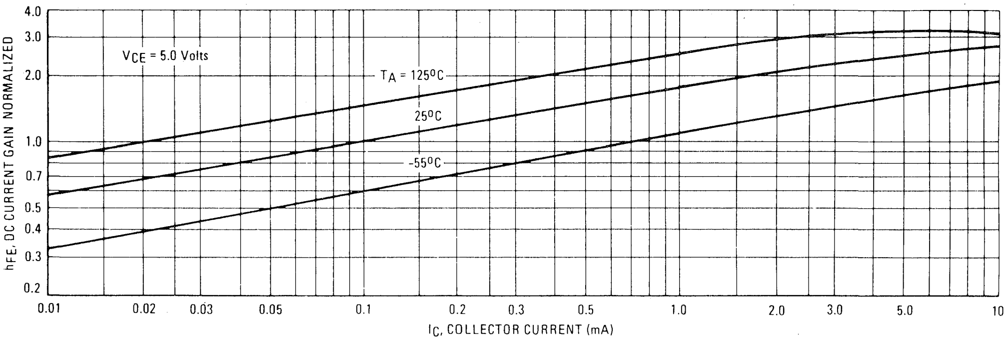


FIGURE 9 – "ON" VOLTAGES

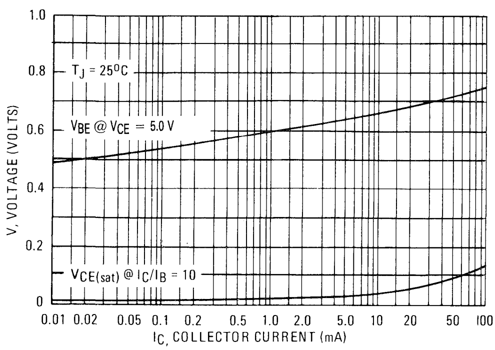


FIGURE 10 – TEMPERATURE COEFFICIENTS

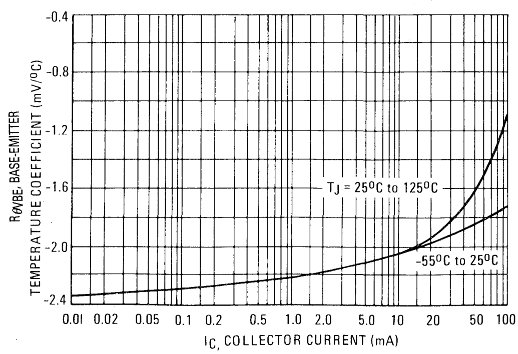


FIGURE 11 — CAPACITANCE

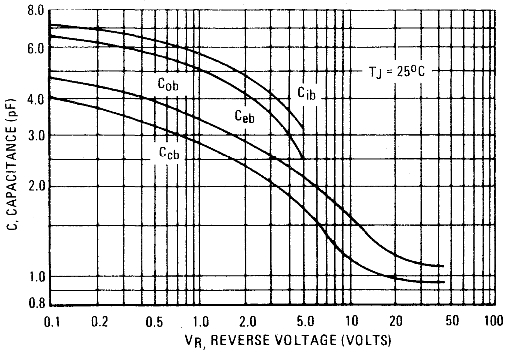
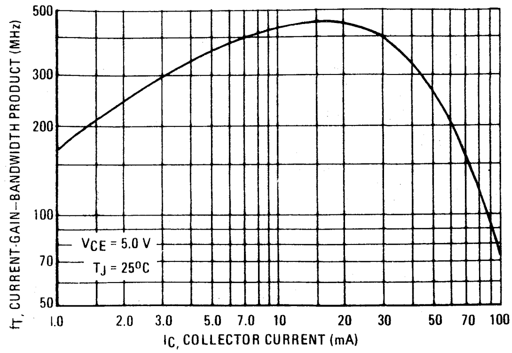


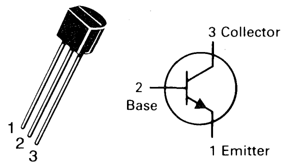
FIGURE 12 — CURRENT-GAIN—BANDWIDTH PRODUCT



2

MPSA20

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPS3904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	4.0	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 Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

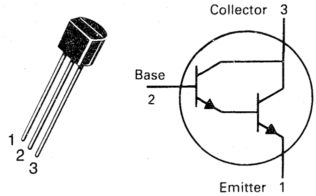
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, 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(2) (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(2) (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 = 1.0 MHz)	C_{obo}	—	4.0	pF

(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 ≤ 2.0%.

MPSA27

CASE 29-04, 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_{CES}	40	50	60	Vdc
Emitter-Base Voltage	V_{EBO}		10		Vdc
Collector Current — Continuous	I_C		500		mAdc
Total Device Dissipation @ $T_A = 25°C$ 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 ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	$V_{(BR)CES}$	60	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30\ V$, $I_E = 0$) ($V_{CB} = 40\ V$, $I_E = 0$) ($V_{CB} = 50\ V$, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
Collector Cutoff Current ($V_{CE} = 30\ V$, $V_{BE} = 0$) ($V_{CE} = 40\ V$, $V_{BE} = 0$) ($V_{CE} = 50\ V$, $V_{BE} = 0$)	I_{CES}	—	—	500	nAdc
Emitter Cutoff Current ($V_{EB} = 10\ Vdc$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10\ mA$, $V_{CE} = 5.0\ V$) ($I_C = 100\ mA$, $V_{CE} = 5.0\ V$)	h_{FE}	10,000 10,000	— —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100\ mA$, $I_B = 0.1\ mAdc$)	$V_{CE(sat)}$	—	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100\ mA$, $V_{CE} = 5.0\ Vdc$)	$V_{BE(on)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small Signal Current Gain ($I_C = 10\ mA$, $V_{CE} = 5.0\ V$, $f = 100\ MHz$)	h_{fe}	1.25	2.4	—	—

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

FIGURE 1 — DC CURRENT GAIN

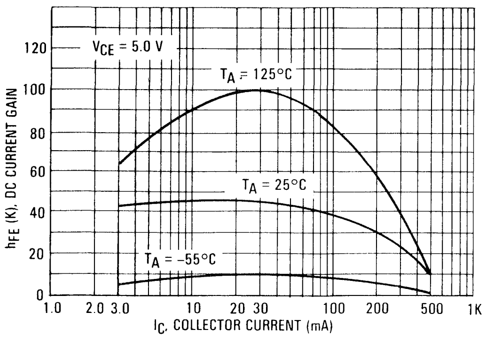


FIGURE 2 — "ON" VOLTAGES

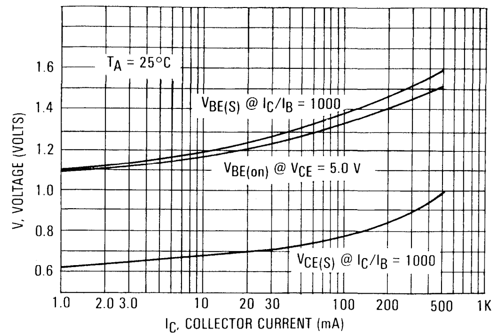


FIGURE 3 — COLLECTOR SATURATION REGION

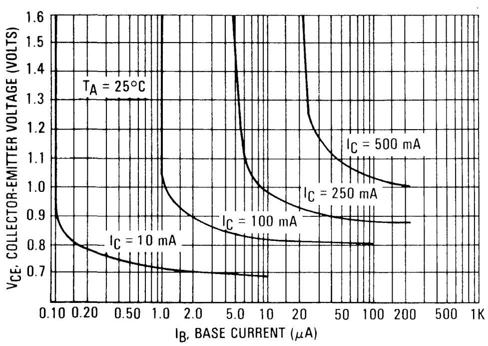


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

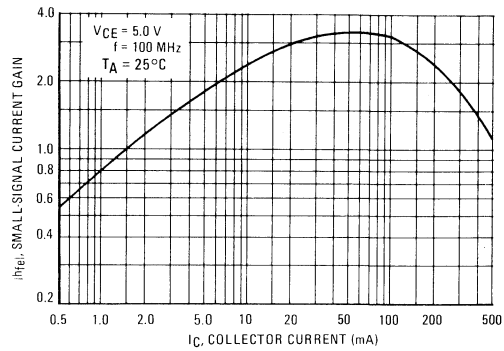
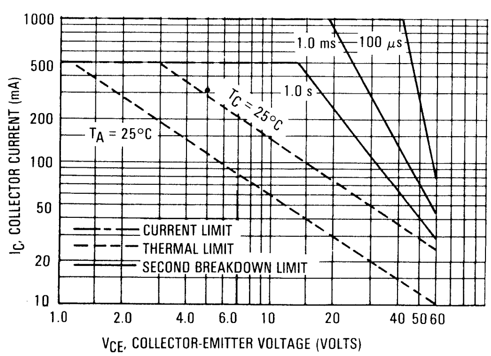
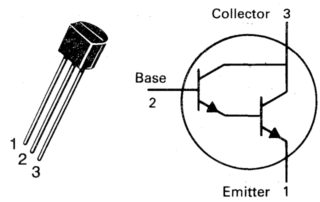


FIGURE 5 — ACTIVE REGION SAFE OPERATING AREA



MPSA28
MPSA29★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

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 @ $T_A = 25°C$ 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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	 MPSA28 MPSA29	$V_{(BR)CES}$	 80 100	 — —	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	 MPSA28 MPSA29	$V_{(BR)CBO}$	 80 100	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc$, $I_C = 0$)		$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MPSA28 MPSA29	I_{CBO}	 — —	 — —	 100 100	nAdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{BE} = 0$) ($V_{CE} = 80$ Vdc, $V_{BE} = 0$)	 MPSA28 MPSA29	I_{CES}	 — —	 — —	 500 500	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		h_{FE}	 10,000 10,000	 — —	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.01$ mAdc) ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	 — —	 0.7 0.8	 1.2 1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	1.4	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	5.0	8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = h_{fe} \cdot f_{test}$.

FIGURE 1 — DC CURRENT GAIN

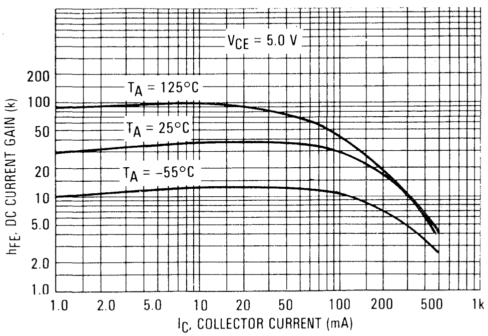


FIGURE 2 — ON VOLTAGES

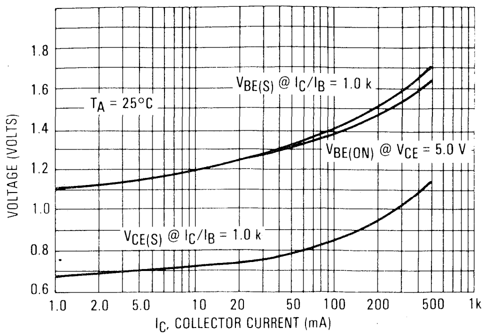


FIGURE 3 — TEMPERATURE COEFFICIENTS

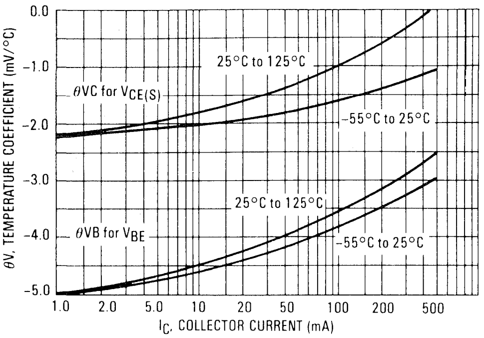


FIGURE 4 — COLLECTOR SATURATION REGION

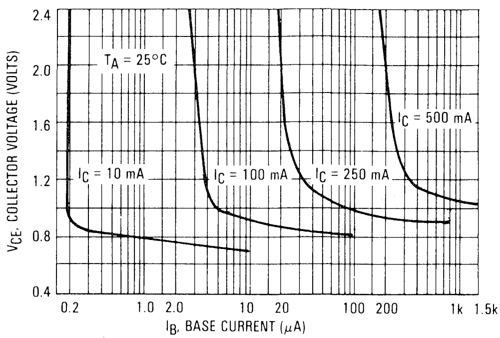


FIGURE 5 — ACTIVE REGION — SAFE OPERATING AREA

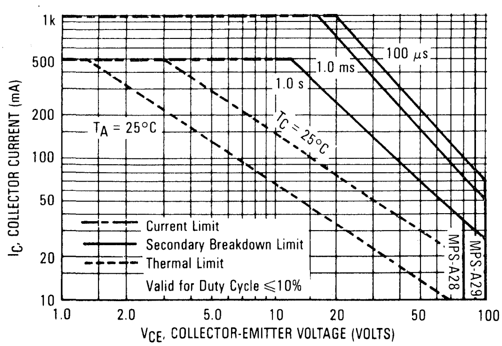
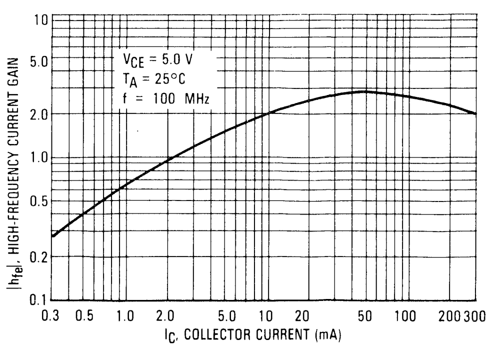
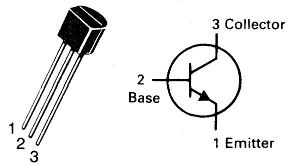


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN



MPSA42★
MPSA43

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

2

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°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	$R_{\theta JA}$	200	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/mW

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)	 MPSA42 MPSA43	$V_{(BR)CEO}$	 300 200	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPSA42 MPSA43	$V_{(BR)CBO}$	 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)	 MPSA42 MPSA43	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)	 MPSA42 MPSA43	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)		h_{FE}	 25 40 40	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	 MPSA42 MPSA43	$V_{CE(sat)}$	 — —	 0.5 0.4	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)	 MPSA42 MPSA43	C_{cb}	 — —	 3.0 4.0	pF

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

2

FIGURE 1 — DC CURRENT GAIN

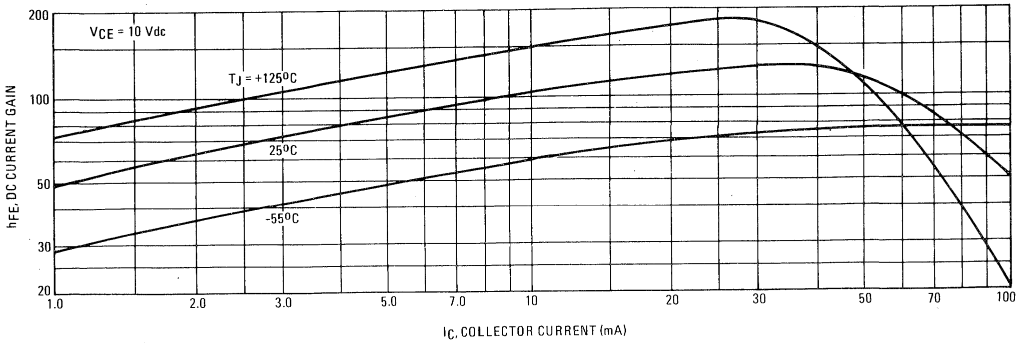


FIGURE 2 — CAPACITANCES

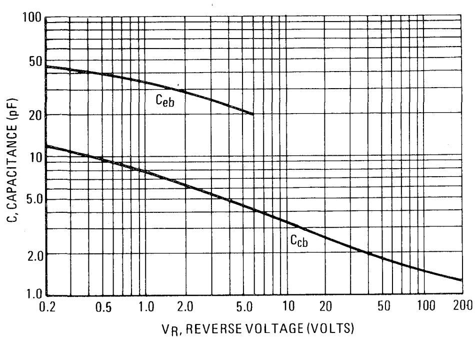


FIGURE 3 — CURRENT-GAIN—BANDWIDTH PRODUCT

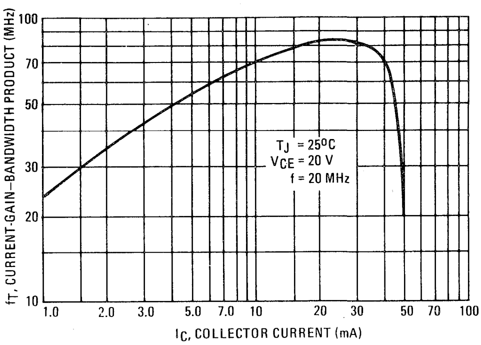


FIGURE 4 — "ON" VOLTAGES

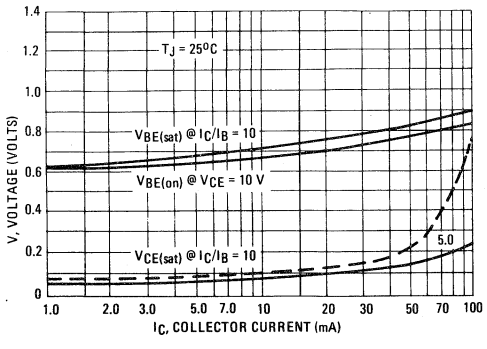
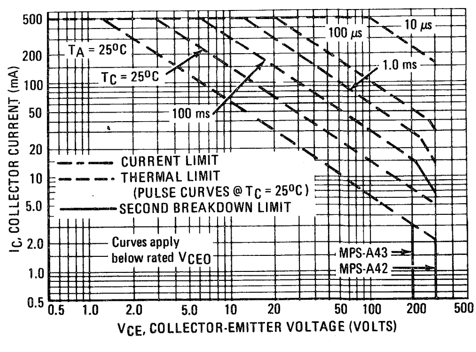
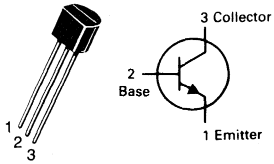


FIGURE 5 — MAXIMUM FORWARD BIAS SAFE OPERATING AREA



MPSA44★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	400	Vdc
Collector-Base Voltage	V_{CBO}	500	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	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	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

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, $I_B = 0$)	$V_{(BR)CEO}$	400	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ µAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	500	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100,$ µAdc, $I_E = 0$)	$V_{(BR)CBO}$	500	—	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, $I_E = 0$)	I_{CBO}	—	0.1	µAdc
Collector Cutoff Current ($V_{CE} = 400$ Vdc, $V_{BE} = 0$)	I_{CES}	—	500	nAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ 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}	—	7.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	130	pF
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	h_{fe}	1.0	—	—

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

FIGURE 1 — DC CURRENT GAIN

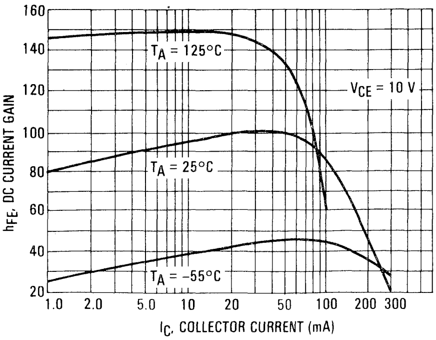


FIGURE 2 — COLLECTOR SATURATION REGION

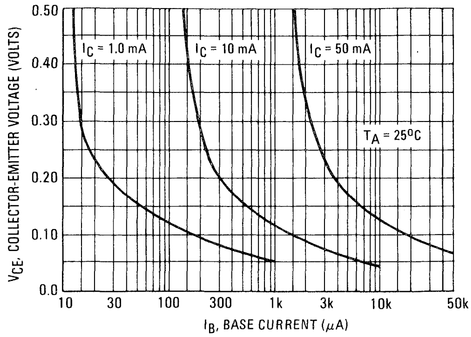


FIGURE 3 — ON VOLTAGES

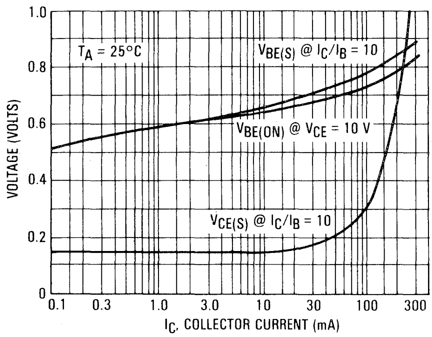


FIGURE 4 — ACTIVE REGION — SAFE OPERATING AREA

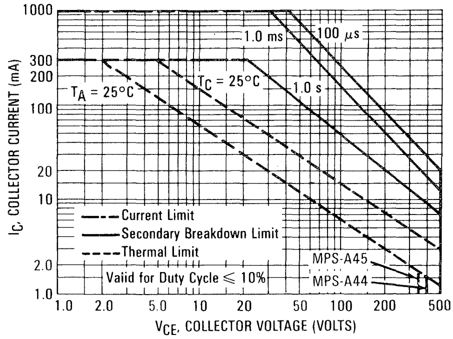


FIGURE 5 — CAPACITANCE

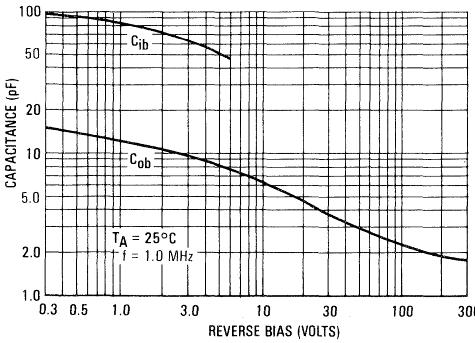


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN

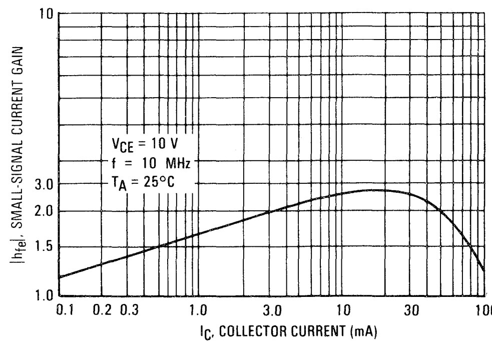


FIGURE 7 — TURN-ON SWITCHING TIMES AND TEST CIRCUIT

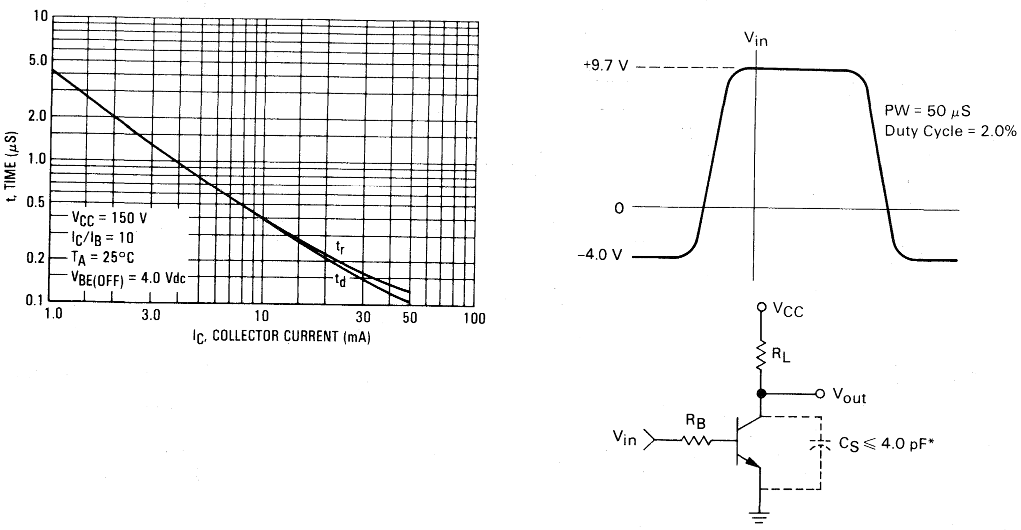
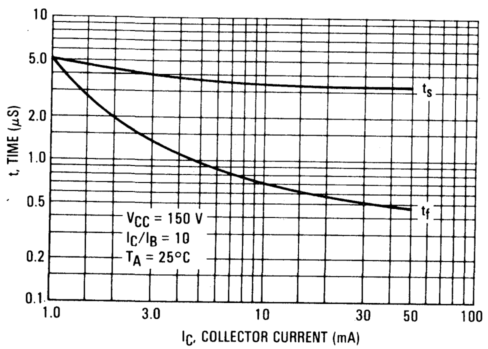
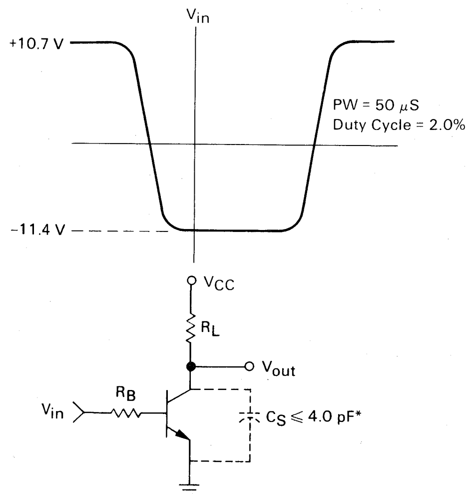


FIGURE 8 — TURN-OFF SWITCHING TIMES AND TEST CIRCUIT





*Total Shunt Capacitance or Test Jig and Connectors.

2

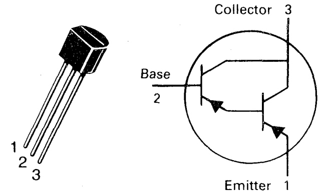
MPSA55, MPSA56

For Specifications, See MPSA05, MPSA06 Data

2

MPSA62 thru MPSA64★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

PNP SILICON

★MPSA64 is a Motorola designated preferred device.

Refer to MPSA75 for graphs.

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_A = 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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

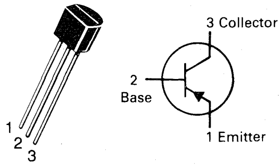
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)	 MPSA62 MPSA63, MPSA64	$V_{(BR)CES}$	 -20 -30	 — —	Vdc
Collector Cutoff Current (V_{CB} = −15 Vdc, I_E = 0) (V_{CB} = −30 Vdc, I_E = 0)	 MPSA62 MPSA63, MPSA64	I_{CBO}	 — —	 −100 −100	nAdc
Emitter Cutoff Current (V_{EB} = −10 Vdc, I_C = 0)		I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −10 mAdc, V_{CE} = −5.0 Vdc) (I_C = −100 mAdc, V_{CE} = −5.0 Vdc)	 MPSA63 MPSA64 MPSA62 MPSA63 MPSA64	h_{FE}	 5000 10,000 20,000 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)	 MPSA62 MPSA63, MPSA64	$V_{CE(sat)}$	 — —	 −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)	 MPSA62 MPSA63, MPSA64	$V_{BE(on)}$	 — —	 −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)	 MPSA63, MPSA64	f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

MPSA70

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

2

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
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

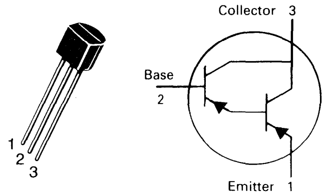
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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)	$V_{(BR)CEO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, 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 = 1.0 MHz)	C_{obo}	—	4.0	pf

MPSA75
MPSA77

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA75	MPSA77	Unit
Collector-Emitter Voltage	V_{CES}	−40	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−10		Vdc
Collector Current — Continuous	I_C	−500		Adc
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	$R_{\theta JA}$	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, V_{BE} = 0)	MPSA75 MPSA77	$V_{(BR)CES}$	−40 −60	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPSA75 MPSA77	$V_{(BR)CBO}$	−40 −60	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = −30 V, I_E = 0) (V_{CB} = −50 V, I_E = 0)	MPSA75 MPSA77	I_{CBO}	— —	— —	−100 −100	nAdc
Collector Cutoff Current (V_{CE} = −30 V, V_{BE} = 0) (V_{CE} = −50 V, V_{BE} = 0)	MPSA75 MPSA77	I_{CES}	— —	— —	−500 −500	nAdc
Emitter Cutoff Current (V_{EB} = −10 Vdc)		I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = −10 mA, V_{CE} = −5.0 V) (I_C = −100 mA, V_{CE} = −5.0 V)		h_{FE}	10,000 10,000	— —	— —	—
Collector-Emitter Saturation Voltage (I_C = −100 mA, I_B = −0.1 mAdc)		$V_{CE(sat)}$	—	—	−1.5	Vdc
Base-Emitter On Voltage (I_C = −100 mA, V_{CE} = −5.0 Vdc)		V_{BE}	—	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — High Frequency (I_C = −10 mA, V_{CE} = −5.0 V, f = 100 MHz)		$\|h_{fe}\|$	1.25	2.4	—	—

FIGURE 1 — DC CURRENT GAIN

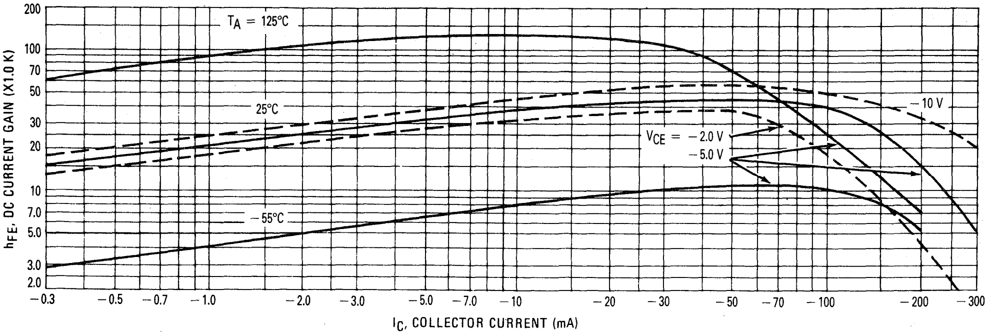


FIGURE 2 — "ON" VOLTAGE

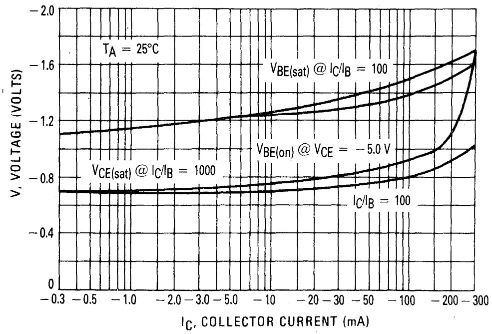


FIGURE 3 — COLLECTOR SATURATION REGION

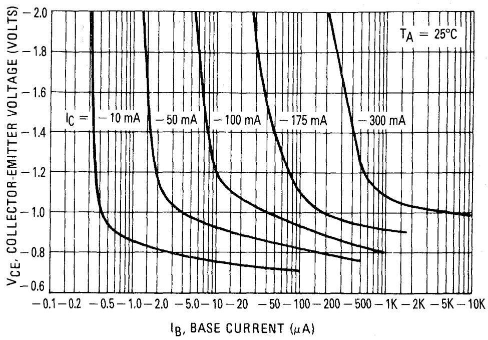


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

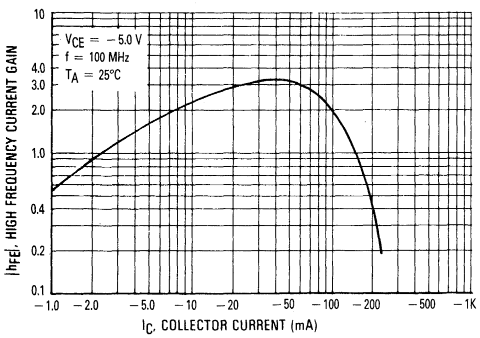
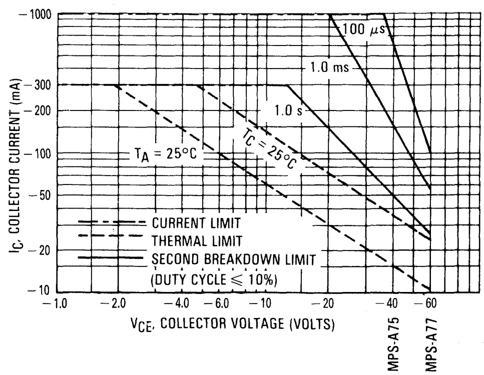


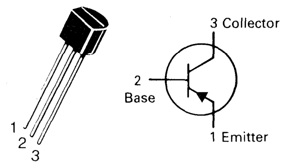
FIGURE 5 — ACTIVE REGION, SAFE OPERATING AREA



2

MPSA92★
MPSA93

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPSA92	MPSA93	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°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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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)	 MPSA92 MPSA93	$V_{(BR)CEO}$	 −300 −200	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	 MPSA92 MPSA93	$V_{(BR)CBO}$	 −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)	 MPSA92 MPSA93	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 MPSA92 MPSA93	h_{FE}	 25 40 25 25	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)	 MPSA92 MPSA93	$V_{CE(sat)}$	 — —	 −0.5 −0.4	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

FIGURE 1 — DC CURRENT GAIN

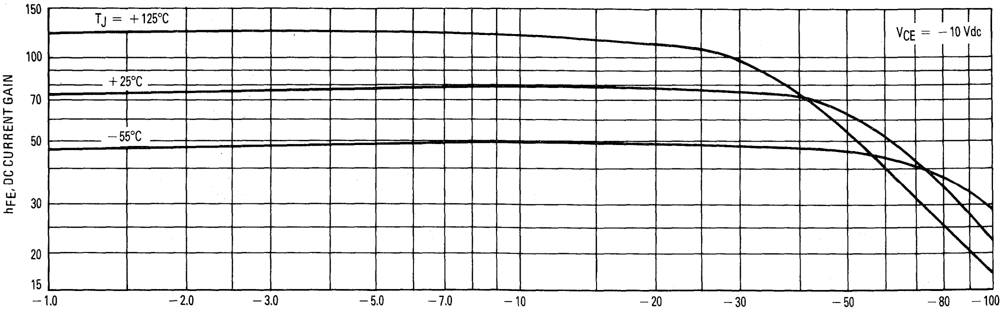


FIGURE 2 — CAPACITANCES

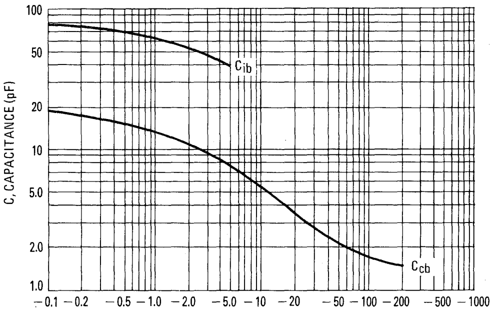


FIGURE 3 — CURRENT-GAIN—BANDWIDTH PRODUCT

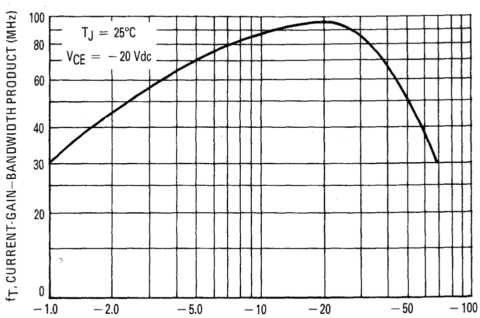


FIGURE 4 — "ON" VOLTAGES

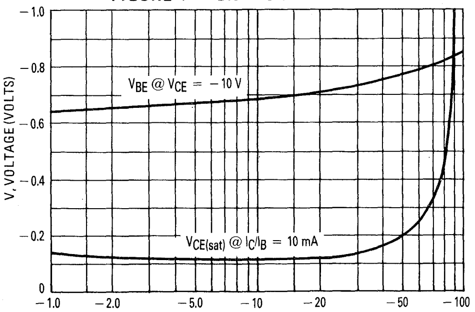
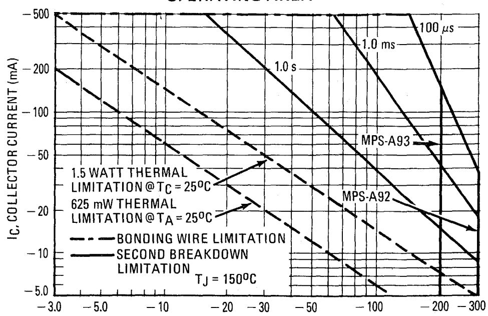
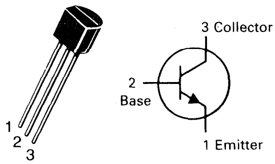


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



MPSH04

CASE 29-04, 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	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 Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

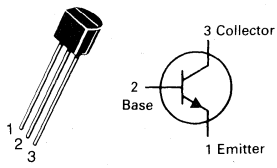
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	80	—	—	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)	$V_{(BR)EBO}$	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}	30	— —	120	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Crrent-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}	—	—	5.0	μmhos
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 MHz) MPSH04	NF	—	—	2.0	dB

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

MPSH07A

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



FM/VHF TRANSISTOR

NPN 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
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	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 Case	$R_{\theta JC}$	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 = 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} = 15 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	—
Base-Emitter On Voltage (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_B = 0, f = 1.0 MHz, base guarded)	C_{ce} (C_{rb})	—	0.3	pF
Noise Figure (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 100 MHz)	NF	—	3.2	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 100 MHz) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 200 MHz)	G_{pb}	 18 14	 — —	dB
Forward AGC Current (Gain Reduction = 30 dB, R_S = 50 Ohms, f = 100 MHz)	I_{AGC}	5.0	8.0	mAdc

AGC CHARACTERISTICS

V_{CC} = 10 Vdc, R_S = 50 Ohms, See Figure 9

—— f = 100 MHz – – – f = 200 MHz

FIGURE 1 – POWER GAIN

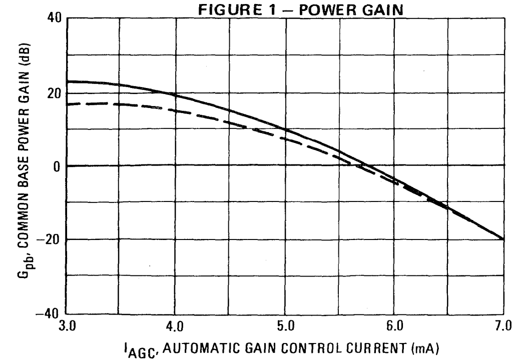
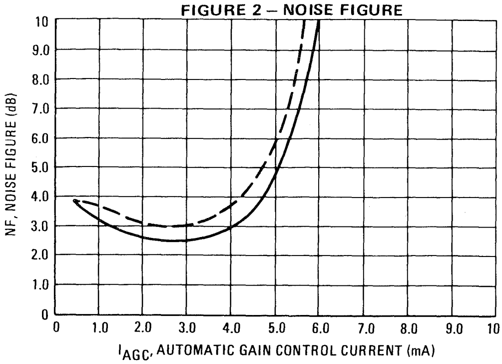


FIGURE 2 – NOISE FIGURE



COMMON-BASE y PARAMETERS

V_{CB} = 10 Vdc, T_A = 25°C

—— f = 100 MHz – – – f = 200 MHz

FIGURE 3 – INPUT ADMITTANCE

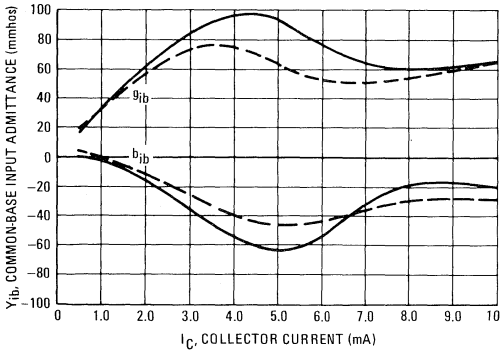


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

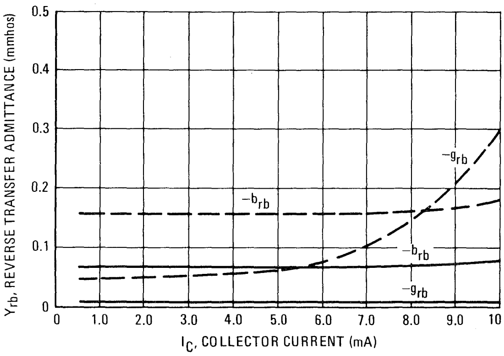


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

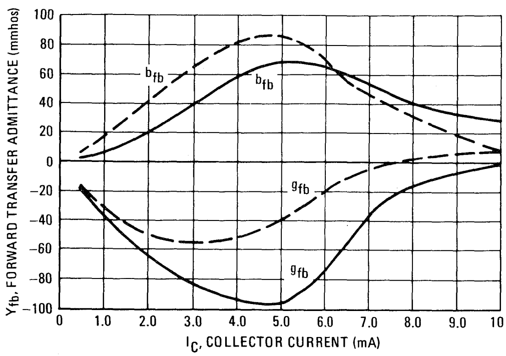


FIGURE 6 – OUTPUT ADMITTANCE

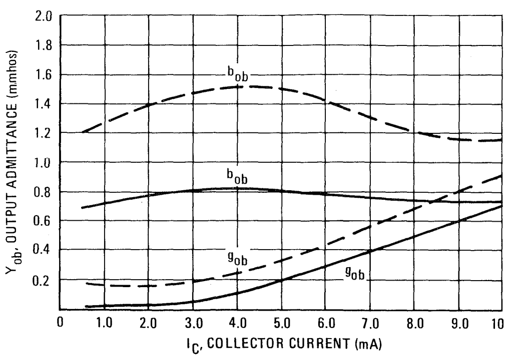


FIGURE 7 — COLLECTOR-BASE TIME CONSTANT

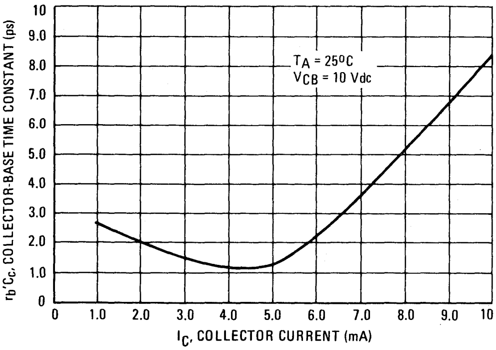


FIGURE 8 — CURRENT-GAIN BANDWIDTH PRODUCT

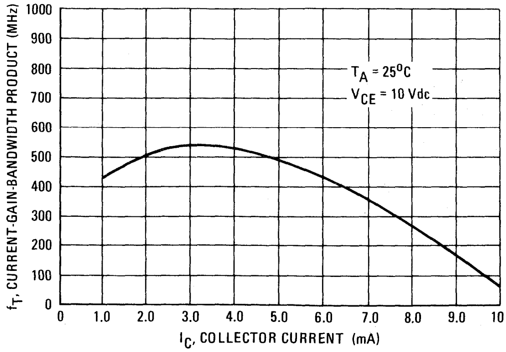
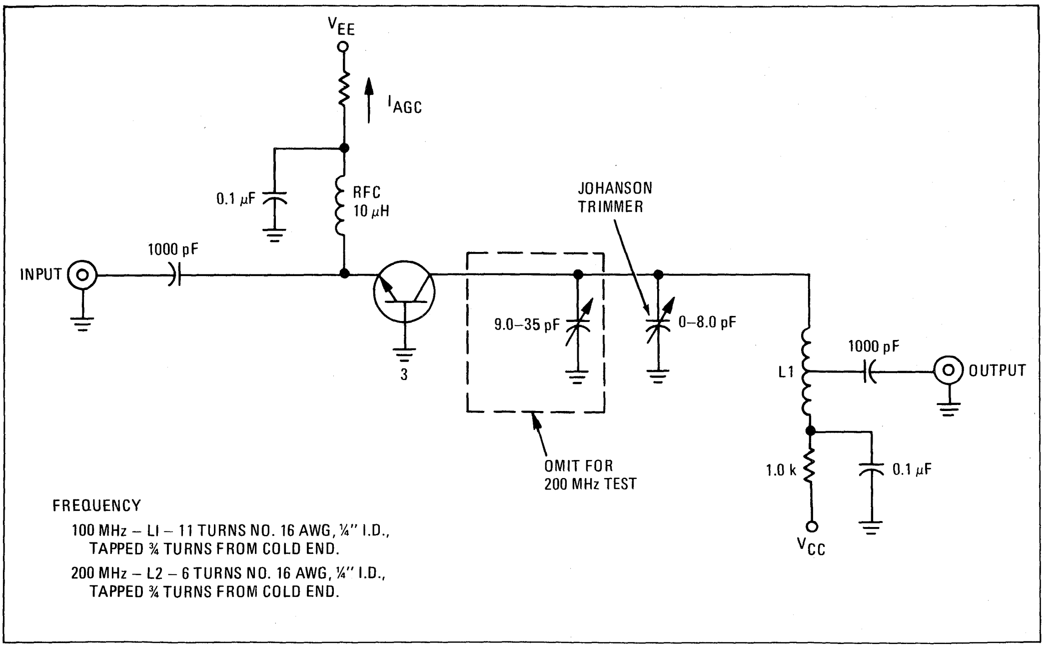
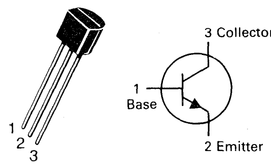


FIGURE 9 — 100-MHz AND 200-MHz COMMON-BASE AMPLIFIER



MPSH10★
MPSH11★

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



VHF/UHF TRANSISTORS

NPN SILICON

★These are Motorola designated preferred devices.

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 Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	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 = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 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 = 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) MPS-H10 MPS-H11	C_{rb}	 0.35 0.6	 0.65 0.9	pF
Collector Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	—	9.0	ps

COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{ib}, INPUT ADMITTANCE

FIGURE 1 – RECTANGULAR FORM

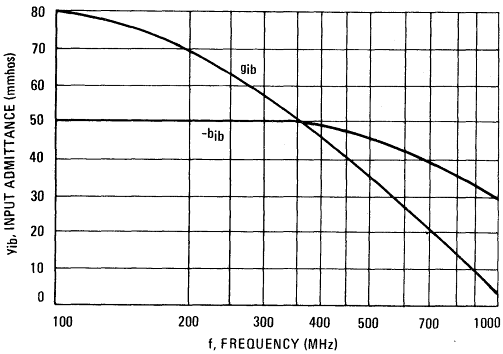
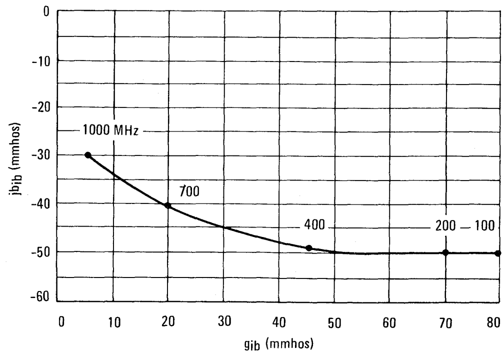


FIGURE 2 – POLAR FORM



COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{fb}, FORWARD TRANSFER ADMITTANCE

FIGURE 3 – RECTANGULAR FORM

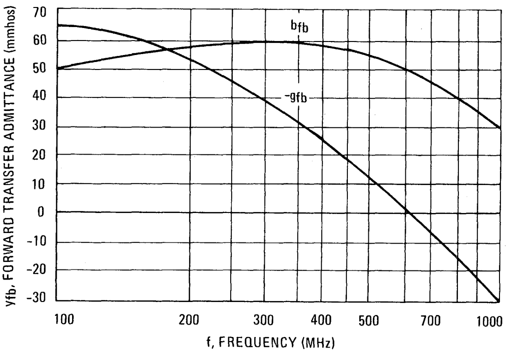
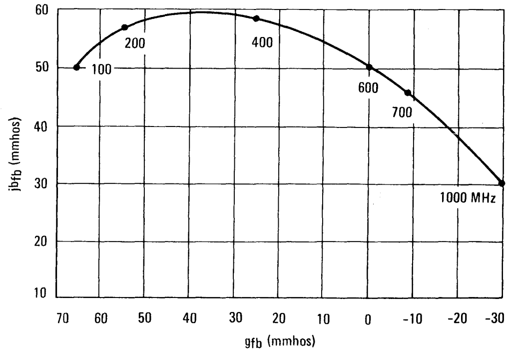


FIGURE 4 – POLAR FORM



y_{rb}, REVERSE TRANSFER ADMITTANCE

FIGURE 5 – RECTANGULAR FORM

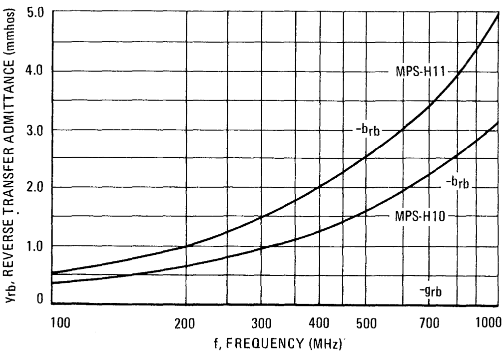
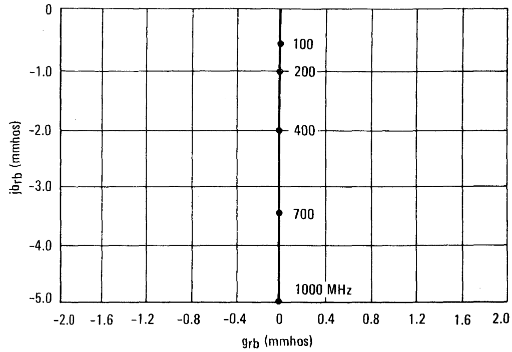


FIGURE 6 – POLAR FORM



y_{ob}, OUTPUT ADMITTANCE

FIGURE 7 – RECTANGULAR FORM

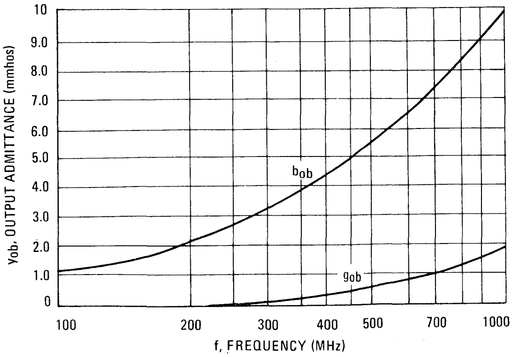
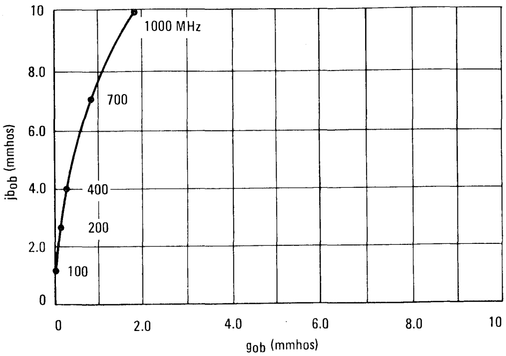
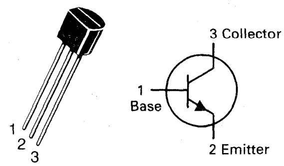


FIGURE 8 – POLAR FORM



MPSH17★

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



CATV TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

2

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
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

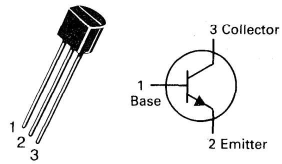
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	357	°C/W

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)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	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}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	250	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	800	—	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	0.3	—	0.9	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	—	—	—
Noise Figure (I_C = 5.0 mAdc, V_{CC} = 12 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	—	—	6.0	dB
FUNCTIONAL TEST					
Amplifier Power Gain (I_C = 5.0 mAdc, V_{CC} = 12 Vdc, R_S = 50 ohms, f = 200 MHz)	G_{pe}	—	24	—	dB

MPSH20★

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



VHF TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

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
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Total Device Dissipation @ T_C = 25°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 CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°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)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, 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 = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 4.0 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}	—	0.5	0.65	pF
Collector Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$rb'C_c$	—	10	—	ps
Conversion Gain (213 to 45 MHz) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, Oscillator Injection = 200 mVdc)	G_C	18	23	—	dB

CONVERSION GAIN CHARACTERISTICS
(TEST CIRCUIT FIGURE 9)

FIGURE 1 – VARIATION WITH COLLECTOR CURRENT

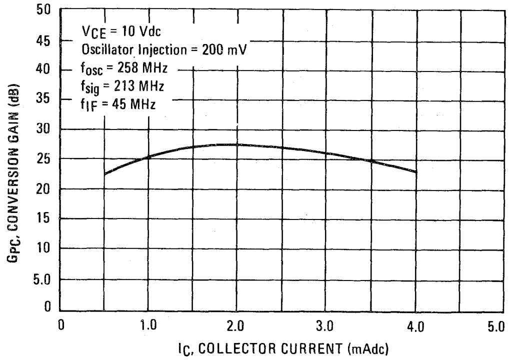
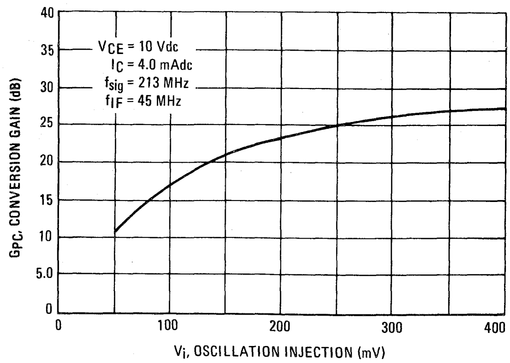


FIGURE 2 – VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

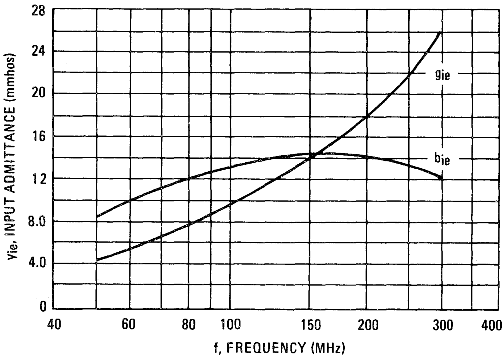
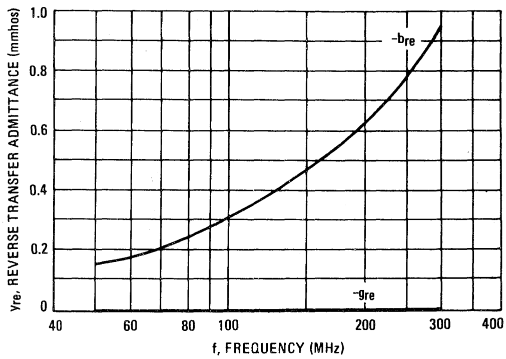


FIGURE 4 – REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

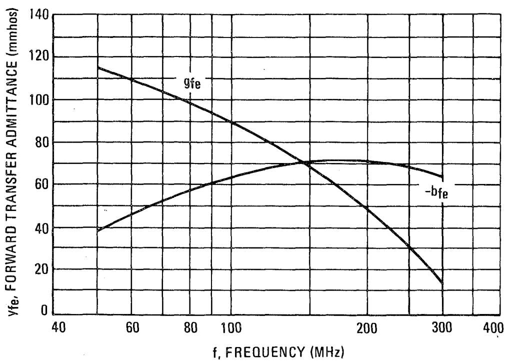
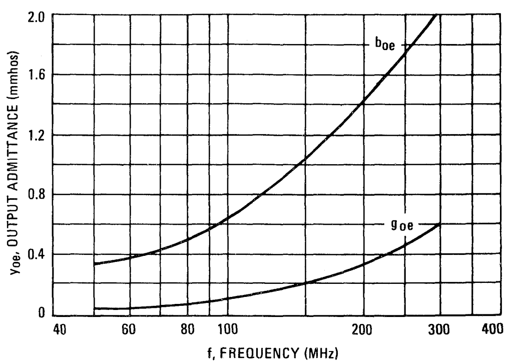


FIGURE 6 – OUTPUT ADMITTANCE



2

FIGURE 7 — CURRENT-GAIN—BANDWIDTH PRODUCT

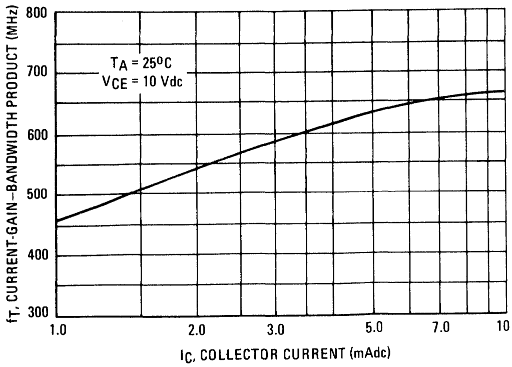


FIGURE 8 — CAPACITANCES

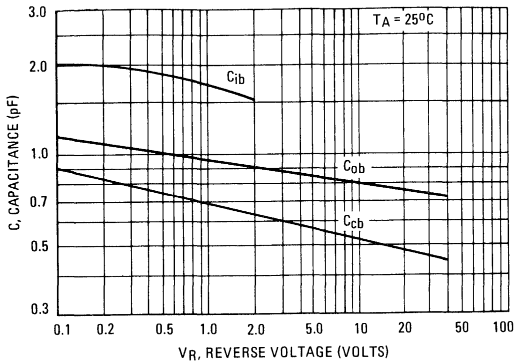
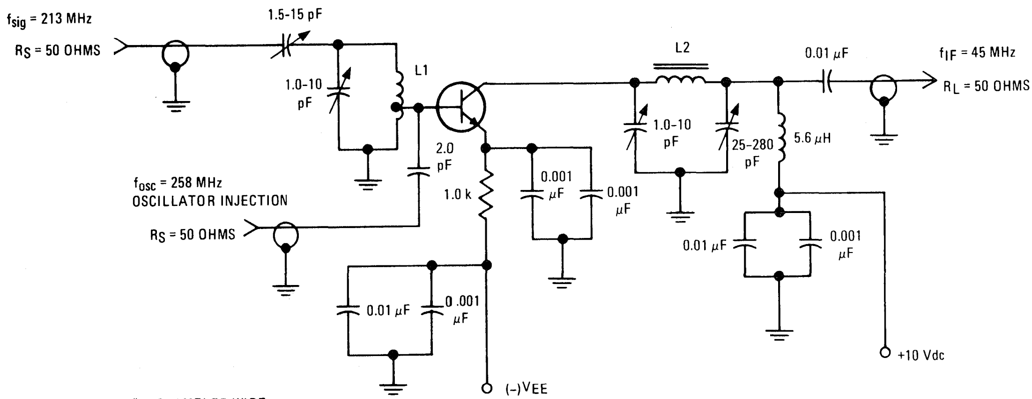


FIGURE 9 — MIXER TEST CIRCUIT

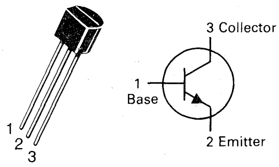


L1 = 3 TURNS #18 ENAMELED WIRE, 1/4" I.D., AIR WOUND, WINDING LENGTH 1/2"; BASE TAPPED 1 TURN FROM GROUND.

L2 = 10 TURNS #26 INSULATED WIRE, WOUND ON 1/4" I.D. COIL FORM, ARNOLD PART NO. A1-10 IRON POWDER CORE.

MPSH24

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



VHF TRANSISTOR

NPN SILICON

2

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	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	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 ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$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 ($I_C = 8.0$ 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	G_C				dB
(213 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)		19	24	—	
(60 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)		24	29	—	

2

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 7)

(V_{CC} = 20 Vdc, R_S = R_L = 50 Ohms, f_{if} = 44 MHz, B.W. = 6.0 MHz)

FIGURE 1 – CONVERSION GAIN versus COLLECTOR CURRENT

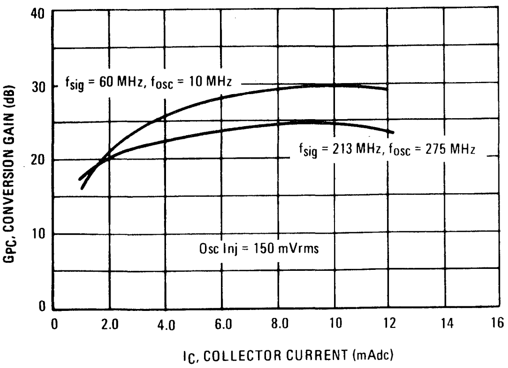
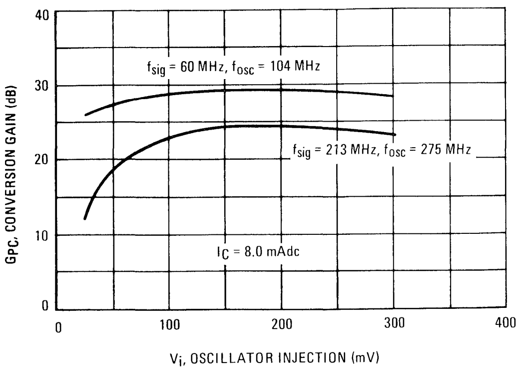


FIGURE 2 – CONVERSION GAIN versus INJECTION LEVEL



COMMON-EMITTER y PARAMETERS

(V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

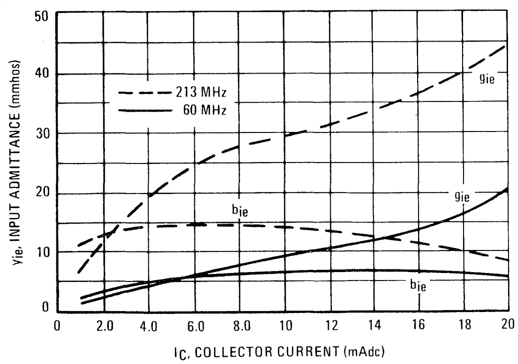


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

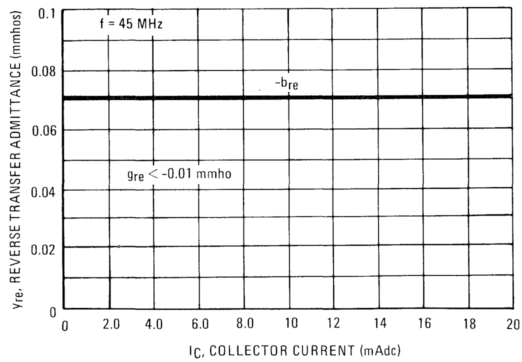


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

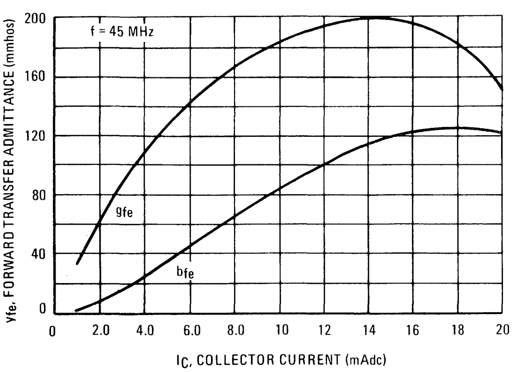


FIGURE 6 – OUTPUT ADMITTANCE

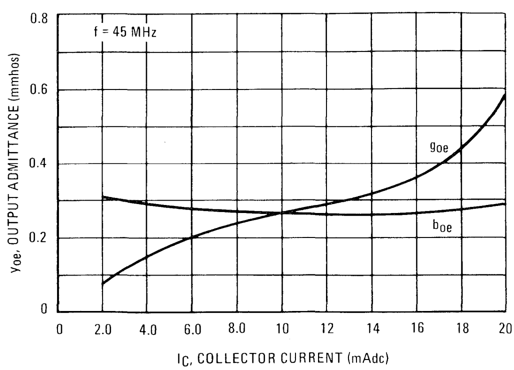
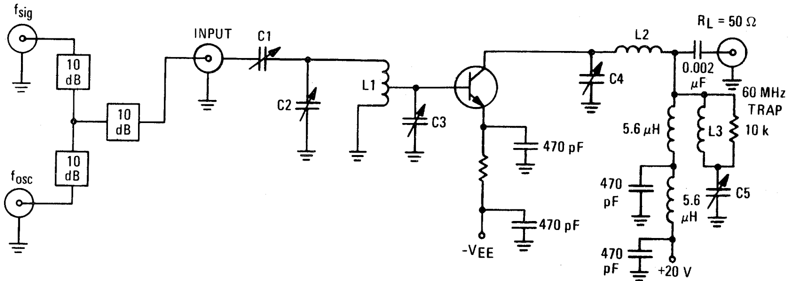


FIGURE 7 – VHF MIXER TEST CIRCUIT

(f_{if} = 44 MHz, B.W. = 6.0 MHz)

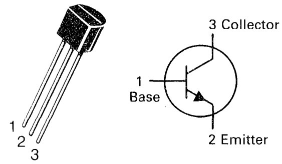
f_{sig}	60 MHz	213 MHz
f_{osc}	105 MHz	258 MHz
C1	1.5-20 pF	1.5-20 pF
C2	8.0-60 pF	6.0-12 pF
C3	8.0-60 pF	1.5-20 pF
C4	3.0-35 pF	–
C5	1.5-20 pF	–
L1	5 Turns #26 Air, Tap 1 Turn	3 Turns #16 Air, Tap ½ Turn
L2	10 Turns #26 Air	10 Turns #26 Arnold A1-10 Core
L3	Ohmite Z235	–



2

MPSH34

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



IF TRANSISTOR

NPN SILICON

Refer to MPSH24 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}	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
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

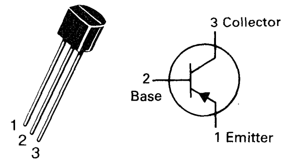
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	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)	$V_{(BR)EBO}$	4.0	—	—	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} = 15 Vdc) (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 15	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = 7.0 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 7.0 mAdc, V_{CE} = 15 Vdc)	$V_{BE(on)}$	—	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 15 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	500	720	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.25	0.32	pF

- Designed for UHF/VHF Amplifier Applications
- High Current Bandwidth Product
  f_T = 2000 MHz @ 10 mAdc

MPSH69★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



RF AMPLIFIER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

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	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	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	$R_{\theta JA}$	357	°C/W

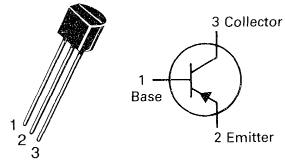
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc)	h_{FE}	30	—	300	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	2000	—	—	MHz
Collector-Base Capacitance (V_{CE} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{rb}	—	—	0.3	pF

2

MPSH81★

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



RF AMPLIFIER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

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°C Derate above 25°C	P_D	350 2.81	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	$R_{\theta JA}$	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)	$V_{(BR)CEO}$	−20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 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 = −5.0 mAdc, V_{CE} = −10 Vdc)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage (I_C = −5.0 mAdc, I_B = −0.5 mAdc)	$V_{CE(sat)}$	—	—	−0.5	Vdc
Base-Emitter On Voltage (I_C = −5.0 mAdc, V_{CE} = −10 Vdc)	$V_{BE(on)}$	—	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −5.0 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance (I_B = 0, V_{CB} = −10 Vdc, f = 1.0 MHz	C_{ce}	—	—	0.65	pF

TYPICAL COMMON-BASE y-PARAMETERS

(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

FIGURE 1 – INPUT ADMITTANCE

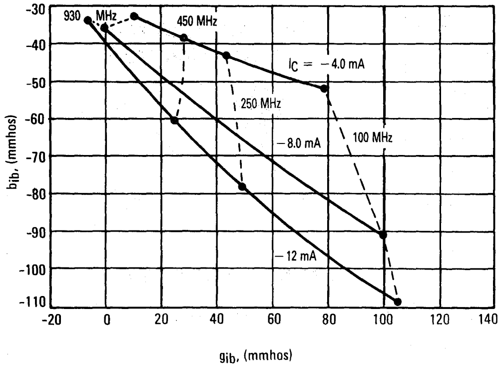


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

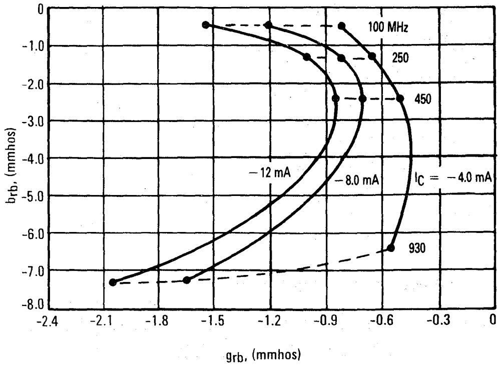


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

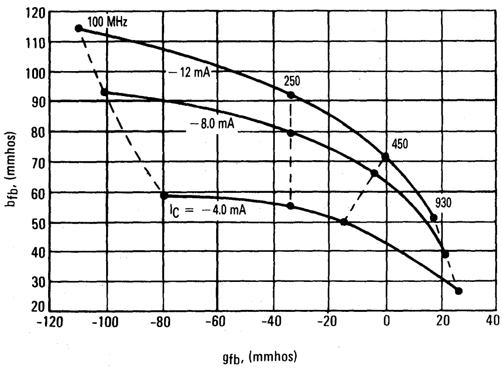


FIGURE 4 – OUTPUT ADMITTANCE

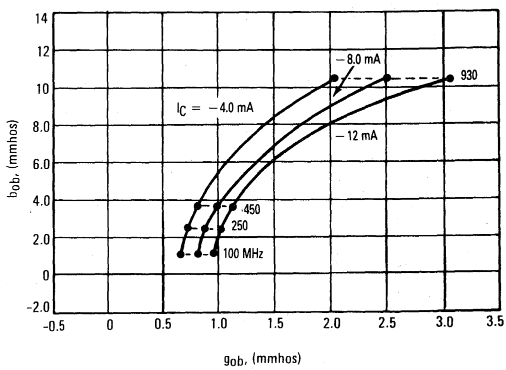
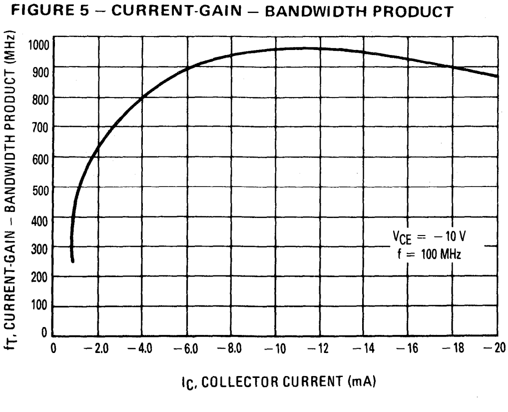


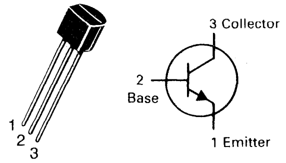
FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT



2

MPSL01

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	120	Vdc
Collector-Base Voltage	V_{CBO}	140	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	150	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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

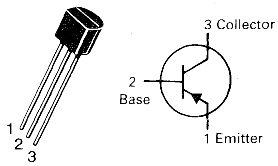
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	120	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	140	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	—	1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	300	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.20 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)(1)	$V_{BE(sat)}$	 — —	 1.2 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	—	—

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

MPSL51

CASE 29-04, 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 — Ctoninuous	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 12.0	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 Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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, 1_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_{EB} = −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 = 20 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%.

2

MAXIMUM RATINGS

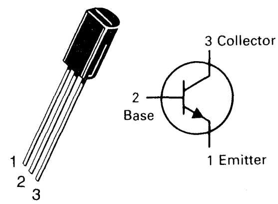
Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPSW01 MPSW01A	V_{CEO}	 30 40	Vdc
Collector-Base Voltage MPSW01 MPSW01A	V_{CBO}	 40 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

MPSW01, A★

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT
HIGH CURRENT TRANSISTORS

NPN SILICON

★MPSW01A is a Motorola designated preferred device.

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, $I_B = 0$)	 MPSW01 MPSW01A	$V_{(BR)CEO}$	 30 40	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPSW01 MPSW01A	$V_{(BR)CBO}$	 40 50	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$)	 MPSW01 MPSW01A	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	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	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 = 1.0 MHz)		C_{obo}	—	20	pF

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

FIGURE 1 — DC CURRENT GAIN

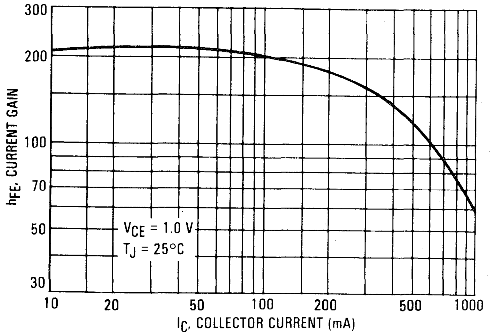


FIGURE 2 — COLLECTOR SATURATION REGION

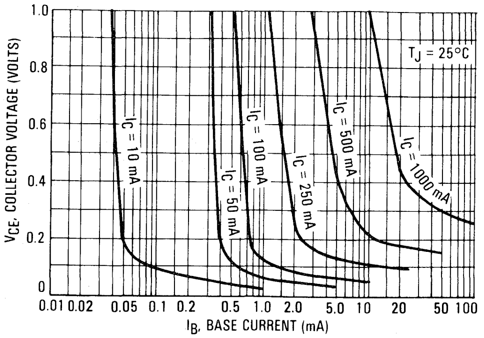


FIGURE 3 — ON VOLTAGES

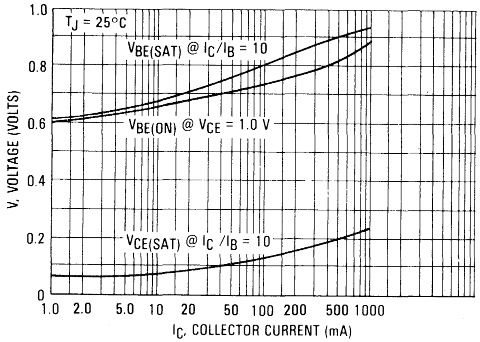


FIGURE 4 — TEMPERATURE COEFFICIENT

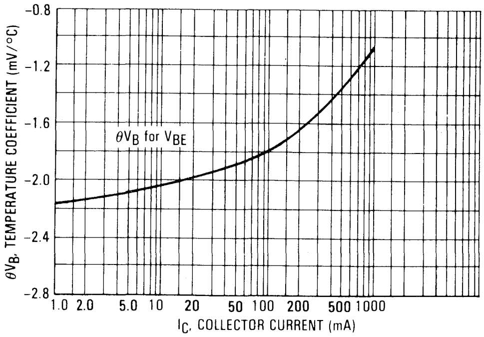


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

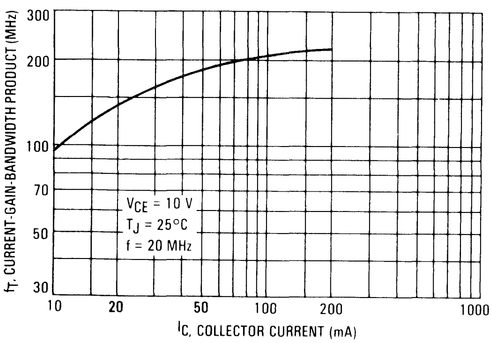
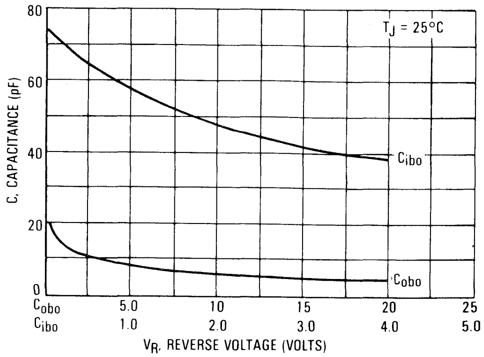
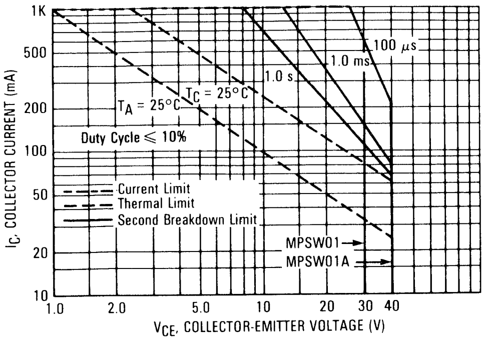


FIGURE 6 — CAPACITANCE



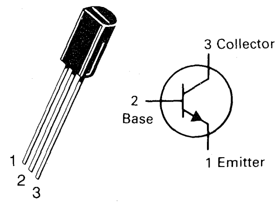
2

FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



MPSW05
MPSW06★

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	MPSW05	MPSW06	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
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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°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, $i_B = 0$)	 MPSW05 MPSW06	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $I_B = 0$) ($V_{CE} = 60$ Vdc, $I_B = 0$)	 MPSW05 MPSW06	I_{CES}	 — —	 0.5 0.5	μAdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$)	 MPSW05 MPSW06	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 ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 80 60	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 250$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.40	Vdc
Base-Emitter Saturation Voltage ($I_C = 250$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)		C_{obo}	—	12	pF

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

FIGURE 1 — D.C. CURRENT GAIN

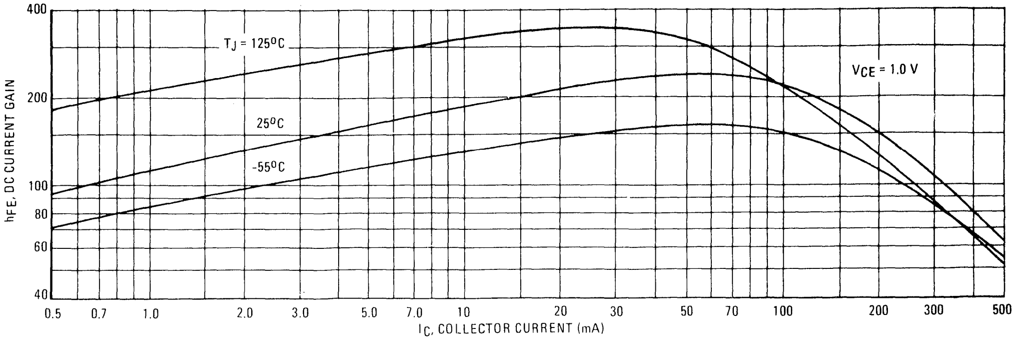


FIGURE 2 — COLLECTOR SATURATION REGION

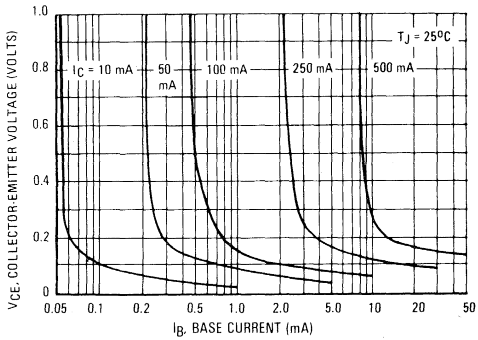


FIGURE 3 — ON VOLTAGES

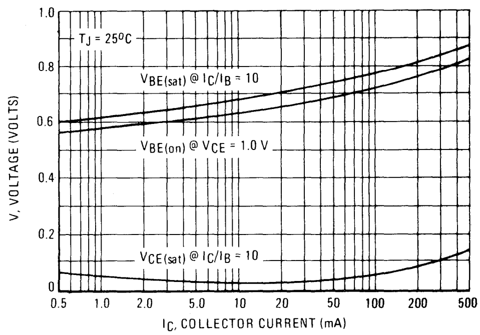


FIGURE 4 — BASE-EMITTER TEMPERATURE COEFFICIENT

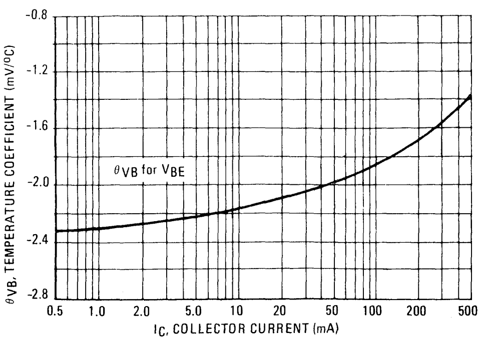


FIGURE 5 — CAPACITANCE

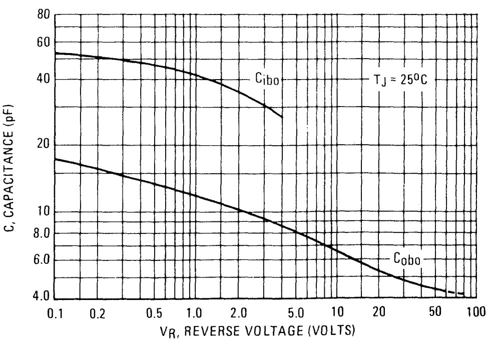


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

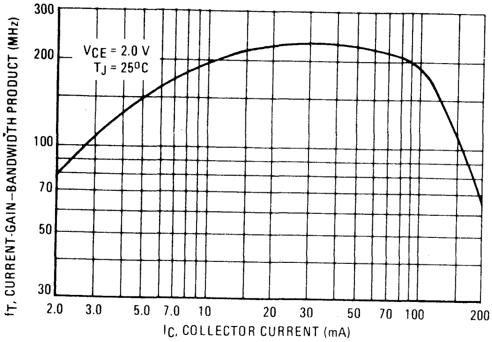
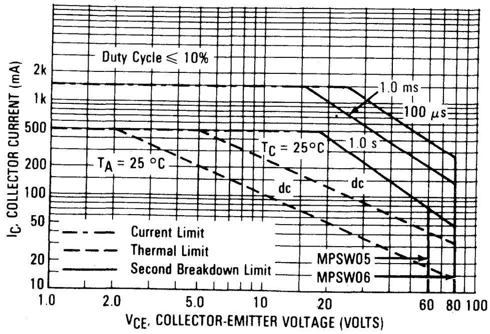


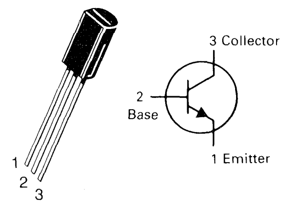
FIGURE 7 — ACTIVE REGION - SAFE OPERATING AREA



2

MPSW10

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT
HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSW42 for graphs.

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}	6.0	Vdc
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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

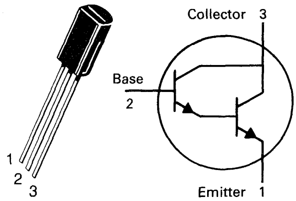
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

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 = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.2	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 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 40	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	—	0.75	Vdc
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	45	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	3.0	pF

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

MPSW13
MPSW14

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT
DARLINGTON TRANSISTORS

NPN SILICON

2

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°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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

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)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	 MPSW13 MPSW14	h_{FE}	 5000 10,000	 — —	—
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MPSW13 MPSW14		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)		$V_{BE(on)}$	—	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

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 1 — ACTIVE REGION SAFE OPERATING AREA

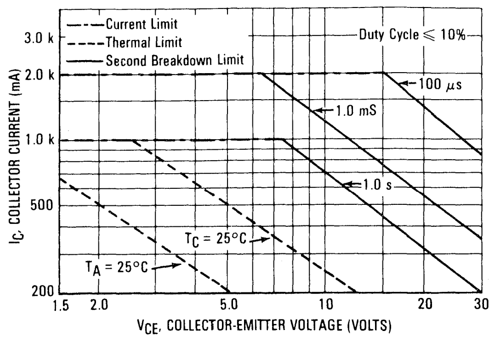


FIGURE 2 — DC CURRENT GAIN

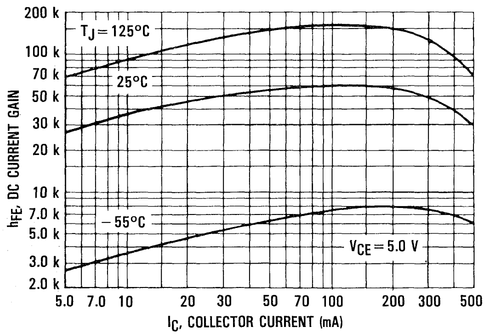


FIGURE 3 — COLLECTOR-SATURATION REGION

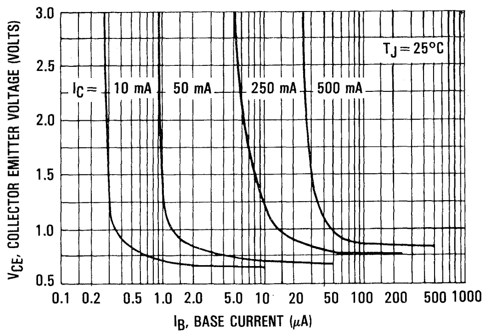


FIGURE 4 — ON VOLTAGES

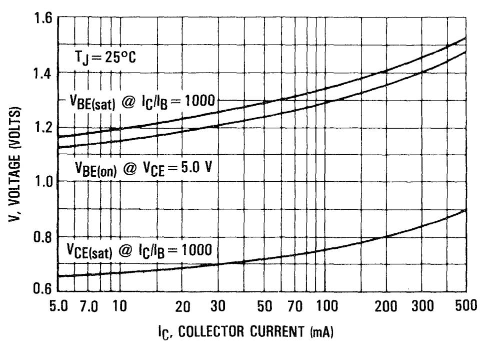


FIGURE 5 — TEMPERATURE COEFFICIENTS

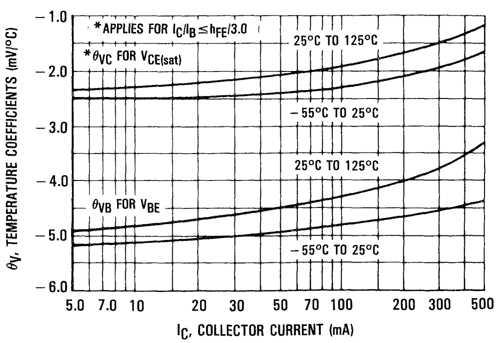


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN

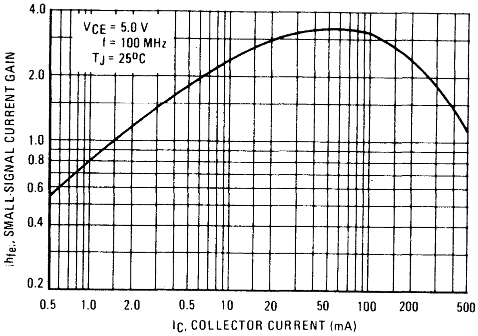
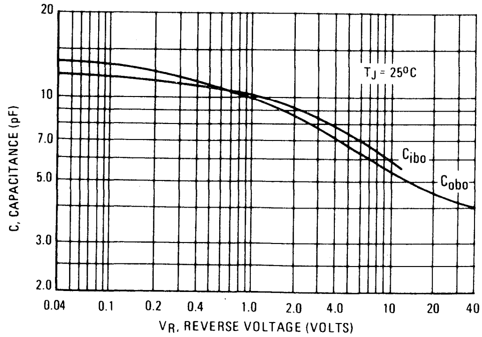


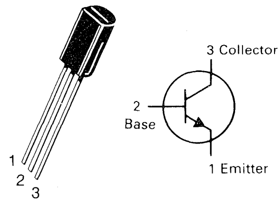
FIGURE 7 — CAPACITANCE



2

MPSW42★

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT HIGH VOLTAGE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

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}	6.0	Vdc
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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°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 = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 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 40	 — — —	—
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
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	3.0	pF

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

2

FIGURE 1 — D.C. CURRENT GAIN

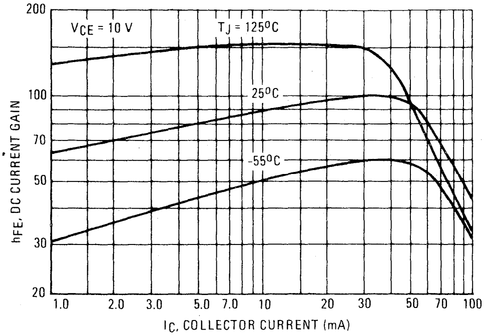


FIGURE 2 — COLLECTOR SATURATION REGION

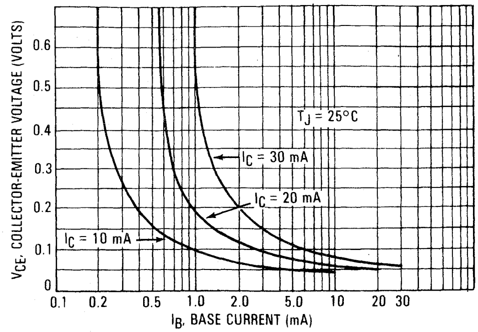


FIGURE 3 — ON VOLTAGES

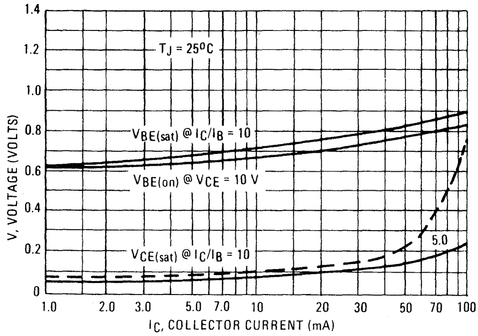


FIGURE 4 — TEMPERATURE COEFFICIENTS

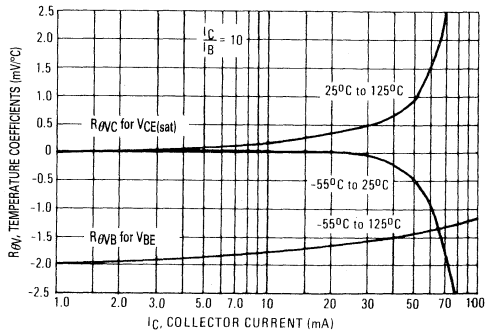


FIGURE 5 — CAPACITANCE

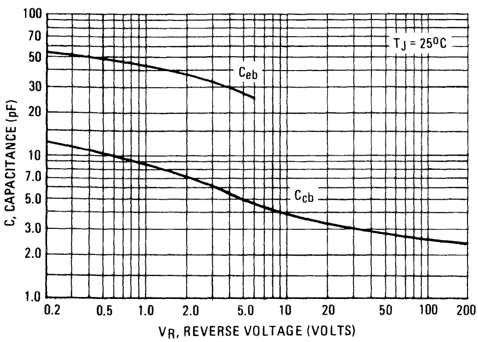
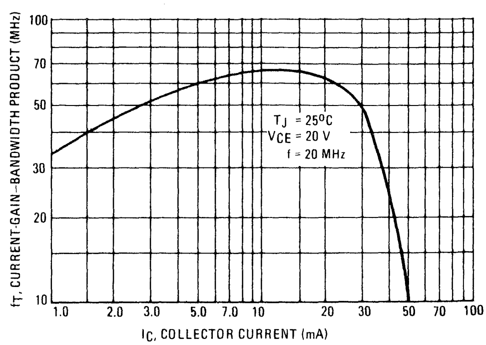
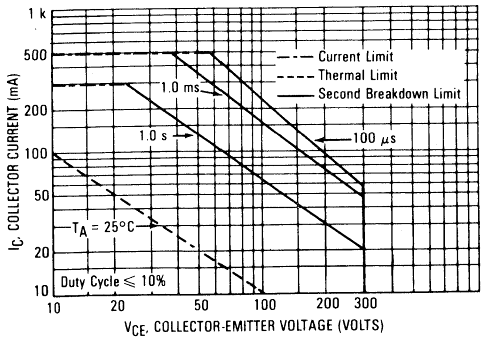


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT



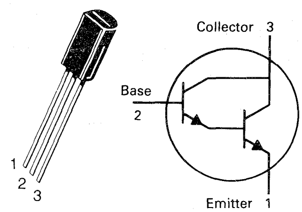
2

FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA



MPSW45,A★

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT DARLINGTON TRANSISTORS

NPN SILICON

★MPSW45A is a Motorola designated preferred device.

Refer to 2N6426 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	MPSW45	MPSW45A	Unit
Collector-Emitter Voltage	V_{CES}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	12	12	Vdc
Collector Current — Continuous	I_C	1.0	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		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	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

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

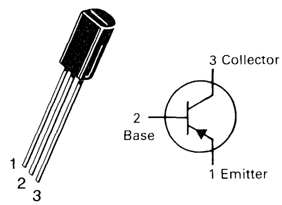
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	 MPSW45 MPSW45A	$V_{(BR)CES}$	 40 50	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPSW45 MPSW45A	$V_{(BR)CBO}$	 50 60	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0)	 MPSW45 MPSW45A	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		h_{FE}	 25,000 15,000 4,000	 150,000 — —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	2.0	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	6.0	pF

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

2

MPSW51,A★

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT
HIGH CURRENT TRANSISTORS

PNP SILICON

★MPSW51A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector-Emitter Voltage	MPSW51 MPSW51A	V_{CEO}	−30 −40	Vdc
Collector-Base Voltage	MPSW51 MPSW51A	V_{CBO}	−40 −50	Vdc
Emitter-Base Voltage		V_{EBO}	−5.0	Vdc
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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°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, $I_B = 0$)	 MPSW51 MPSW51A	$V_{(BR)CEO}$	 −30 −40	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = -100$ μAdc, $I_E = 0$)	 MPSW51 MPSW51A	$V_{(BR)CBO}$	 −40 −50	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = -100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = -30$ Vdc, $I_E = 0$) ($V_{CB} = -40$ Vdc, $I_E = 0$)	 MPSW51 MPSW51A	I_{CBO}	 — —	 −0.1 −0.1	μAdc
Emitter Cuttoff Current ($V_{EB} = -3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	−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) ($I_C = -1000$ 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	Vdc
Base-Emitter On Voltage ($I_C = -1000$ mAdc, $V_{CE} = -1.0$ Vdc)		$V_{BE(on)}$	—	−1.2	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 = 1.0 MHz)		C_{obo}	—	30	pF

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

FIGURE 1 — DC CURRENT GAIN

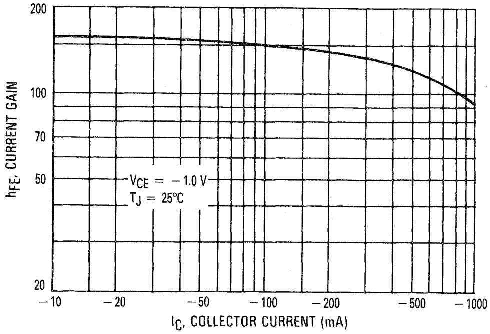


FIGURE 2 — COLLECTOR SATURATION REGION

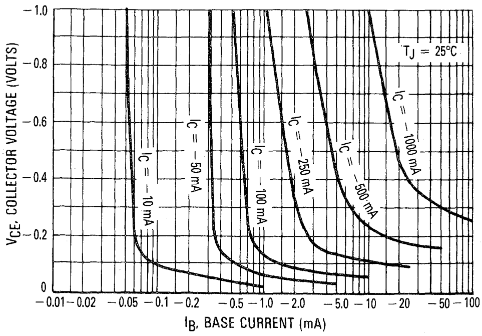


FIGURE 3 — ON VOLTAGES

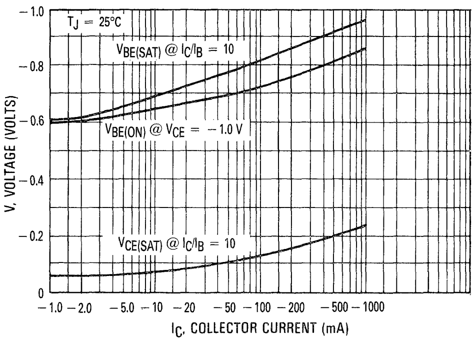


FIGURE 4 — TEMPERATURE COEFFICIENT

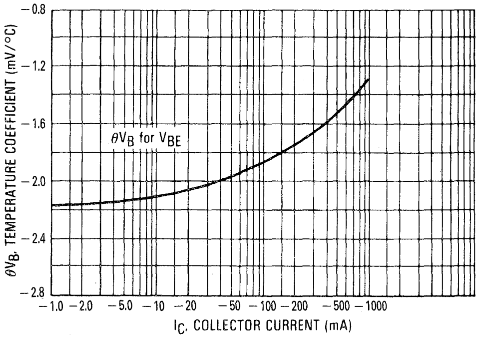


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

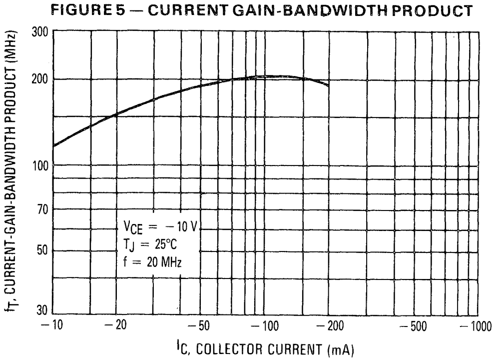
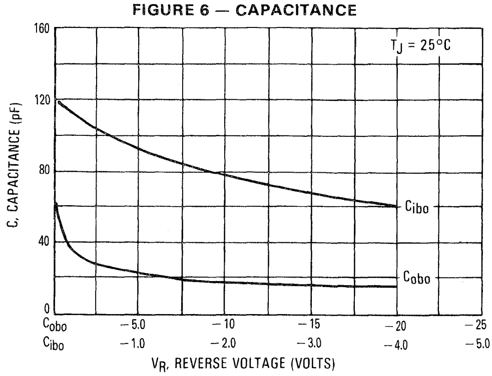
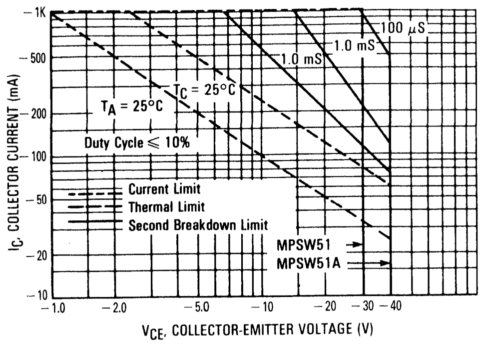


FIGURE 6 — CAPACITANCE



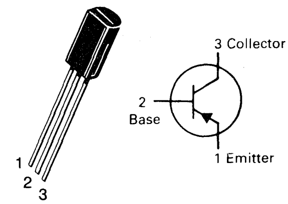
2

FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



MPSW55
MPSW56★

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPSW55	MPSW56	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
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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°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)	 MPSW55 MPSW56	$V_{(BR)CEO}$	 −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} = −40 Vdc, I_B = 0) (V_{CE} = −60 Vdc, I_B = 0)	 MPSW55 MPSW56	I_{CES}	 — —	 −0.5 −0.5	μAdc
Collector Cutoff Current (V_{CB} = −40 Vdc, I_E = 0) (V_{CB} = −60 Vdc, I_E = 0)	 MPSW55 MPSW56	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 = −50 mAdc, V_{CE} = −1.0 Vdc) (I_C = −250 mAdc, V_{CE} = −1.0 Vdc)		h_{FE}	 100 50	 — —	—
Collector-Emitter Saturation Voltage (I_C = −250 mAdc, I_B = −10 mAdc)		$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter On Voltage (I_C = −250 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	—	−1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −250 mAdc, V_{CE} = −5.0 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, f = 1.0 MHz)		C_{obo}	—	15	pF

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

2

FIGURE 1 — D.C. CURRENT GAIN

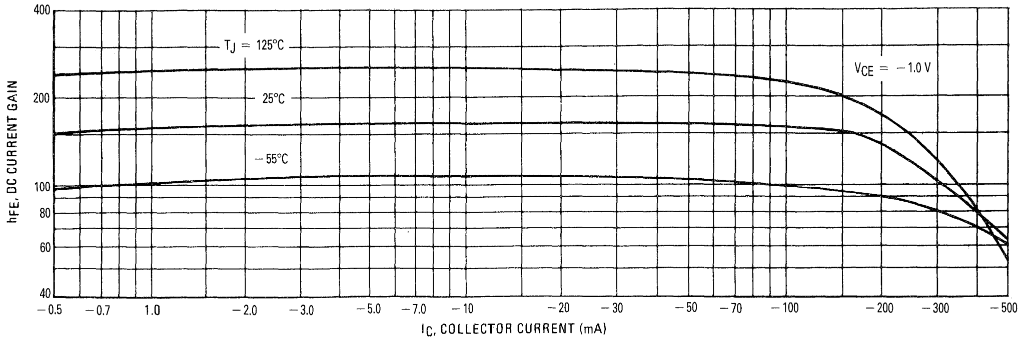


FIGURE 2 — COLLECTOR SATURATION REGION

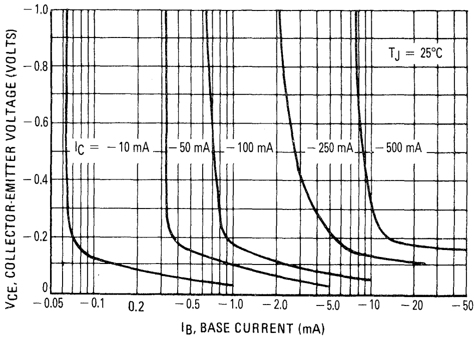


FIGURE 3 — ON VOLTAGES

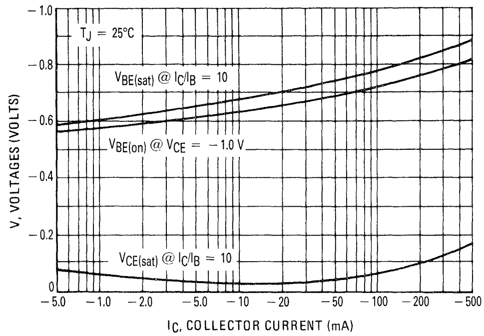


FIGURE 4 — BASE-EMITTER TEMPERATURE COEFFICIENT

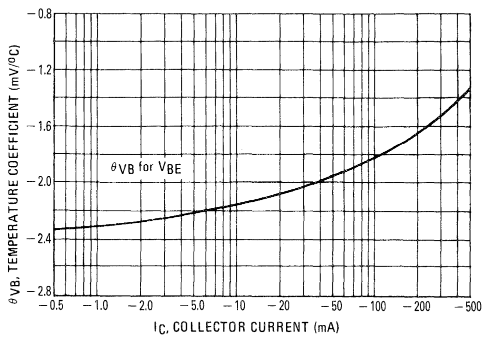


FIGURE 5 — CAPACITANCE

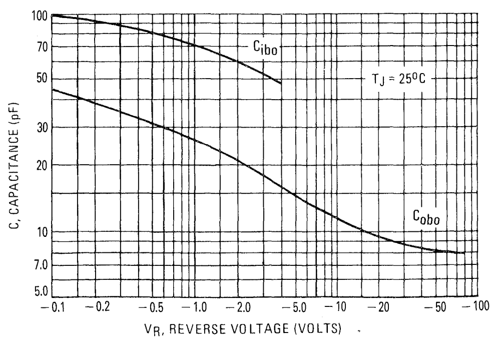


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

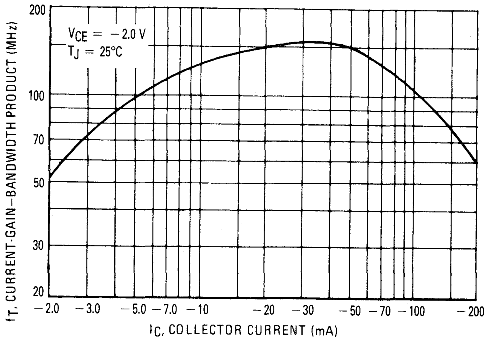
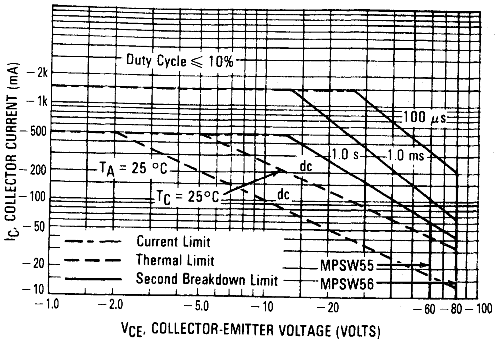


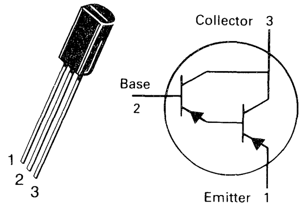
FIGURE 7 — ACTIVE REGION - SAFE OPERATING AREA



2

MPSW63
MPSW64★

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT
DARLINGTON TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

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	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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = -100$ μAdc, $V_{BE} = 0$)		$V_{(BR)CES}$	−30	—	Vdc
Collector Cutoff Current ($V_{CB} = -30$ Vdc, $I_E = 0$)		I_{CBO}	—	−100	nAdc
Emitter Cutoff Current ($V_{EB} = -10$ Vdc, $I_C = 0$)		I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = -10$ mAdc, $V_{CE} = -5.0$ Vdc)	 MPSW63 MPSW64	h_{FE}	 5,000 10,000	 — —	—
($I_C = -100$ mAdc, $V_{CE} = -5.0$ Vdc)	MPSW63 MPSW64		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)		$V_{BE(on)}$	—	−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

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

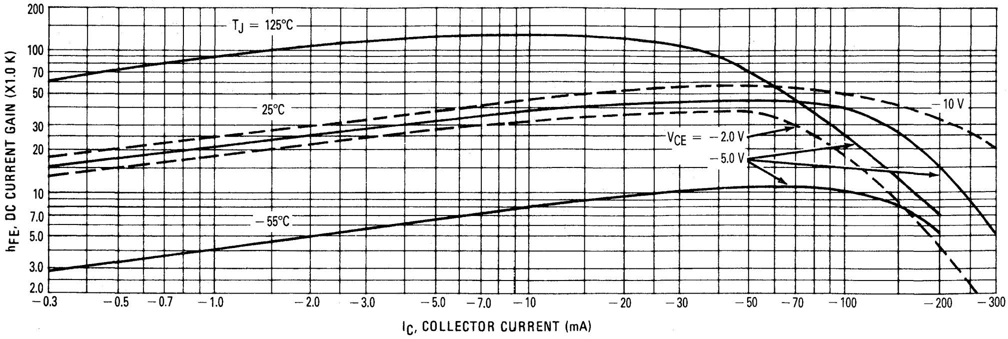


FIGURE 2 — "ON" VOLTAGE

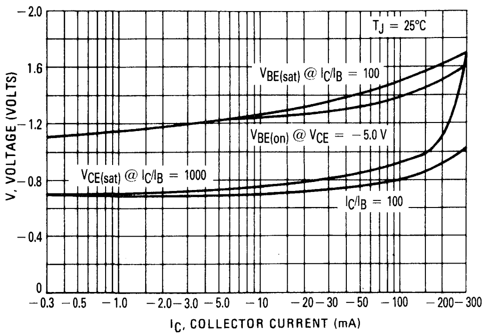


FIGURE 3 — COLLECTOR SATURATION REGION

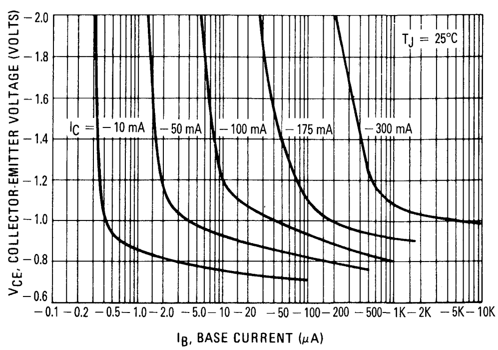


FIGURE 4 — TEMPERATURE COEFFICIENTS

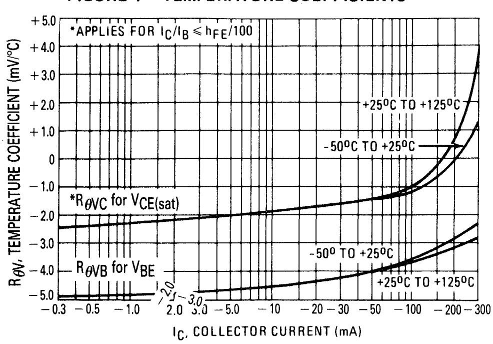
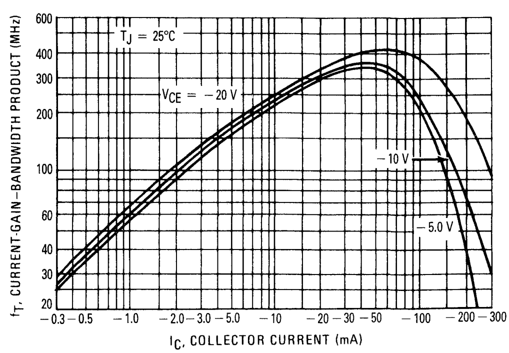


FIGURE 5 — CURRENT-GAIN—BANDWIDTH PRODUCT



2

FIGURE 6 — CAPACITANCE

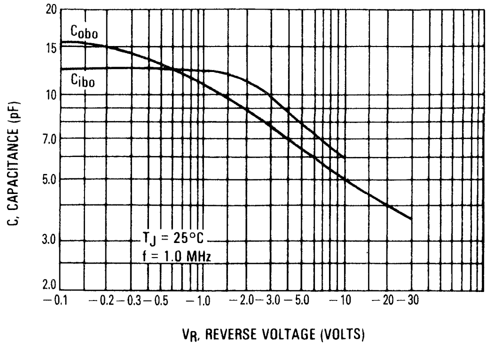
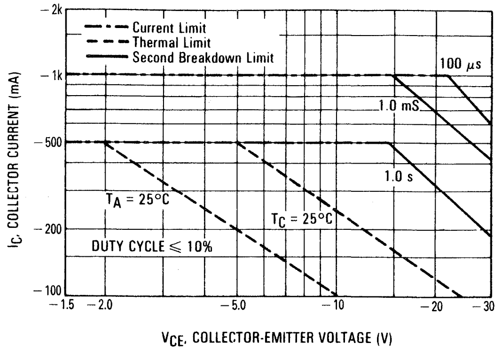


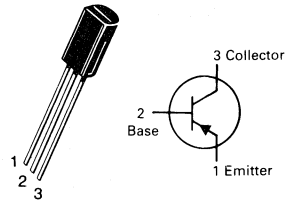
FIGURE 7 — ACTIVE REGION, SAFE OPERATING AREA



2

MPSW92★

CASE 29-05, STYLE 1
TO-92 (TO-226AE)



ONE WATT HIGH VOLTAGE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

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	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 Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°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 ($I_E = -100$ 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
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)	h_{FE}	 25 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
Collector-Base Capacitance ($V_{CB} = -20$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	6.0	pF

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

2

FIGURE 1 — D.C. CURRENT GAIN

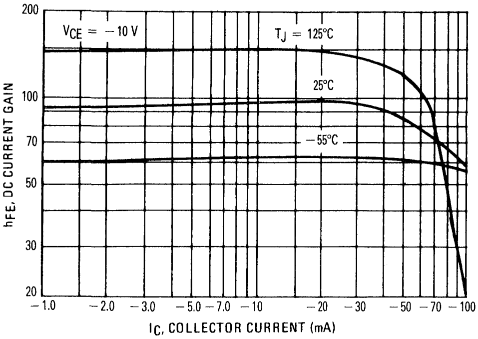


FIGURE 2 — COLLECTOR SATURATION REGION

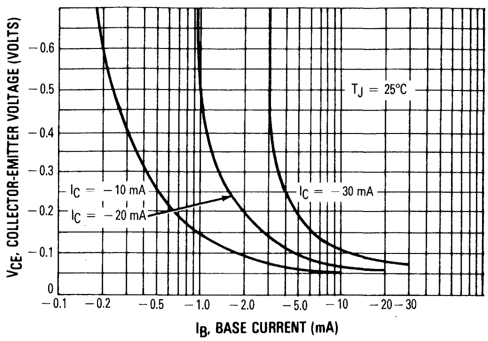


FIGURE 3 — ON VOLTAGES

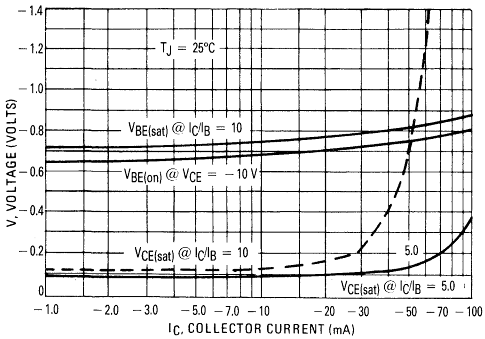


FIGURE 4 — TEMPERATURE COEFFICIENTS

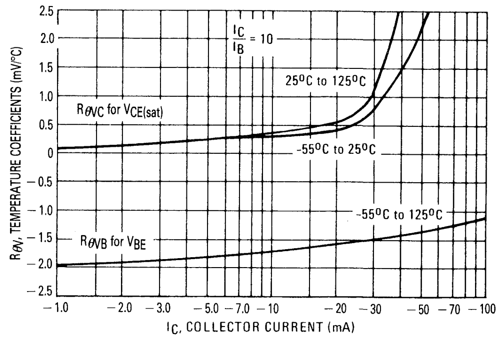


FIGURE 5 — CAPACITANCE

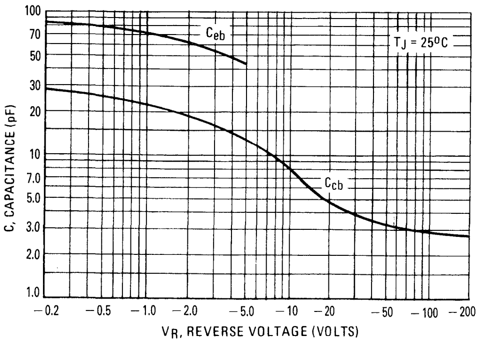


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

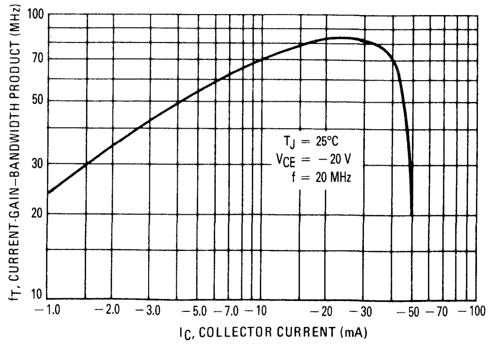
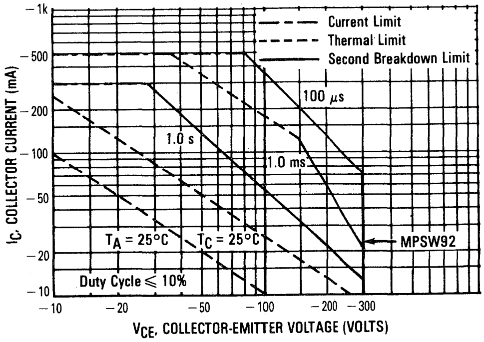


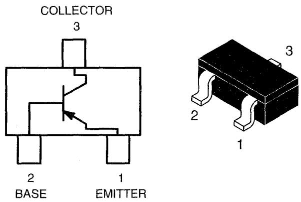
FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA



2

MSA1022-BT1★
MSA1022-CT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
PNP RF AMPLIFIER
TRANSISTORS
SURFACE MOUNT

★**These are Motorola designated preferred devices.**

2

MAXIMUM RATINGS ($T_A = 25°C$)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	–30	V
Collector-Emitter Voltage	V_{CEO}	–20	V
Emitter-Base Voltage	V_{EBO}	–5	V
Collector Current-Continuous	I_C	–30	mA

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

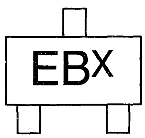
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector Cutoff Current	I_{CBO}	$V_{CB} = -10$ V, $I_E = 0$	—	– 0.1	µA
Collector-Emitter Breakdown Voltage	I_{CEO}	$V_{CE} = -20$ V, $I_B = 0$	—	–100	µA
Emitter-Base Breakdown Voltage	I_{EBO}	$V_{EB} = -5$ V, $I_C = 0$	—	–10	µA
DC Current Gain	h_{FE}*	$V_{CE} = -10$ V, $I_C = -1$ mA			
		MSA1022-BT1	70	140	—
		MSA1022-CT1	110	220	—
Current-Gain — Bandwidth Product	f_T	$V_{CB} = -10$ V, $I_E = 1$ mA	150	—	MHz

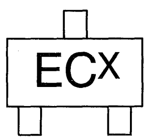
*Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSA1022-BT1

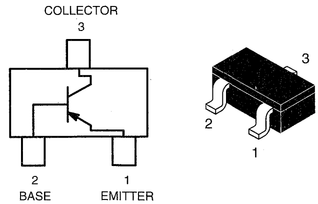


MSA1022-CT1

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSB709-RT1★
MSB709-ST1

CASE 318D-03, STYLE 1



SC-59 PACKAGE
PNP GENERAL PURPOSE
AMPLIFIER TRANSISTORS
SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	–25	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	–25	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	–7	Vdc
Collector Current-Continuous	I_C	–100	mAdc
Collector Current-Peak	$I_{C(P)}$	–200	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

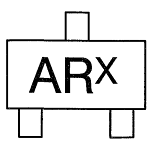
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = –2.0 mA, I_B = 0	–25	–	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = –10 μA, I_E = 0	–25	–	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = –10 μA, I_E = 0	–7	–	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = –20 V, I_E = 0	–	–0.1	μA
Collector-Emitter Cutoff Current	I_{CEO}	V_{CE} = –10 V, I_B = 0	–	–100	μA
DC Current Gain	h_{FE1}*	V_{CE} = –10 V, I_C = –2.0 mA MSB709-RT1 MSB709-ST1	 210 290	 340 460	 – –
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = –100 mA, I_B = –10 mA	–	–0.5	Vdc

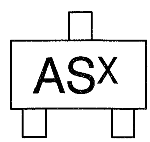
*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSB709-RT1

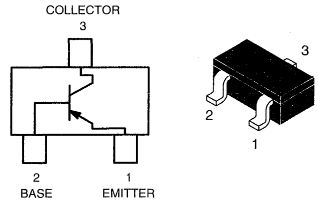


MSB709-ST1

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSB710-QT1
MSB710-RT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
PNP GENERAL PURPOSE
AMPLIFIER TRANSISTORS
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	–30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	–25	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	–7	Vdc
Collector Current-Continuous	I_C	–500	mAdc
Collector Current-Peak	$I_{C(P)}$	–1	Adc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

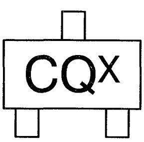
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = –10 mA, I_B = 0	–25	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = –10 µA, I_E = 0	–30	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = –10 µA, I_C = 0	–7	—	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = –20 V, I_E = 0	—	–0.1	µA
DC Current Gain	h_{FE1}*	V_{CE} = –10 V, I_C = –150 mA			
		MSB710-QT1	85	170	—
		MSB710-RT1	120	240	—
	h_{FE2}*	V_{CE} = –10 V, I_C = 500 mA	40	—	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = –300 mA, I_B = –30 mA	—	–0.6	Vdc
Collector-Base Saturation Voltage	$V_{BE(sat)}$	I_C = –300 mA, I_B = –30 mA	—	–1.5	Vdc
Output Capacitance	C_{ob}	V_{CB} = –10 V, I_E = 0, f = 1.0 MHz	—	15	pF

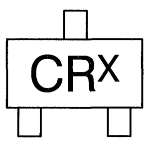
*Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSB710-QT1

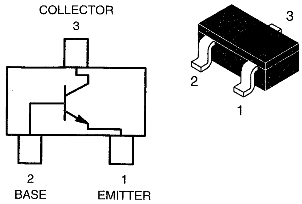


MSB710-RT1

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSC1621T1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE NPN SWITCHING TRANSISTOR SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current-Continuous	I_C	200	mA

THERMAL CHARACTERISTICS

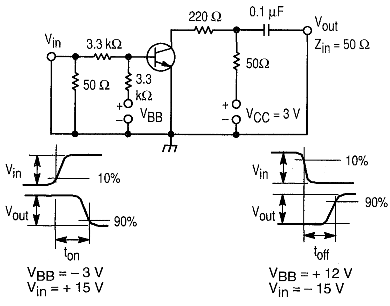
Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

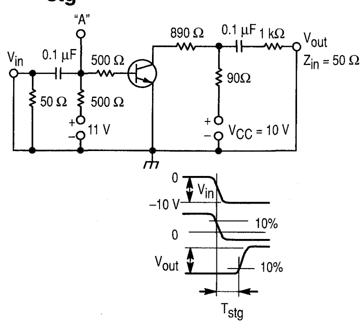
Characteristic	Symbol	Condition	Min	Max	Unit
Collector Cutoff Current	I_{CBO}	V_{CB} = 30 V, I_E = 0	—	0.1	μA
Emitter Base Cutoff Current	I_{EBO}	V_{EB} = 4.0 V, I_C = 0	—	0.1	μA
DC Current Gain	h_{FE}*	V_{CE} = 0.5 V, I_C = 1 mA	40	180	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 10 mA, I_B = 1.0 mA	—	0.25	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 10 mA, I_B = 1.0 mA	—	0.85	V
Current-Gain — Bandwidth Product	f_T	V_{CE} = 10 V, I_E = –10 mA	200	—	MHz
Output Capacitance	C_{ob}	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz	—	6.0	pF
Turn On Time	t_{on}	I_C = 10 mA in Equivalent Test Circuit	—	20	ns
Storage Temperature Range	T_{stg}		—	20	ns
Turn Off Time	t_{off}		—	40	ns

*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

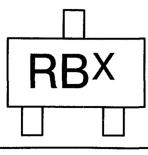
t_{on}, t_{off} EQUIVALENT TEST CIRCUIT



T_{stg} EQUIVALENT TEST CIRCUIT



Marking Symbol



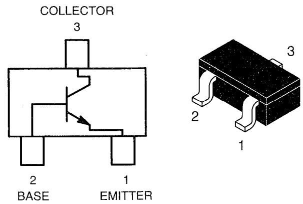
DEVICE MARKING

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

2

MSC2295-BT1★
MSC2295-CT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN RF AMPLIFIER
TRANSISTORS
SURFACE MOUNT

★These are Motorola designated preferred devices.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	20	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	5	Vdc
Collector Current-Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

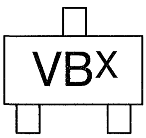
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = 10 V, I_E = 0	—	0.1	μA
DC Current Gain	h_{FE}*	V_{CB} = 10 V, I_E = –1 mA MSC2295-BT1 MSC2295-CT1	 70 110	 140 220	 — —
Collector-Gain — Bandwidth Product	f_T	V_{CB} = 10 V, I_E = –1 mA	150	—	MHz
Reverse Transistor Capacitance	C_{re}	V_{CE} = 10 V, I_C = 1 mA, f = 10.7 MHz	—	1.5	pF

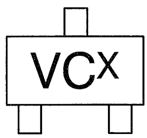
*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSC2295-BT1

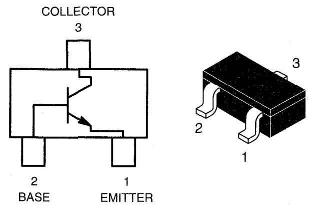


MSC2295-CT1

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSC2404-CT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN RF AMPLIFIER
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	20	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	3	Vdc
Collector Current-Continuous	I_C	15	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	150	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

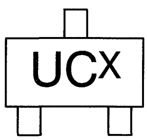
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 10 μA, I_E = 0	30	—	Vdc
Collector Emitter Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 μA, I_C = 0	3	—	Vdc
DC Current Gain	h_{FE}*	V_{CB} = 6 V, I_E = –1 mA	65	160	—
Current-Gain — Bandwidth Product	f_T	V_{CB} = 6 V, I_E = –1 mA	450	—	MHz
Reverse Transfer Capacitance	C_{re}	V_{CE} = 6 V, I_C = 1 mA, f = 10.7 MHz	—	1	pF

*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol

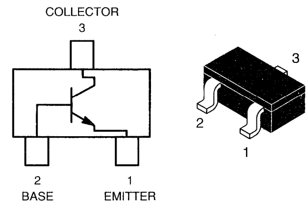


The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

2

MSC3130T1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN RF AMPLIFIER
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	15	V
Collector-Emitter Voltage	V_{CEO}	10	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current-Continuous	I_C	50	mA

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

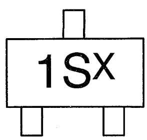
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 V, I_E = 0	—	1	µA
Collector-Emitter Breakdown Voltage	V_{CEO}	I_C = 2 mA, I_B = 0	10	—	V
Emitter-Base Breakdown Voltage	V_{EBO}	I_E = 10 µA, I_C = 0	3	–	V
DC Current Gain	h_{FE}*	V_{CE} = 4 V, I_C = 5 mA	75	400	–
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 20 mA, I_B = 4 mA	–	0.5	V
Current-Gain — Bandwidth Product	f_T	V_{CB} = 4 V, I_E = –5 mA	1.4	2.5	GHz

*Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

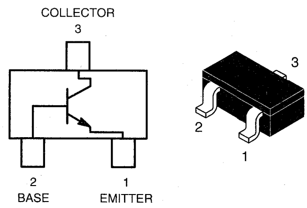
Marking Symbol



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSD601-RT1★
MSD601-ST1

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN GENERAL PURPOSE
AMPLIFIER TRANSISTORS
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	25	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	7	Vdc
Collector Current-Continuous	I_C	100	mAdc
Collector Current-Peak	$I_{C(P)}$	200	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

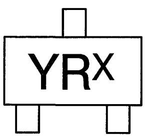
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 2.0 mA, I_B = 0	25	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 10 μA, I_E = 0	30	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 μA, I_C = 0	7	—	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = 20 V, I_E = 0	—	0.1	μA
Collector-Emitter Cutoff Current	I_{CEO}	V_{CE} = 10 V, I_B = 0	—	100	μA
DC Current Gain	h_{FE1}*	V_{CE} = 10 V, I_C = 2.0 mA			
		MSD601-RT1	210	340	—
		MSD601-ST1	290	460	—
	h_{FE2}*	V_{CE} = 2.0 V, I_C = 100 mA	90	—	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 100 mA, I_B = 10 mA	—	0.5	Vdc

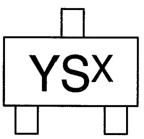
*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSD601-RT1

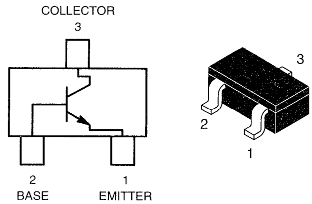


MSD601-ST1

The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSD602-RT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN GENERAL PURPOSE
AMPLIFIER TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	25	Vdc
Emitter-Base Voltage	$V_{E(BR)BO}$	7	Vdc
Collector Current-Continuous	I_C	500	mAdc
Collector Current-Peak	$I_{C(P)}$	1	Adc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

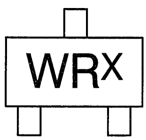
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 10 mA, I_B = 0	25	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 10 µA, I_E = 0	30	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 µA, I_C = 0	7	—	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = 20 V, I_E = 0	—	0.1	µA
DC Current Gain	h_{FE1}*	V_{CE} = 10 V, I_C = 150 mA	120	240	—
	h_{FE2}*	V_{CE} = 10 V, I_C = 500 mA	40	—	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 300 mA, I_B = 30 mA	—	0.6	Vdc
Output Capacitance	C_{ob}	V_{CB} = 10 V, I_E = 0, f = 1 MHz	—	15	pF

*Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

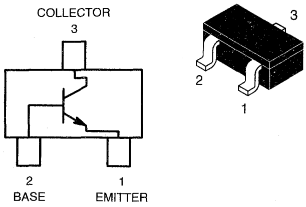
Marking Symbol



The “X” represents a smaller alpha digit Date Code. The Date Code indicate the actual month in which the part was manufactured.

MSD1328-RT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN LOW VOLTAGE
OUTPUT AMPLIFIER
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	25	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	20	Vdc
Emitter-Base Voltage	$V_{E(BR)BO}$	12	Vdc
Collector Current-Continuous	I_C	500	mAdc
Collector Current-Peak	$I_{C(P)}$	1000	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

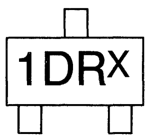
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 1.0 mA, I_B = 0	20	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 10 μA, I_E = 0	25	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 μA, I_E = 0	12	—	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = 25 V, I_E = 0	—	0.1	μA
DC Current Gain	h_{FE}*	V_{CE} = 2 V, I_C = 500 mA	200	350	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 500 mA, I_B = 20 mA	—	0.4	Vdc
Base–Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 500 mA, I_B = 50 mA	—	1.2	Vdc

*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MMUN2111T1
MMUN2112T1
MMUN2113T1
MMUN2114T1
Motorola Preferred Devices

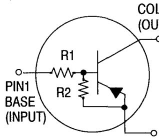
2

Bias Resistor Transistor

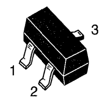
PNP Silicon Surface Mount Transistor With Monolithic Bias Resistor Network

This new series of digital transistors is designed to replace a single device and its external resistor bias network. The BRT (Bias Resistor Transistor) contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base-emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space. The device is housed in the SOT-23 package which is designed for low power surface mount applications.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- The SOT-23 package can be soldered using wave or reflow. The modified gull-winged leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 8 mm embossed tape and reel
  Use the Device Number to order the 7 inch/3000 unit reel. Replace "T1" with "T3" in the Device Number to order the 13 inch/10,000 unit reel.



PNP SILICON BIAS RESISTOR TRANSISTOR



CASE 318-07, STYLE 6
SOT-23 (TO-236AB)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	200 1.6	mW mW/°C

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	625	°C/W
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +150	°C
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

DEVICE MARKING AND RESISTOR VALUES

Device	Marking	R1 (K)	R2 (K)
MMUN2111T1	A6A	10	10
MMUN2112T1	A6B	22	22
MMUN2113T1	A6C	47	47
MMUN2114T1	A6D	10	47

* Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0)		I_{CBO}	—	—	100	nAdc
Collector-Emitter Cutoff Current (V_{CE} = 50 V, I_B = 0)		I_{CEO}	—	—	500	nAdc
Emitter-Base Cutoff Current (V_{EB} = 6.0 V, I_C = 0)	MMUN2111T1	I_{EBO}	—	—	0.5	mAdc
	MMUN2112T1		—	—	0.2	
	MMUN2113T1		—	—	0.1	
	MMUN2114T1		—	—	0.2	
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS*						
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA)	MMUN2111T1	h_{FE}	35	60	—	
	MMUN2112T1		60	100	—	
	MMUN2113T1		80	140	—	
	MMUN2114T1		80	140	—	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_E = 0.3 mA)		$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (on)		V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ)	MMUN2111T1		—	—	0.2	
	MMUN2112T1		—	—	0.2	
	MMUN2114T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MMUN2113T1		—	—	0.2	
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
Input Resistor	MMUN2111T1	R1	7.0	10	13	k Ω
	MMUN2112T1		15.4	22	28.6	
	MMUN2113T1		32.9	47	61.1	
	MMUN2114T1		7.0	10	13	
Resistor Ratio	MMUN2111T1/MMUN2112T1/MMUN2113T1	R_1/R_2	0.8	1.0	1.2	
	MMUN2114T1		0.17	0.21	0.25	

* Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

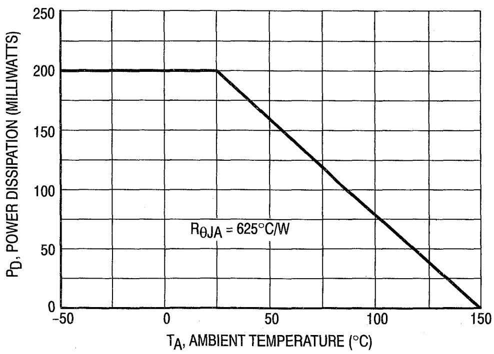


Figure 1. Derating Curve

2

TYPICAL ELECTRICAL CHARACTERISTICS — MMUN2111T1

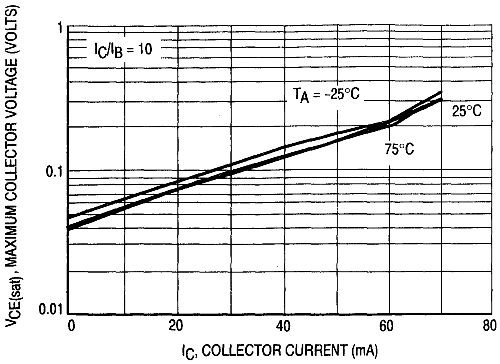


Figure 2. $V_{CE(sat)}$ versus I_C

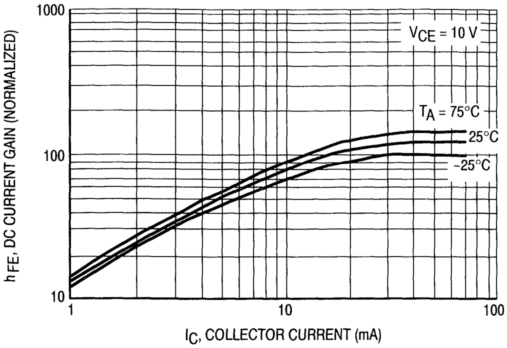


Figure 3. DC Current Gain

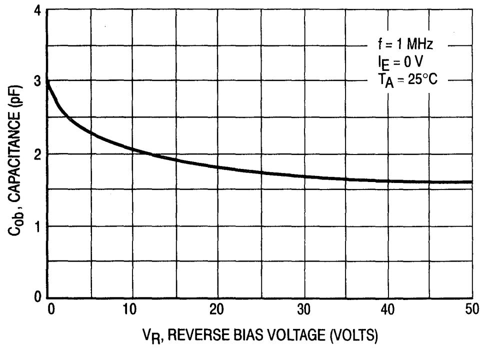


Figure 4. Output Capacitance

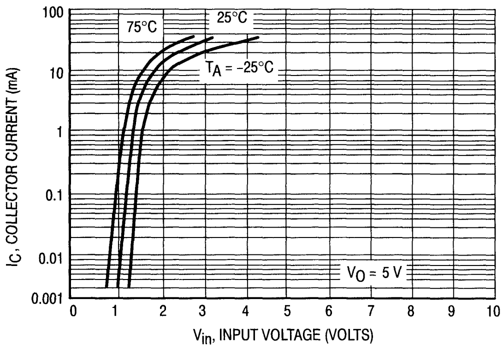


Figure 5. Output Current versus Input Voltage

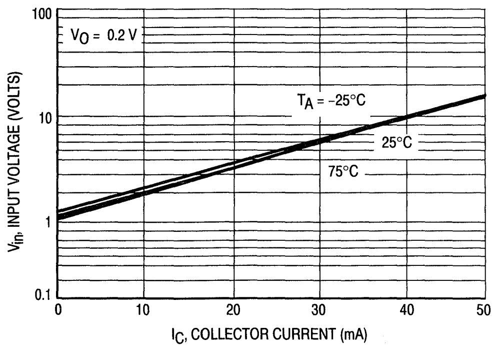


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MMUN2112T1

2

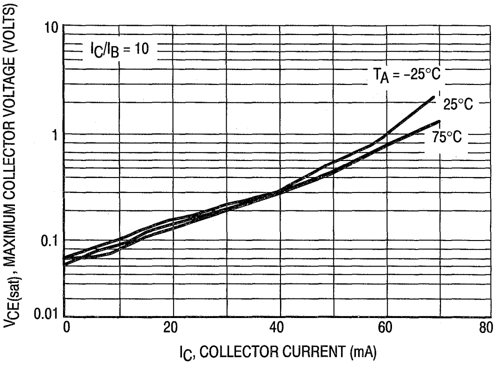


Figure 7. $V_{CE(sat)}$ versus I_C

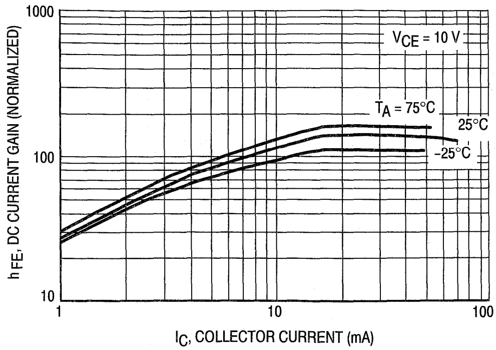


Figure 8. DC Current Gain

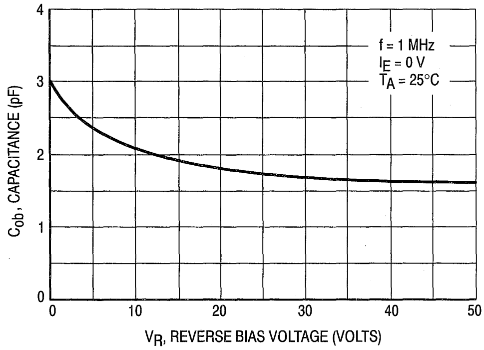


Figure 9. Output Capacitance

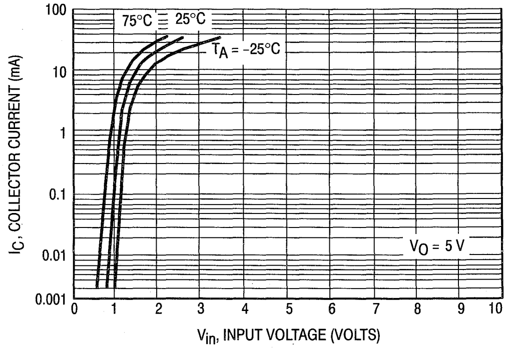


Figure 10. Output Current versus Input Voltage

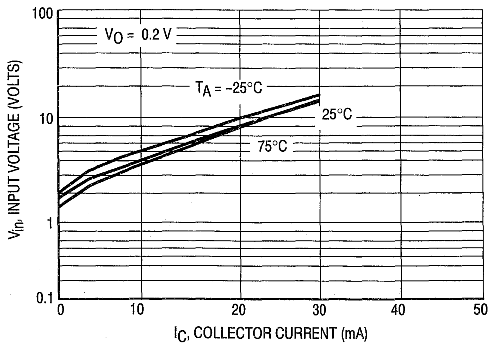


Figure 11. Input Voltage versus Output Current

2

TYPICAL ELECTRICAL CHARACTERISTICS — MMUN2113T1

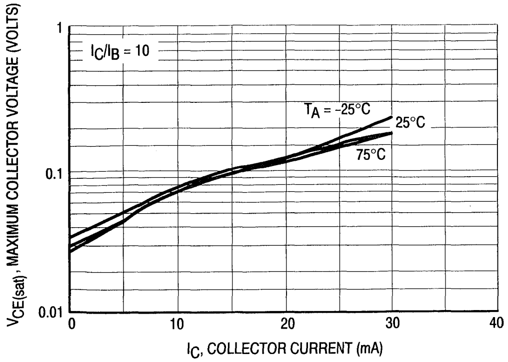


Figure 12. $V_{CE(sat)}$ versus I_C

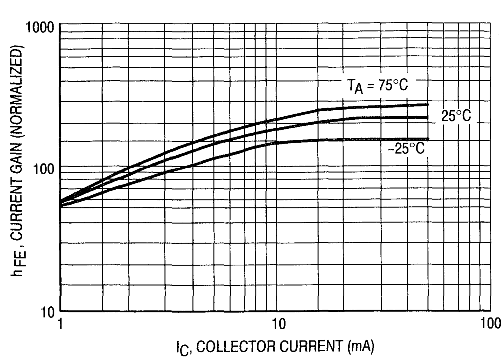


Figure 13. DC Current Gain

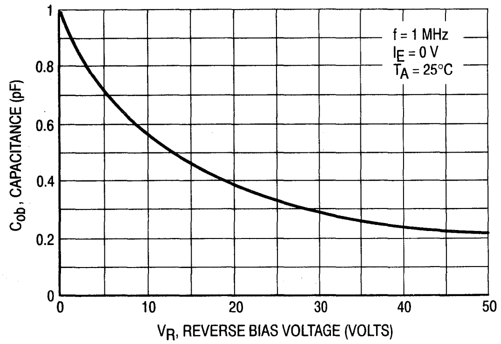


Figure 14. Output Capacitance

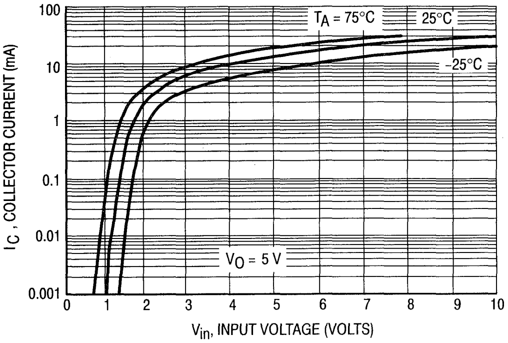


Figure 15. Output Current versus Input Voltage

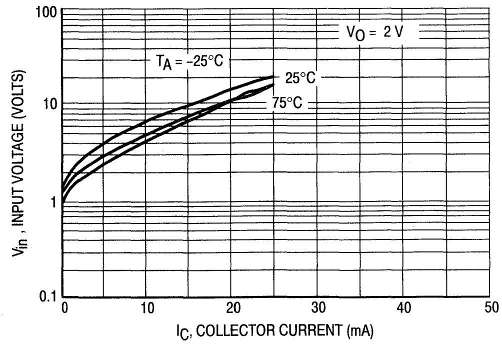


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MMUN2114T1

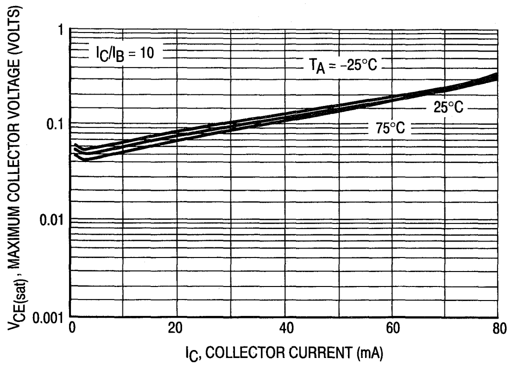


Figure 17. $V_{CE(sat)}$ versus I_C

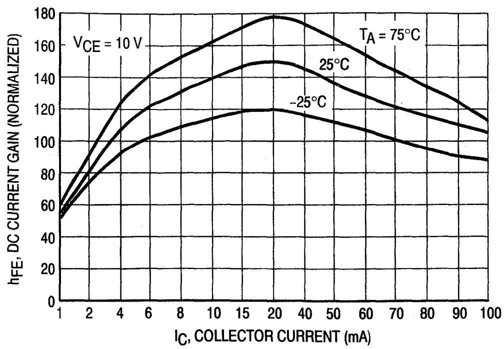


Figure 18. DC Current Gain

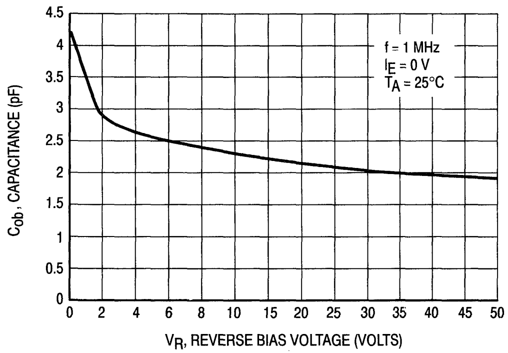


Figure 19. Output Capacitance

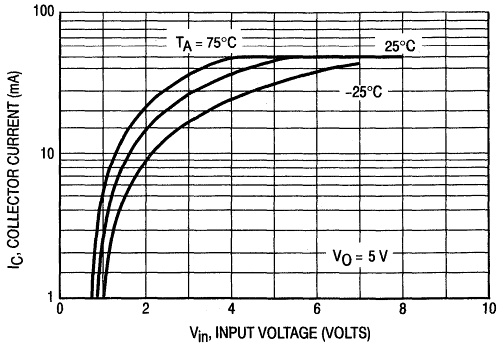


Figure 20. Output Current versus Input Voltage

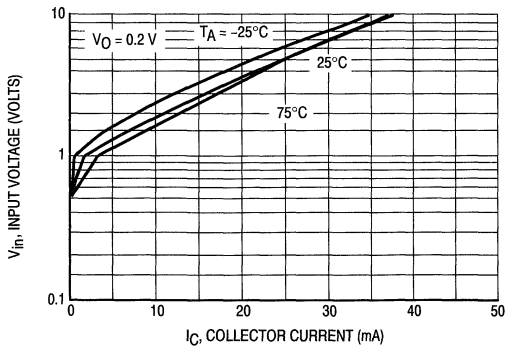


Figure 21. Input Voltage versus Output Current

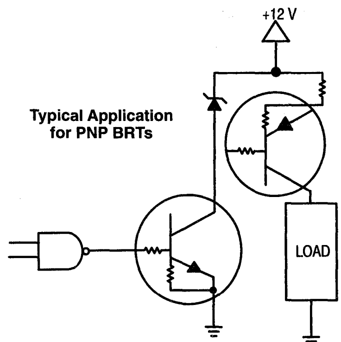


Figure 22. Inexpensive, Unregulated Current Source

2

Bias Resistor Transistor

NPN Silicon Surface Mount Transistor With Monolithic Bias Resistor Network

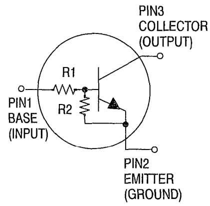
MMUN2211T1
MMUN2212T1
MMUN2213T1
MMUN2214T1

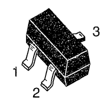
Motorola Preferred Devices

NPN SILICON BIAS RESISTOR TRANSISTOR

This new series of digital transistors is designed to replace a single device and its internal resistor bias network. The BRT (Bias Resistor Transistor) contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base-emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space. The device is housed in the SOT-23 package which is designed for low power surface mount applications.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- The SOT-23 package can be soldered using wave or reflow. The modified gull-winged leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 8 mm embossed tape and reel
  Use the Device Number to order the 7 inch/3000 unit reel.
  Replace "T1" with "T3" in the Device Number to order the 13 inch/10,000 unit reel.





CASE 318-07, STYLE 6
SOT-23 (TO-236AB)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	200 1.6	mW mW/°C

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	625	°C/W
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +150	°C
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

DEVICE MARKING AND RESISTOR VALUES

Device	Marking	R1 (K)	R2 (K)
MMUN2211T1	A8A	10	10
MMUN2212T1	A8B	22	22
MMUN2213T1	A8C	47	47
MMUN2214T1	A8D	10	47

* Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0)		I_{CBO}	—	—	100	nAdc
Collector-Emitter Cutoff Current (V_{CE} = 50 V, I_B = 0)		I_{CEO}	—	—	500	nAdc
Emitter-Base Cutoff Current (V_{EB} = 6.0 V, I_C = 0)	MMUN2211T1 MMUN2212T1 MMUN2213T1 MMUN2214T1	I_{EBO}	— — — —	— — — —	0.5 0.2 0.1 0.2	mAdc
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS*						
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA)	MMUN2211T1 MMUN2212T1 MMUN2213T1 MMUN2214T1	h_{FE}	35 60 80 80	60 100 140 140	— — — —	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA)		$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (ON) (V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ)	MMUN2211T1 MMUN2212T1 MMUN2214T1	V_{OL}	— — —	— — —	0.2 0.2 0.2	Vdc
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MMUN2213T1	V_{OL}	—	—	0.2	
Output Voltage (OFF) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
Input Resistor	MMUN2211T1 MMUN2212T1 MMUN2213T1 MMUN2214T1	R1	7.0 15.4 32.9 7.0	10 22 47 10	13 28.6 61.1 13	k Ω
Resistor Ratio	MMUN2211T1/MMUN2212T1/MMUN2213T1 MMUN2214T1	R1/R2	0.8 0.17	1.0 0.21	1.2 0.25	

* Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

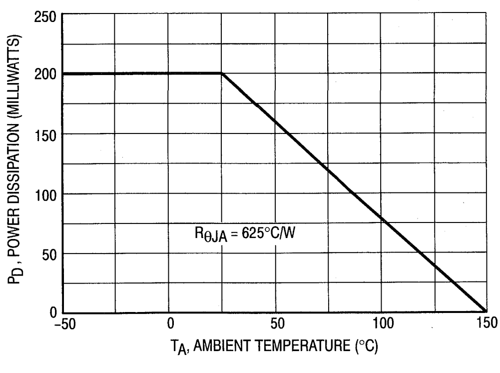


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MMUN2211T1

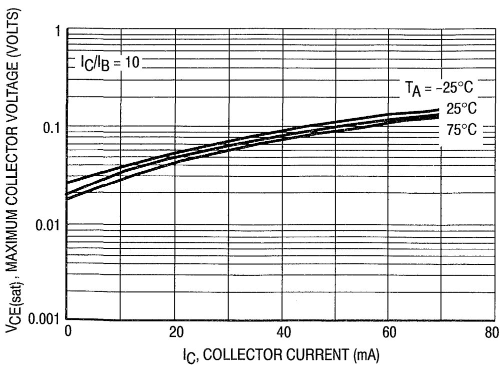


Figure 2. $V_{CE(sat)}$ versus I_C

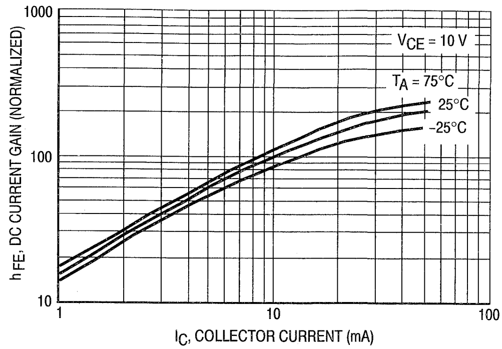


Figure 3. DC Current Gain

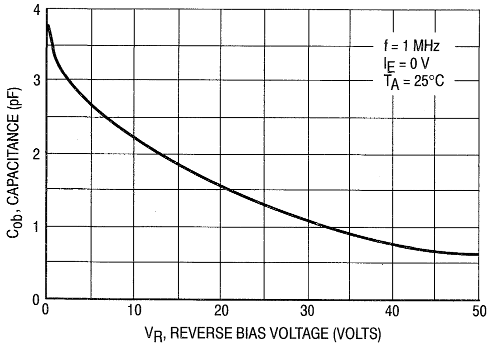


Figure 4. Output Capacitance

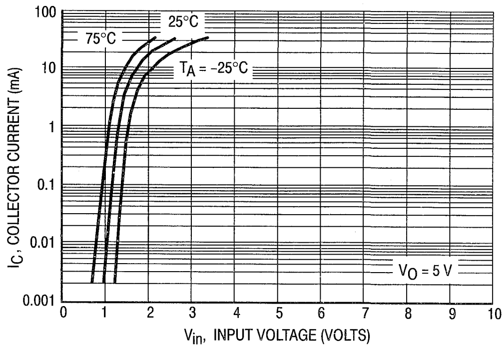


Figure 5. Output Current versus Input Voltage

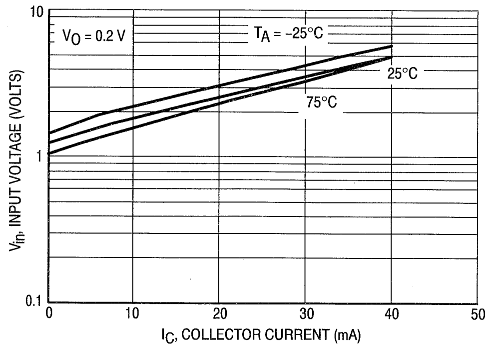


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MMUN2212T1

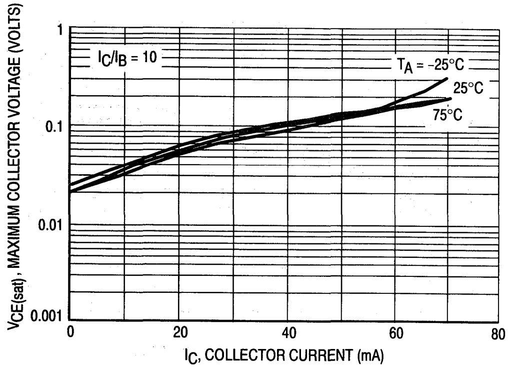


Figure 7. $V_{CE(sat)}$ versus I_C

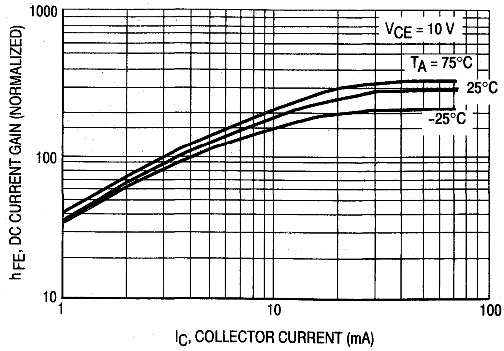


Figure 8. DC Current Gain

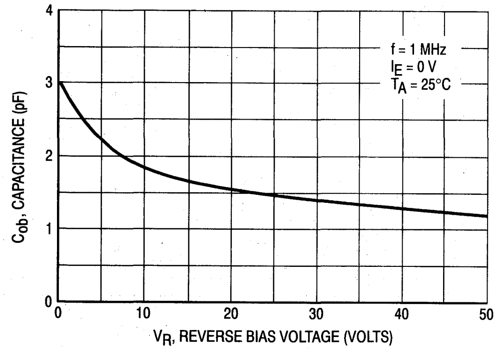


Figure 9. Output Capacitance

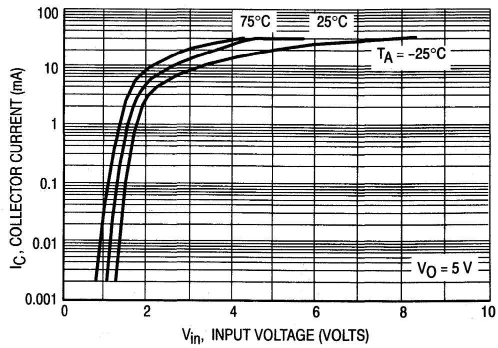


Figure 10. Output Current versus Input Voltage

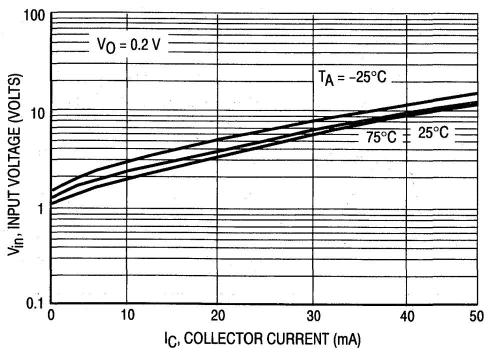


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MMUN2213T1

2

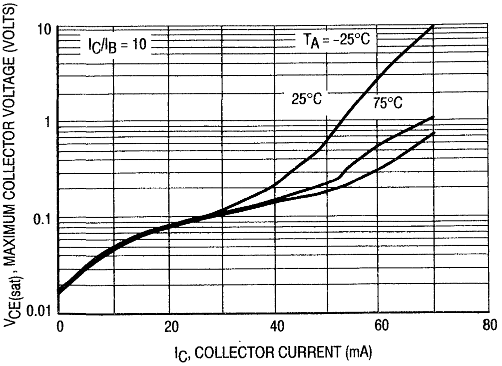


Figure 12. $V_{CE(sat)}$ versus I_C

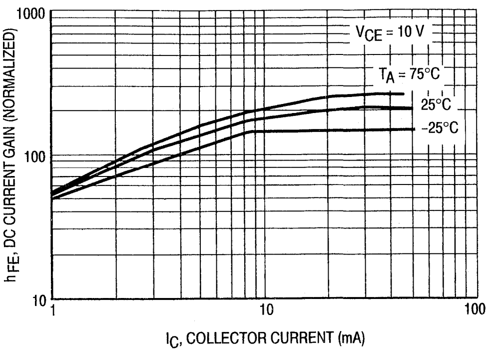


Figure 13. DC Current Gain

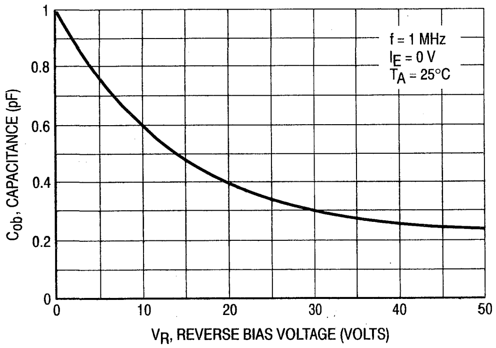


Figure 14. Output Capacitance

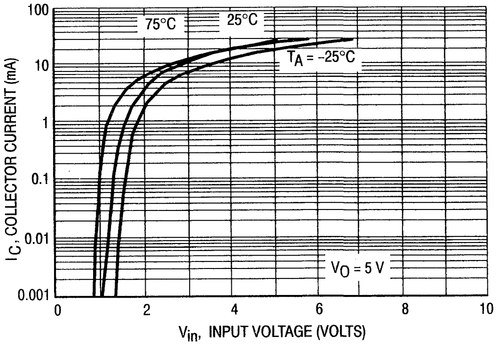


Figure 15. Output Current versus Input Voltage

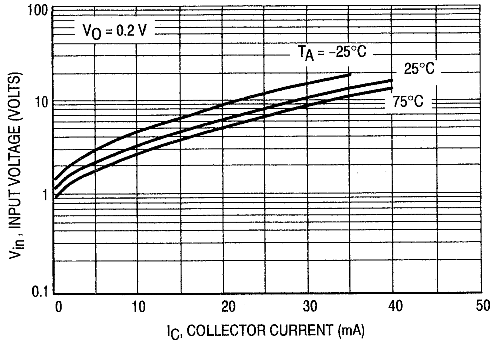


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MMUN2214T1

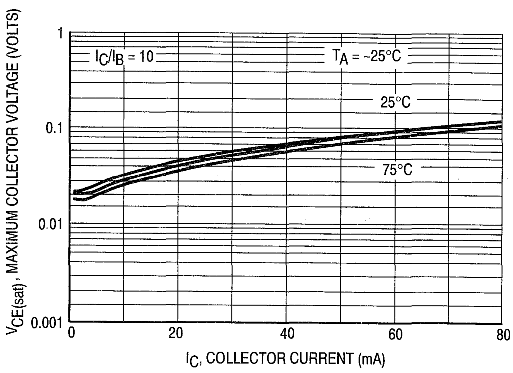


Figure 17. $V_{CE(sat)}$ versus I_C

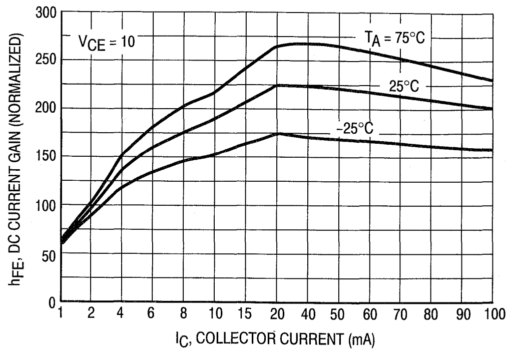


Figure 18. DC Current Gain

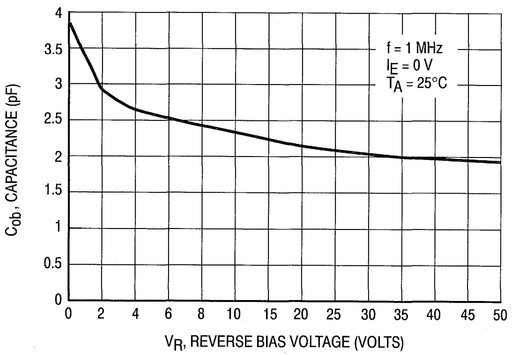


Figure 19. Output Capacitance

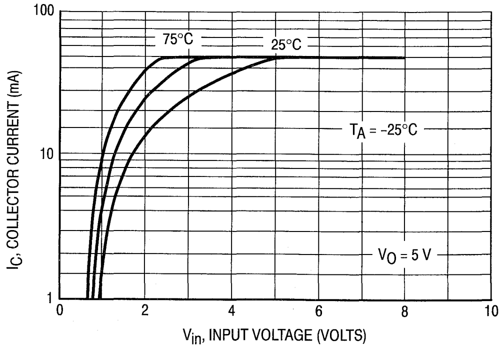


Figure 20. Output Current versus Input Voltage

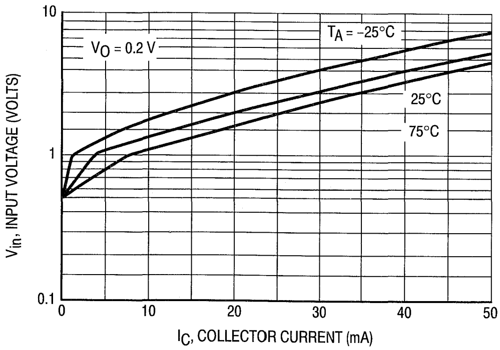


Figure 21. Input Voltage versus Output Current

TYPICAL APPLICATIONS FOR NPN BRTs

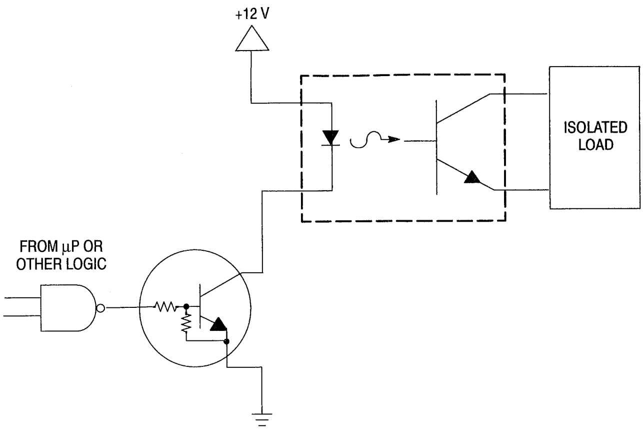


Figure 22. Level Shifter: Connects 12 or 24 Volt Circuits to Logic

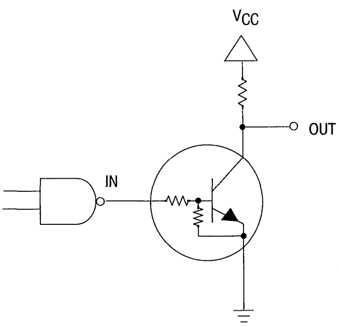


Figure 23. Open Collector Inverter: Inverts the Input Signal

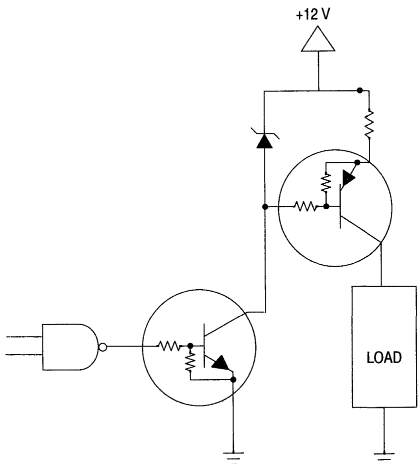


Figure 24. Inexpensive, Unregulated Current Source

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Bias Resistor Transistor

PNP Silicon Surface Mount Transistor With Monolithic Bias Resistor Network

MUN2111T1
MUN2112T1
MUN2113T1
MUN2114T1

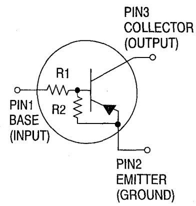
Motorola Preferred Devices

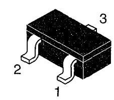
2

This new series of digital transistors is designed to replace a single device and its external resistor bias network. The BRT (Bias Resistor Transistor) contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base-emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space. The device is housed in the SC-59 package which is designed for low power surface mount applications.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- The SC-59 package can be soldered using wave or reflow. The modified gull-winged leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 8 mm embossed tape and reel
  Use the Device Number to order the 7 inch/3000 unit reel.

PNP SILICON
BIAS RESISTOR
TRANSISTOR





CASE 318D-03, STYLE 1
(SC-59)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	200 1.6	mW mW/°C

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	625	°C/W
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +150	°C
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

DEVICE MARKING AND RESISTOR VALUES

Device	Marking	R1 (K)	R2 (K)
MUN2111T1	6A	10	10
MUN2112T1	6B	22	22
MUN2113T1	6C	47	47
MUN2114T1	6D	10	47

* Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

2

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0)		I_{CBO}	—	—	100	nAdc
Collector-Emitter Cutoff Current (V_{CE} = 50 V, I_B = 0)		I_{CEO}	—	—	500	nAdc
Emitter-Base Cutoff Current (V_{EB} = 6.0 V, I_C = 0)	MUN2111T1	I_{EBO}	—	—	0.5	mAdc
	MUN2112T1		—	—	0.2	
	MUN2113T1		—	—	0.1	
	MUN2114T1		—	—	0.2	
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS*						
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA)	MUN2111T1	h_{FE}	35	60	—	
	MUN2112T1		60	100	—	
	MUN2113T1		80	140	—	
	MUN2114T1		80	140	—	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_E = 0.3 mA)		$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (on)		V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ)	MUN2111T1		—	—	0.2	
	MUN2112T1		—	—	0.2	
	MUN2114T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MUN2113T1		—	—	0.2	
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
Input Resistor	MUN2111T1	R1	7.0	10	13	k Ω
	MUN2112T1		15.4	22	28.6	
	MUN2113T1		32.9	47	61.1	
	MUN2114T1		7.0	10	13	
Resistor Ratio	MUN2111T1/MUN2112T1/MUN2113T1	R_1/R_2	0.8	1.0	1.2	
	MUN2114T1		0.17	0.21	0.25	

* Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

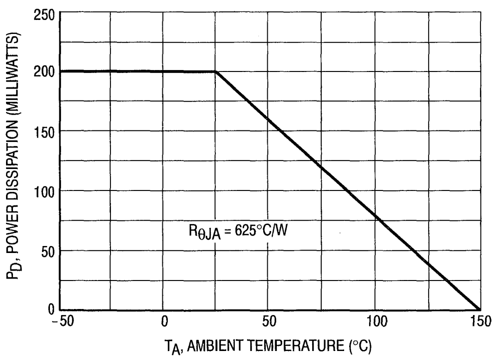


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2111T1

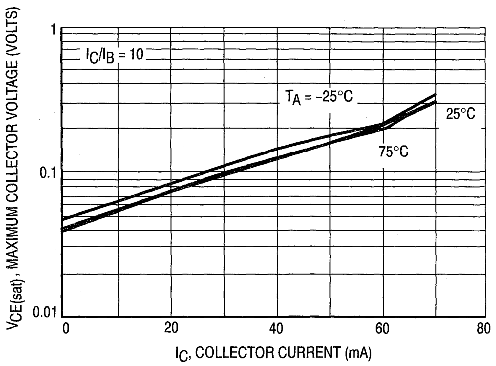


Figure 2. $V_{CE(sat)}$ versus I_C

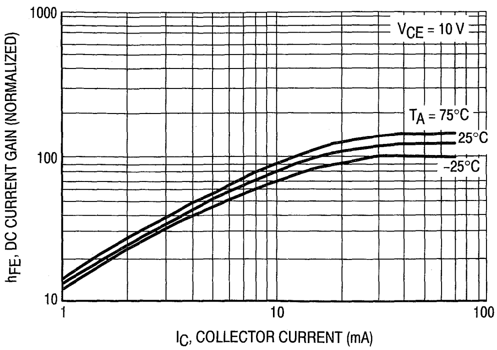


Figure 3. DC Current Gain

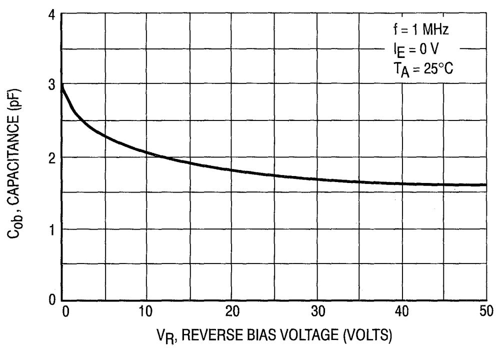


Figure 4. Output Capacitance

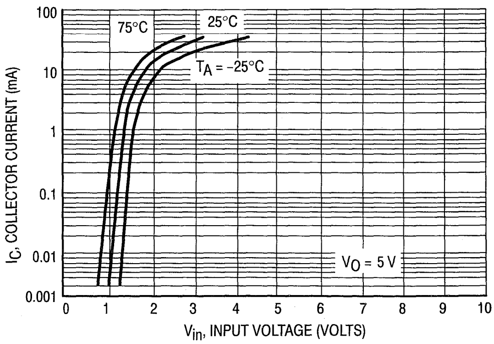


Figure 5. Output Current versus Input Voltage

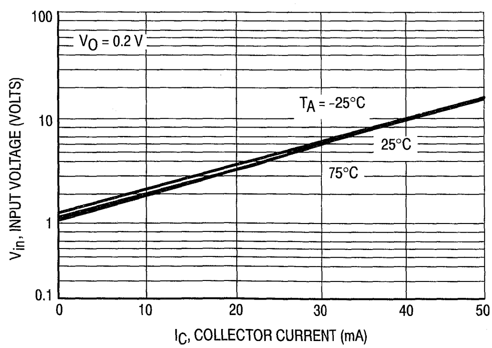


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2112T1

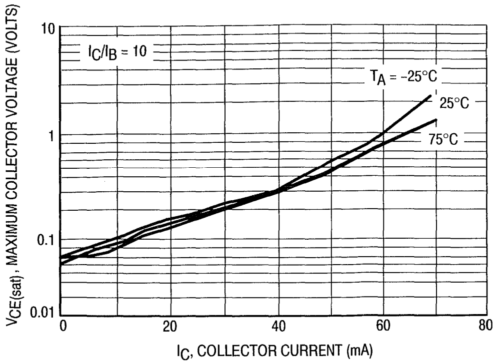


Figure 7. $V_{CE(sat)}$ versus I_C

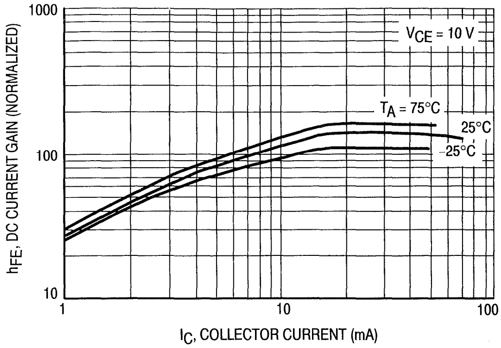


Figure 8. DC Current Gain

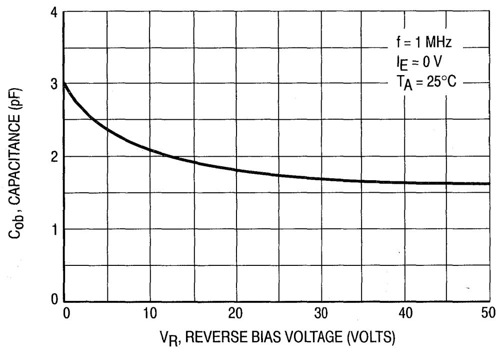


Figure 9. Output Capacitance

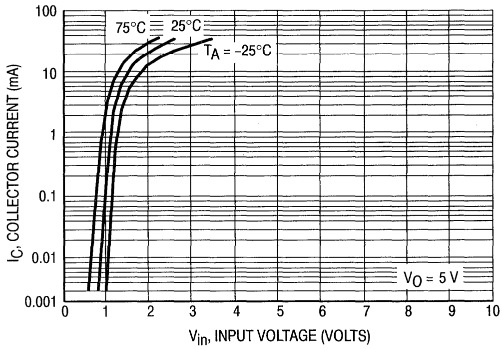


Figure 10. Output Current versus Input Voltage

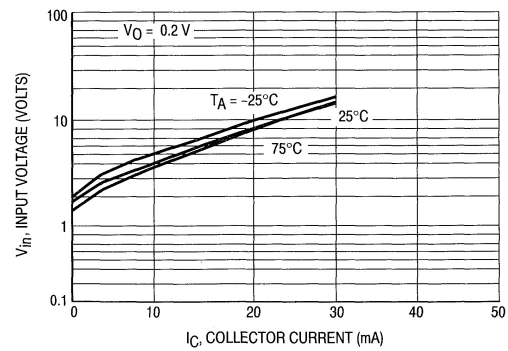


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2113T1

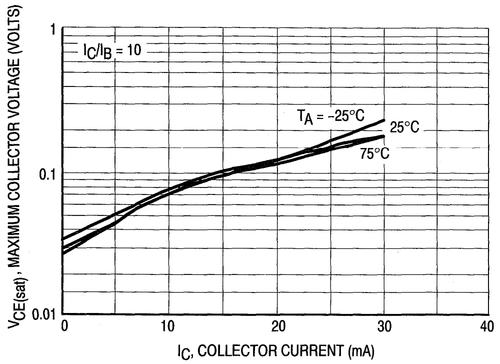


Figure 12. $V_{CE(sat)}$ versus I_C

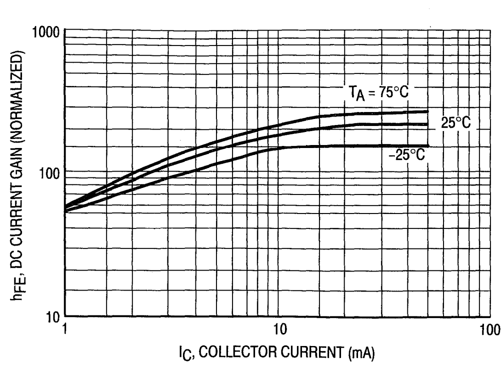


Figure 13. DC Current Gain

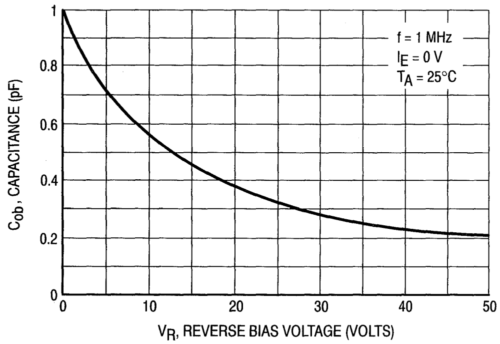


Figure 14. Output Capacitance

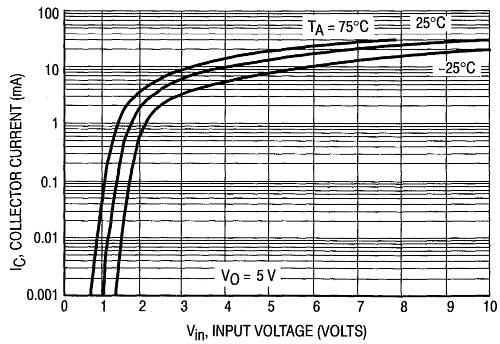


Figure 15. Output Current versus Input Voltage

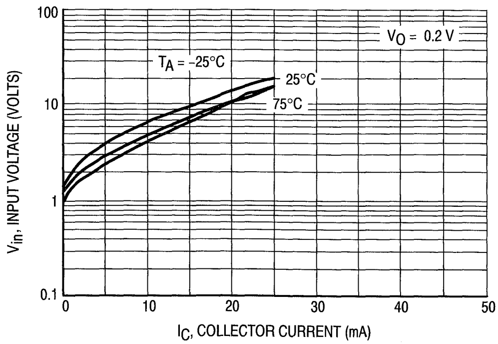


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2114T1

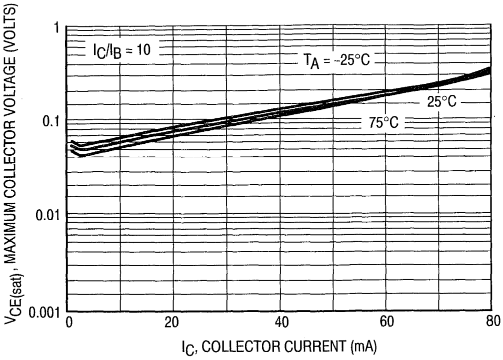


Figure 17. $V_{CE(sat)}$ versus I_C

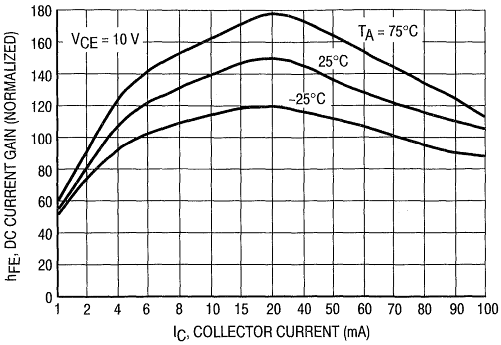


Figure 18. DC Current Gain

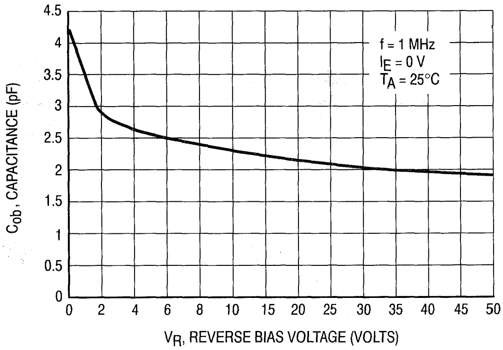


Figure 19. Output Capacitance

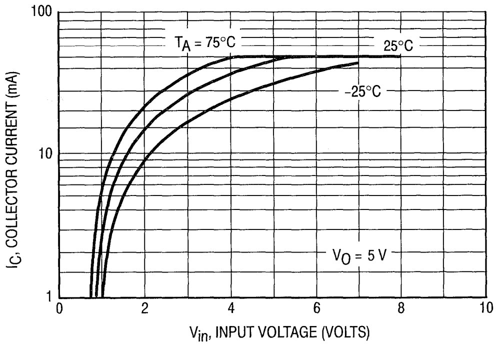


Figure 20. Output Current versus Input Voltage

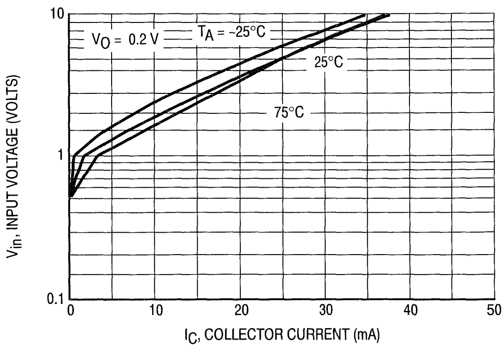


Figure 21. Input Voltage versus Output Current

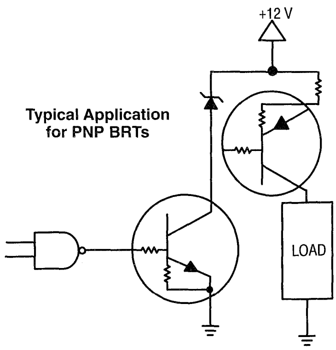


Figure 22. Inexpensive, Unregulated Current Source

Bias Resistor Transistor

NPN Silicon Surface Mount Transistor With Monolithic Bias Resistor Network

MUN2211T1
MUN2212T1
MUN2213T1
MUN2214T1

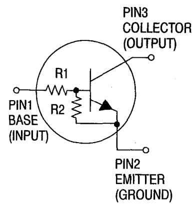
Motorola Preferred Devices

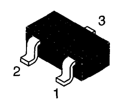
NPN SILICON BIAS RESISTOR TRANSISTOR

2

This new series of digital transistors is designed to replace a single device and its internal resistor bias network. The BRT (Bias Resistor Transistor) contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base-emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space. The device is housed in the SC-59 package which is designed for low power surface mount applications.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- The SC-59 package can be soldered using wave or reflow. The modified gull-winged leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 8 mm embossed tape and reel
  Use the Device Number to order the 7 inch/3000 unit reel.





CASE 318D-03, STYLE 1
(SC-59)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	200 1.6	mW mW/°C

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	625	°C/W
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +150	°C
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

DEVICE MARKING AND RESISTOR VALUES

Device	Marking	R1 (K)	R2 (K)
MUN2211T1	8A	10	10
MUN2212T1	8B	22	22
MUN2213T1	8C	47	47
MUN2214T1	8D	10	47

* Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

2

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0)		I_{CBO}	—	—	100	nAdc
Collector-Emitter Cutoff Current (V_{CE} = 50 V, I_B = 0)		I_{CEO}	—	—	500	nAdc
Emitter-Base Cutoff Current (V_{EB} = 6.0 V, I_C = 0)	MUN2211T1	I_{EBO}	—	—	0.5	mAdc
	MUN2212T1		—	—	0.2	
	MUN2213T1		—	—	0.1	
	MUN2214T1		—	—	0.2	
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS*						
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA)	MUN2211T1	h_{FE}	35	60	—	
	MUN2212T1		60	100	—	
	MUN2213T1		80	140	—	
	MUN2214T1		80	140	—	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA)		$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (ON)		V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ)	MUN2211T1		—	—	0.2	
	MUN2212T1		—	—	0.2	
	MUN2214T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MUN2213T1	V_{OL}	—	—	0.2	
Output Voltage (OFF) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
Input Resistor	MUN2211T1	R1	7.0	10	13	k Ω
	MUN2212T1		15.4	22	28.6	
	MUN2213T1		32.9	47	61.1	
	MUN2214T1		7.0	10	13	
Resistor Ratio	MUN2211T1/MUN2212T1/MUN2213T1	R1/R2	0.8	1.0	1.2	
	MUN2214T1		0.17	0.21	0.25	

* Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

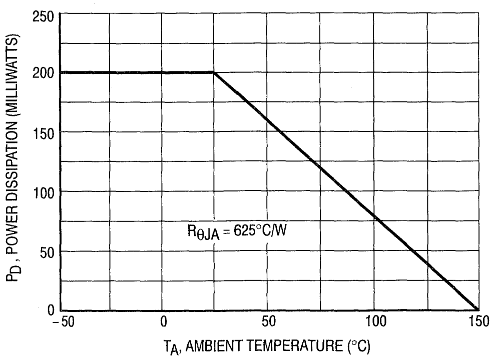


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2211T1

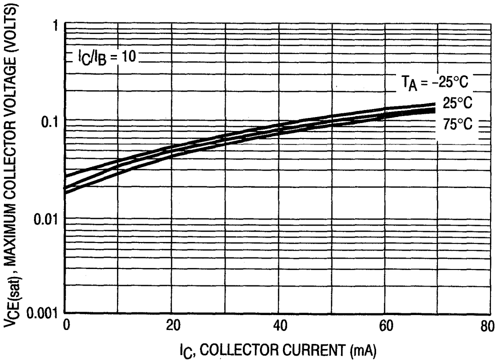


Figure 2. $V_{CE(sat)}$ versus I_C

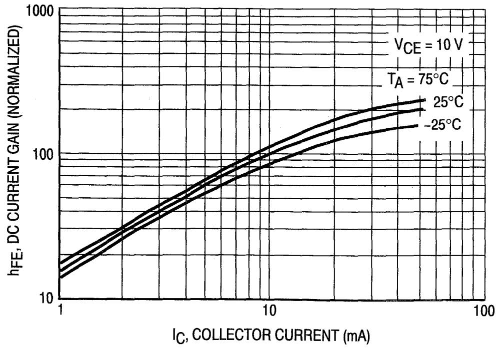


Figure 3. DC Current Gain

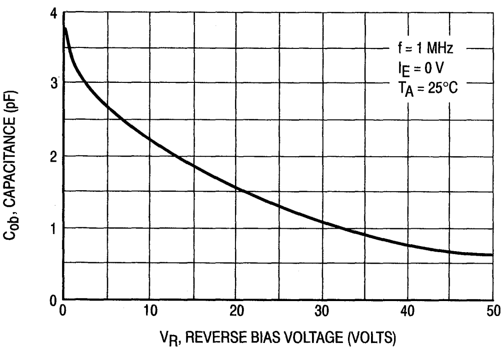


Figure 4. Output Capacitance

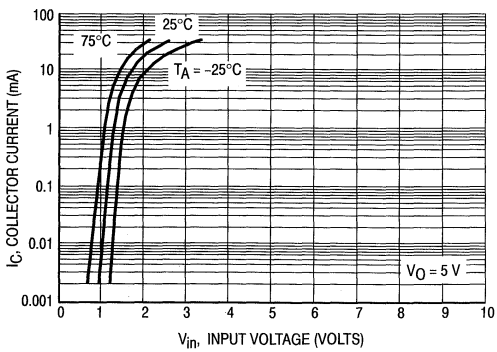


Figure 5. Output Current versus Input Voltage

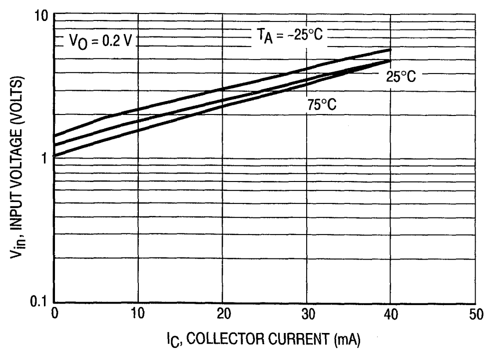


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2212T1

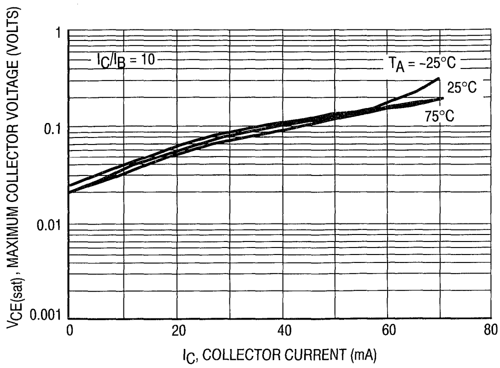


Figure 7. $V_{CE(sat)}$ versus I_C

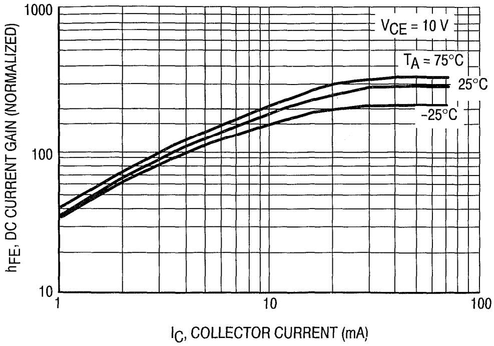


Figure 8. DC Current Gain

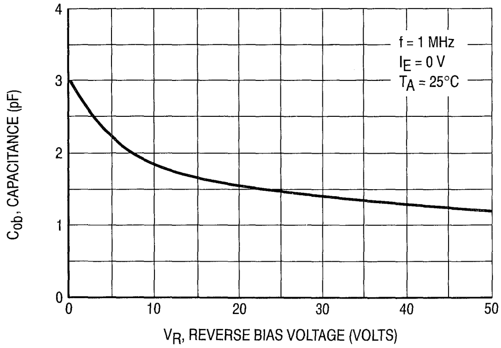


Figure 9. Output Capacitance

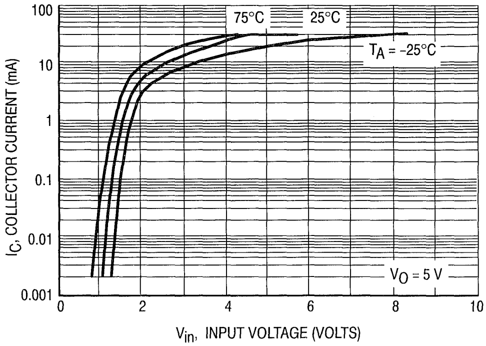


Figure 10. Output Current versus Input Voltage

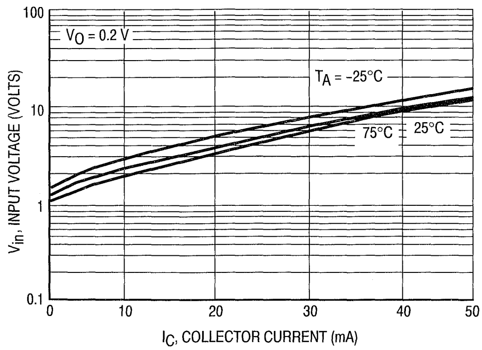


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2213T1

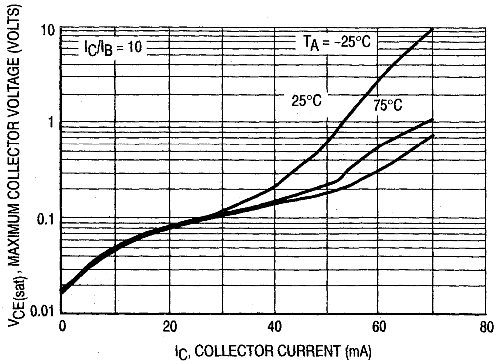


Figure 12. $V_{CE(sat)}$ versus I_C

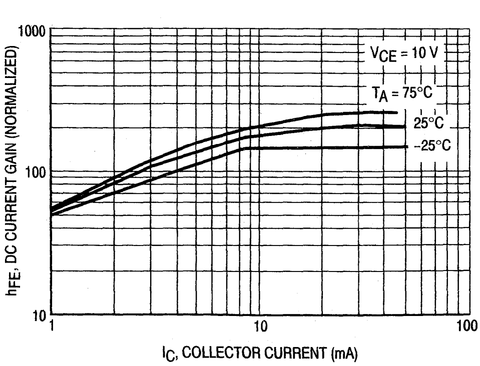


Figure 13. DC Current Gain

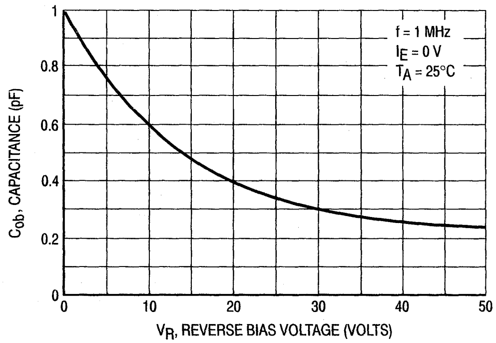


Figure 14. Output Capacitance

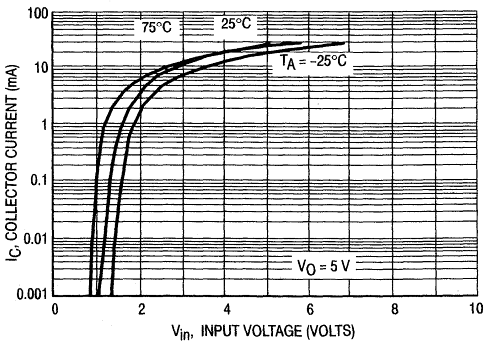


Figure 15. Output Current versus Input Voltage

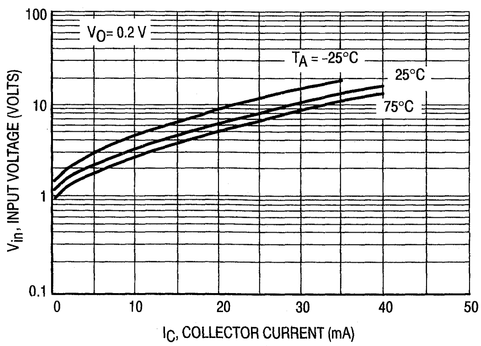


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2214T1

2

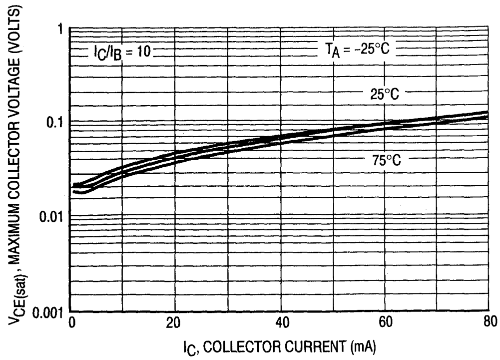


Figure 17. $V_{CE(sat)}$ versus I_C

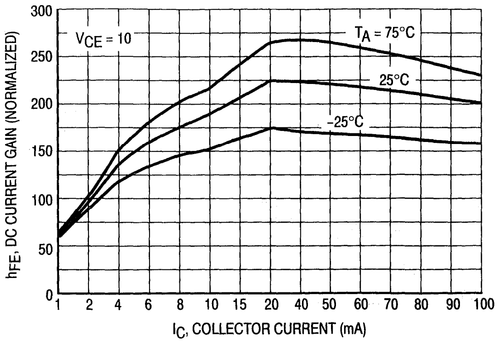


Figure 18. DC Current Gain

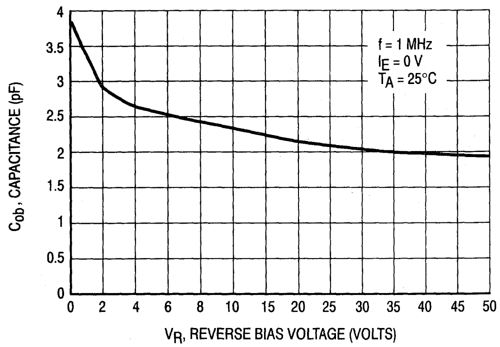


Figure 19. Output Capacitance

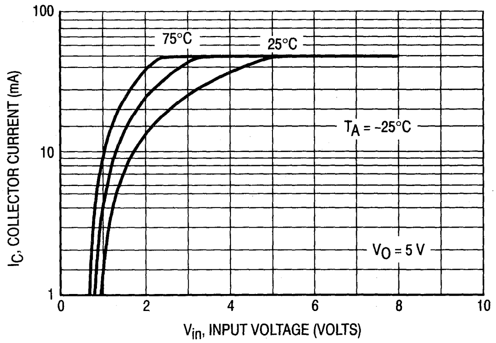


Figure 20. Output Current versus Input Voltage

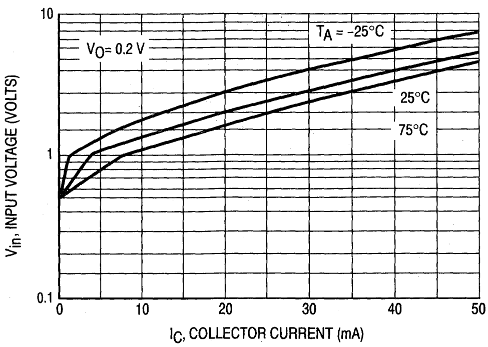


Figure 21. Input Voltage versus Output Current

TYPICAL APPLICATIONS FOR NPN BRTs

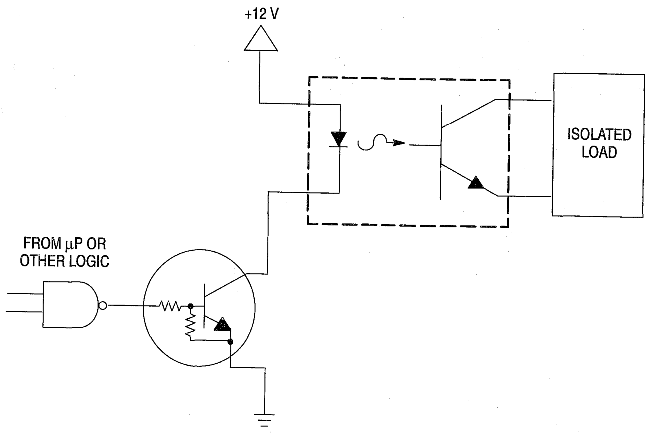


Figure 22. Level Shifter: Connects 12 or 24 Volt Circuits to Logic

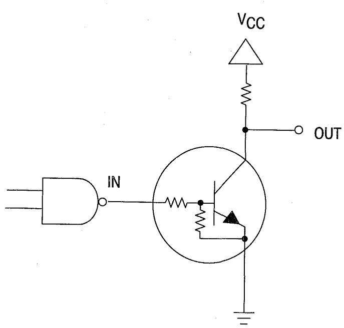


Figure 23. Open Collector Inverter: Inverts the Input Signal

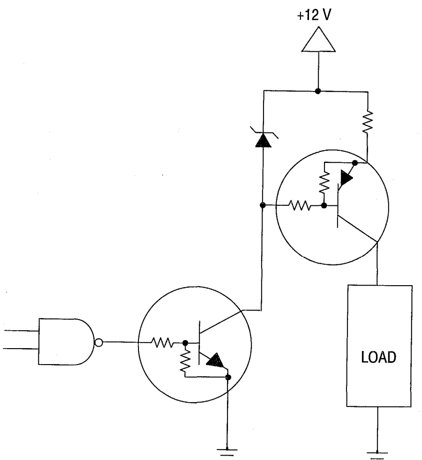


Figure 24. Inexpensive, Unregulated Current Source

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Bias Resistor Transistor

PNP Silicon Surface Mount Transistor With Monolithic Bias Resistor Network

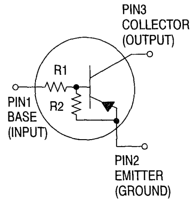
MUN5111T1
MUN5112T1
MUN5113T1
MUN5114T1

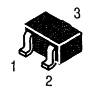
Motorola Preferred Devices

PNP SILICON BIAS RESISTOR TRANSISTORS

This new series of digital transistors is designed to replace a single device and its external resistor bias network. The BRT (Bias Resistor Transistor) contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base-emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space. The device is housed in the SC-70/SOT-323 package which is designed for low power surface mount applications.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- The SC-70/SOT-323 package can be soldered using wave or reflow. The modified gull-winged leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 8 mm embossed tape and reel
  Use the Device Number to order the 7 inch/3000 unit reel.
  Replace "T1" with "T3" in the Device Number to order the 13 inch/10,000 unit reel.





CASE 419-02, STYLE 3
SC-70/SOT-323

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	150 1.2	mW mW/°C

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	833	°C/W
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +150	°C
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

DEVICE MARKING AND RESISTOR VALUES

Device	Marking	R1 (K)	R2 (K)
MUN5111T1	6A	10	10
MUN5112T1	6B	22	22
MUN5113T1	6C	47	47
MUN5114T1	6D	10	47

* Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0)		I_{CBO}	—	—	100	nAdc
Collector-Emitter Cutoff Current (V_{CE} = 50 V, I_B = 0)		I_{CEO}	—	—	500	nAdc
Emitter-Base Cutoff Current (V_{EB} = 6.0 V, I_C = 0)	MUN5111T1	I_{EBO}	—	—	0.5	mAdc
	MUN5112T1		—	—	0.2	
	MUN5113T1		—	—	0.1	
	MUN5114T1		—	—	0.2	
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS*						
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA)	MUN5111T1	h_{FE}	35	60	—	
	MUN5112T1		60	100	—	
	MUN5113T1		80	140	—	
	MUN5114T1		80	140	—	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_E = 0.3 mA)		$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (on) (V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ)	MUN5111T1	V_{OL}	—	—	0.2	Vdc
	MUN5112T1		—	—	0.2	
	MUN5114T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MUN5113T1		—	—	0.2	
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
Input Resistor	MUN5111T1	R1	7.0	10	13	kΩ
	MUN5112T1		15.4	22	28.6	
	MUN5113T1		32.9	47	61.1	
	MUN5114T1		7.0	10	13	
Resistor Ratio	MUN5111T1/MUN5112T1/MUN5113T1	R_1/R_2	0.8	1.0	1.2	
	MUN5114T1		0.17	0.21	0.25	

* Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

2

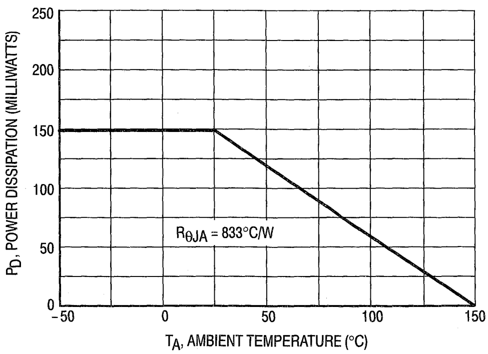


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5111T1

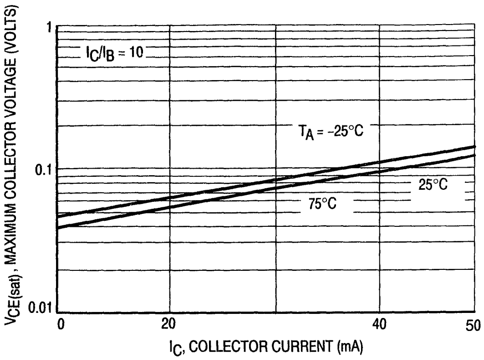


Figure 2. $V_{CE(sat)}$ versus I_C

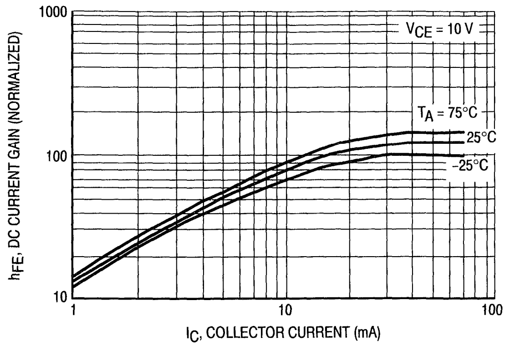


Figure 3. DC Current Gain

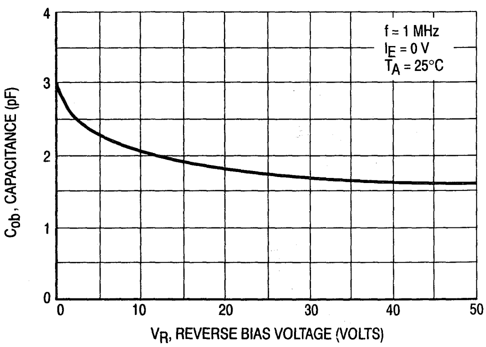


Figure 4. Output Capacitance

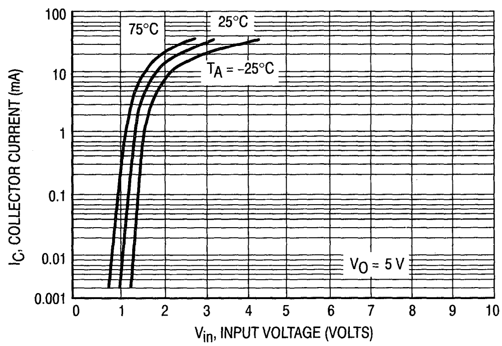


Figure 5. Output Current versus Input Voltage

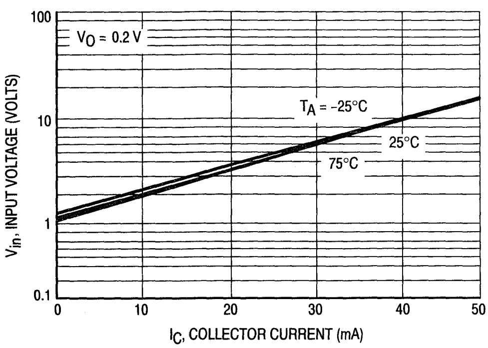


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5112T1

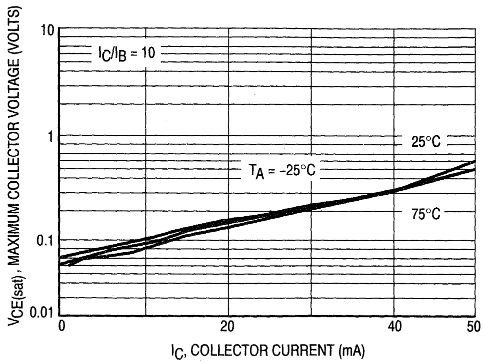


Figure 7. $V_{CE(sat)}$ versus I_C

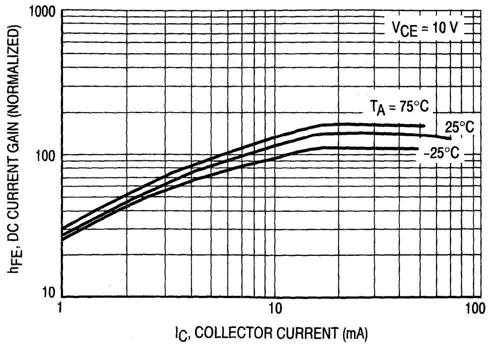


Figure 8. DC Current Gain

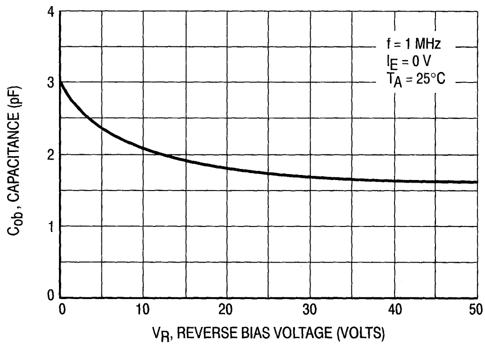


Figure 9. Output Capacitance

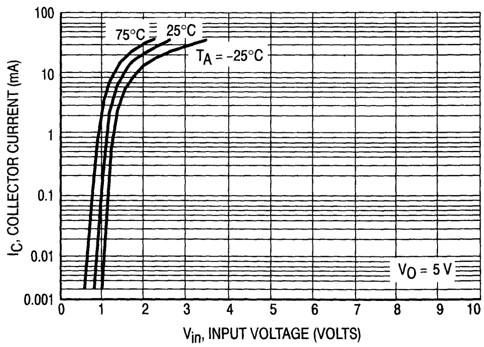


Figure 10. Output Current versus Input Voltage

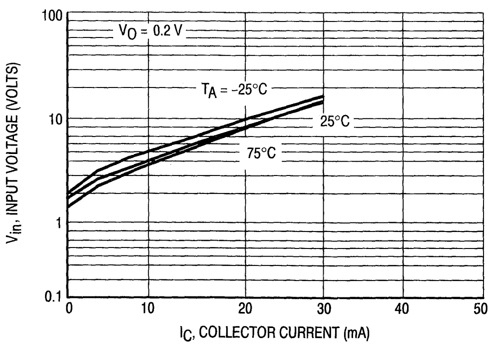


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5113T1

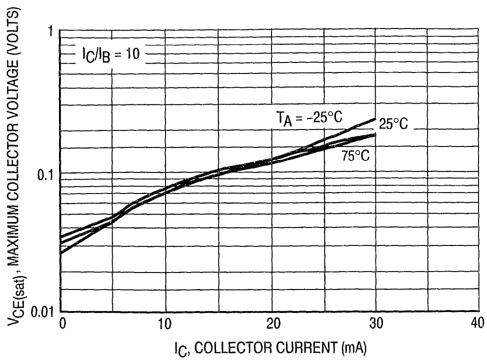


Figure 12. $V_{CE(sat)}$ versus I_C

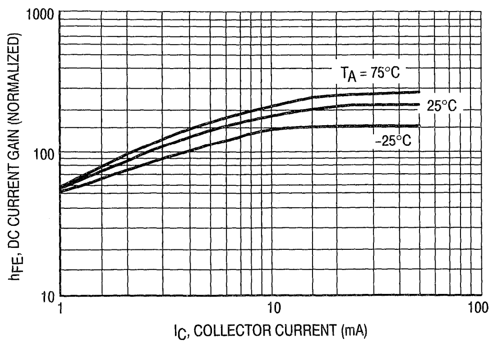


Figure 13. DC Current Gain

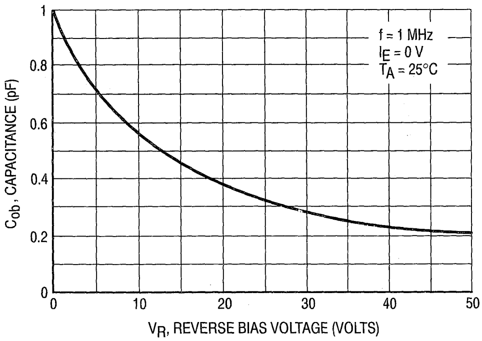


Figure 14. Output Capacitance

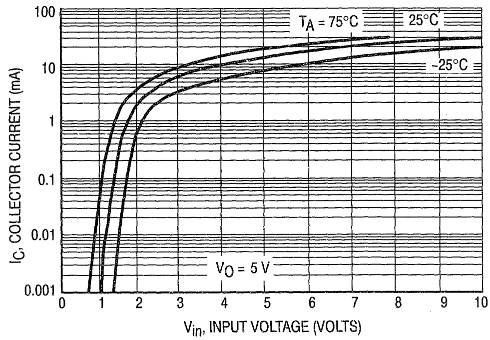


Figure 15. Output Current versus Input Voltage

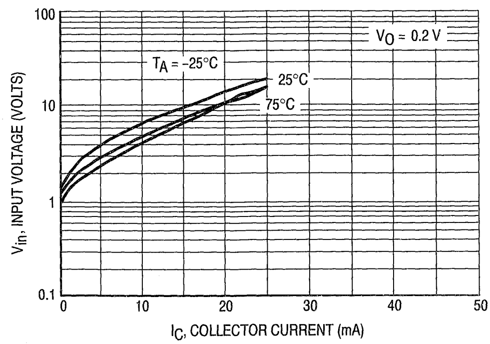


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5114T1

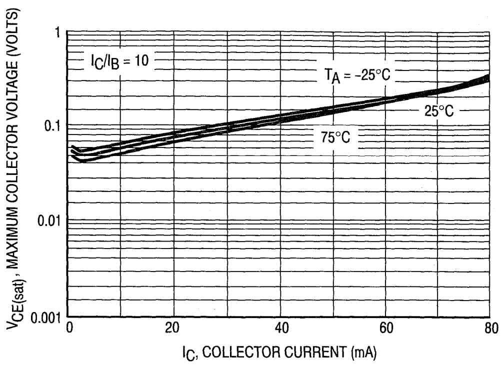


Figure 17. $V_{CE(sat)}$ versus I_C

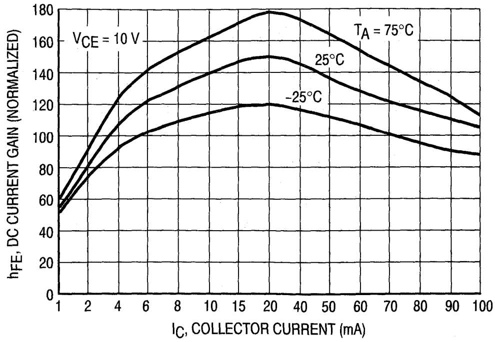


Figure 18. DC Current Gain

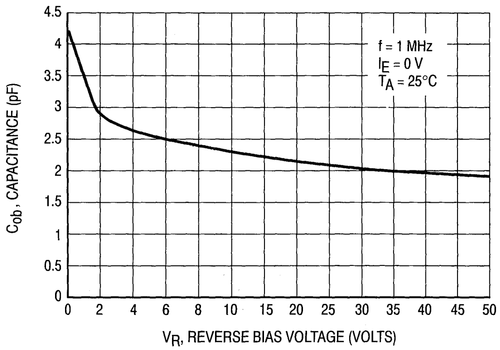


Figure 19. Output Capacitance

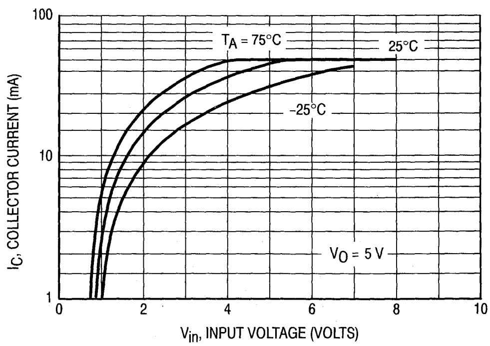


Figure 20. Output Current versus Input Voltage

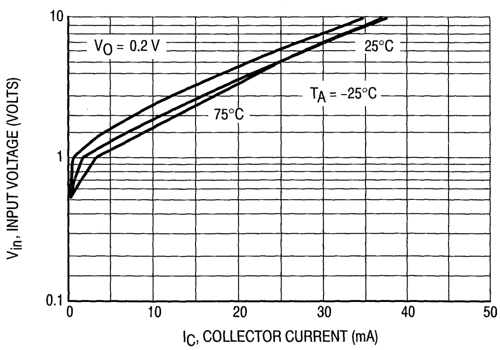


Figure 21. Input Voltage versus Output Current

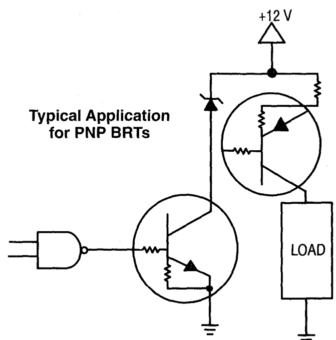


Figure 22. Inexpensive, Unregulated Current Source

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Bias Resistor Transistor

NPN Silicon Surface Mount Transistor With Monolithic Bias Resistor Network

2

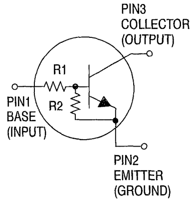
MUN5211T1
MUN5212T1
MUN5213T1
MUN5214T1

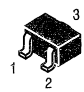
Motorola Preferred Devices

This new series of digital transistors is designed to replace a single device and its internal resistor bias network. The BRT (Bias Resistor Transistor) contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base-emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space. The device is housed in the SC-70/SOT-323 package which is designed for low power surface mount applications.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- The SC-70/SOT-323 package can be soldered using wave or reflow. The modified gull-winged leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 8 mm embossed tape and reel
  Use the Device Number to order the 7 inch/3000 unit reel. Replace "T1" with "T3" in the Device Number to order the 13 inch/10,000 unit reel.

NPN SILICON
BIAS RESISTOR
TRANSISTORS





CASE 419-02, STYLE 3
SC-70/SOT-323

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	150 1.2	mW mW/°C

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	833	°C/W
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +150	°C
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

DEVICE MARKING AND RESISTOR VALUES

Device	Marking	R1 (K)	R2 (K)
MUN5211T1	8A	10	10
MUN5212T1	8B	22	22
MUN5213T1	8C	47	47
MUN5214T1	8D	10	47

* Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0)	I_{CBO}	—	—	100	nAdc
Collector-Emitter Cutoff Current (V_{CE} = 50 V, I_B = 0)	I_{CEO}	—	—	500	nAdc
Emitter-Base Cutoff Current (V_{EB} = 6.0 V, I_C = 0) MUN5211T1 MUN5212T1 MUN5213T1 MUN5214T1	I_{EBO}	— — — —	— — — —	0.5 0.2 0.1 0.2	mAdc
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 2.0 mA, I_B = 0)	$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS*					
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA) MUN5211T1 MUN5212T1 MUN5213T1 MUN5214T1	h_{FE}	35 60 80 80	60 100 140 140	— — — —	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA)	$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (ON) (V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ) MUN5211T1 MUN5212T1 MUN5214T1 (V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ) MUN5213T1	V_{OL}	 — — — —	 — — — —	 0.2 0.2 0.2 0.2	Vdc
Output Voltage (OFF) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)	V_{OH}	4.9	—	—	Vdc
Input Resistor MUN5211T1 MUN5212T1 MUN5213T1 MUN5214T1	R1	7.0 15.4 32.9 7.0	10 22 47 10	13 28.6 61.1 13	k Ω
Resistor Ratio MUN5211T1/MUN5212T1/MUN5213T1 MUN5214T1	R1/R2	0.8 0.17	1.0 0.21	1.2 0.25	

* Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

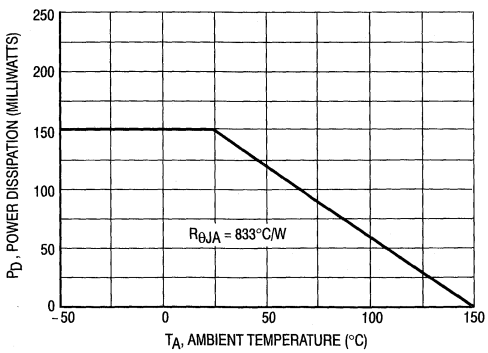


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5211T1

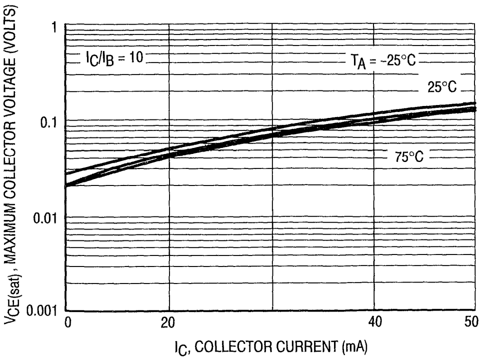


Figure 2. $V_{CE(sat)}$ versus I_C

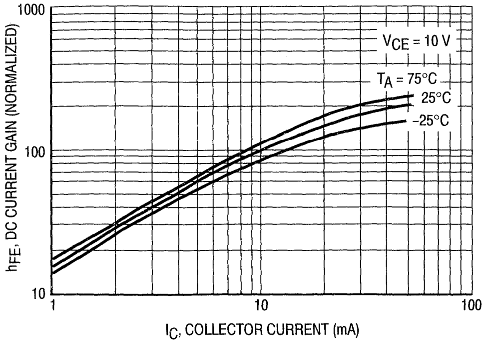


Figure 3. DC Current Gain

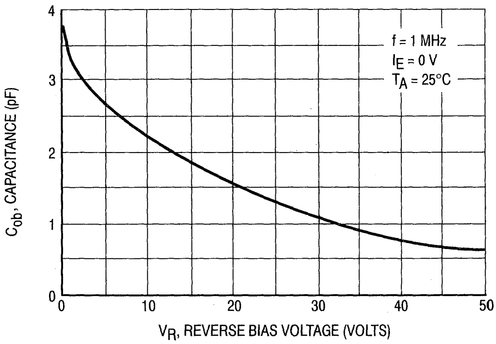


Figure 4. Output Capacitance

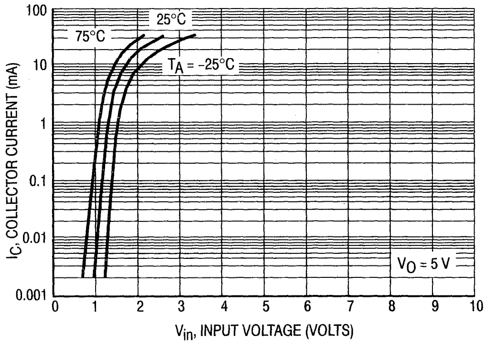


Figure 5. Output Current versus Input Voltage

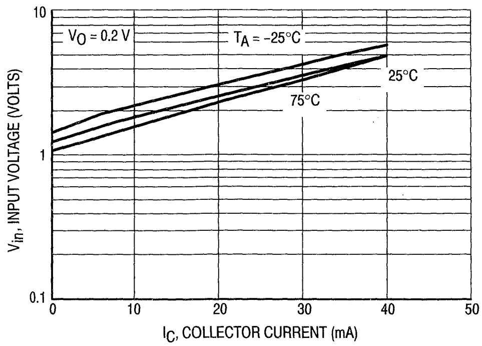


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5212T1

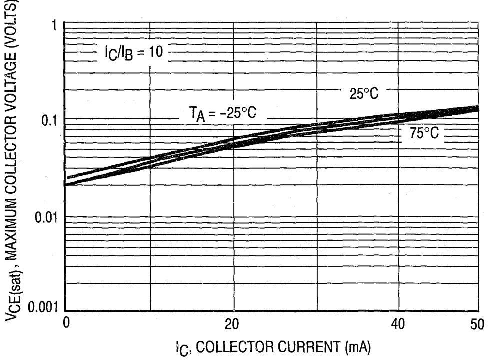


Figure 7. $V_{CE(sat)}$ versus I_C

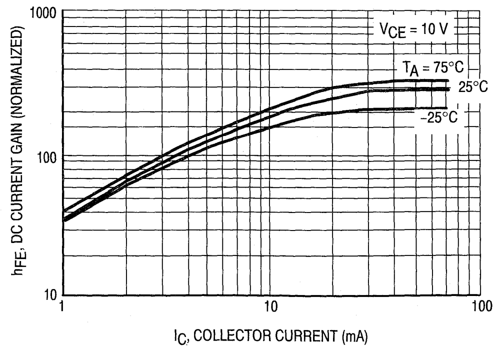


Figure 8. DC Current Gain

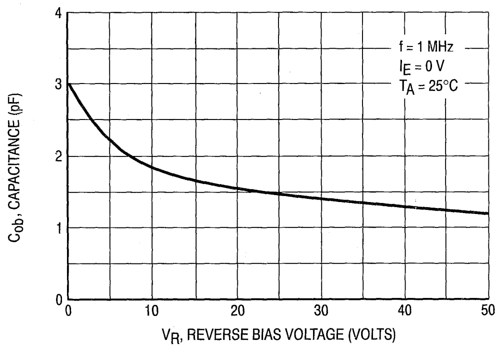


Figure 9. Output Capacitance

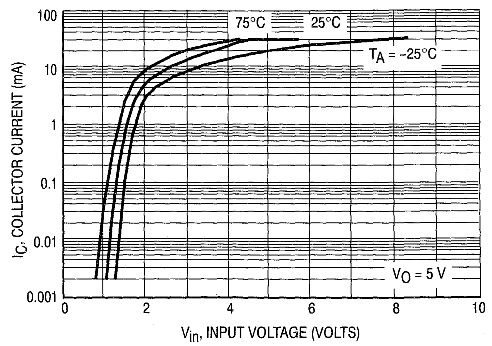


Figure 10. Output Current versus Input Voltage

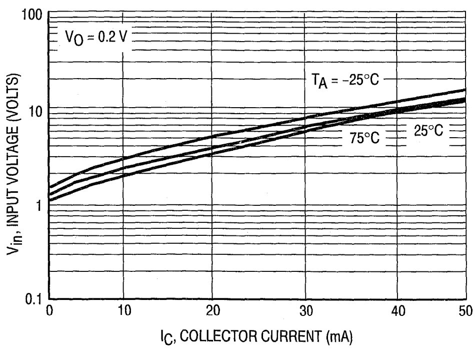


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5213T1

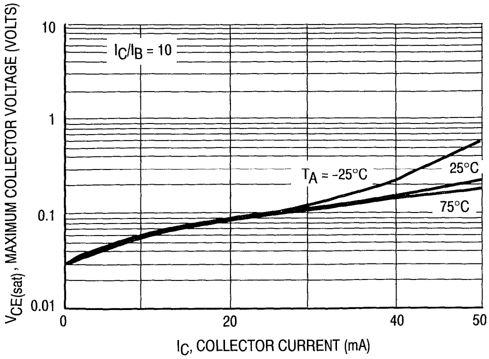


Figure 12. $V_{CE(sat)}$ versus I_C

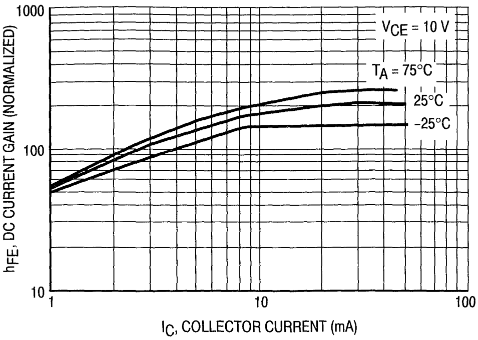


Figure 13. DC Current Gain

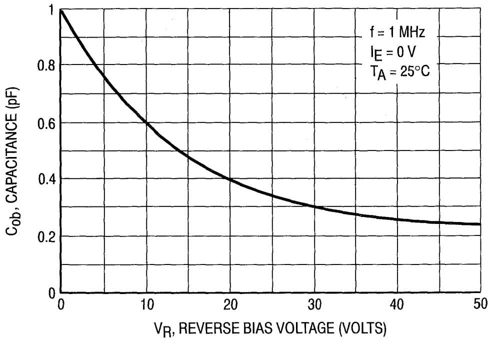


Figure 14. Output Capacitance

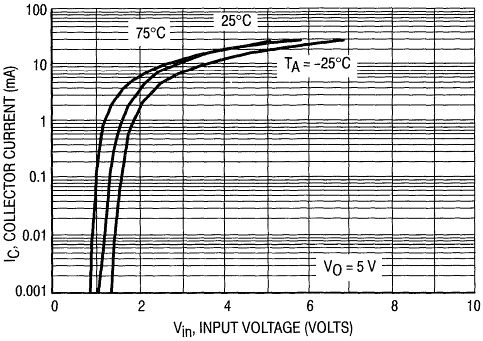


Figure 15. Output Current versus Input Voltage

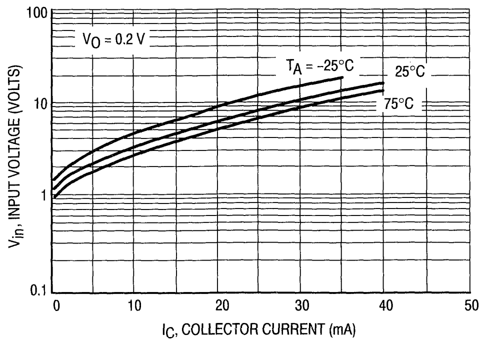


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5214T1

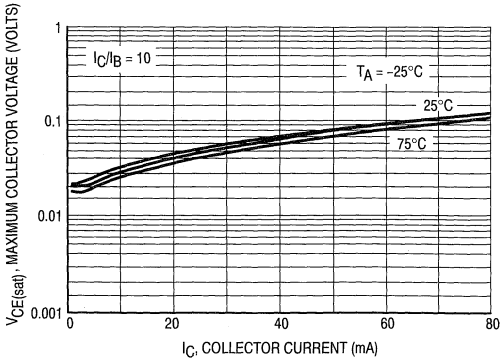


Figure 17. $V_{CE(sat)}$ versus I_C

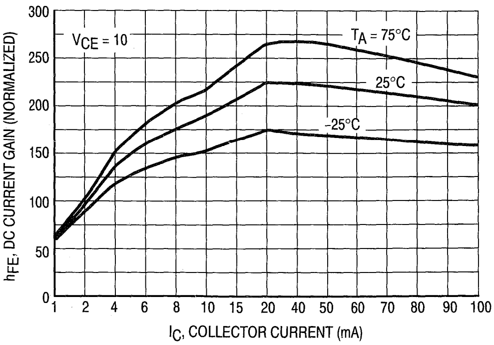


Figure 18. DC Current Gain

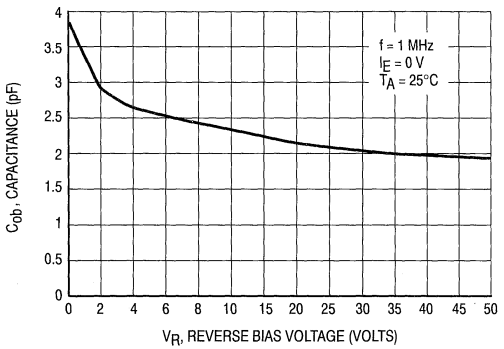


Figure 19. Output Capacitance

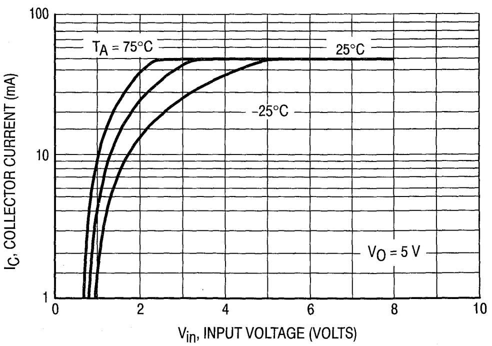


Figure 20. Output Current versus Input Voltage

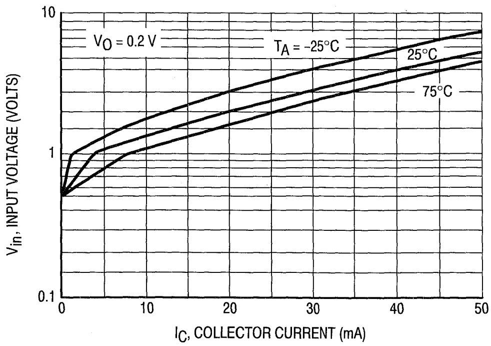


Figure 21. Input Voltage versus Output Current

TYPICAL APPLICATIONS FOR NPN BRTs

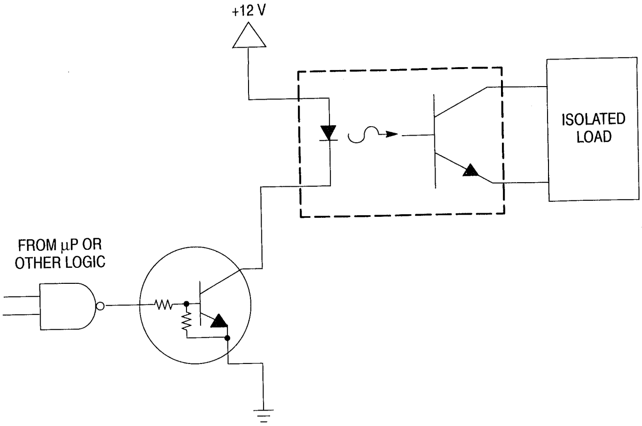


Figure 22. Level Shifter: Connects 12 or 24 Volt Circuits to Logic

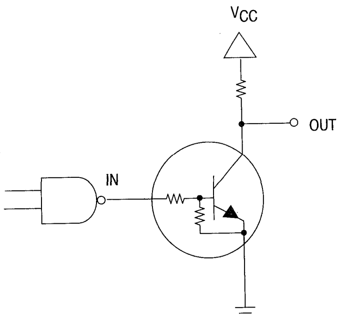


Figure 23. Open Collector Inverter: Inverts the Input Signal

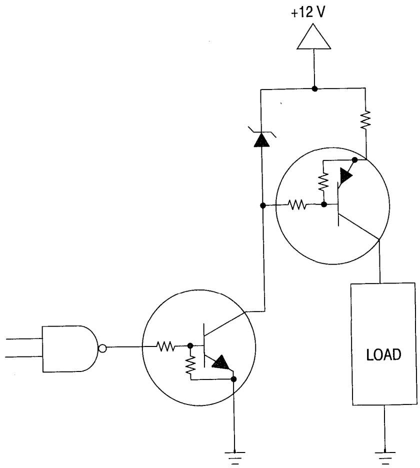
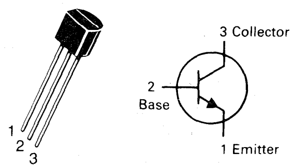


Figure 24. Inexpensive, Unregulated Current Source

PBF259, S

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

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

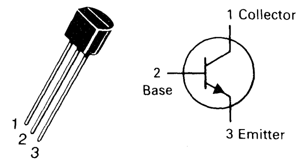
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

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 = 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
Emitter Cutoff Current (V_{EB} = 3.0 V)	I_{EBO}	—	20	nAdc
Collector Cutoff Current (V_{CE} = 10 V)	I_{CEO}	—	50	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 20 mAdc, V_{CE} = 10 Vdc) PBF259S (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) All Types (I_C = 30 mAdc, V_{CE} = 10 Vdc) 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 = 60 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

2

PBF259RS

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	PBF493RS	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

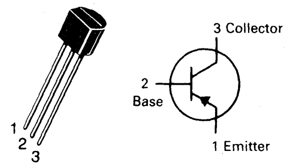
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 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
Emitter Cutoff Current (V_{EB} = 3.0 V)	I_{EBO}	—	20	nAdc
Collector Cutoff Current (V_{CE} = 10 V)	I_{CEO}	—	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)	h_{FE}	 60 25 25	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 1.5 mAdc) (I_C = 30 mAdc, I_B = 60 mAdc)	$V_{CE(sat)}$	 — —	 0.5 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mA, I_B = 2.0 mA)	$V_{BE(sat)}$	—	0.9	V
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

PBF493, S

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

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	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

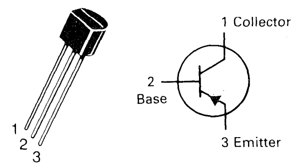
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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 = −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} = −200 Vdc, I_E = 0)		I_{CBO}	—	−0.25	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 V)		I_{EBO}	—	−20	nAdc
Collector Cutoff Current (V_{CE} = −10 V)		I_{CEO}	—	−250	nAdc
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 = −30 mAdc, V_{CE} = −10 Vdc)	 PBF493S All Types All Types	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, RS

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA42 for graphs.

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	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

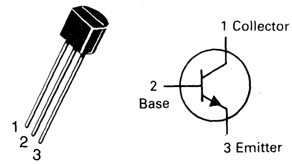
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

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)		$V_{(BR)CEO}$	−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} = −200 Vdc, I_E = 0)		I_{CBO}	—	−0.25	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 V)		I_{EBO}	—	−20	nAdc
Collector Cutoff Current (V_{CE} = −10 Vdc)		I_{CEO}	—	−250	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −30 mAdc, V_{CE} = −10 Vdc)	 PBF493RS All Types All Types	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

P2N2222A

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MPS2222 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
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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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)	$V_{(BR)CEO}$	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_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{CEX}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.01 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
Collector Cutoff Current (V_{CE} = 10 V)	I_{CEO}	—	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 40	 — — — — 300 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	 — —	 0.3 1.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	 0.6 —	 1.2 2.0	Vdc

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

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	300	—	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}	—	25	pF
Input Impedance		h_{ie}			kΩ
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			0.25	1.25	
Voltage Feedback Ratio		h_{re}			$X10^{-4}$
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			25	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)		$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)		N_F	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −2.0 V, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_s	—	225	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.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

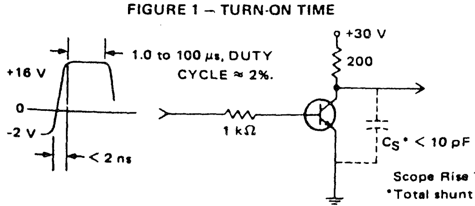
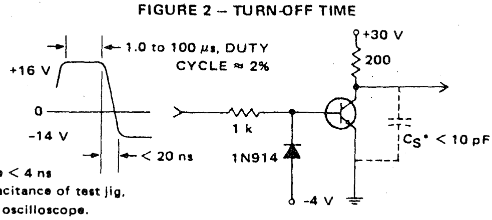


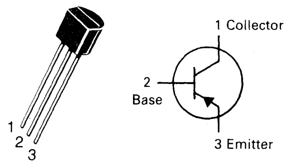
FIGURE 2 — TURN-OFF TIME



Scope Rise Time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

P2N2907A

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPS2907 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
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	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°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 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_{CE} = −30 Vdc, $V_{EB(off)}$ = −0.5 Vdc)	I_{CEX}	—	−50	nAdc
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_{EB} = −3.0 Vdc)	I_{EBO}	—	−10	nAdc
Collector Cutoff Current (V_{CE} = −10 V)	I_{CEO}	—	−10	nAdc
Base Cutoff Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −0.5 Vdc)	I_{BEX}	—	−50	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 = −150 mAdc, V_{CE} = −10 Vdc)(1) (I_C = −500 mAdc, V_{CE} = −10 Vdc)(1)	h_{FE}	 75 100 100 100 50	 — — — 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 −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

2

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 = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 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 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = −15 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

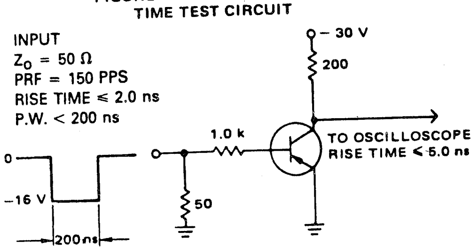
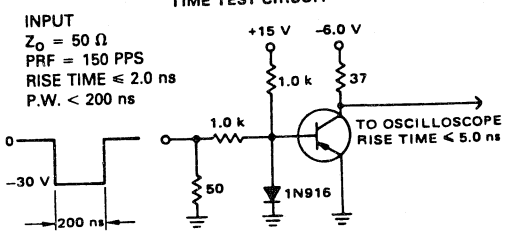
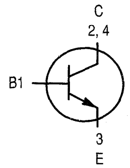


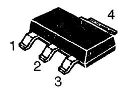
FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



PZT2222AT1★

CASE 318E-04, STYLE 1
(TO-261AA)





SOT-223 PACKAGE
NPN SILICON
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage (Open Collector)	V_{EBO}	6.0	Vdc
Collector Current	I_C	600	mAdc
Total Power Dissipation up to $T_A = 25°C$*	P_D	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

DEVICE MARKING

P1F

ELECTRICAL CHARACTERISTICS ($T_J = 25°C$ 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, $I_E = 0$)	$V_{(BR)CBO}$	75	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ µAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Base-Emitter Cutoff Current ($V_{CE} = 60$ Vdc, $V_{BE} = -3.0$ Vdc)	I_{BEX}	—	20	nAdc
Collector-Emitter Cutoff Current ($V_{CE} = 60$ Vdc, $V_{BE} = -3.0$ Vdc)	I_{CEX}	—	10	nAdc
Emitter-Base Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	10	nAdc

*Device mounted on an epoxy printed circuit board 1.575 inches x 1.575 inches x 0.059 inches; mounting pad for the collector lead min. 0.93 inches^2.

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS (continued)				
Collector-Base Cutoff Current	I_{CBO}			
(V_{CB} = 60 Vdc, I_E = 0)		—	10	nAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 125°C)		—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		70	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = – 55°C)		35	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		40	—	
Collector-Emitter Saturation Voltages	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	1.0	
Base-Emitter Saturation Voltages	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	2.0	
Input Impedance	h_{ie}			kΩ
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)		2.0	8.0	
(V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)		0.25	1.25	
Voltage Feedback Ratio	h_{re}			—
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)		—	8.0×10^{-4}	
(V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)		—	4.0×10^{-4}	
Small-Signal Current Gain	$\|h_{fe}\|$			—
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)		50	300	
(V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)		75	375	
Output Admittance	h_{oe}			μmhos
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)		5.0	25	
(V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)		25	200	
Noise Figure (V_{CE} = 10 Vdc, I_C = 100 μAdc, f = 1.0 kHz)	F	—	4.0	dB
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_c	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_e	—	25	pF

SWITCHING TIMES (T_A = 25°C)

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, $I_{B(on)}$ = 15 mAdc, $V_{BE(off)}$ = –0.5 Vdc) Figure 1	t_d	—	10	ns
Rise Time		t_r	—	25	
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, $I_{B(on)}$ = $I_{B(off)}$ = 15 mAdc) Figure 2	t_s	—	225	ns
Fall Time		t_f	—	60	

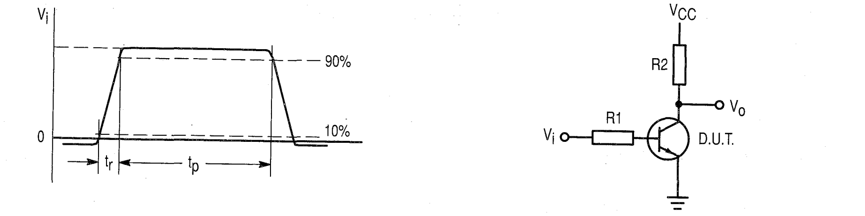


Figure 1. Input Waveform and Test Circuit for Determining Delay Time and Rise Time

V_i = – 0.5 V to +9.9 V, V_{CC} = +30 V, R1 = 619 Ω, R2 = 200 Ω.

PULSE GENERATOR:

PULSE DURATION	$t_p \leq$	200 ns
RISE TIME	$t_r \leq$	2 ns
DUTY FACTOR	δ =	0.02

OSCILLOSCOPE:

INPUT IMPEDANCE	Z_i >	100 kΩ
INPUT CAPACITANCE	C_i <	12 pF
RISE TIME	t_r <	5 ns

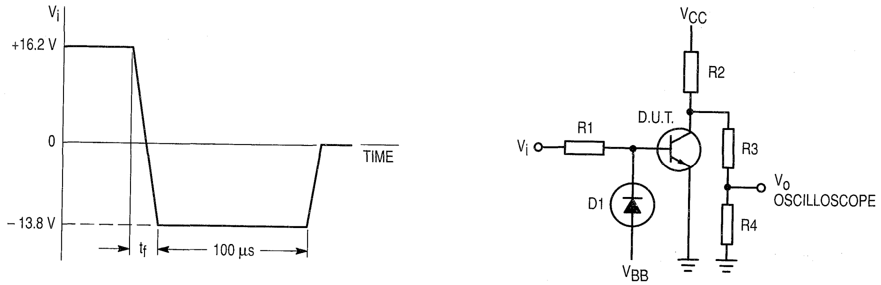


Figure 2. Input Waveform and Test Circuit for Determining Storage Time and Fall Time

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

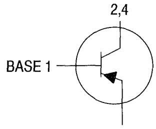
PNP Silicon Epitaxial Transistor

PZT2907AT1

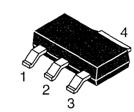
Motorola Preferred Device

This PNP Silicon Epitaxial transistor is designed for use in linear and switching applications. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- NPN Complement is PZT2222AT1
- The SOT-223 package can be soldered using wave or reflow
- SOT-223 package ensures level mounting, resulting in improved thermal conduction, and allows visual inspection of soldered joints. The formed leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 12 mm tape and reel
  Use PZT2907AT1 to order the 7 inch/1000 unit reel.
  Use PZT2907AT3 to order the 13 inch/4000 unit reel.



SOT-223 PACKAGE
PNP SILICON
TRANSISTOR
SURFACE MOUNT



CASE 318E-04, STYLE 1
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

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	I_C	−600	mAdc
Total Power Dissipation @ T_A = 25°C* Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Lead Temperature for Soldering, 0.0625″ from case Time in Solder Bath	T_L	260 5	°C Sec

DEVICE MARKING

P2F

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−60	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector-Base Cutoff Current (V_{CB} = −50 Vdc, I_E = 0)	I_{CBO}	—	—	−10	nAdc
Collector-Emitter Cutoff Current (V_{CE} = −30 Vdc, V_{BE} = 0.5 Vdc)	I_{CEX}	—	—	−50	nAdc
Base-Emitter Cutoff Current (V_{CE} = −30 Vdc, V_{BE} = −0.5 Vdc)	I_{BEX}	—	—	−50	nAdc

*Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 sq. in.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS*						
DC Current Gain		h_{FE}				—
(I_C = –0.1 mAdc, V_{CE} = –10 Vdc)			75	—	—	
(I_C = –1.0 mAdc, V_{CE} = –10 Vdc)			100	—	—	
(I_C = –10 mAdc, V_{CE} = –10 Vdc)			100	—	—	
(I_C = –150 mAdc, V_{CE} = –10 Vdc)			100	—	300	
(I_C = –500 mAdc, V_{CE} = –10 Vdc)			50	—	—	
Collector-Emitter Saturation Voltages		$V_{CE(sat)}$				Vdc
(I_C = –150 mAdc, I_B = –15 mAdc)			—	—	–0.4	
(I_C = –500 mAdc, I_B = –50 mAdc)			—	—	–1.6	
Base-Emitter Saturation Voltages		$V_{BE(sat)}$				Vdc
(I_C = –150 mAdc, I_B = –15 mAdc)			—	—	–1.3	
(I_C = –500 mAdc, I_B = –50 mAdc)			—	—	–2.6	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = –50 mAdc, V_{CE} = –20 Vdc, f = 100 MHz)		f_T	200	—	—	MHz
Output Capacitance (V_{CB} = –10 Vdc, I_E = 0, f = 1.0 MHz)		C_c	—	—	8.0	pF
Input Capacitance (V_{EB} = –2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_e	—	—	30	pF
SWITCHING TIMES						
Turn-On Time	(V_{CC} = –30 Vdc, I_C = –150 mAdc, I_{B1} = –15 mAdc)	t_{on}	—	—	45	ns
Delay Time		t_d	—	—	10	
Rise Time		t_r	—	—	40	
Turn-Off Time	(V_{CC} = –6.0 Vdc, I_C = –150 mAdc, I_{B1} = I_{B2} = –15 mAdc)	t_{off}	—	—	100	ns
Storage Time		t_s	—	—	80	
Fall Time		t_f	—	—	30	

*Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle = 2.0%.

2

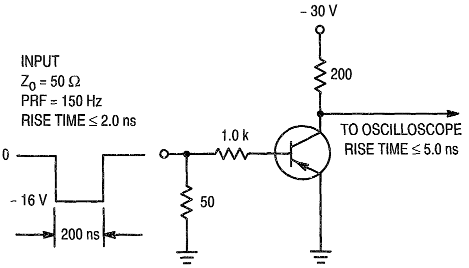


Figure 1. Delay and Rise Time Test Circuit

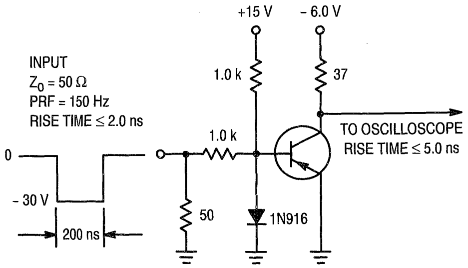


Figure 2. Storage and Fall Time Test Circuit

TYPICAL ELECTRICAL CHARACTERISTICS

2

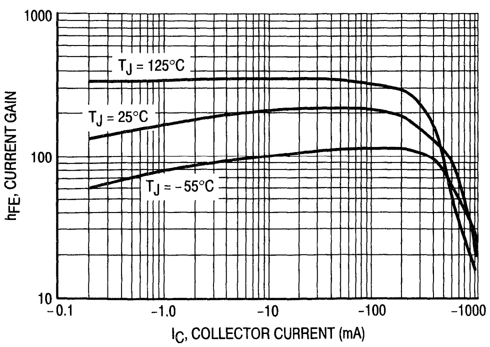


Figure 3. DC Current Gain

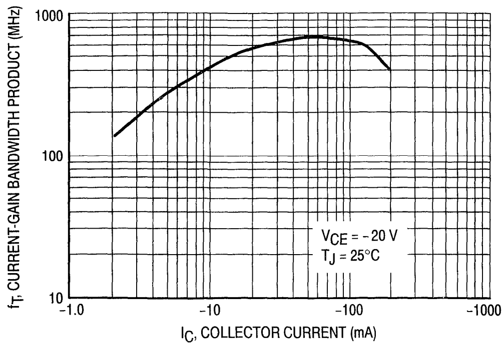


Figure 4. Current Gain Bandwidth Product

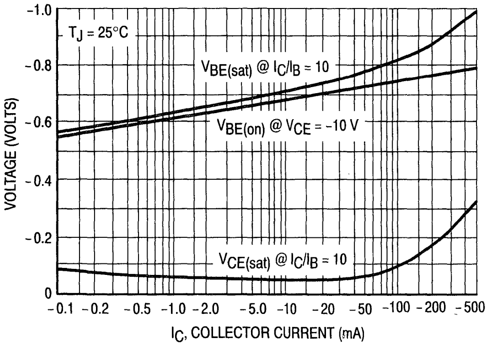


Figure 5. "ON" Voltage

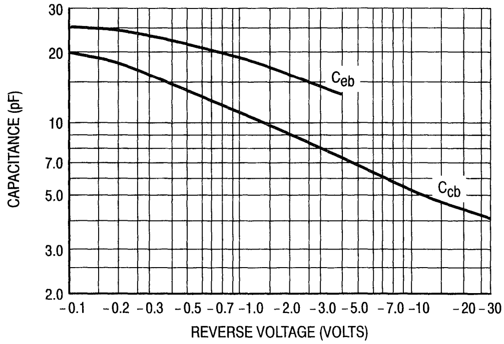


Figure 6. Capacitances

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

NPN Small-Signal Darlington Transistor

PZTA14T1

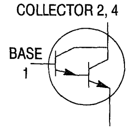
Motorola Preferred Device

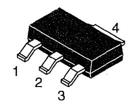
2

This NPN small signal darlington transistor is designed for use in switching applications, such as print hammer, relay, solenoid and lamp drivers. The device is housed in the SOT-223 package, which is designed for medium power surface mount applications.

- High f_T: 125 MHz Minimum
- The SOT-223 Package can be Soldered Using Wave or Reflow.
- SOT-223 package ensures level mounting, resulting in improved thermal conduction, and allows visual inspection of soldered joints. The formed leads absorb thermal stress during soldering, eliminating the possibility of damage to the die.
- Available in 12 mm Tape and Reel
  Use PZTA14T1 to order the 7 inch/1000 unit reel
  Use PZTA14T3 to order the 13 inch/4000 unit reel
- The PNP Complement is PZTA64T1

MEDIUM POWER NPN SILICON DARLINGTON TRANSISTOR SURFACE MOUNT





CASE 318E-04, STYLE 1
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current	I_C	300	mAdc
Total Power Dissipation @ T_A = 25°C	P_D*	1.5	Watts
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

P1N

THERMAL CHARACTERISTICS

Thermal Resistance Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a FR-4 glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.0625 in.; mounting pad for the collector lead = 0.93 sq. in.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

2

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

Characteristics	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	$V_{(BR)CES}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	10	—	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
Emitter-Base Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	—	—	0.1	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		10,000	—	—	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		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)	$V_{BE(on)}$	—	—	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	f_T	125	—	—	MHz

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

TYPICAL ELECTRICAL CHARACTERISTICS

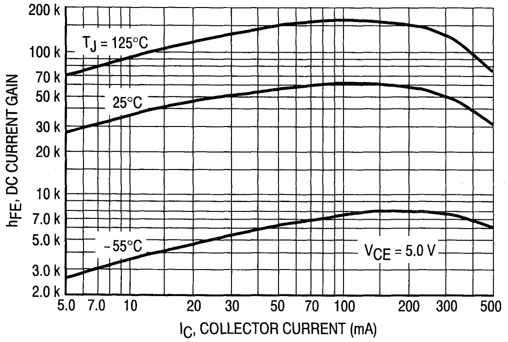


Figure 1. DC Current Gain

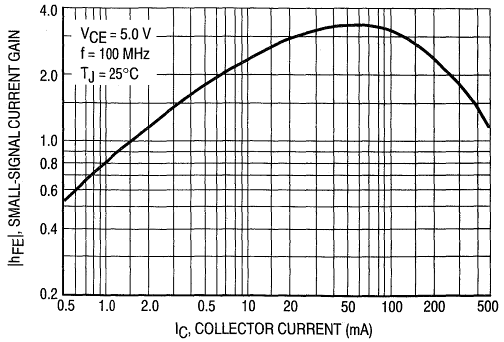


Figure 2. High Frequency Current Gain

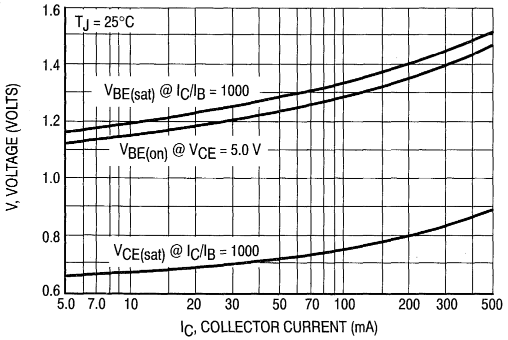


Figure 3. "On" Voltages

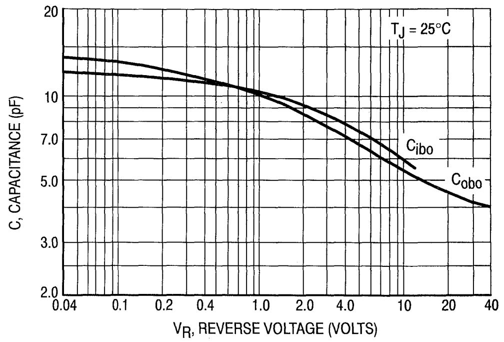


Figure 4. Capacitance

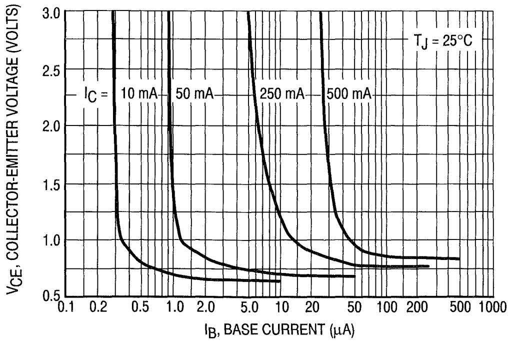


Figure 5. Collector Saturation Region

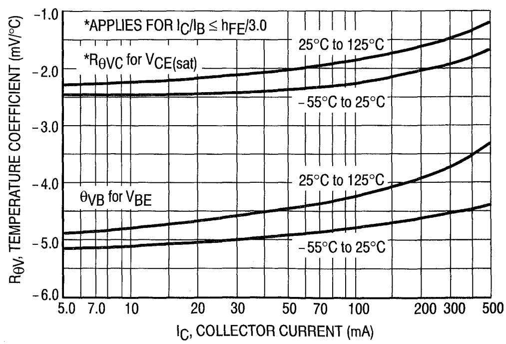
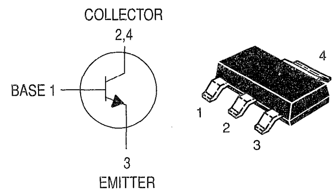


Figure 6. Temperature Coefficients

2

PZTA42T1★

CASE 318E-04, STYLE 1
(TO-261AA)



SOT-223 PACKAGE
NPN SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Open Base)	V_{CEO}	300	Vdc
Collector-Base Voltage (Open Emitter)	V_{CBO}	300	Vdc
Emitter-Base Voltage (Open Collector)	V_{EBO}	6.0	Vdc
Collector Current (DC)	I_C	500	mAdc
Total Power Dissipation up to $T_A = 25°C$*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

P1D

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°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 ($I_E = 100$ µAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector-Base Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$)	I_{CBO}	—	0.1	µAdc
Emitter-Base Cutoff Current ($V_{BE} = 6.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	µAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)		25	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		40	—	
($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		40	—	
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	50	—	MHz
Feedback Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{re}	—	3.0	pF
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

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.
(1) Pulse Test Conditions, $t_p = 300$ µs, $\delta = 0.02$.

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

PNP Small-Signal Darlington Transistor

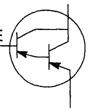
PZTA64T1

Motorola Preferred Device

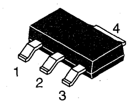
2

This PNP small-signal darlington transistor is designed for use in preamplifiers input applications or wherever it is necessary to have a high input impedance. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- High f_T: 125 MHz Minimum
- The SOT-223 Package can be Soldered Using Wave or Reflow.
- SOT-223 package ensures level mounting, resulting in improved thermal conduction, and allows visual inspection of soldered joints. The formed leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 12 mm Tape and Reel
  Use PZTA64T1 to order the 7 inch/1000 unit reel.
  Use PZTA64T3 to order the 13 inch/4000 unit reel.
- NPN Complement is PZTA14T1



**SOT-223 PACKAGE
PNP SILICON
DARLINGTON
TRANSISTOR
SURFACE MOUNT**



**CASE 318E-04, STYLE 1
TO-261AA**

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

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
Total Power Dissipation @ T_A = 25°C	P_D*	1.5	Watts
Collector Current	I_C	500	mAdc
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to +150	°C

DEVICE MARKING

P2V

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

* Device mounted on a FR-4 glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.0625 in.; mounting pad for the collector lead = 0.93 sq. in.

Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

2

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)	$V_{(BR)CES}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	$V_{(BR)EBO}$	10	—	Vdc
Emitter-Base Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain	h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		10,000	—	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		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 (V_{CE} = 5.0 Vdc, I_C = 100 mAdc)	$V_{BE(on)}$	—	2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	125	—	MHz

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

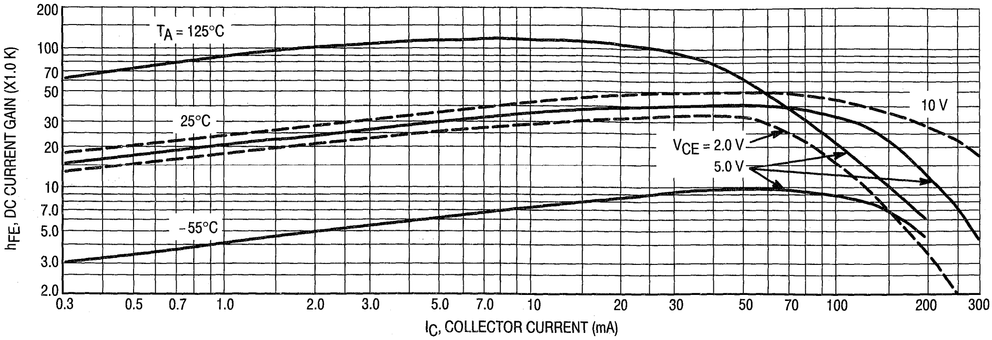


Figure 1. DC Current Gain

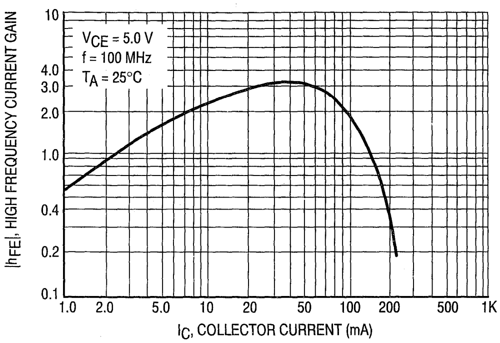


Figure 2. High Frequency Current Gain

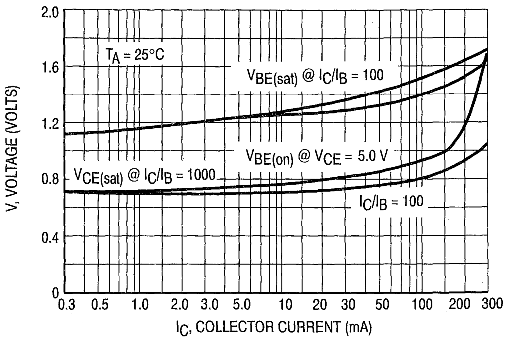


Figure 3. "On" Voltage

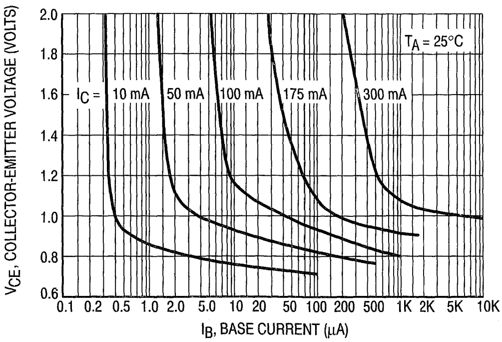
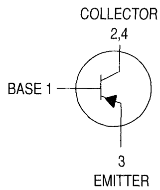


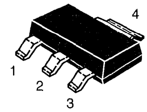
Figure 4. Collector Saturation Region

2

PZTA92T1★

CASE 318E-04, STYLE 1
(TO-261AA)





SOT-223 PACKAGE
PNP SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT

★**This is a Motorola designated preferred device.**

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	I_C	– 500	mAdc
Total Power Dissipation up to T_A = 25°C*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

P2D

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

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

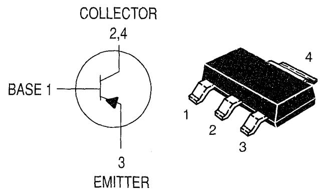
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = – 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	– 300	—	Vdc
Collector-Base Breakdown Voltage (I_C = – 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	– 300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = – 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	– 5.0	—	Vdc
Collector-Base Cutoff Current (V_{CB} = – 200 Vdc, I_E = 0)	I_{CBO}	—	– 0.25	μAdc
Emitter-Base Cutoff Current (V_{BE} = – 3.0 Vdc, I_C = 0)	I_{EBO}	—	– 0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (1)	h_{FE}			—
(I_C = – 1.0 mAdc, V_{CE} = – 10 Vdc)		25	—	
(I_C = – 10 mAdc, V_{CE} = – 10 Vdc)		40	—	
(I_C = – 30 mAdc, V_{CE} = – 10 Vdc)		25	—	
Saturation Voltages				Vdc
(I_C = – 20 mAdc, I_B = – 2.0 mAdc)	$V_{CE(sat)}$	—	– 0.5	
(I_C = – 20 mAdc, I_B = – 2.0 mAdc)	$V_{BE(sat)}$	—	– 0.9	
DYNAMIC CHARACTERISTICS				
Collector-Base Capacitance @ f = 1.0 MHz (V_{CB} = – 20 Vdc, I_E = 0)	C_{cb}	—	6.0	pF
Current-Gain — Bandwidth Product (I_C = – 10 mAdc, V_{CE} = – 20 Vdc, f = 100 MHz)	f_T	50	—	MHz

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

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

PZTA96T1★

CASE 318E-04, STYLE 1
(TO-261AA)



SOT-223 PACKAGE
PNP SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	– 450	Vdc
Collector-Base Voltage	V_{CBO}	– 450	Vdc
Emitter-Base Voltage	V_{EBO}	– 5.0	Vdc
Collector Current	I_C	– 500	mAdc
Total Power Dissipation up to T_A = 25°C*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

ZTA96

THERMAL CHARACTERISTICS

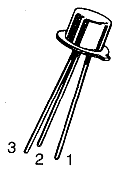
Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C

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

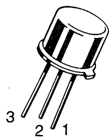
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = –1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	– 450	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = –100 μAdc, I_E = 0)	$V_{(BR)CBO}$	– 450	—	Vdc
Emitter-Base Breakdown Voltage (I_E = –10 μAdc, I_C = 0)	$V_{(BR)EBO}$	– 5.0	—	Vdc
Collector-Base Cutoff Current (V_{CB} = –400 Vdc, I_E = 0)	I_{CBO}	—	– 0.1	μAdc
Emitter-Base Cutoff Current (V_{BE} = –4.0 Vdc, I_C = 0)	I_{EBO}	—	– 0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = –10 mAdc, V_{CE} = –10 Vdc)	h_{FE}	50	150	—
Saturation Voltages (I_C = –20 mAdc, I_B = –2.0 mAdc) (I_C = –20 mAdc, I_B = –2.0 mAdc)	 $V_{CE(sat)}$ $V_{BE(sat)}$	 — —	 – 0.6 – 1.0	Vdc

* Device mounted on an epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

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



CASE 22-03
(TO-206AA)
TO-18



CASE 79-04
(TO-205AD)
TO-39

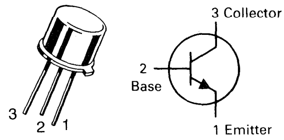
Motorola's metal-can transistor product offering includes: general purpose, switching, high voltage, choppers, Darlingtons, and low noise amplifiers.

Metal-Can Transistors

3

2N697

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N2218A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
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°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 Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	290	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	88	°C/W

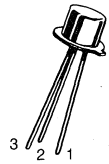
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

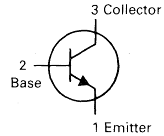
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} = 10 ohms)	$V_{(BR)CER}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 1.0 100	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	120	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{obo}	—	35	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	h_{fe}	2.5	—	MHz

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

2N718A
2N956

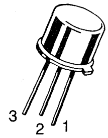
CASE 22-03, STYLE 1
TO-18 (TO-206AA)





2N1711

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N718A 2N956	2N1711	Unit
Collector-Emitter Voltage	V_{CER}	50		Vdc
Collector-Base Voltage	V_{CBO}	75		Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
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

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N718A 2N956	2N1711	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	58	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	219	°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 mAdc, pulsed; R_{BE} ≤ 10 ohms)(1)		$V_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, 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°C)		I_{CBO}	 — —	 0.001 —	 0.01 10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	 2N718A, 2N956, 2N1711	I_{EBO}	 — —	 — —	 0.010 0.005	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.01 mAdc, V_{CE} = 10 Vdc)	 2N956, 2N1711	h_{FE}	 20	 —	 —	—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N956, 2N1711		20 35	— —	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N956, 2N1711		35 75	— —	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	2N718A, 2N956, 2N1711		20 35	— —	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N718A, 2N956, 2N1711		40 100	— —	120 300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N718A, 2N956, 2N1711		20 40	— —	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.24	1.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	—	1.0	1.3	Vdc

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

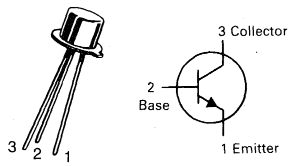
3

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

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N718A,		60	300	—	
	2N956, 2N1711		70	300		
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{obo}	—	4.0	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1 MHz)		C_{ibo}	—	20	80	pF
Input Impedance		h_{ib}				ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)			24	—	34	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			4.0	—	8.0	
Voltage Feedback Ratio		h_{rb}				$X10^{-4}$
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N718A,		—	—	3.0	
	2N956, 2N1711		—	—	5.0	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N718A,		—	—	3.0	
	2N956, 2N1711		—	—	5.0	
Small-Signal Current Gain		h_{fe}				—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N718A,		30	—	100	
	2N956, 2N1711		50	—	200	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A,		35	—	150	
	2N956, 2N1711		70	—	300	
Output Admittance		h_{ob}				μmhos
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)			0.05	—	0.5	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			0.05	—	0.5	
Noise Figure		NF				dB
(I_C = 300 μAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A,		—	—	12	
	2N956, 2N1711		—	—	8.0	

2N720A★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N3019 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	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°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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

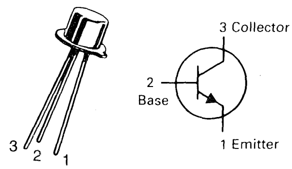
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} ≤ 10 ohms)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	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}	— —	.010 15	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	.010	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	— —	1.2 5.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	— —	0.9 1.3	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 MHz)	C_{obo}	—	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1 MHz)	C_{ibo}	—	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	1.25 1.50	X 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 45	100 —	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	— —	0.5 0.5	μmhos

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

2N930, A

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N930	2N930A	Unit
Collector-Emitter Voltage	V_{CEO}	45	45	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°C Derate above 25°C	P_D	0.5 3.33		W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9		Watt mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +175		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°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 mAdc, I_B = 0)		$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N930 2N930A	$V_{(BR)CBO}$	45 60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 2N930 2N930A	$V_{(BR)EBO}$	 5.0 6.0	— —	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	—	2.0	nAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	 2N930 2N930A	I_{CBO}	 — —	 10 2.0	nAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, V_{BE} = 0) (V_{CE} = 45 Vdc, V_{BE} = 0, T_A = 170°C)	 2N930 2N930A 2N930 2N930A	I_{CES}	 — — — —	 10 2.0 10 2.0	nAdc μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	 2N930 2N930A	I_{EBO}	 — —	 10 2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C) (I_C = 500 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(1)	 2N930A 2N930 2N930A 2N930 2N930A 2N930 2N930A	h_{FE}	60 100 20 30 150 — — —	— 300 — — — — 600 600	—

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

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N930	$V_{CE(sat)}$	—	1.0	Vdc
	2N930A		—	0.5	
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N930	$V_{BE(sat)}$	0.6	1.0	Vdc
	2N930A		0.7	0.9	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)	2N930	f_T	30	—	MHz
	2N930A		45	—	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	2N930	C_{obo}	—	8.0	pF
	2N930A		—	6.0	
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_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	150	600	—
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 k ohms, f = 1.0 kHz)		NF	—	3.0	dB

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

FIGURE 1 — COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

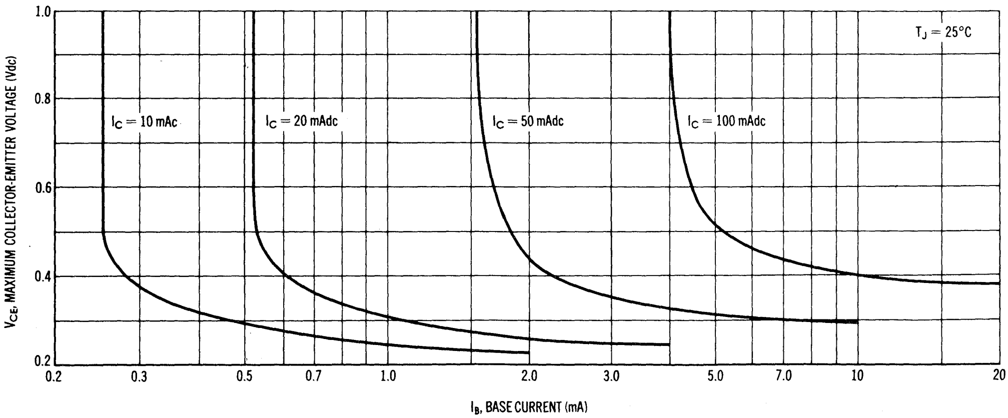


FIGURE 2 — MINIMUM CURRENT GAIN CHARACTERISTICS

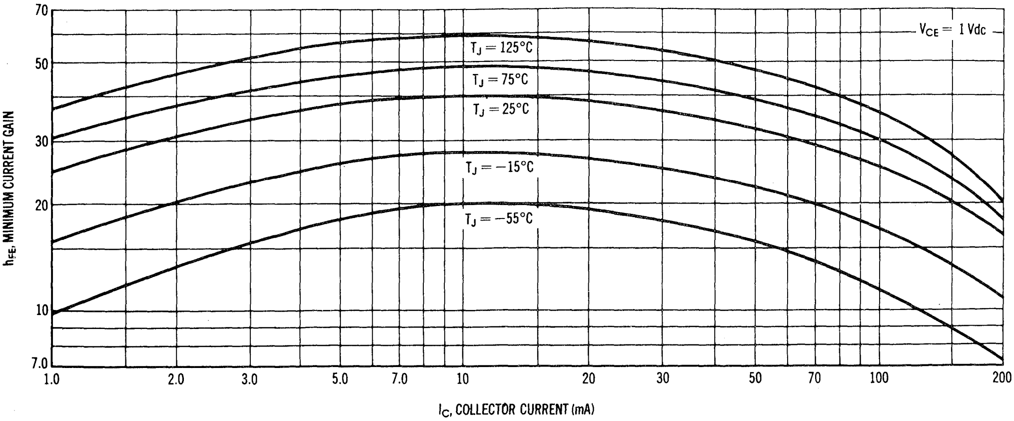


FIGURE 3 — LIMITS OF SATURATION VOLTAGES

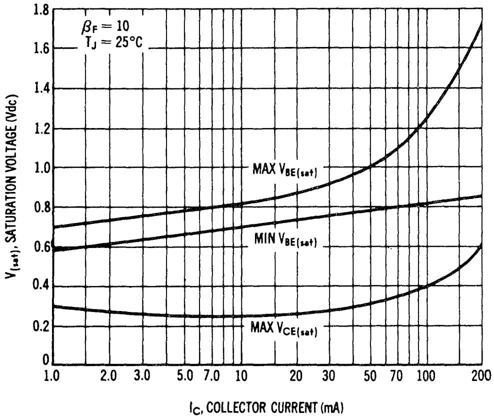
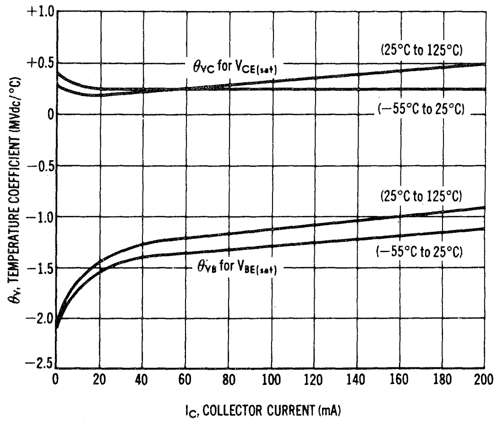


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS



TYPICAL SWITCHING CHARACTERISTICS

FIGURE 5 — TURN-ON TIME VARIATIONS WITH VOLTAGE

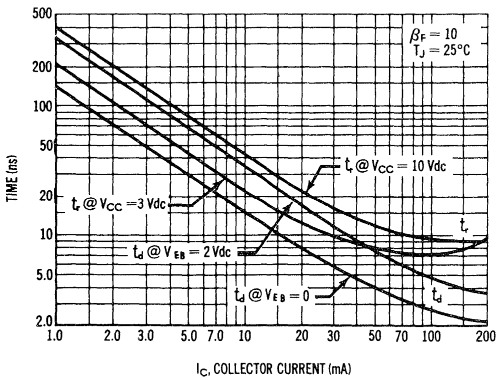


FIGURE 6 — RISE TIME BEHAVIOR

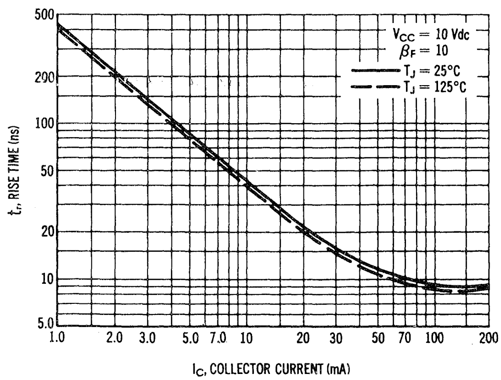


FIGURE 7 — STORAGE TIME BEHAVIOR

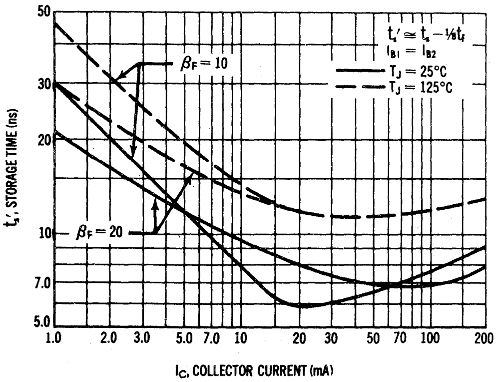


FIGURE 8 — FALL TIME BEHAVIOR

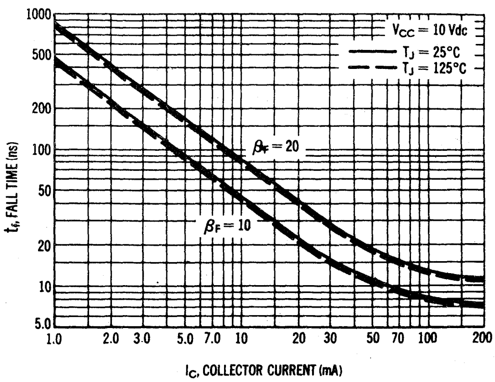


FIGURE 9 — JUNCTION CAPACITANCE VARIATIONS

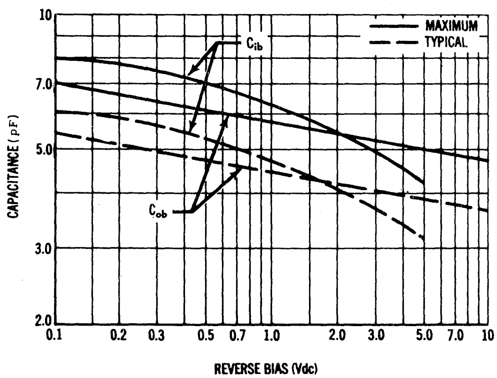
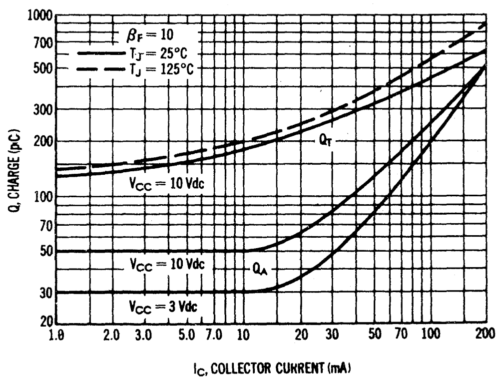


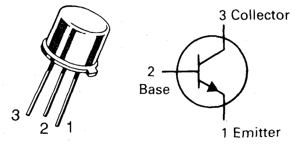
FIGURE 10 — MAXIMUM CHARGE DATA



3

2N1613

CASE 79-04, 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 (R_{BE} ≤ 10 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°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	3.0 17.15	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 Ambient	$R_{\theta JA}$	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	°C/W

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

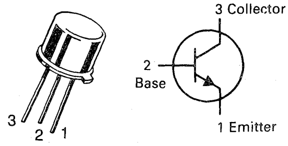
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} ≤ 10 Ohms)	$V_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 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°C)	I_{CBO}	— —	— —	10 10	nAdc 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} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	20 35 20 40 20	35 50 — 80 30	— — — 120 —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)(1)	$V_{CE(sat)}$	—	0.3	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)(1)	$V_{BE(sat)}$	—	0.78	1.3	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}	—	10	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	50	80	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	— —	3.0 3.0	$X\ 10^{-4}$
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_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	0.05 0.05	— —	0.5 0.5	μmhos
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 Ohms, f = 1.0 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 ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N1711 For Specifications, See 2N718A Data.

2N1893

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	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°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	3.0 17.2	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 Ambient	$R_{\theta JA}$	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	°C/W

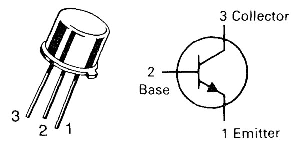
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, R_{BE} = 10 ohms)(1)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)(1)	$V_{CEO(sus)}$	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 15	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	— —	1.2 0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	— —	0.9 1.3	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 = 1.0 MHz)	C_{obo}	—	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	1.25 1.5	$X\ 10^{-4}$
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 45	100 —	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	— —	0.5 0.5	μmho

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

2N2102

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	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 @ $T_A = 25°C$ 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 Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, $R_{BE} \leq 10$ ohms)(2)	$V_{CER(sus)}$	80	—	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 100$ mAdc, $I_B = 0$)(2)	$V_{CEO(sus)}$	65	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{EB} = 1.5$ Vdc)	$V_{(BR)CEX}$	120	—	—	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 ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	— —	2.0 2.0	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ 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)(2) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$)(2) ($I_C = 150$ 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)(2)	$V_{CE(sat)}$	—	0.15	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)(2)	$V_{BE(sat)}$	—	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 = 1.0 MHz)	C_{obo}	—	6.0	15	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	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	$X\ 10^{-4}$
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	μmho
Noise Figure ($I_C = 300$ μAdc, $V_{CE} = 10$ 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

(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

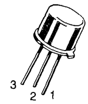
Rating	Symbol	2N2219 2N2222	2N2218A 2N2219A 2N2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	800	800	mAdc
		2N2218A 2N2219,A	2N2222,A	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 0.8 4.57	 0.4 2.28	 Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 3.0 17.1	 1.2 6.85	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

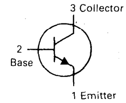
THERMAL CHARACTERISTICS

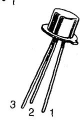
Characteristic	Symbol	2N2218A 2N2219,A	2N2222,A	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	437.5	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	145.8	°C/W

2N2218A,2N2219,A★ 2N2222,A★

2N2218, A/2N2219,A
CASE 79-04
TO-39 (TO-205AD)
STYLE 1







A/2N2222,A
CASE 22-03
TO-18 (TO-206AA)
STYLE 1

GENERAL PURPOSE TRANSISTORS

NPN SILICON

★2N2219A and 2N2222A are Motorola designated preferred devices.

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)	 Non-A Suffix A-Suffix	$V_{(BR)CEO}$	 30 40	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 Non-A Suffix A-Suffix	$V_{(BR)CBO}$	 60 75	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 Non-A Suffix A-Suffix	$V_{(BR)EBO}$	 5.0 6.0	 — —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	 A-Suffix	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 Non-A Suffix A-Suffix	I_{CBO}	 — — — —	 0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	 A-Suffix	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)	 2N2218A 2N2219,A, 2N2222,A	h_{FE}	 20 35	 — —	—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2218A 2N2219,A, 2N2222,A		25 50	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N2218A 2N2219,A, 2N2222,A		35 75	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)(1)	2N2218A 2N2219,A, 2N2222,A		15 35	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2218A 2N2219,A, 2N2222,A		40 100	120 300	

3

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

Characteristic		Symbol	Min	Max	Unit
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N2218A 2N2219,A, 2N2222,A		20 50	— —	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2219, 2N2222 2N2218A 2N2219A, 2N2222A		30 25 40	— — —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix A-Suffix	$V_{CE(sat)}$	— —	0.4 0.3	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix A-Suffix		— —	1.6 1.0	
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix A-Suffix	$V_{BE(sat)}$	0.6 0.6	1.3 1.2	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix A-Suffix		— —	2.6 2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	All Types, Except 2N2219A, 2N2222A	f_T	250 300	— —	MHz
Output Capacitance(3) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance(3) (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	Non-A Suffix A-Suffix	C_{ibo}	— —	30 25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A 2N2219A, 2N2222A	h_{ie}	1.0 2.0	3.5 8.0	kohms
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A 2N2219A, 2N2222A		0.2 0.25	1.0 1.25	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A 2N2219A, 2N2222A	h_{re}	— —	5.0 8.0	$X\ 10^{-4}$
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A 2N2219A, 2N2222A		— —	2.5 4.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A 2N2219A, 2N2222A	h_{fe}	30 50	150 300	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A 2N2219A, 2N2222A		50 75	300 375	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A 2N2219A, 2N2222A	h_{oe}	3.0 5.0	15 35	μmhos
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A 2N2219A, 2N2222A		10 15	100 200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20Vdc, f = 31.8 MHz)	A-Suffix	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)	2N2222A	NF	—	4.0	dB
Real Part of Common-Emitter High Frequency Input Impedance (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 300 MHz)	2N2218A, 2N2219A 2N2222A	$Re(h_{ie})$	—	60	Ohms

(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.
(3) 2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

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

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 12)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 13)	t_s	—	225	ns
Fall Time		t_f	—	60	ns
Active Region Time Constant (I_C = 150 mAdc, V_{CE} = 30 Vdc) (See Figure 11 for 2N2218A, 2N2219A, 2N2221A, 2N2222A)		T_A	—	2.5	ns

3

FIGURE 1 — NORMALIZED DC CURRENT GAIN

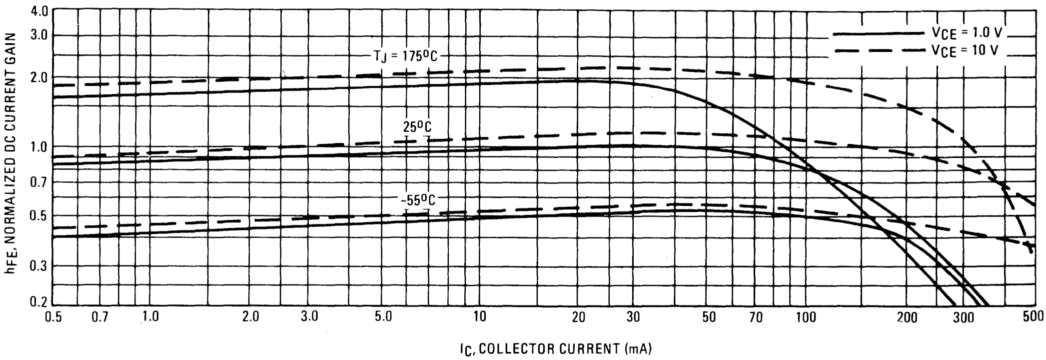
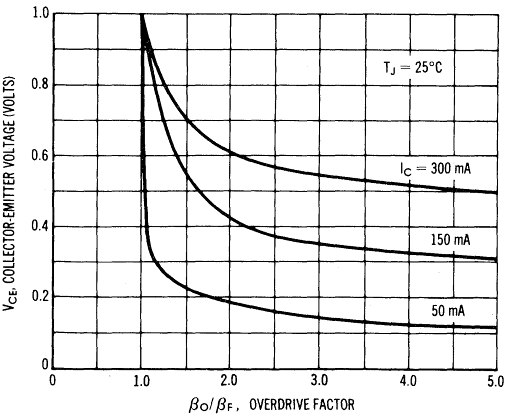


FIGURE 2 — COLLECTOR CHARACTERISTICS IN SATURATION REGION



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_F (forced gain) is the ratio of I_C/I_{BF} in a circuit.

EXAMPLE: For type 2N2219, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_C = 150 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, β_o = 62 and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_F} = \frac{h_{FE} \text{ @ } 1.0\text{ V}}{I_C/I_{BF}} \qquad 2.5 = \frac{62}{150/I_{BF}} \qquad I_{BF} \approx 6.0 \text{ mA}$$

FIGURE 3 — "ON" VOLTAGES

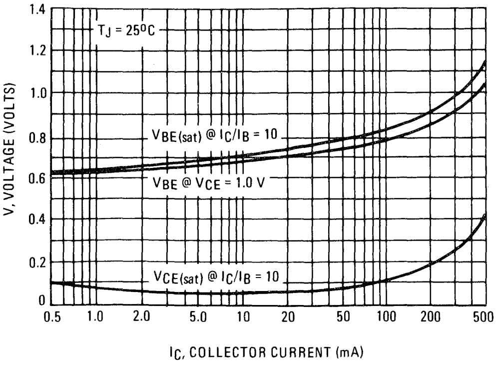
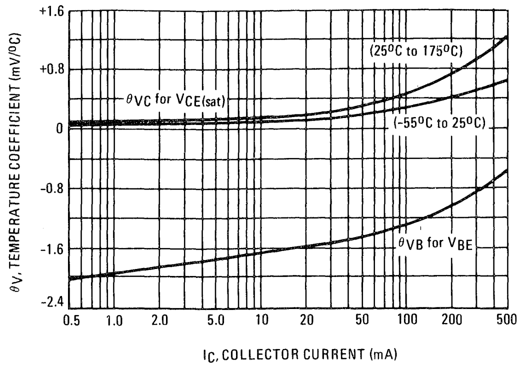


FIGURE 4 — TEMPERATURE COEFFICIENTS



3

h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°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

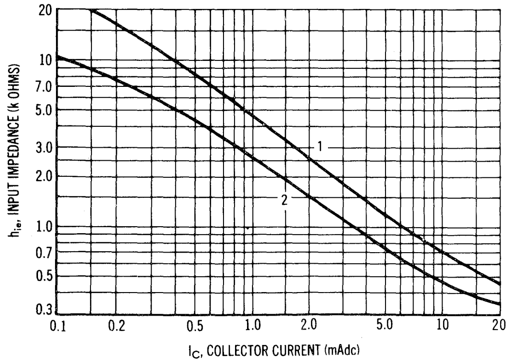


FIGURE 6 — VOLTAGE FEEDBACK RATIO

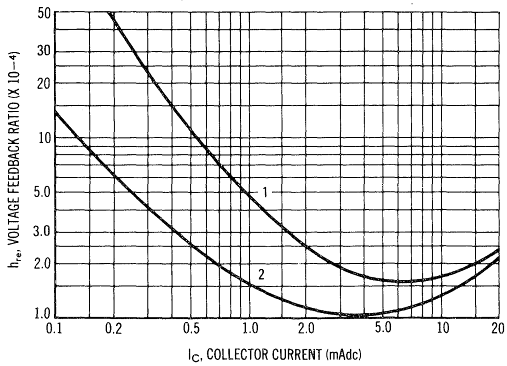


FIGURE 7 — CURRENT GAIN

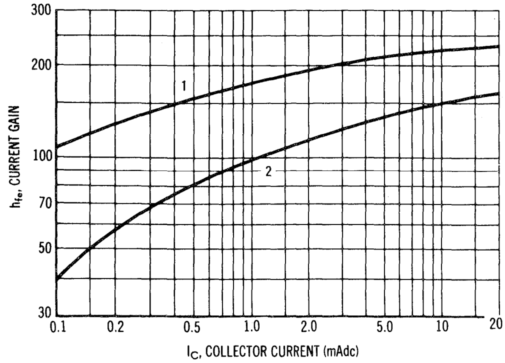
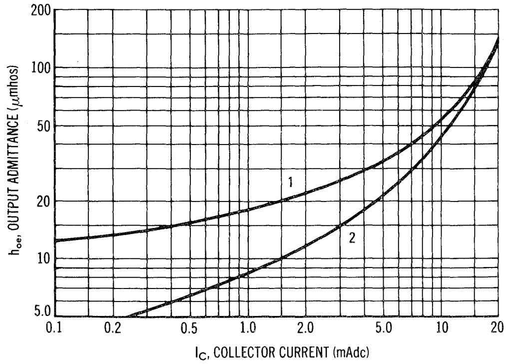


FIGURE 8 — OUTPUT ADMITTANCE



SWITCHING TIME CHARACTERISTICS

FIGURE 9 — TURN-ON TIME

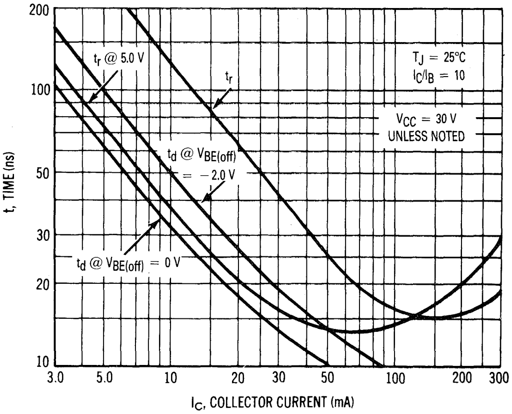


FIGURE 10 — CHARGE DATA

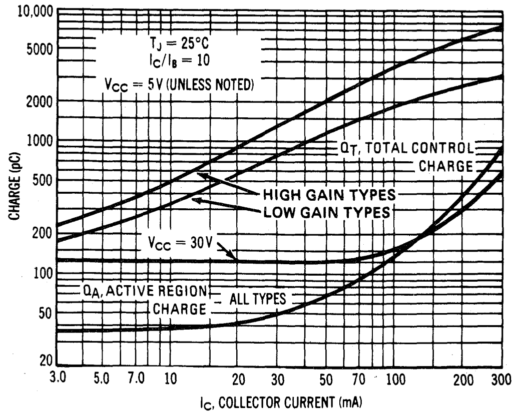
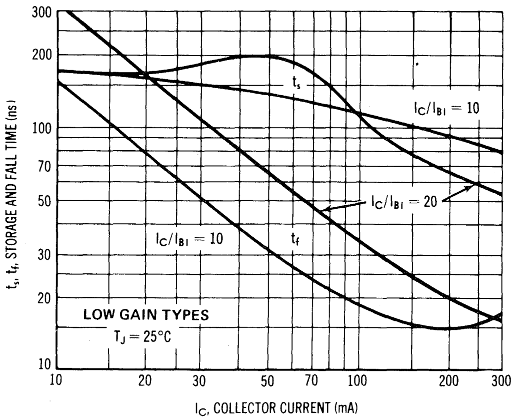


FIGURE 11 — TURN-OFF BEHAVIOR



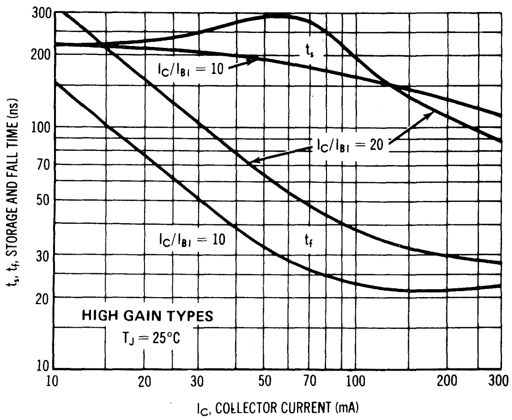


FIGURE 12 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

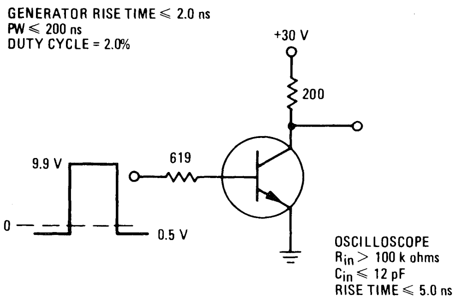
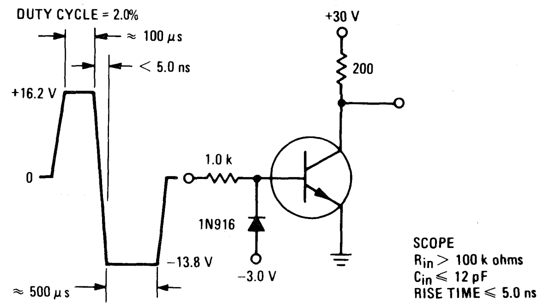


FIGURE 13 — STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT

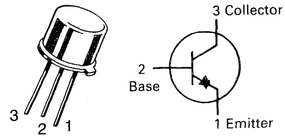


3

3

2N2270

CASE 79-04, STYLE 1
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, $R_{BE} \leqslant$ 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	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 Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°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 = 100 mAdc, $R_{BE} \leqslant$ 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°C) (V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	— —	— —	0.05 100	μAdc
Emitter Cutoff Current (V_{EB} = 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)(2)	h_{FE}	 30 50	 90 135	 — 200	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)(2)	$V_{CE(sat)}$	—	0.15	0.9	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)(2)	$V_{BE(sat)}$	—	0.88	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	10	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	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 $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.

MAXIMUM RATINGS

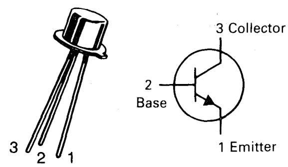
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current (10 μs pulse)	$I_{C(Peak)}$	500	mA
Collector Current — Continuous	I_C	200	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	.68 6.85	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 Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	147	°C/W

2N2369,A★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTORS

NPN SILICON

★2N2369A is a Motorola designated preferred device.

3

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 μA, 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 = 10 μA, I_B = 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 = 150°C)	 2N2369 2N2369A	I_{CBO}	 — —	 0.4 30	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N2369A	I_{CES}	—	0.4	μAdc
Base Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N2369A	I_B	—	0.4	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 = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = −55°C) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc)	 2N2369 2N2369A 2N2369 2N2369A 2N2369A	h_{FE}	 40 — 20 20 30	 120 120 — — —	—

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

Characteristic		Symbol	Min	Max	Unit
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N2369A		20	—	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	2N2369		20	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N2369		—	0.25	
	2N2369A		—	0.20	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)	2N2369A		—	0.30	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N2369A		—	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2369A		—	0.50	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types		0.70	0.85	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)	2N2369A		0.59	—	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = −55°C)	2N2369A		—	1.02	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N2369A		—	1.15	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2369A		—	1.60	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	500	—	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, f = 1.0 MHz)		C_{ibo}	—	4.0	pF
SWITCHING CHARACTERISTICS					
Storage Time (I_C = I_{B1} = 10 mAdc, I_{B2} = −10 mAdc)		t_s	—	13	ns
Turn-On Time (I_C = 10 mAdc, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA, V_{CC} = 3.0 Vdc)		t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA, V_{CC} = 3.0 Vdc)		t_{off}	—	18	ns

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

SWITCHING TIME EQUIVALENT TEST CIRCUITS FOR 2N2369, 2N3227

FIGURE 1 — t_{on} CIRCUIT — 10 mA

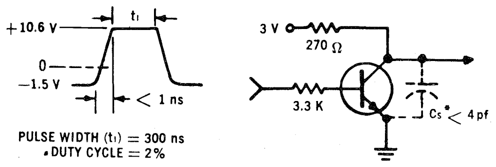


FIGURE 3 — t_{off} CIRCUIT — 10 mA

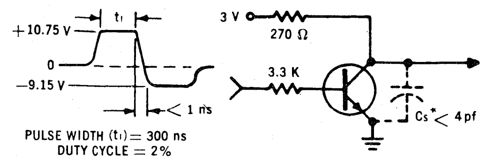


FIGURE 2 — t_{on} CIRCUIT — 100 mA

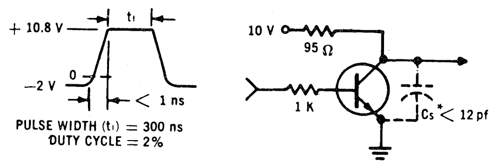
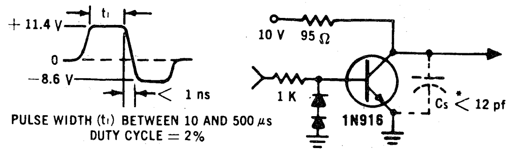


FIGURE 4 — t_{off} CIRCUIT — 100 mA



* Total shunt capacitance of test jig and connectors.

FIGURE 5 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

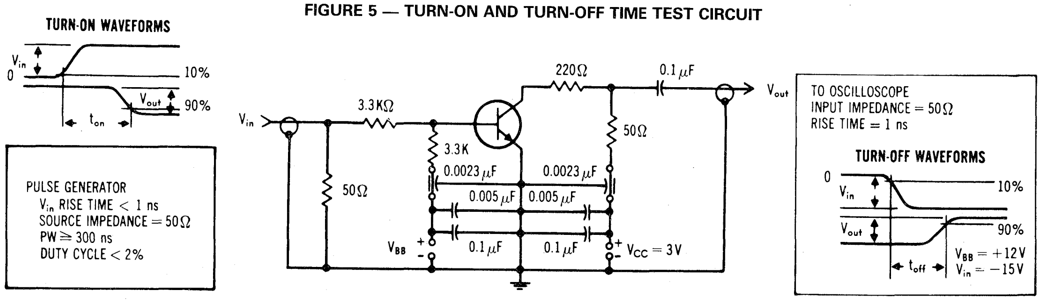


FIGURE 6 — JUNCTION CAPACITANCE VARIATIONS

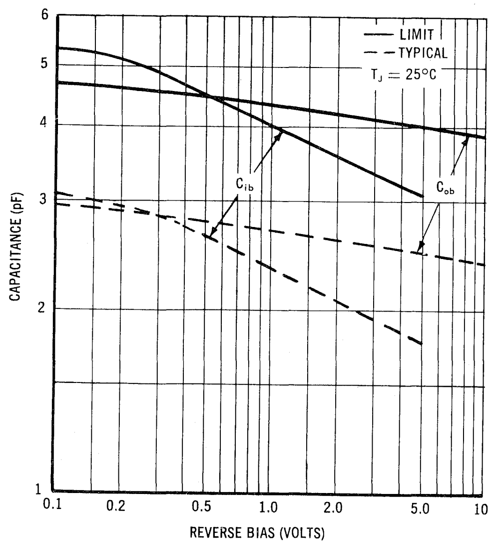
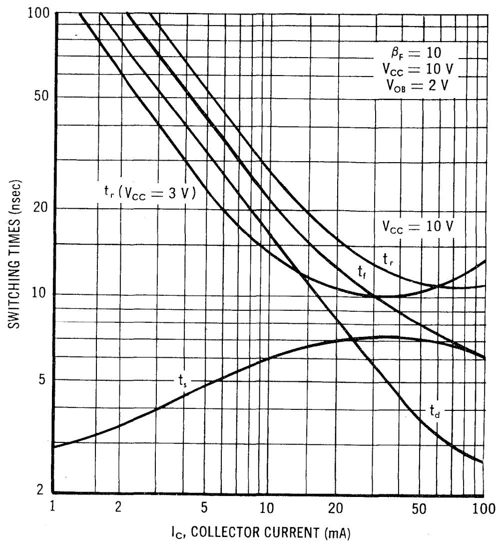


FIGURE 7 — TYPICAL SWITCHING TIMES



3

FIGURE 8 — MAXIMUM CHARGE DATA

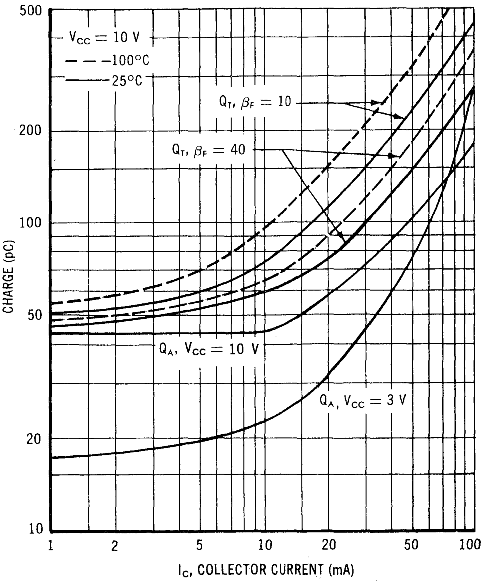


FIGURE 9 — Q_T TEST CIRCUIT

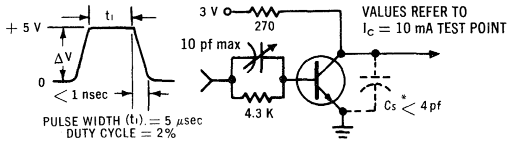


FIGURE 10 — TURN-OFF WAVE FORM

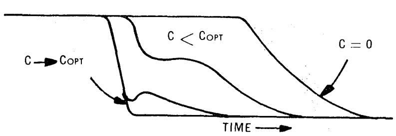


FIGURE 11 — STORAGE TIME EQUIVALENT TEST CIRCUIT

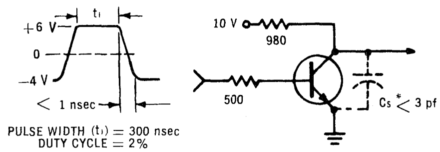


FIGURE 12 — MAXIMUM COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

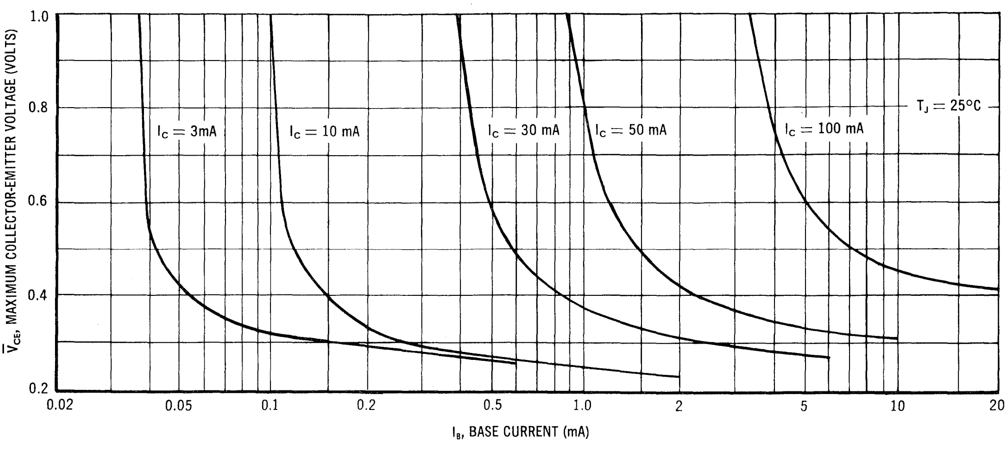


FIGURE 13 — MINIMUM CURRENT GAIN CHARACTERISTICS

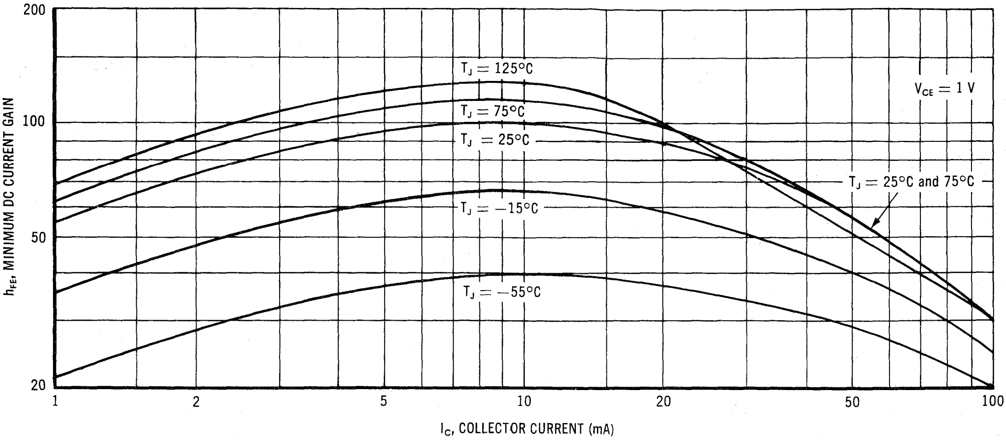


FIGURE 14 — SATURATION VOLTAGE LIMITS

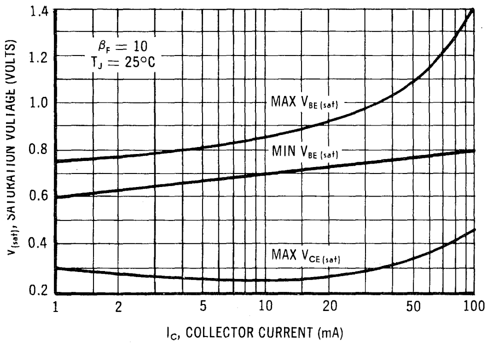
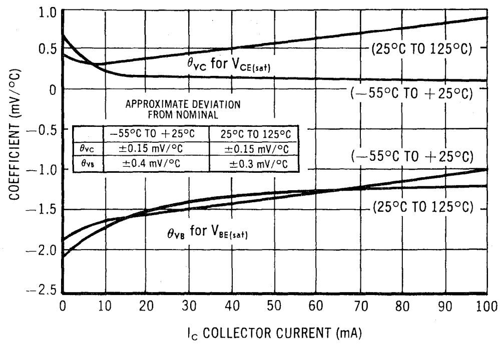


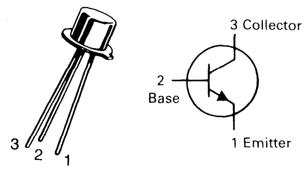
FIGURE 15 — TYPICAL TEMPERATURE COEFFICIENTS



3

2N2484★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



AMPLIFIER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

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
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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	485	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

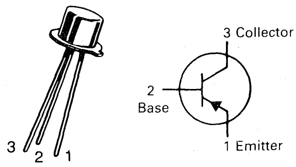
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	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, $I_C = 0$)	$V_{(BR)EBO}$	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	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	10	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) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$) ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 500$ 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)(2)	h_{FE}	30 100 20 175 200 250 —	190 250 40 275 300 350 400	— 500 — — — — 800	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	—	0.25	0.35	Vdc
Base-Emitter On Voltage ($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	0.5	0.65	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 0.05$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz) ($I_C = 0.5$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)	f_T	15 60	50 100	— —	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	3.0	6.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	4.0	6.0	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{ie}	3.5	—	24	kΩ
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{re}	—	—	800	x 10^{-6}
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = kHz)	h_{fe}	150	—	900	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{oe}	—	—	40	μmhos
Noise Figure ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ f = 100 Hz, BW = 20 Hz) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ f = 1.0 kHz, BW = 200 Hz) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ f = 10 kHz, BW = 2.0 kHz) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ f = 1.0 kHz)	NF	— — — —	8.0 — — —	10 3.0 2.0 3.0	dB

(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 ≤ 2.0%.

2N2894

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	−12	Vdc
Collector-Base Voltage	V_{CEO}	−12	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−200	mAdc
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	1200 6.85	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 Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

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

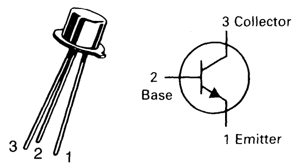
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Emitter Sustaining Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{CEO(sus)}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_B = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −6.0 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	—	−10	μAdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0)	I_{CES}	—	−80	nAdc
Base Current (V_{CE} = −6.0 Vdc, V_{BE} = 0)	I_B	—	−80	nAdc
ON CHARACTERISTICS				
DC Current Gain(2) (I_C = −10 mAdc, V_{CE} = −0.3 Vdc) (I_C = −30 mAdc, V_{CE} = −0.5 Vdc) (I_C = −30 mAdc, V_{CE} = −0.5 Vdc, T_A = −55°C) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc)(2)	h_{FE}	 30 40 17 25	 — 150 — —	—
Collector-Emitter Saturation Voltage(2) (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)	$V_{CE(sat)}$	 — — —	 −0.15 −0.2 −0.5	Vdc
Base-Emitter Saturation Voltage(2) (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)	$V_{BE(sat)}$	 −0.78 −0.85 —	 −0.98 −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	400	—	MHz
Output Capacitance (V_{CB} = −5.0 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}	—	6.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = −2.0 Vdc, V_{EB} = −3.0 Vdc, I_{B1} = −1.5 mAdc)	t_{on}	—	60	ns
Turn-Off Time (V_{CC} = −2.0 Vdc, I_C = −30 mAdc, I_{B1} = I_{B2} = −1.5 mAdc)	t_{off}	—	90	ns

(1) Applicable from 0.01 to 10 mAdc.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤2.0%.

3

2N2895, 2N2896

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N2895	2N2896	Unit
Collector-Emitter Voltage	V_{CEO}	65	90	Vdc
Collector-Emitter Voltage	V_{CER}	80	140	Vdc
Collector-Base Voltage	V_{CBO}	120	140	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	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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CER}$			Vdc
(I_C = 100 mAdc, R_{BE} = 10 ohms)	2N2895		80	—	
	2N2896		140	—	
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N2895		65	—	
	2N2896		90	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	120	—	Vdc
(I_C = 0.1 mAdc, I_E = 0)	2N2895		140	—	
	2N2896				
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 60 Vdc, I_C = 0)	2N2895		—	0.002	
	2N2896		—	0.01	
(V_{CB} = 60 Vdc, I_E = 0, T_A = +150°C)	2N2895		—	2.0	
(V_{CB} = 90 Vdc, I_E = 0)	2N2896		—	0.01	
(V_{CB} = 90 Vdc, I_E = 0, T_A = +150°C)	2N2896		—	10	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 5.0 Vdc, I_C = 0)	2N2895		—	0.005	
	2N2896		—	0.01	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 10 Vdc)	2N2895		10	—	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	2N2895		20	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2896		35	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2895		35	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	2N2895,2N2896		20	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2895		40	120	
	2N2896		60	200	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2895		25	—	

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

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 Adc)	$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	120	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	80	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) 2N2895	h_{fe}	50	200	—
2N2896		50	275	
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 500 Ohms, SN2895 f = 1.0 kHz)	NF	—	8.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.8%.

3

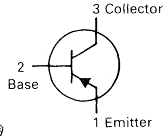
PNP SILICON ANNULAR HERMETIC TRANSISTORS

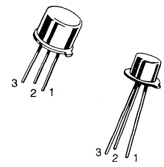
. . . designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

- High DC Current Gain Specified — 0.1 to 500 mAdc
- High Current-Gain — Bandwidth Product — f_T = 200 MHz (Min) @ I_C = 50 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- 2N2904, A thru 2N2907, A Complement to NPN 2N2218, A, 2N2219, A, 2N2221, A, 2N2222, A

2N2904,A★ thru 2N2907,A★

2N2904,A/2N2905,A
CASE 79-04, STYLE 1
TO-39 (TO-205AD)





2N2906,A/2N2907,A
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTORS
PNP SILICON

★2N2905A and 2N2907A are Motorola designated preferred devices.

3

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**	
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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max		Unit
		2N2904,A; 2N2905,A	**2N2906,A; 2N2907,A**	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	292	438	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	146	°C/W

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)	Non-A Suffix A-Suffix	$V_{(BR)CEO}$	−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} = −0.5 Vdc)		I_{CEX}	—	—	−50	nAdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0)	Non-A Suffix A-Suffix	I_{CBO}	— —	— —	−0.02 −0.01	μAdc
(V_{CB} = −50 Vdc, I_E = 0, T_A = 150°C)	Non-A Suffix A-Suffix		— —	— —	−20 −10	
Base Current (V_{CE} = −30 Vdc, V_{EB} = −0.5 Vdc)		I_B	—	—	−50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −10 Vdc)	2N2904, 2N2906 2N2905, 2N2907 2N2904A, 2N2906A 2N2905A, 2N2907A	h_{FE}	20 35 40 75	— — — —	— — — —	—

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

(continued)

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (continued)						
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc)	2N2904, 2N2906	h_{FE}	25	—	—	
	2N2905, 2N2907		50	—	—	
	2N2904A, 2N2906A		40	—	—	
	2N2905A, 2N2907A		100	—	—	
(I_C = −10 mAdc, V_{CE} = −10 Vdc)	2N2904, 2N2906		35	—	—	
	2N2905, 2N2907		75	—	—	
	2N2904A, 2N2906A		40	—	—	
	2N2905A, 2N2907A		100	—	—	
(I_C = −150 mAdc, V_{CE} = −10 Vdc)(1)	2N2904,A, 2N2906,A		40	—	120	
	2N2905,A, 2N2907,A		100	—	300	
(I_C = −500 mAdc, V_{CE} = −10 Vdc)(1)	2N2904, 2N2906		20	—	—	
	2N2905, 2N2907		30	—	—	
	2N2904A, 2N2906A		40	—	—	
	2N2905A, 2N2907A		50	—	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = −150 mAdc, I_B = −15 mAdc)			—	—	−0.4	
(I_C = −500 mAdc, I_B = −50 mAdc)			—	—	−1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = −150 mAdc, I_B = −15 mAdc)(1)			—	—	−1.3	
(I_C = −500 mAdc, I_B = −50 mAdc)(1)			—	—	−2.6	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	200	—	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	—	—	8.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	—	—	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc) (Figure 15a)	t_{on}	—	26	45	ns
Delay Time		t_d	—	6.0	10	
Rise Time		t_r	—	20	40	
Turn-Off Time	(V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = −15 mAdc) (Figure 15b)	t_{off}	—	70	100	ns
Storage Time		t_s	—	50	80	
Fall Time		t_f	—	20	30	

(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.

FIGURE 1 — NORMALIZED DC CURRENT GAIN

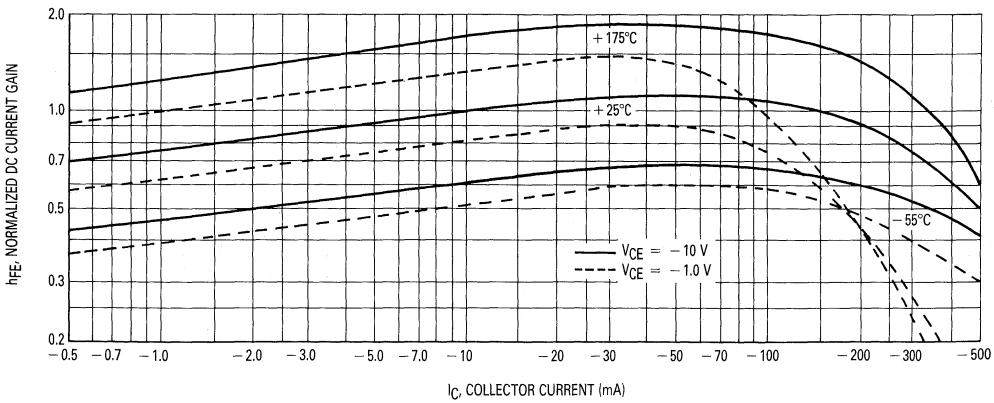
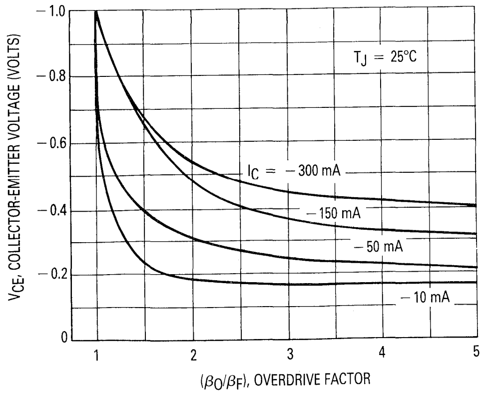


FIGURE 2 — NORMALIZED COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O (current gain at 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 2N2905, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_C = 150 mA an overdrive factor of at least 3 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.60 of h_{FE} @ 10 volts. Using the guaranteed minimum of 100 @ 150 mA and 10 V, β_O = 60 and substituting values in the overdrive equation, we find:

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE}\ @\ 1\ V}{I_C/I_{BF}} \qquad 3 = \frac{60}{150/I_{BF}} \qquad I_{BF} \approx 7.5\ mA$$

FIGURE 3 — "ON" VOLTAGES

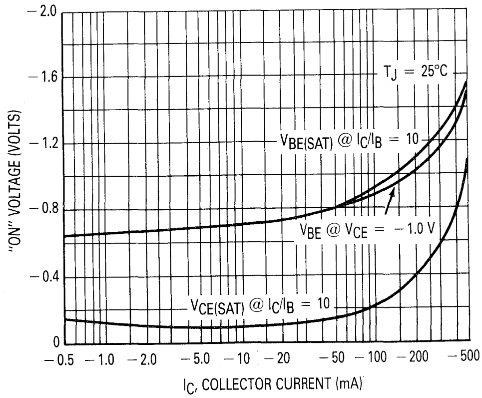
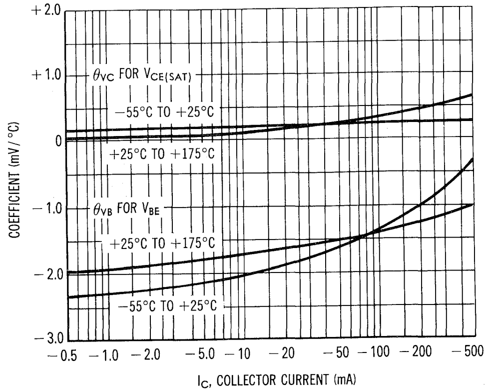


FIGURE 4 — TEMPERATURE COEFFICIENTS



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

FIGURE 5 — FREQUENCY EFFECTS

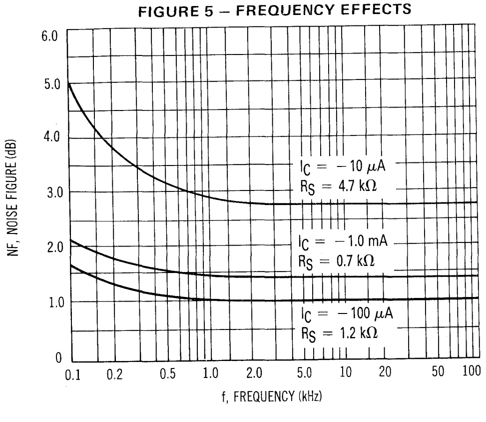
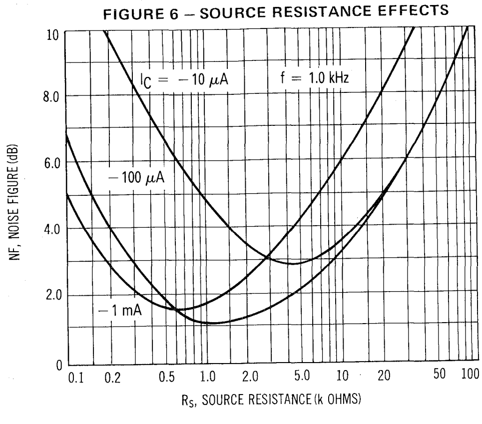


FIGURE 6 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°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 7 — INPUT IMPEDANCE

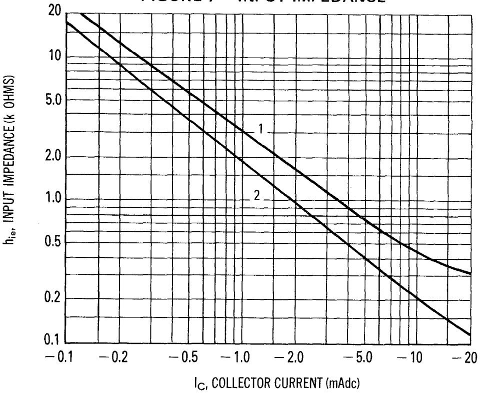


FIGURE 8 — VOLTAGE FEEDBACK RATIO

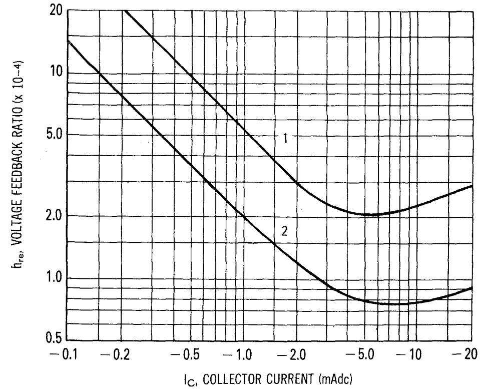


FIGURE 9 — CURRENT GAIN

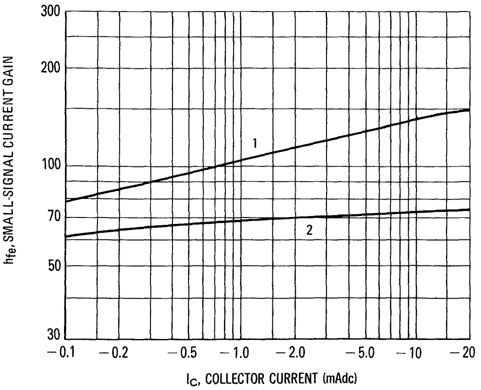


FIGURE 10 — OUTPUT ADMITTANCE

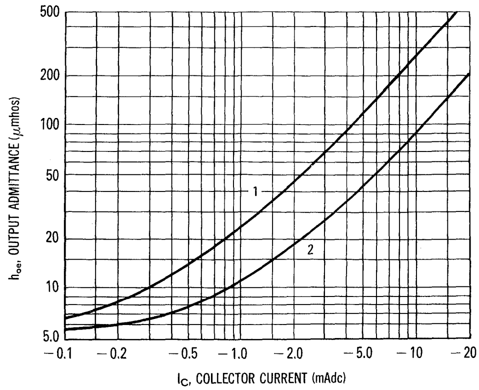


FIGURE 11 — TURN ON TIME

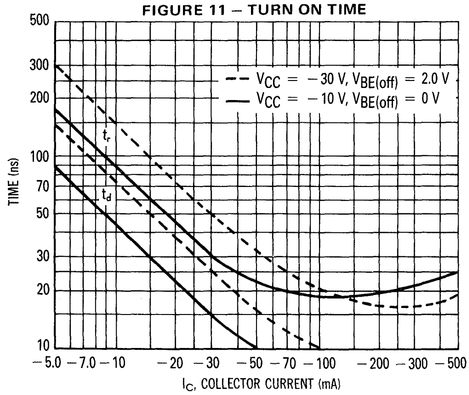
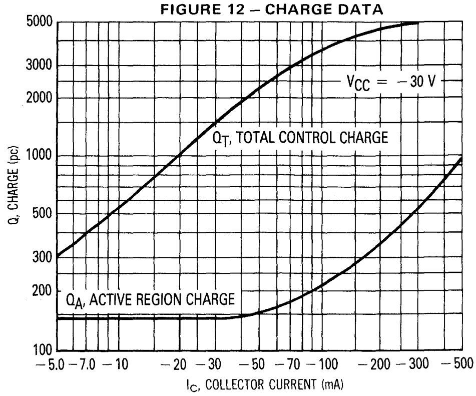


FIGURE 12 — CHARGE DATA



3

FIGURE 13 — STORAGE TIME

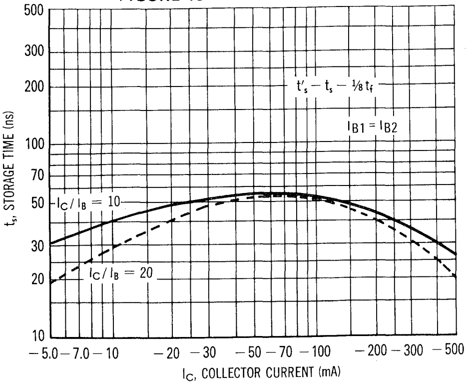


FIGURE 14 — FALL TIME

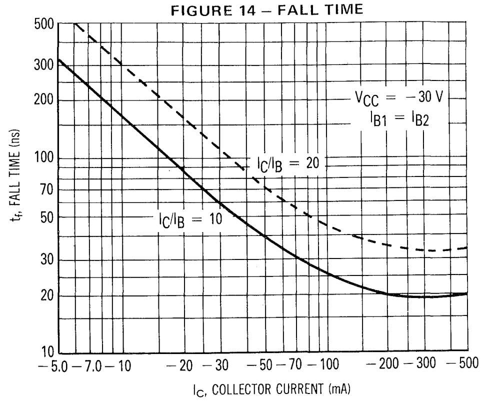


FIGURE 15a — DELAY AND RISE TIME TEST CIRCUIT

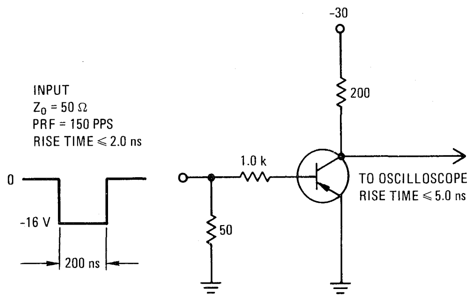


FIGURE 15b — STORAGE AND FALL TIME TEST CIRCUIT

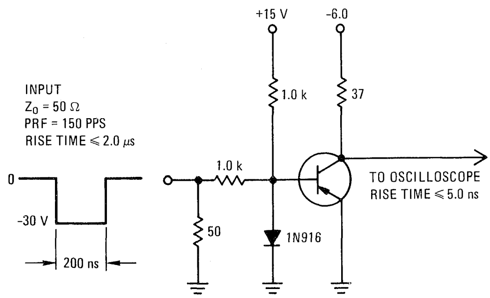


FIGURE 16 — CURRENT-GAIN—BANDWIDTH PRODUCT

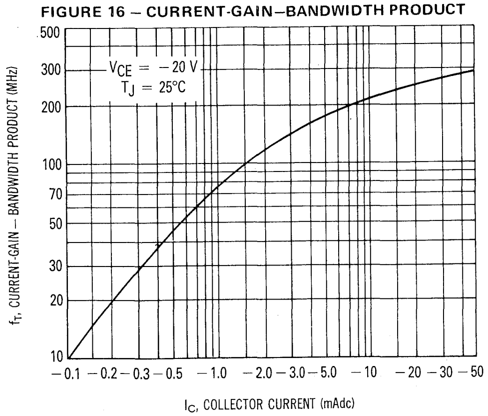


FIGURE 17 — CAPACITANCES

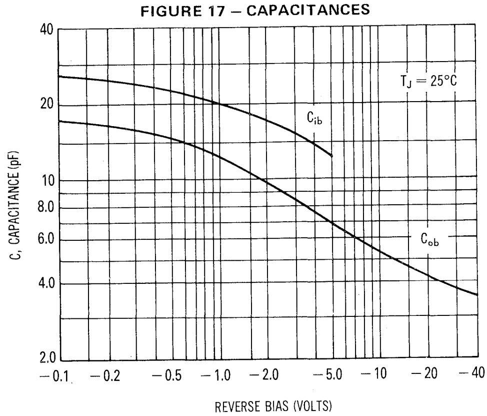
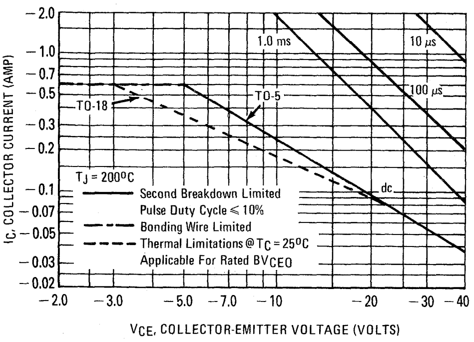


FIGURE 18 — ACTIVE REGION SAFE OPERATING AREAS



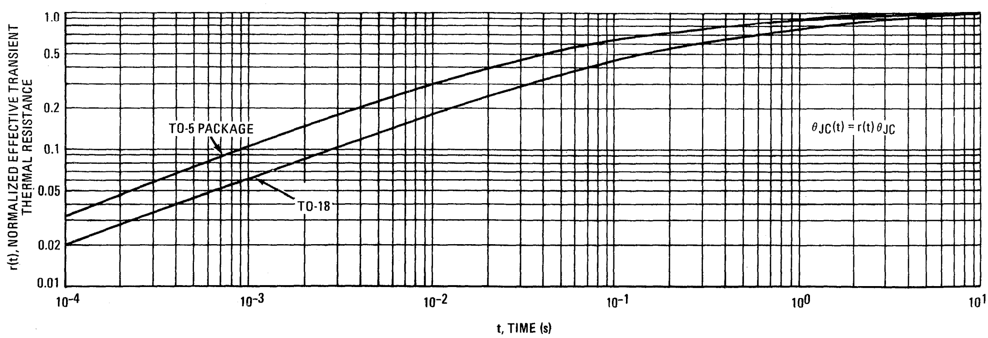
This graph shows the maximum I_C-V_{CE} limits of the device both from the standpoint of thermal dissipation (at 25°C case temperature), and secondary breakdown. For case temperatures other than 25°C, the thermal dissipation curve must be modified in accordance with the derating factor in the Maximum Ratings table.

To avoid possible device failure, the collector load line must fall below the limits indicated by the applicable curve. Thus, for certain operating conditions the device is thermally limited, and for others it is limited by secondary breakdown.

For pulse applications, the maximum I_C-V_{CE} product indicated by the dc thermal limits can be exceeded. Pulse thermal limits may be calculated by using the transient thermal resistance curve of Figure 19.

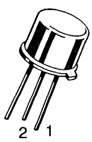
3

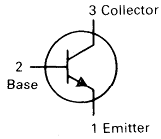
FIGURE 19 — THERMAL RESISTANCE



2N3019★
2N3020

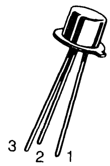
CASE 79-04, STYLE 1
TO-39 (TO-205AD)





2N3700★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL TRANSISTORS

NPN SILICON

★2N3019 and 2N3700 are Motorola designated preferred devices.

3

MAXIMUM RATINGS

Rating	Symbol	2N3019 2N3020	2N3700	Unit
Collector-Emitter Voltage	V_{CEO}	80	80	Vdc
Collector-Base Voltage	V_{CBO}	140	140	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	7.0	Vdc
Collector Current — Continuous	I_C	1.0	1.0	Adc
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 Ambient	$R_{\theta JA}$	217	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	97	°C/W

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

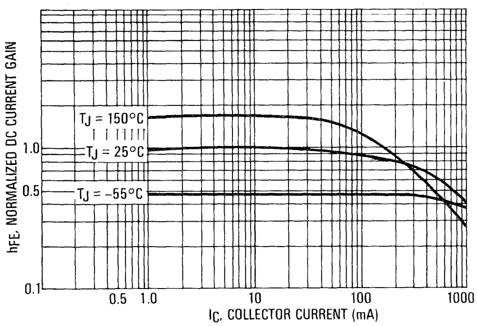
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, I_B = 0)		$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	140	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	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_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	 2N3700, 2N3019 2N3020	h_{FE}	 50 30	 — 100	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N3700, 2N3019 2N3020		90 40	— 120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N3700, 2N3019 2N3020		100 40	300 120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_C = −55°C)(1)	2N3700, 2N3019		40	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N3700, 2N3019 2N3020		50 30	— 100	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)(1)	All Types		15	—	
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
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	 2N3020 2N3019, 2N3700	f_T	 80 100	 — 400	MHz

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

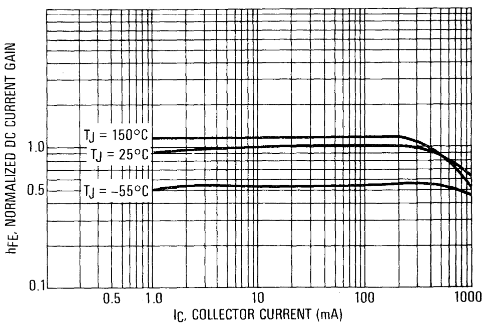
Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz		C_{ibo}	—	60	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N3700, 2N3019	h_{fe}	80	400	—
	2N3020		30	200	
Collector Base Time Constant (I_E = 10 mAdc, V_{CB} = 10 Vdc, f = 79.8 MHz)	2N3019, 2N3020	$rb'C_c$	—	400	ps
	2N3700		15	400	
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)	2N3019, 2N3700	NF	—	4	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

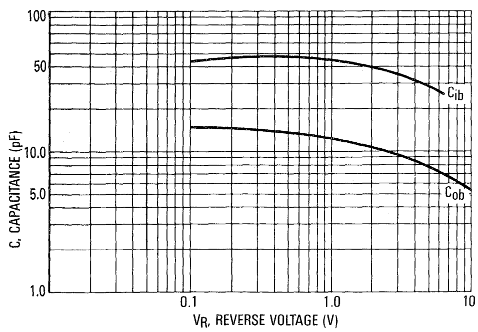
DC CURRENT GAIN
2N3019, 2N3700



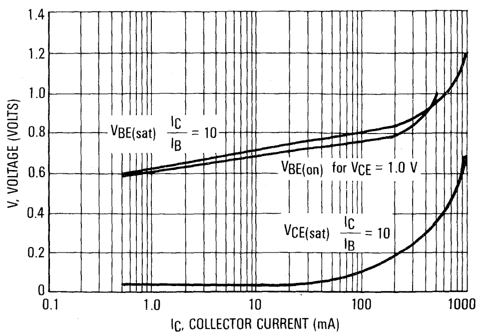
DC CURRENT GAIN
2N3020



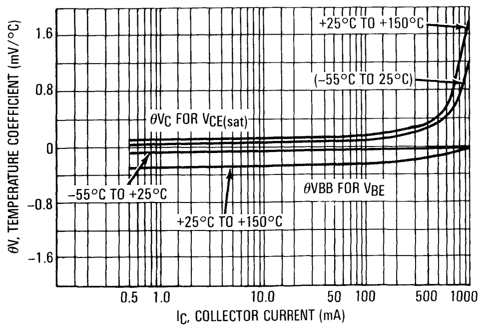
CAPACITANCE



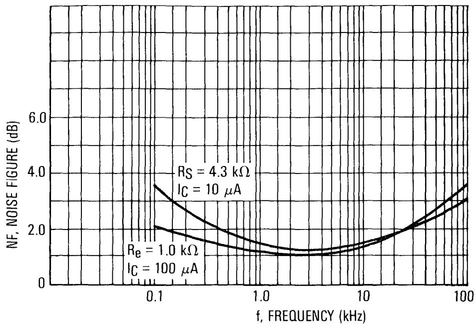
"ON" VOLTAGES



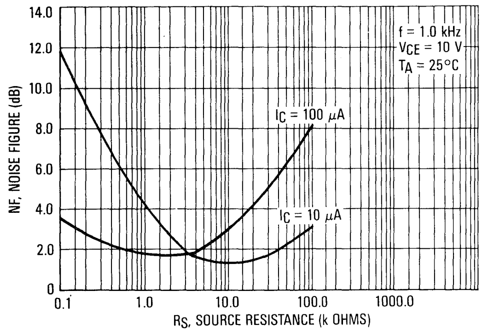
TEMPERATURE COEFFICIENTS



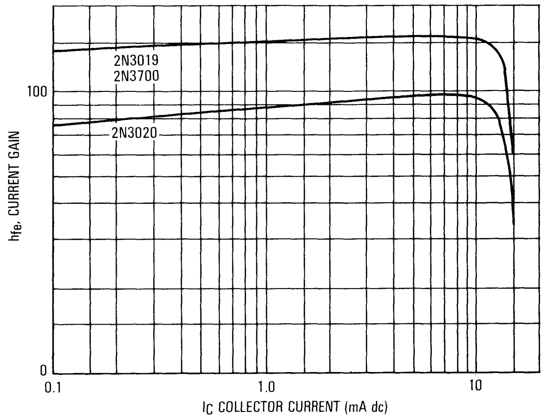
FREQUENCY EFFECTS



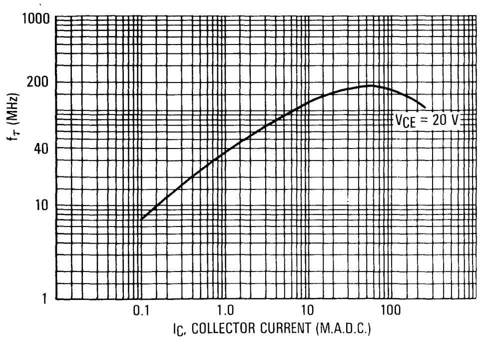
SOURCE RESISTANCE EFFECTS



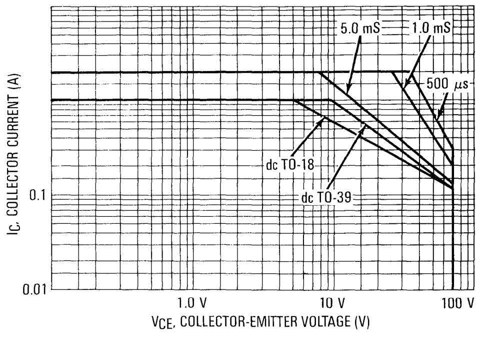
CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT — 1 kHz h_{fe}



CURRENT GAIN — BANDWIDTH PRODUCT

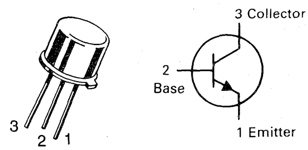


ACTIVE REGION SAFE OPERATING AREA



2N3053, A

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3053	2N3053A	Unit
Collector-Emitter Voltage(1)	V_{CEO}	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°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

(1) Applicable 0 to 100 mA (Pulsed):
Pulse Width ≤ 300 μsec., Duty Cycle ≤ 2.0%.
0 to 700 mA; Pulse Width ≤ 10 μsec., Duty Cycle ≤ 2.0%.

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

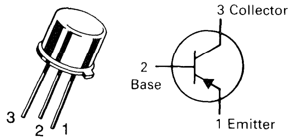
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	 2N3053 2N3053A	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Emitter Breakdown Voltage(2) (I_C = 100 mAdc, R_{BE} = 10 ohms)	 2N3053 2N3053A	$V_{(BR)CER}$	 50 70	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N3053 2N3053A	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 60 Vdc, $V_{EB(OFF)}$ = 1.5 Vdc)	 2N3053 2N3053A	I_{CEX}	—	0.25	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	 2N3053	I_{EBO}	—	0.25	μAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N3053 2N3053A	I_{BL}	—	0.25	μAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 2.5 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)		h_{FE}	25 50	— 250	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	 2N3053 2N3053A	$V_{CE(sat)}$	 — —	 1.4 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	 2N3053 2N3053A	$V_{BE(sat)}$	 — 0.6	 1.7 1.0	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	 2N3053 2N3053A	$V_{BE(on)}$	 — —	 1.7 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 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}	—	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	80	pF

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

3

2N3244

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Characteristic	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	−1.0	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 Ambient	$R_{\theta JA}$	0.175	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	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 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_{EB} = −3.0 Vdc)	I_{BEV}	—	−80	nAdc
Collector Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc)	I_{CEX}	—	−50	nAdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0) (V_{CB} = −30 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 −0.050 −10	μAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	−30	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = −150 mAdc, V_{CE} = −1.0 Vdc) (I_C = −500 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 Adc, V_{CE} = −5.0 Vdc)	h_{FE}	 60 50 25	 — 150 —	—
Collector-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)	$V_{CE(sat)}$	 — — —	 −0.3 −0.5 −1.0	Vdc

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

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = −150 mAdc, I_B = −15 mAdc)			—	−1.1	
(I_C = −500 mAdc, I_B = −50 mAdc)			−0.75	−1.5	
(I_C = −1.0 Adc, I_B = −100 mAdc)			—	−2.0	
(I_C = −750 mA, I_B = −75 mA)			—	−2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)		f_T	175	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	25	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	100	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = −500 mA, I_{B1} = −50 mA V_{BE} = +2.0 V, V_{CC} = −30 V)	t_d	—	15	ns
Rise Time		t_r	—	35	ns
Storage Time	(I_C = −500 mA, V_{CC} = −30 V I_{B1} = I_{B2} = −50 mA)	t_s	—	140	ns
Fall Time		t_f	—	45	ns
Total Control Charge (I_C = −500 mA, I_B = −50 mA, V_{CC} = −30 V)		Q_T	—	14	nC

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

3

FIGURE 1 — MINIMUM CURRENT GAIN CHARACTERISTICS

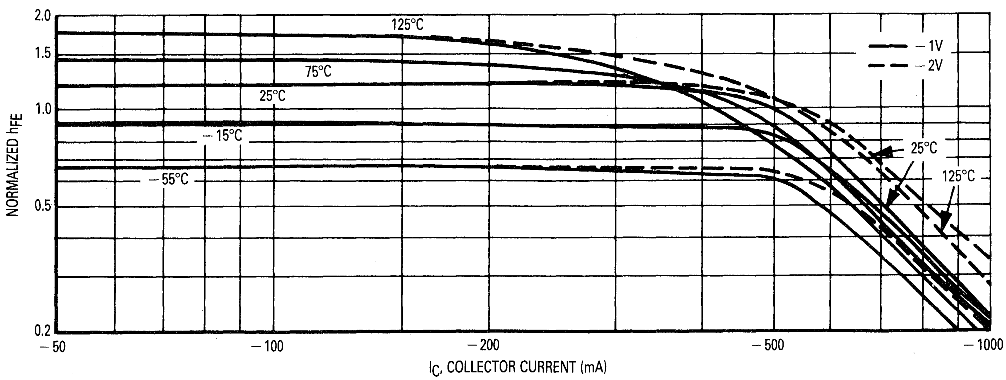


FIGURE 2 — COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS

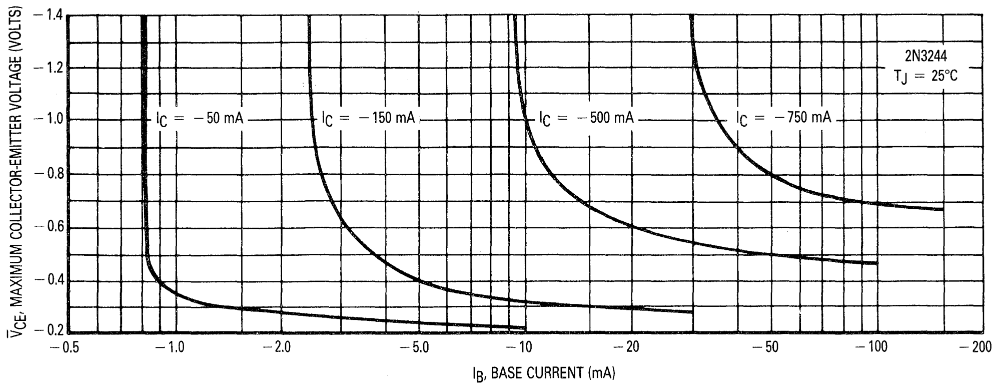


FIGURE 3 — MAXIMUM SATURATION VOLTAGES

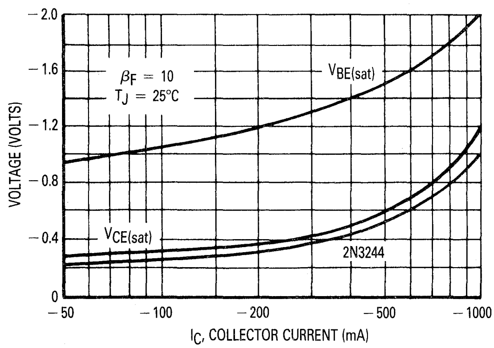


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS

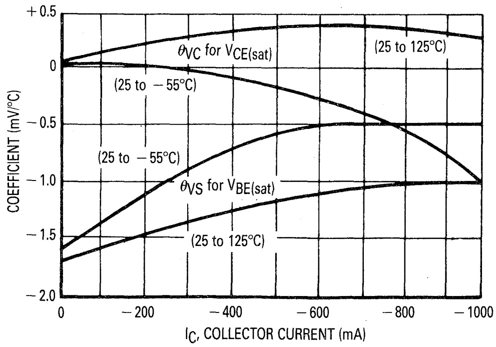


FIGURE 5 — JUNCTION CAPACITANCE

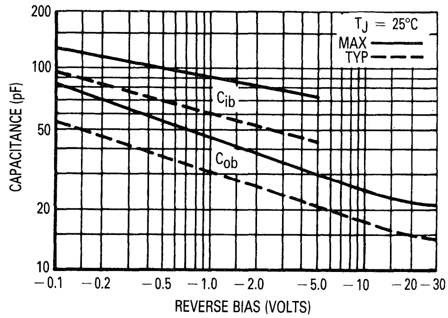


FIGURE 6 — TYPICAL SWITCHING TIMES

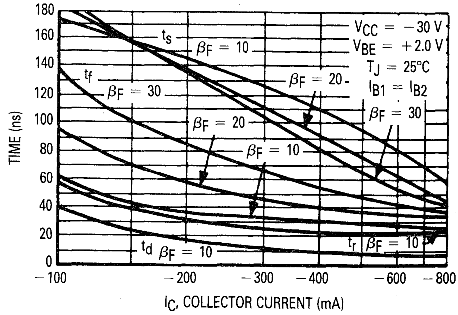


FIGURE 7 — CHARGE DATA

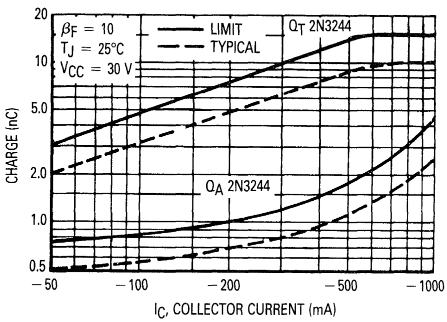


FIGURE 8 — TURN-ON EQUIVALENT TEST CIRCUIT

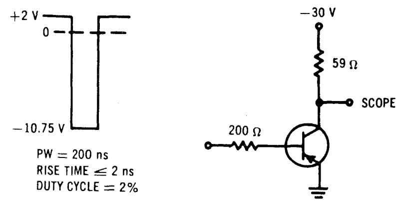


FIGURE 9 — TURN-OFF EQUIVALENT TEST CIRCUIT

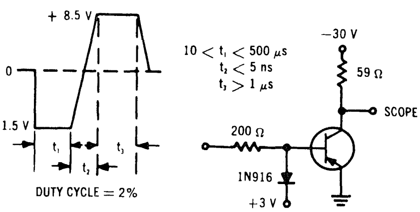


FIGURE 10 — Q_T TEST CIRCUIT

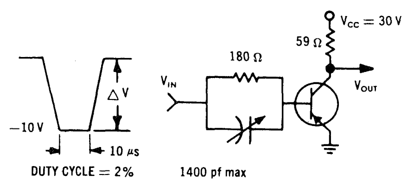
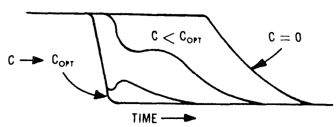
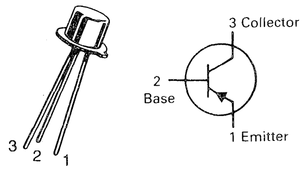


FIGURE 11 — TURN-OFF WAVEFORM



2N3250
2N3251,A★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★2N3251A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	2N3250 2N3251	2N3251A	Unit
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°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 Temperature Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°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 mAdc)	2N3250, 2N3251 2N3251A	$V_{(BR)CEO}$	−40 −60	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc)	2N3250, 2N3251 2N3251A	$V_{(BR)CBO}$	−50 −60	—	Vdc
Emitter-Base Breakdown Voltage I_E = −10 μAdc)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CE} = −40 Vdc, V_{EB} = −3.0 Vdc)		I_{CEX}	—	−20	nA
Base Cutoff Current (V_{CE} = −40 Vdc, V_{EB} = −3.0 Vdc)		I_{BL}	—	−50	nAdc
ON CHARACTERISTICS					
DC Forward Current Transfer Ratio		h_{FE}			—
(I_C = −0.1 mAdc, V_{CE} = −10 Vdc)	2N3250 2N3251, 2N3251A		40 80	— —	
(I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc)	2N3250 2N3251, 2N3251A		45 90	— —	
(I_C = −10 mAdc, V_{CE} = −1.0 Vdc)(1)	2N3250 2N3251, 2N3251A		50 100	150 300	
(I_C = −50 mAdc, V_{CE} = −1.0 Vdc)(1)	2N3250 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 2N3251, 2N3251A	f_T	250 300	— —	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capaciatance (V_{EB} = −1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF

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

Characteristic		Symbol	Min	Max	Unit
Input Impedance (I_C = −1.0 mA, V_{CE} = −10 V, f = 1.0 kHz)	2N3250 2N3251, 2N3251A	h_{ie}	1.0 2.0	6.0 12	kohms
Voltage Feedback Ratio (I_C = −1.0 mA, V_{CE} = −10 V, f = 1.0 kHz)	2N3250 2N3251, 2N3251A	h_{re}	— —	10 20	X 10^{-4}
Small-Signal Current Gain (I_C = −1.0 mA, V_{CE} = −10 V, f = 1.0 kHz)	2N3250 2N3251, 2N3251A	h_{fe}	50 100	200 400	—
Output Admittance (I_C = −1.0 mA, V_{CE} = −10 V, f = 1.0 kHz)	2N3250 2N3251, 2N3251A	h_{oe}	4.0 10	40 60	μmhos
Collector Base Time Constant (I_C = −10 mA, V_{CE} = −20 V, f = 31.8 MHz)		rb'C_C	—	250	ps
Noise Figure (I_C = −100 μA, V_{CE} = −5.0 V, R_S = 1.0 kΩ, f = 100 Hz)		NF	—	6.0	dB

SWITCHING CHARACTERISTICS

Characteristic			Symbol	Max	Unit
Delay Time	(V_{CC} = −3.0 Vdc, V_{BE} = +0.5 Vdc		t_d	35	ns
Rise Time	I_C = −10 mAdc, I_{B1} = −1.0 mA)		t_r	35	ns
Storage Time	I_C = −10 mAdc, I_{B1} = I_{B1} = −1.0 mAdc) (V_{CC} = −3.0 V)	2N3250 2N3251, 2N3251A	t_s	175 200	ns
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

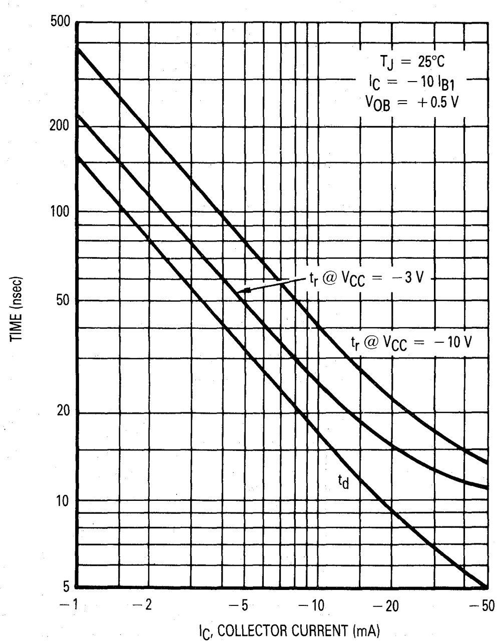
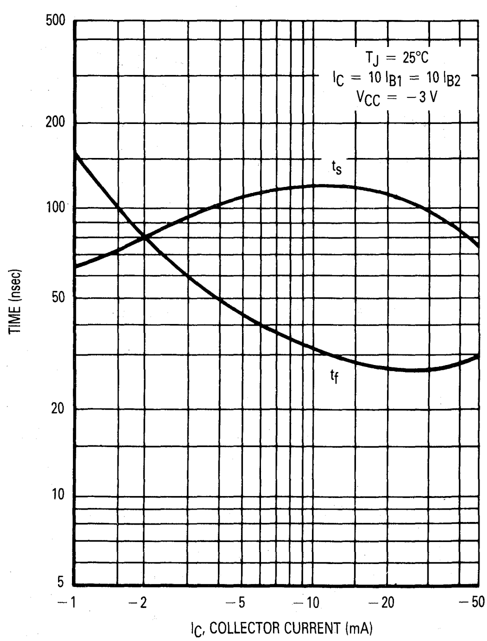


FIGURE 2 — STORAGE AND FALL TIME



3

AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS
(V_{CE} = 6.0 V, T_A = 25°C)

FIGURE 3 — FREQUENCY

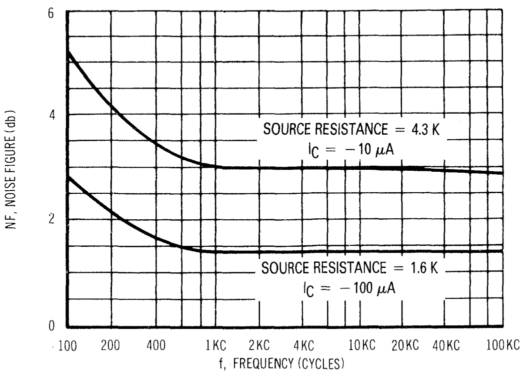
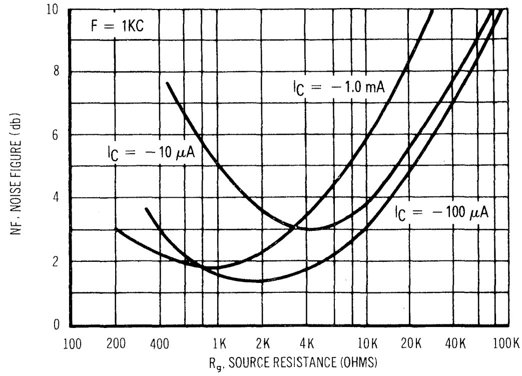


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS
V_{CE} = 10 V, f = 1.0 kc, T_A = 25°C

FIGURE 5 — CURRENT GAIN

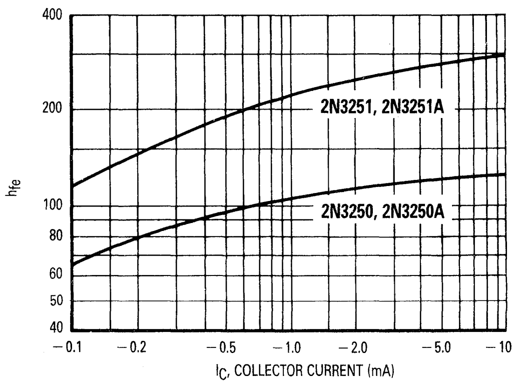


FIGURE 6 — OUTPUT ADMITTANCE

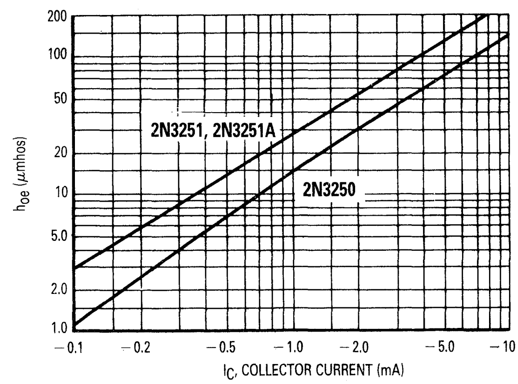


FIGURE 7 — VOLTAGE FEEDBACK RATIO

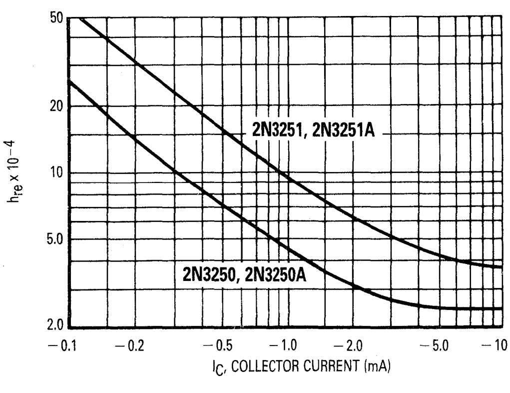


FIGURE 8 — INPUT IMPEDANCE

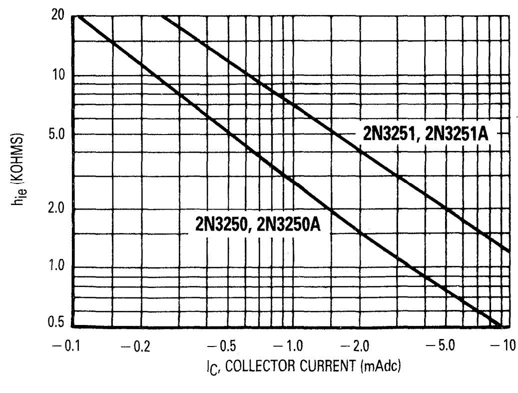
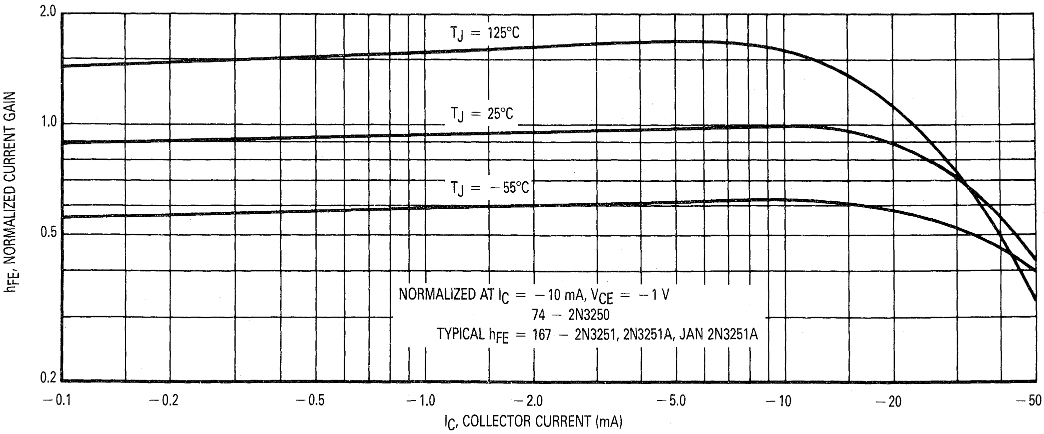
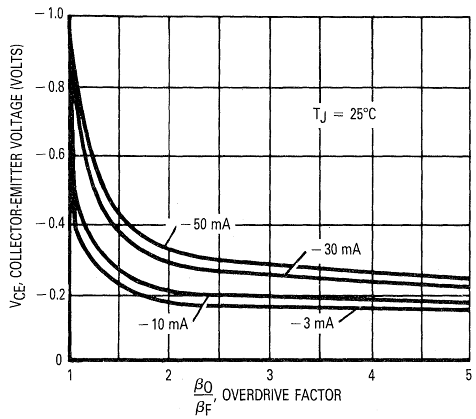


FIGURE 9 — NORMALIZED CURRENT GAIN CHARACTERISTICS



3

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/I_{BF} in a circuit. EXAMPLE: For type 2N3251, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 10 mA.

Observe that at I_C = 10 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 typically 167 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design)...

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\ \text{Volt}}{I_C/I_{BF}} \qquad 2.5 = \frac{167}{10\ \text{mA}/I_{BF}} \qquad I_{BF} \approx -6.68\ \text{mA}$$

FIGURE 11 — SATURATION VOLTAGES

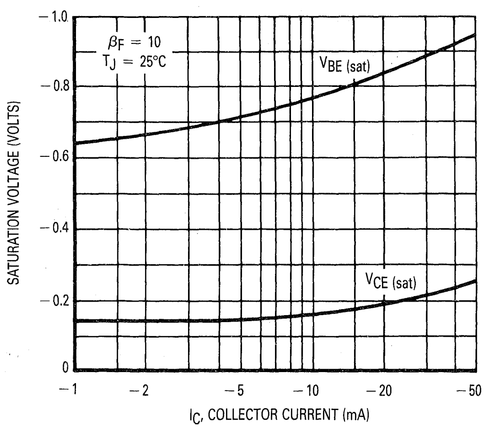


FIGURE 12 — TEMPERATURE COEFFICIENTS

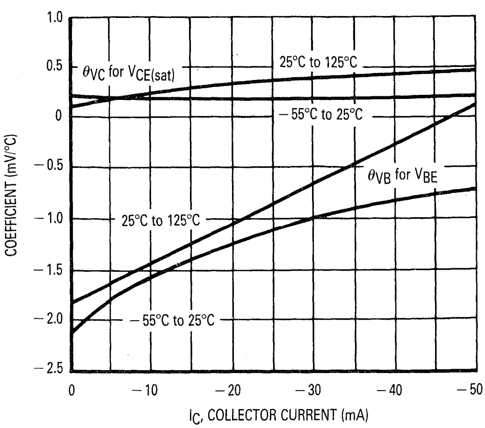


FIGURE 13 — f_T AND $r_b'C_c$ versus I_C

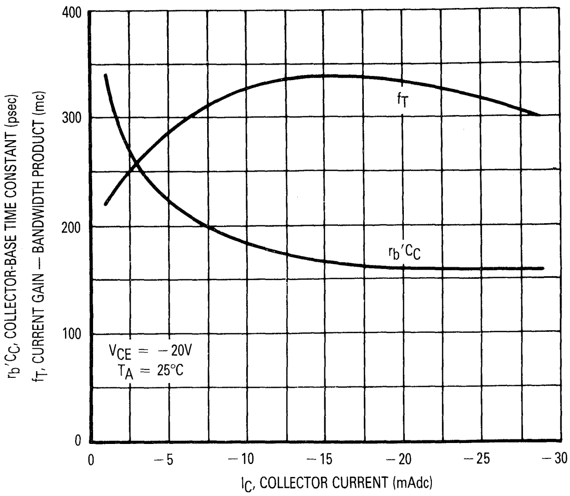


FIGURE 14 — 30 MC EQUIVALENT CIRCUIT

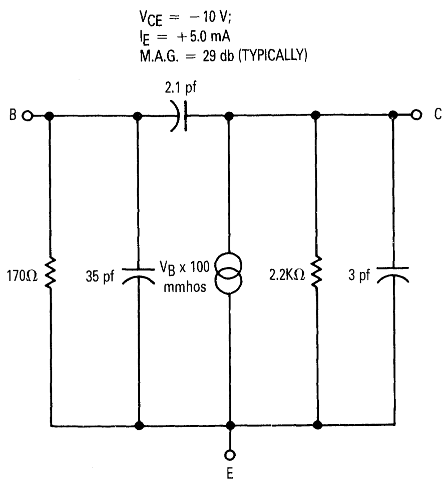


FIGURE 15 — JUNCTION CAPACITANCE

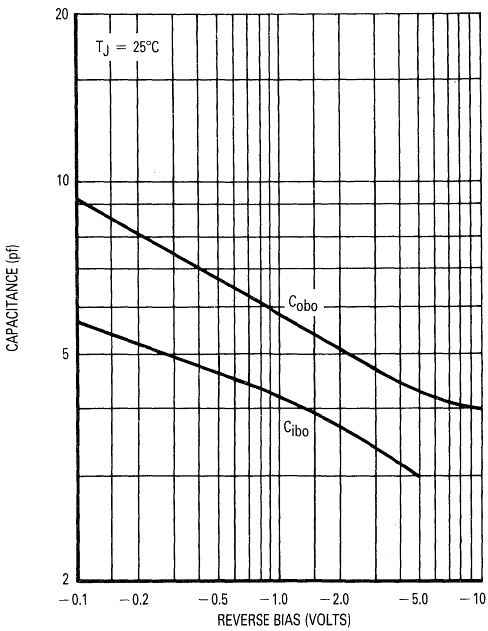
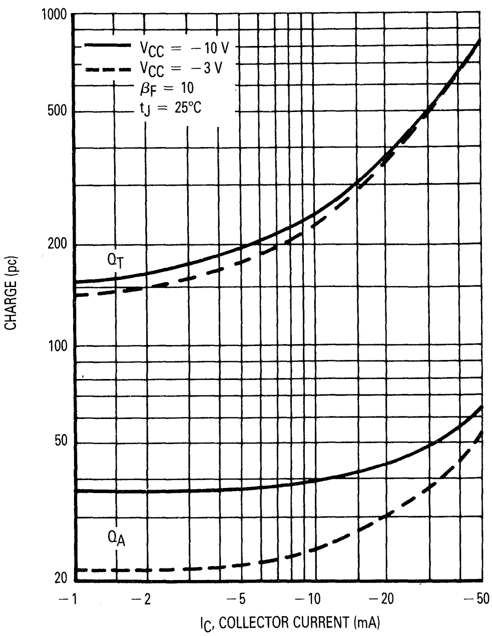
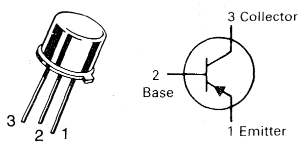


FIGURE 16 — CHARGE DATA



2N3467★
2N3468★

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTORS

PNP SILICON

★These are Motorola designated preferred devices.

3

MAXIMUM RATINGS

Rating	Symbol	2N3467	2N3468	Unit
Emitter-Collector 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		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 Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	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 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_{EB} = −3.0 Vdc)		I_{BEV}	—	−120	nAdc
Collector Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc)		I_{CEX}	—	−100	nAdc
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	$V_{CE(sat)}$	 — —	 −3.0 −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

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

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	2N3467 2N3468	f_T	175 150	— —	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	25	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	100	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = −500 mA, I_{B1} = −50 mA, V_{BE} = 2.0 V, V_{CC} = 30 V)	t_d	—	10	ns
Rise Time		t_r	—	30	ns
Storage Time	(I_C = −500 mA, I_{B1} = I_{B2} = −50 mA, V_{CC} = −30 V)	t_s	—	60	ns
Fall Time		t_f	—	30	ns
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)		Q_T	—	6.0	nC

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

FIGURE 1 — STORAGE TIME VARIATION WITH TEMPERATURE

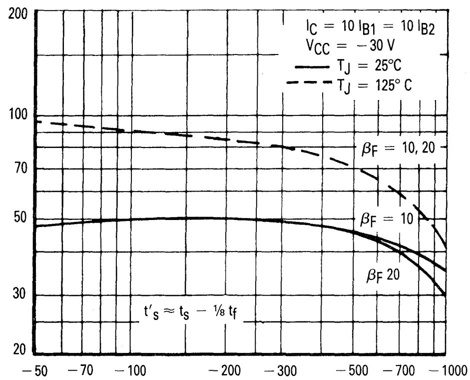


FIGURE 2 — LIMITS OF SATURATION VOLTAGE

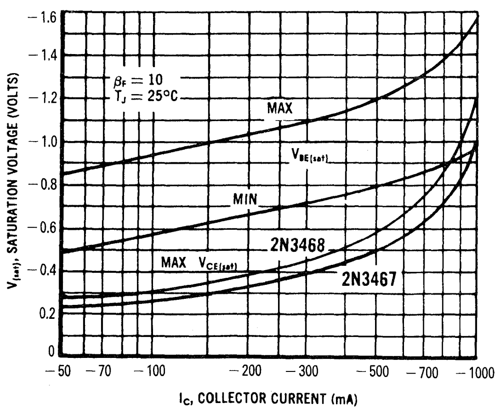
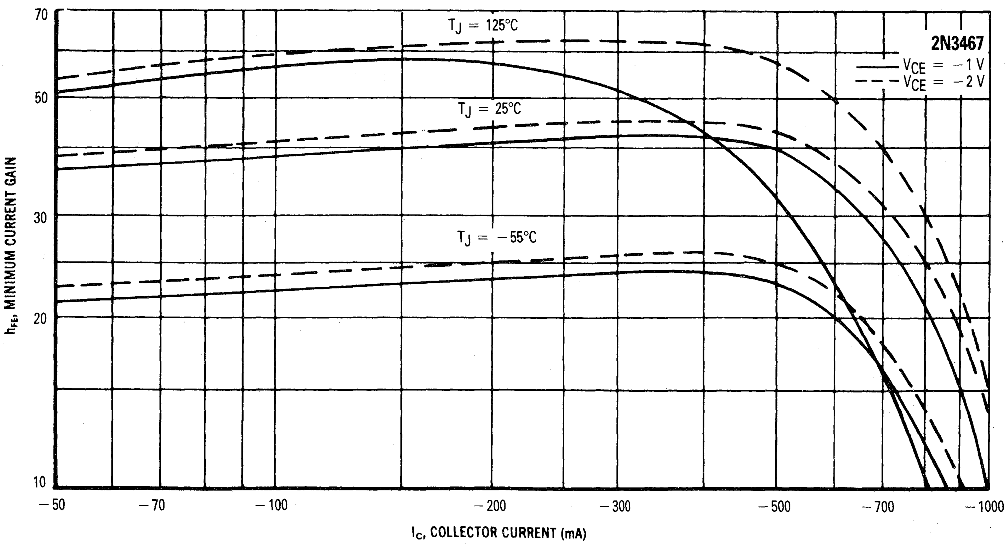
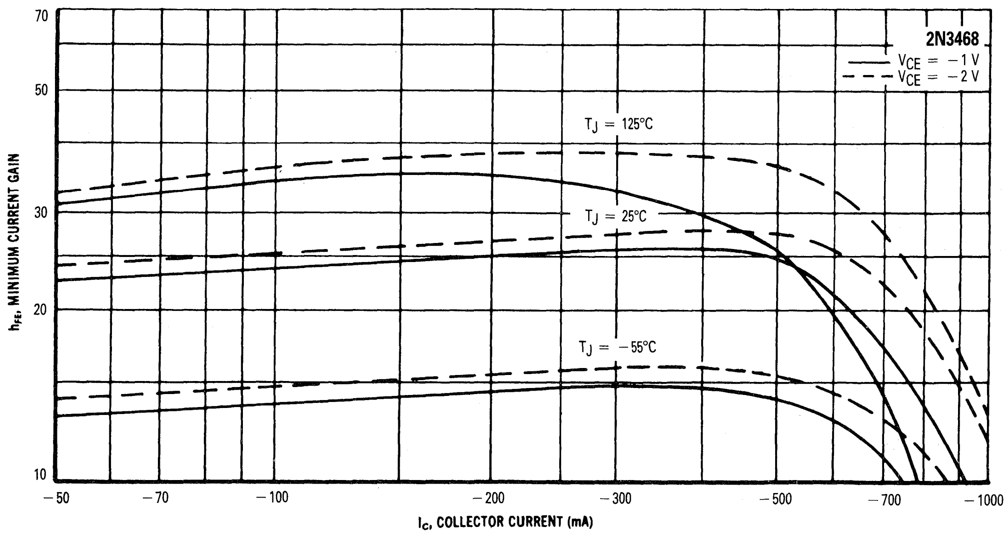


FIGURE 3 — MINIMUM CURRENT GAIN CHARACTERISTICS

2N3467



2N3468



3

MAXIMUM RATINGS

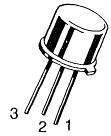
Rating	Symbol	Value		Unit
Emitter-Collector Voltage	V_{CEO}	−120		Vdc
Collector-Base Voltage	V_{CBO}	−120		Vdc
Emitter-Base Voltage	V_{EBO}	−4.5		Vdc
Collector Current — Continuous	I_C	−100		mAdc
		2N3495	2N3497	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 3.43	400 2.28	mW mW/°C
Total 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.

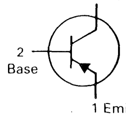
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

2N3495

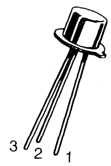


CASE 79-04, STYLE 1
TO-39 (TO-205AD)



2N3497

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTORS

PNP 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)	$V_{(BR)CEO}$	−120	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	Vdc
Collector Cutoff Current (V_{CB} = −90 Vdc, I_E = 0)	I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −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)	h_{FE}	 35 40 40 40	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−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	150	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	30	pF
Input Impedance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	H_{ie}	0.1	1.2	k ohms
Voltage Feedback Ratio (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{re}	—	2.0	X 10^{-4}
Small-Signal Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{fe}	40	300	—

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

Characteristic	Symbol	Min	Max	Unit
Output Admittance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{oe}	—	300	μmhos
Real Part of Input Impedance (I_C = −20 mAdc, V_{CE} = −10 Vdc, f = 300 MHz)	$Re(h_{ie})$	—	30	Ohms
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = −30 Vdc, I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	300	ns
Turn-Off Time (V_{CC} = −30 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	1000	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.

FIGURE 1 — TURN-ON TIME TEST CIRCUIT

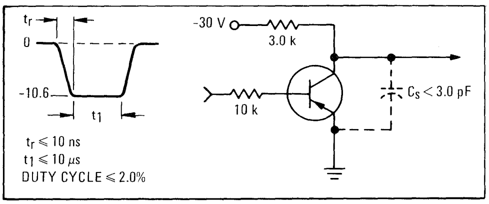


FIGURE 2 — TURN-OFF TIME TEST CIRCUIT

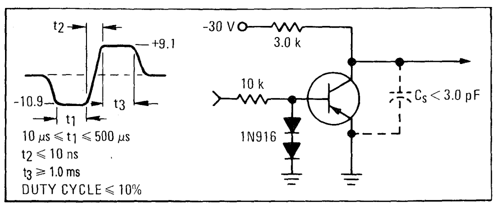


FIGURE 3 — V_{CE} (sat) versus I_C

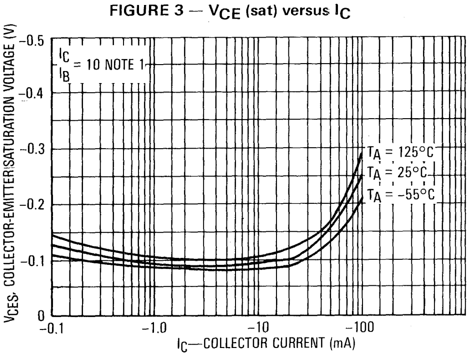


FIGURE 4 — I_{CBO} versus T_A

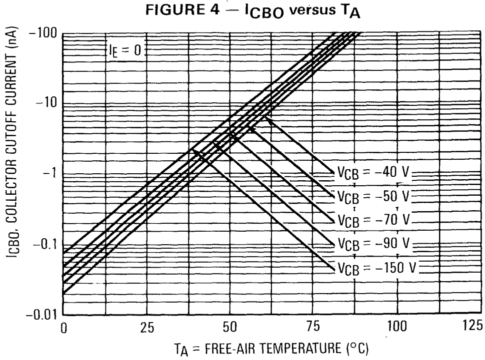


FIGURE 5 — h_{FE} versus I_C

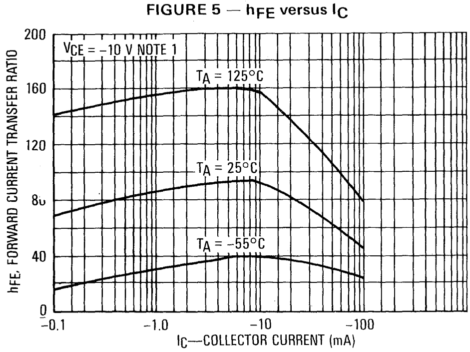
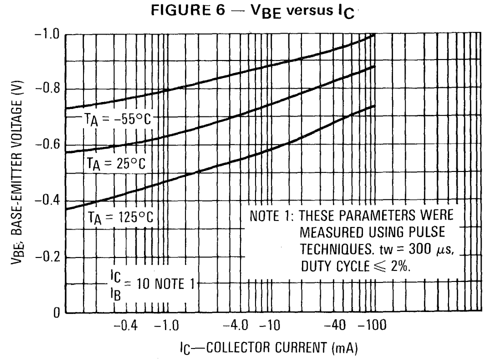


FIGURE 6 — V_{BE} versus I_C



3

FIGURE 7 — f_T versus I_C

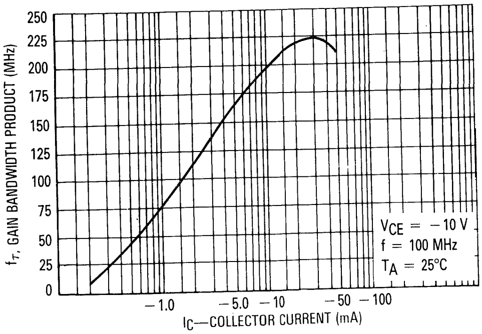


FIGURE 8 — C_{OBO} versus V_{CB}

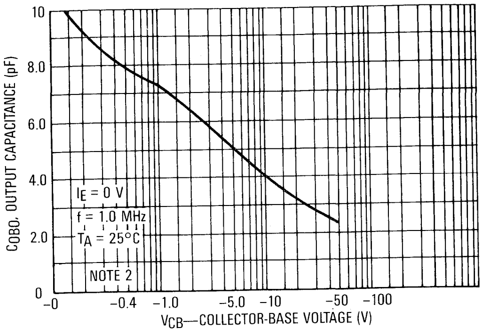
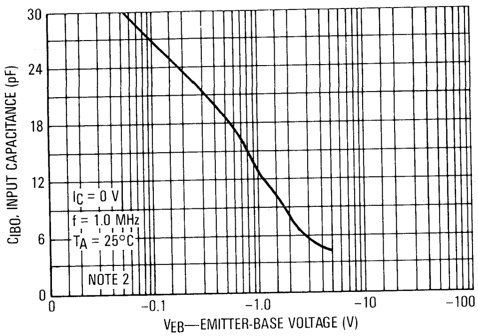


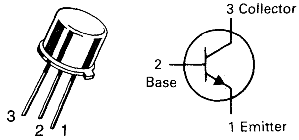
FIGURE 9 — C_{IBO} versus V_{EB}



NOTE 2: CAPACITANCE MEASURE MADE WITH TO-18 PACKAGE.

2N3499 thru 2N3501★

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★2N3501 is a Motorola designated preferred device.

3

MAXIMUM RATINGS

Rating	Symbol	2N3499	2N3500 2N3501	Unit
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 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 Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

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)	2N3499 2N3500, 2N3501	$V_{(BR)CEO}$	100 150	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	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		I_{CBO}				μAdc
(V_{CB} = 50 Vdc, I_E = 0)	2N3499		—	—	−0.050	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	—	50	
(V_{CB} = 75 Vdc, I_E = 0)	2N3500, 2N3501		—	—	0.050	
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)			—	—	50	
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	25	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3500 2N3499, 2N3501		20 35	— —	— —	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3500 2N3499, 2N3501		25 50	— —	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N3500 2N3499, 2N3501		35 75	— —	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N3500 2N3499, 2N3501		40 100	— —	120 300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)	2N3500 2N3501		15 20	— —	— —	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N3499		20	—	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types		—	—	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	All Types		—	—	0.25	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501		—	—	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3499		—	—	0.6	

3

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

Characteristic		Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types		—	—	0.8	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	All Types		—	—	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501		—	—	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3499		—	—	1.4	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)		f_T	150	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N3499	C_{obo}	—	—	10	pF
	2N3500, 2N3501		—	—	8.0	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	—	80	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3500	h_{ie}	0.2	—	1.0	k ohms
	2N3499, 2N3501		0.25	—	1.25	
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3500	h_{re}	—	—	2.5	$X 10^{-4}$
	2N3499, 2N3501		—	—	4.0	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3500	h_{fe}	50	—	300	—
	2N3499, 2N3501		75	—	375	
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3500	h_{oe}	—	—	100	μmhos
	2N3499, 2N3501		—	—	200	
SWITCHING CHARACTERISTICS						
Delay Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)} = -2.0$ Vdc)		t_d	—	20	—	ns
Rise Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)} = -2.0$ Vdc)		t_r	—	35	—	ns
Storage Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_s	—	800	—	ns
Fall Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_f	—	80	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 1 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3499

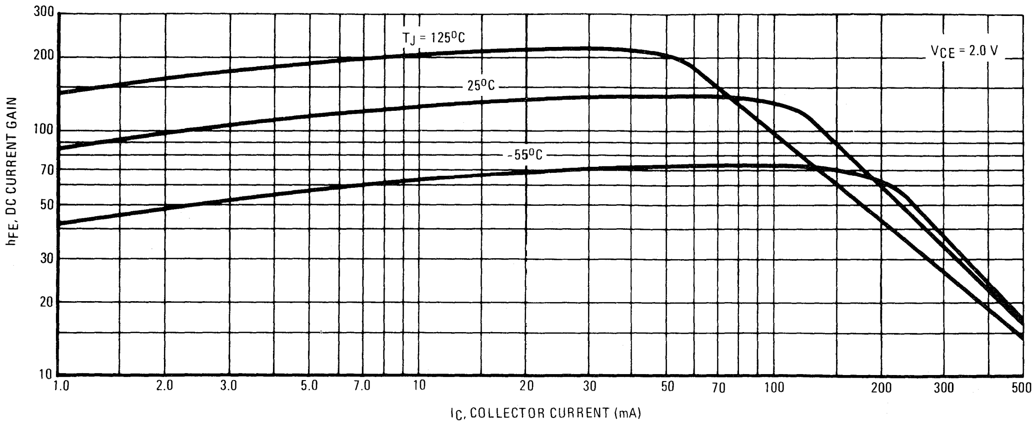


FIGURE 2 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

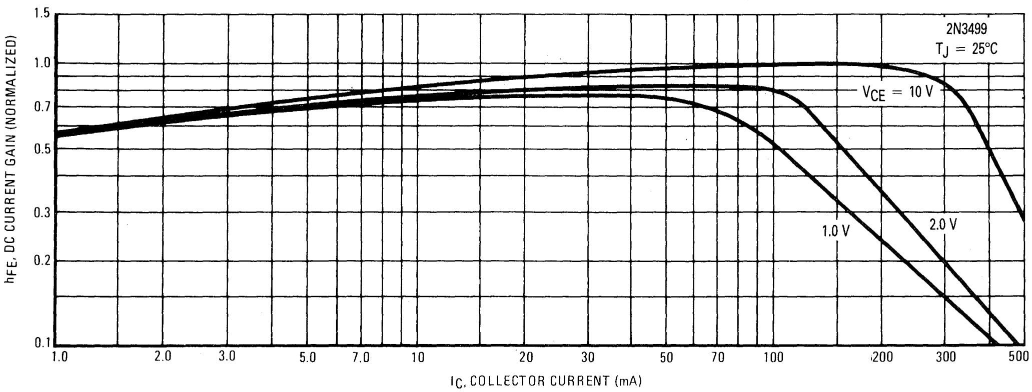
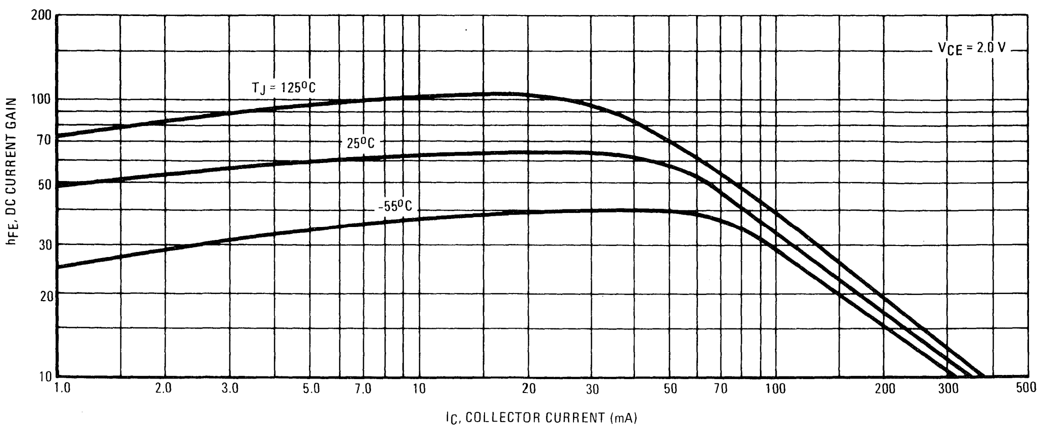


FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3500



2N3501

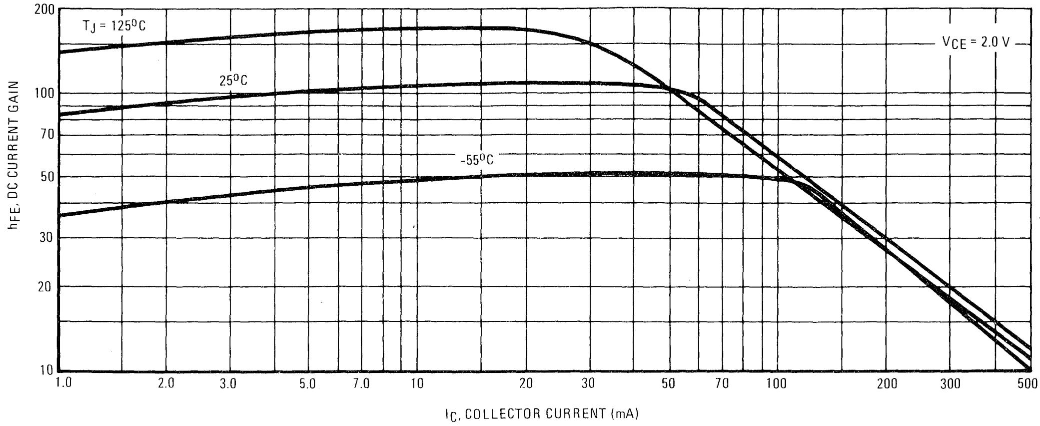
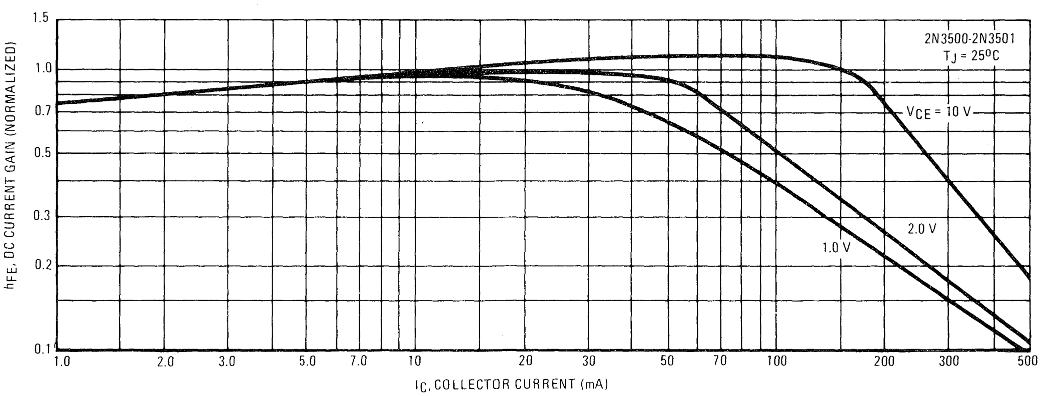


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



3

FIGURE 5 – "ON" VOLTAGES

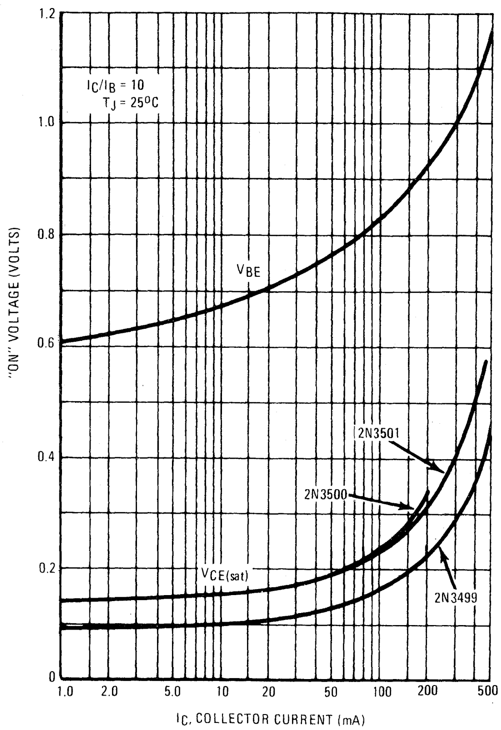


FIGURE 6 – TEMPERATURE COEFFICIENTS

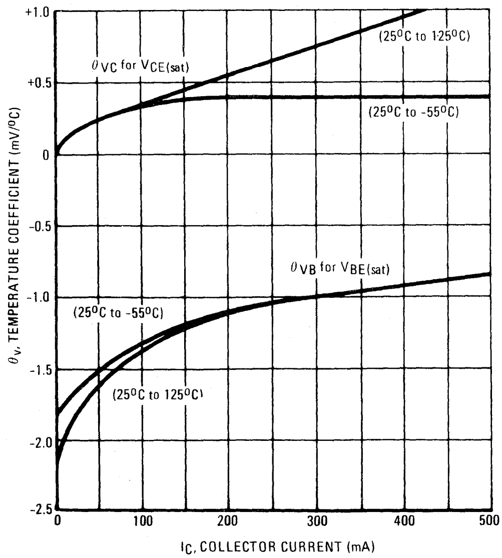
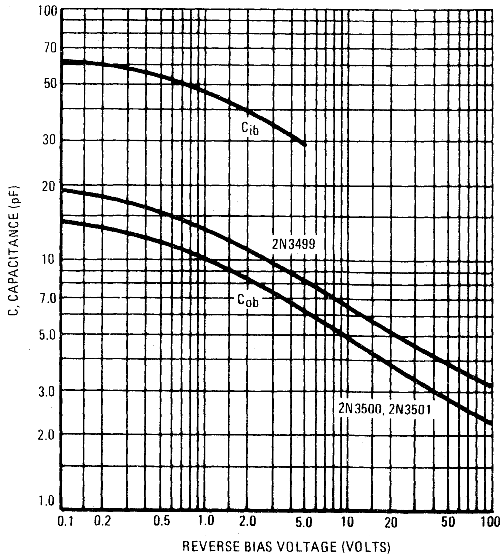


FIGURE 7 – CAPACITANCE



3

AUDIO SMALL-SIGNAL h PARAMETER CHARACTERISTICS

(V_{CE} = 10 Vdc, T_A = 25°C, f = 1.0 kHz)

FIGURE 8 – CURRENT GAIN

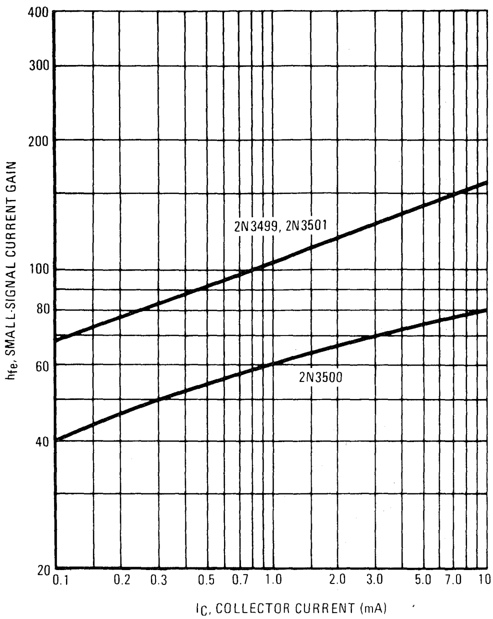


FIGURE 9 – OUTPUT IMPEDANCE

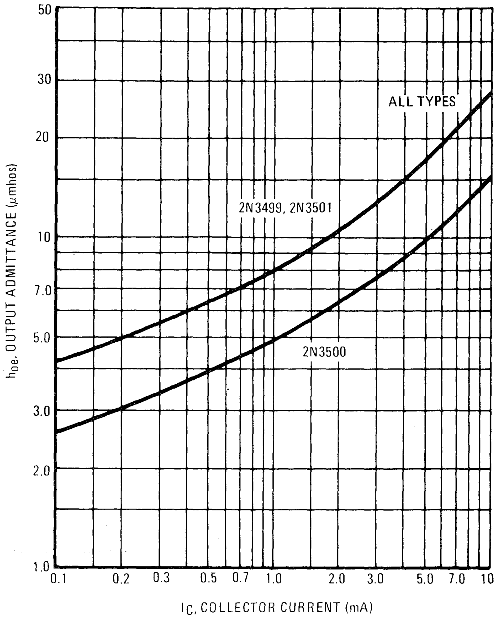


FIGURE 10 – INPUT IMPEDANCE

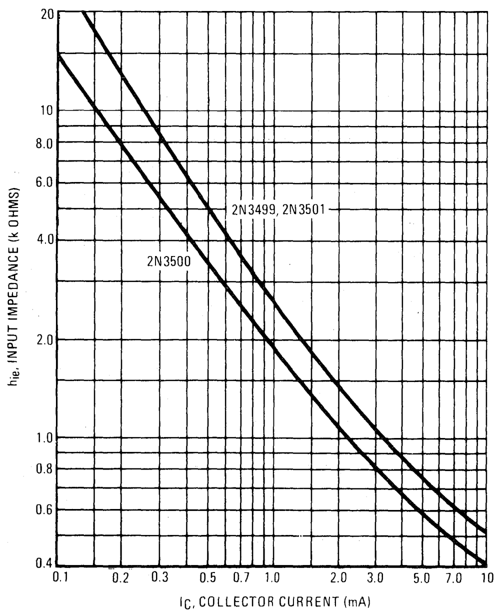
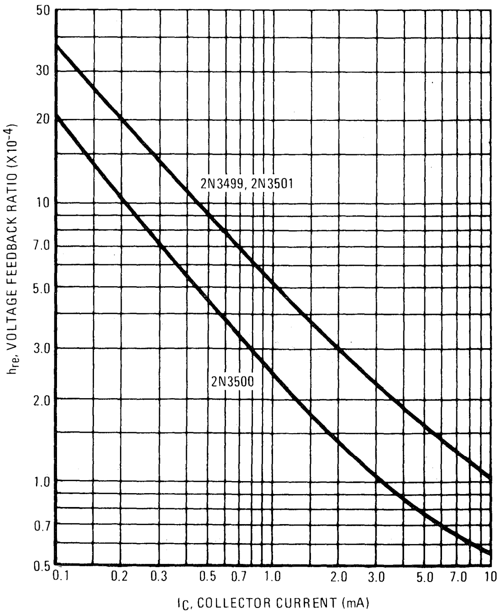
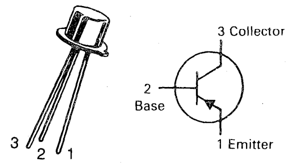


FIGURE 11 – VOLTAGE FEEDBACK RATIO



2N3546

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Characteristic	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
DC Collector Current	I_C	−200	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 Derate above 25°C	P_D	1.2 6.9	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 Ambient	$R_{\theta JA}$	0.49	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°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 mAdc, I_B = 0)	$V_{(BR)CEO}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	Vdc
Base Cutoff Current (V_{CE} = −10 Vdc, V_{EB} = −3.0 Vdc)	I_{BEV}	—	−0.10	μAdc
Collector Cutoff Current (V_{CE} = −10 Vdc, V_{EB} = −3.0 Vdc)	I_{CEX}	—	−0.010	μAdc
Collector Cutoff Current (V_{CB} = −10 Vdc) (V_{CB} = −10 Vdc, T_A = 150°C)	I_{CBO}	— —	−0.010 −10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = 10 mAdc, V_{CE} = −1.0 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)(1) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)(1)	h_{FE}	 20 30 15 25 15	 — 120 — — —	—
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)	$V_{CE(sat)}$	 — — —	 −0.15 −0.25 −0.50	Vdc
Base-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)	$V_{BE(sat)}$	 −0.7 −0.8 —	 −0.9 −1.3 −1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	700	—	MHz
Output Capacitance (V_{CB} = −10 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}	—	5.0	pF

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

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	I_C = −50 mA, I_{B1} = −5.0 mA V_{BE} = 2.0 V, V_{CC} = −3.0 V	t_d	—	10	ns
Rise Time		t_r	—	15	ns
Storage Time	I_C = −50 mA, I_{B1} = I_{B2} = −5.0 mA V_{CC} = −3.0 V	t_s	—	20	ns
Fall Time		t_f	—	15	ns
Turn-On Time		t_{on}	—	40	ns
Turn-Off Time		t_{off}	—	30	ns
Total Control Charge (I_C = 50 mA, I_B = 5.0 mA, V_{CC} = 3.0 V)		Q_T	—	400	pC

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

3

FIGURE 1 — LIMITS OF SATURATION VOLTAGES

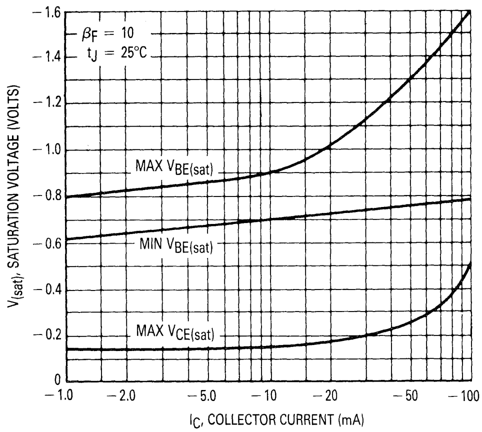


FIGURE 2 — STORAGE TIME BEHAVIOR

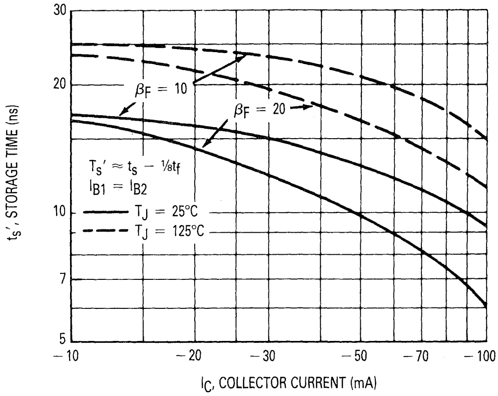


FIGURE 3 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

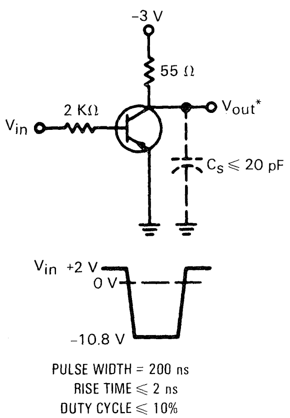


FIGURE 4 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT

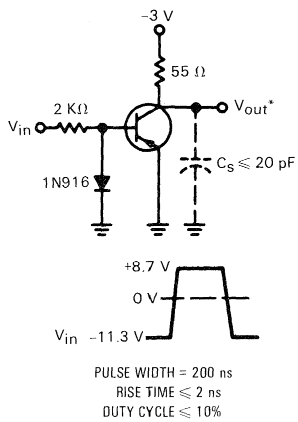
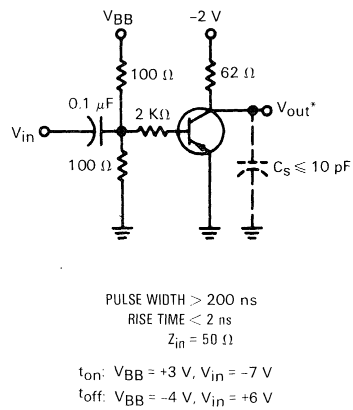
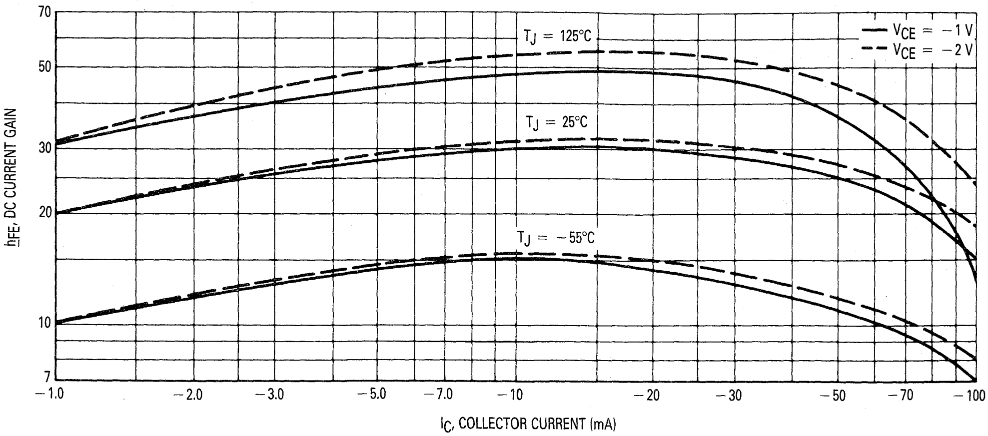


FIGURE 5 — SWITCHING TIME TEST CIRCUIT



*OSCILLOSCOPE RISE TIME ≤ 1 ns

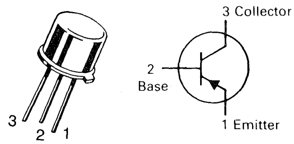
FIGURE 6 — MINIMUM CURRENT GAIN CHARACTERISTICS



3

2N3634 thru 2N3637

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3634 2N3635	2N3636 2N3637	Unit
Collector-Emitter Voltage	V_{CEO}	−140	−175	Vdc
Collector-Base Voltage	V_{CBO}	−140	−175	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 Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	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 mAdc, I_B = 0)	2N3634, 2N3635 2N3636, 2N3637	$V_{(BR)CEO}$	−140 −175	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	2N3634, 2N3635 2N3636, 2N3637	$V_{(BR)CBO}$	−140 −175	— —	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)		I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −10 Vdc)	2N3634, 2N3636 2N3635, 2N3637	h_{FE}	40 80	— —	—
(I_C = −1.0 mAdc, V_{CE} = −10 Vdc)	2N3634, 2N3636 2N3635, 2N3637		45 90	— —	
(I_C = −10 mAdc, V_{CE} = −10 Vdc)(1)	2N3634, 2N3636 2N3635, 2N3637		50 100	— —	
(I_C = −50 mAdc, V_{CE} = −10 Vdc)(1)	2N3634, 2N3636 2N3635, 2N3637		50 100	150 300	
(I_C = −150 mAdc, V_{CE} = −10 Vdc)(1)	2N3634, 2N3636 2N3635, 2N3637		25 50	— —	
Collector-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{CE(sat)}$	— —	−0.3 −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)		$V_{BE(sat)}$	— −0.65	−0.8 −0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = −30 Vdc, I_C = −30 mAdc, f = 100 MHz)	2N3634, 2N3636 2N3635, 2N3637	f_T	150 200	— —	MHz

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

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	10	pF
Input Capacitance (V_{EB} = −1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	75	pF
Input Impedance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	h_{ie}	100 200	600 1200	ohms
Voltage Feedback Ratio (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{re}	—	3.0	X 10^{-4}
Small-Signal Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	h_{fe}	40 80	160 320	—
Output Admittance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{oe}	—	200	µmhos
Noise Figure (I_C = −0.5 mAdc, V_{CE} = −10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)		NF	—	3.0	dB
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −100 Vdc, V_{BE} = 4.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc)	t_{on}	—	400	ns
Turn-Off Time		t_{off}	—	600	ns

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

3

FIGURE 1 — JUNCTION CAPACITANCE VARIATIONS

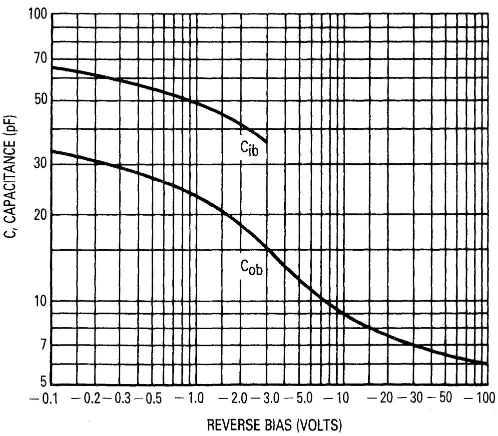


FIGURE 2 — GAIN-BANDWIDTH PRODUCT

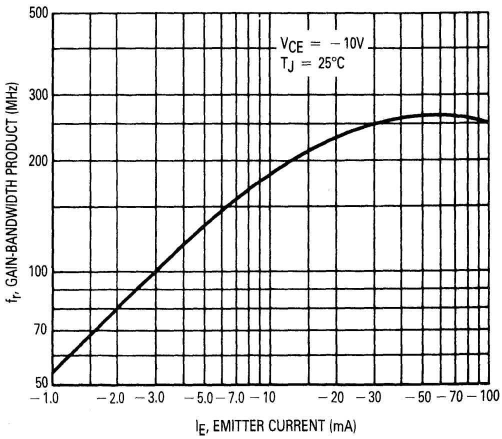
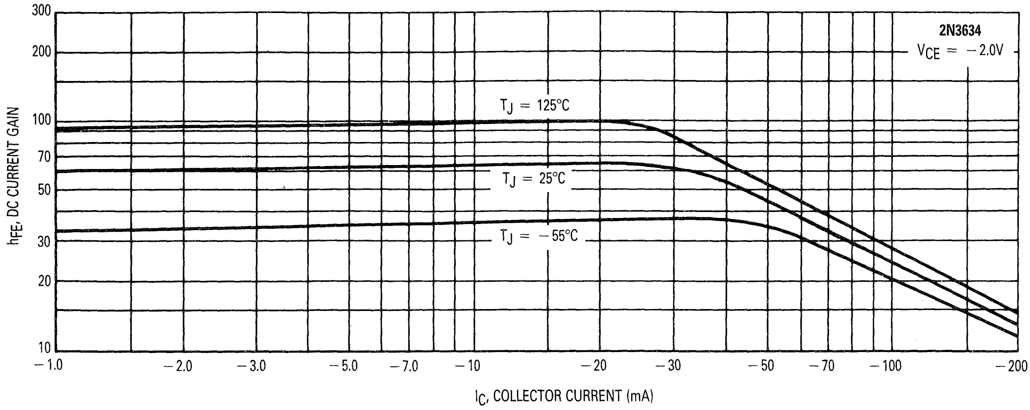


FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

2N3634



2N3637

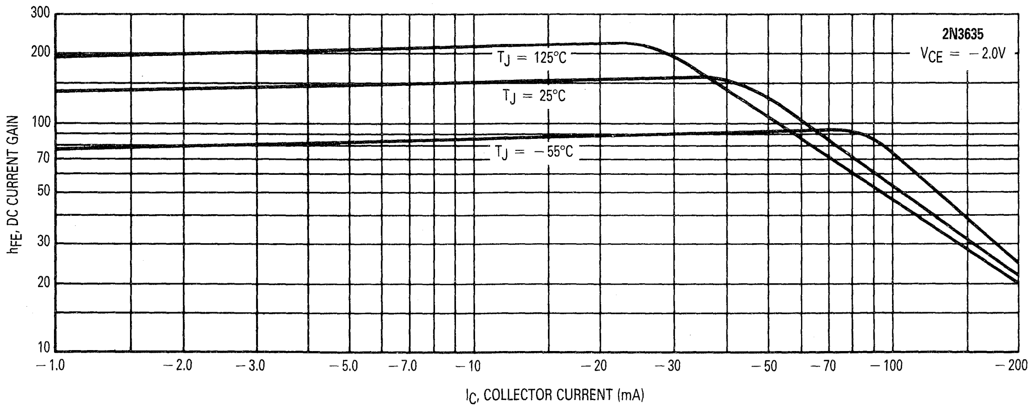


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

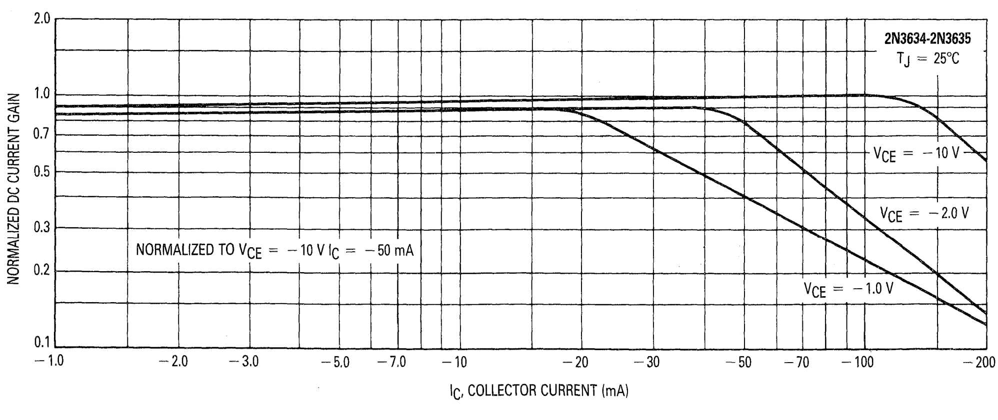
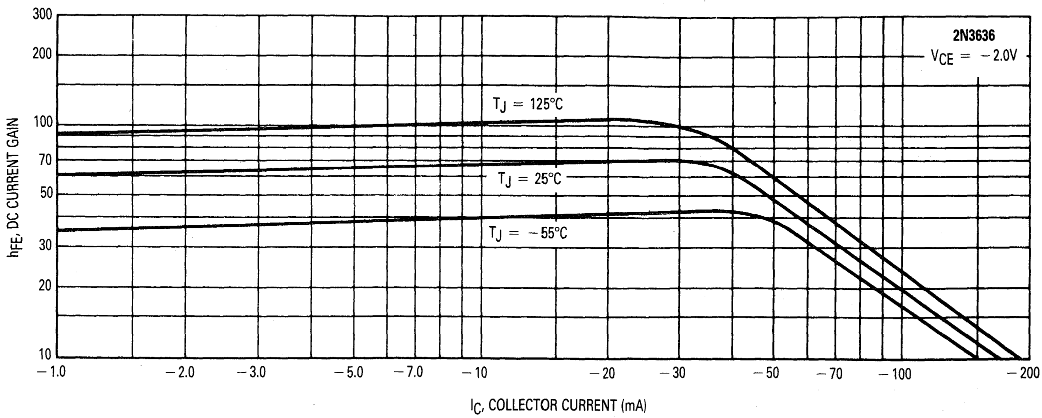


FIGURE 5 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

2N3636



2N3637

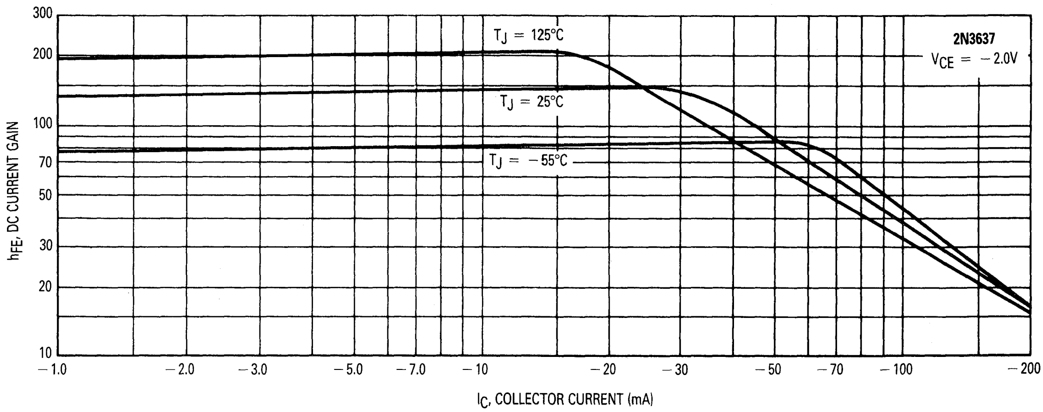
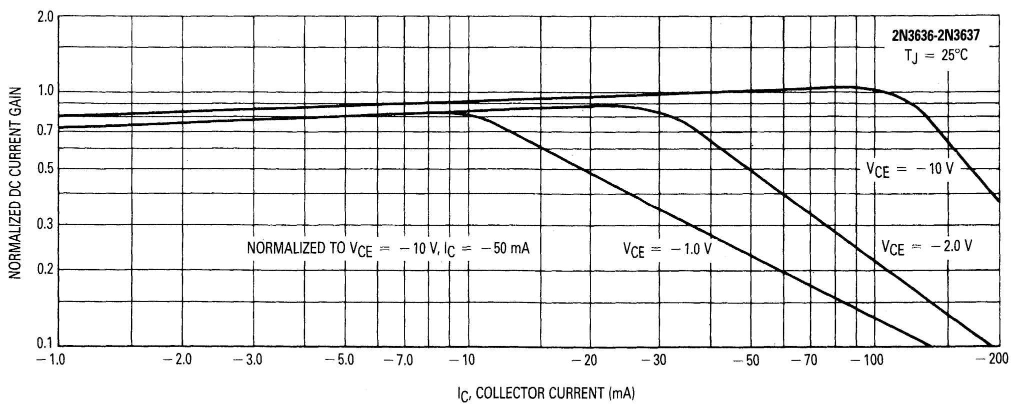


FIGURE 6 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE



3

FIGURE 7 — INPUT IMPEDANCE

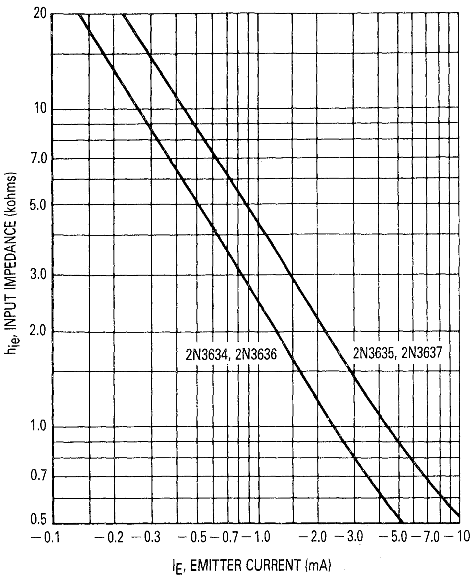


FIGURE 8 — OUTPUT IMPEDANCE

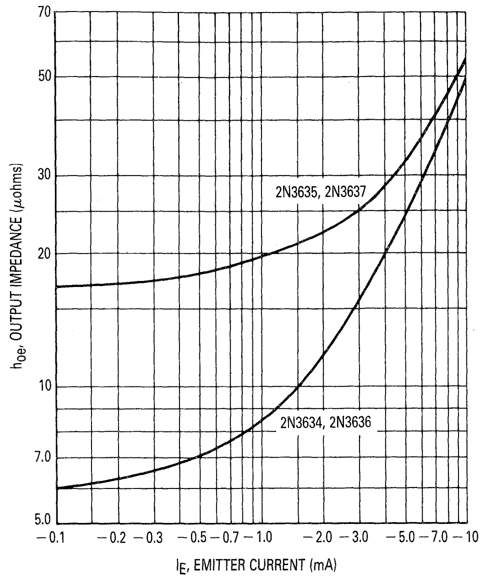


FIGURE 9 — CURRENT GAIN

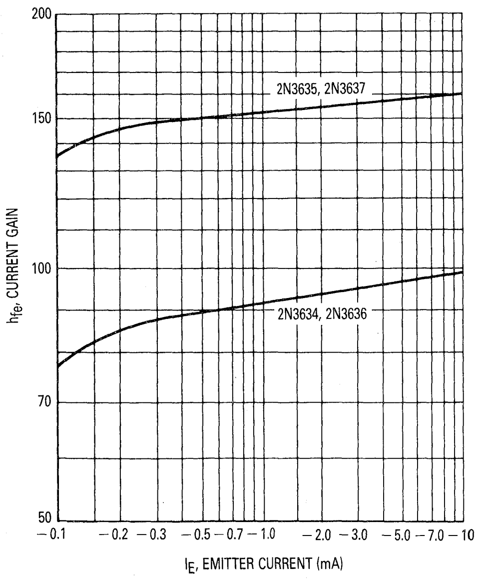


FIGURE 10 — VOLTAGE FEEDBACK RATIO

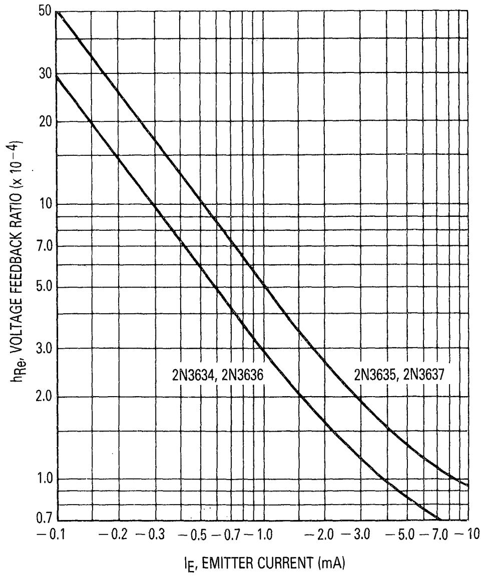


FIGURE 11 — SATURATION VOLTAGES

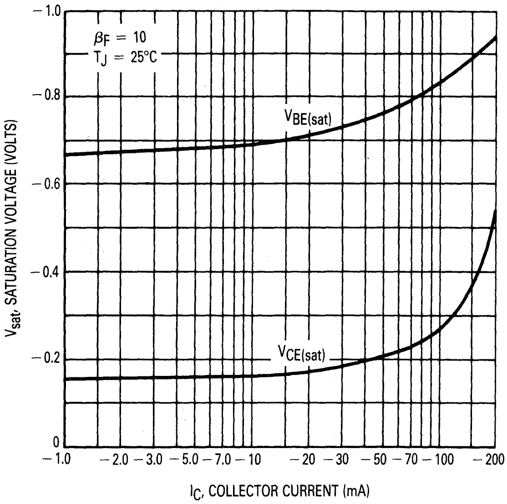
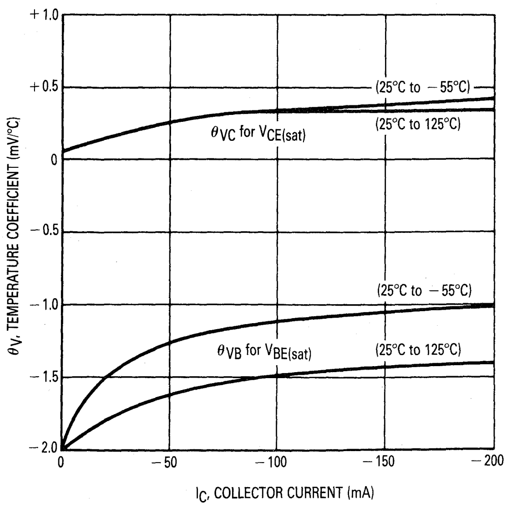
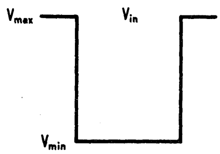


FIGURE 12 — TEMPERATURE COEFFICIENTS



3

FIGURE 13 — SWITCHING TIME TEST CIRCUIT



P.W. ≅ 20 μs
DUTY CYCLE ≤ 2%
RISE TIME ≤ 20 ns

	V_{max}	V_{min}
TURN-ON	+4.0 V	−5.65 V
TURN-OFF	+4.1 V	−5.9 V

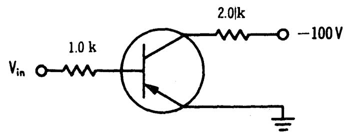


FIGURE 14 — TURN-ON TIME VARIATIONS WITH VOLTAGE

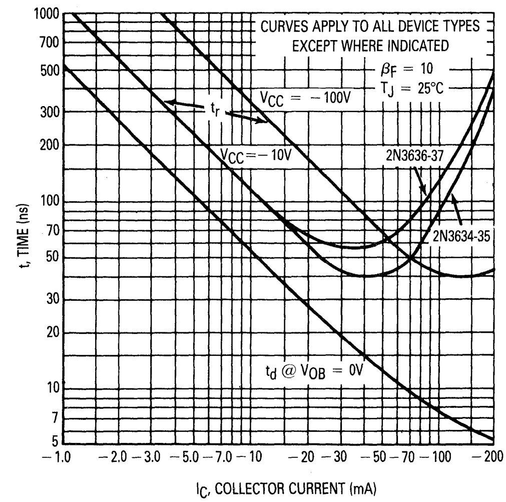
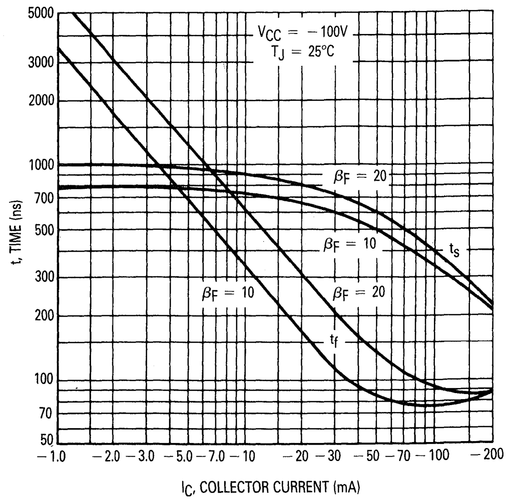
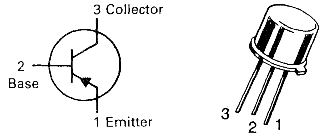


FIGURE 15 — TURN-OFF TIME VARIATIONS WITH CIRCUIT GAIN



2N3762

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



SWITCHING 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
		TO-39 2N3762	
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	4.0 22.8	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	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	44	°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 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_{CE} = −20 Vdc, V_{EB} = −2.0 Vdc) (V_{CE} = −20 Vdc, V_{EB} = −2.0 Vdc, T_A = 100°C)	I_{CEX}	 — —	 −0.10 −10	μAdc
Base Cutoff Current (V_{CE} = −20 Vdc, V_{EB} = −2.0 Vdc)	I_{BL}	—	−0.2	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc) (I_C = −150 mAdc, V_{CE} = −1.0 Vdc) (I_C = −500 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 Adc, V_{CE} = −1.5 Vdc) (I_C = −1.5 Adc, V_{CE} = −5.0 Vdc)	h_{FE}	 35 40 35 30 30	 — — — 120 —	—
Collector-Emitter Saturation Voltage(1) (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)	$V_{CE(sat)}$	 — — — —	 −0.1 −0.22 −0.5 −0.9	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 = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc)	$V_{BE(sat)}$	 — — — −0.9	 −0.8 −1.0 −1.2 −1.4	Vdc

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

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	15	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	80	pF
Current Gain — High Frequency (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)		$\|h_{fe}\|$	1.8	—	—
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −30 V, V_{BE} = 2.0 V, I_C = −1.0 Amp, I_{B1} = −100 mA)	t_d	—	8.0	ns
Rise Time		t_r	—	3.5	ns
Storage Time	V_{CC} = −30 V, I_C = −1.0 Amp, I_{B1} = I_{B2} = −100 mA)	t_s	—	80	ns
Fall Time		t_f	—	35	ns
Total Control Charge (I_C = −1.0 Amp, I_B = −100 mA, V_{CC} = −30 V)		Q_T	—	30	pC

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

3

"ON" CONDITION CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

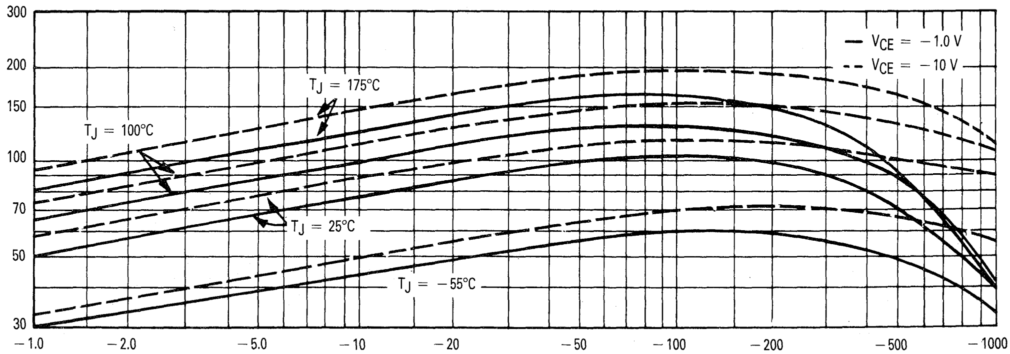
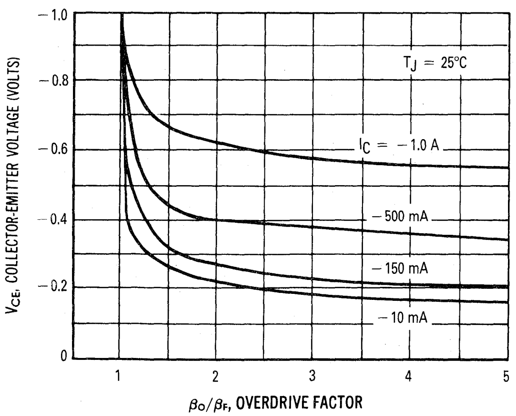


FIGURE 2 — COLLECTOR SATURATION REGION



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 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).

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\text{ Volt}}{I_C/I_{BF}} \qquad 2 = \frac{54}{500\text{ mA}/I_{BF}} \qquad I_{BF} \approx 18.5\text{ mA typ}$$

FIGURE 3 — "ON" VOLTAGES

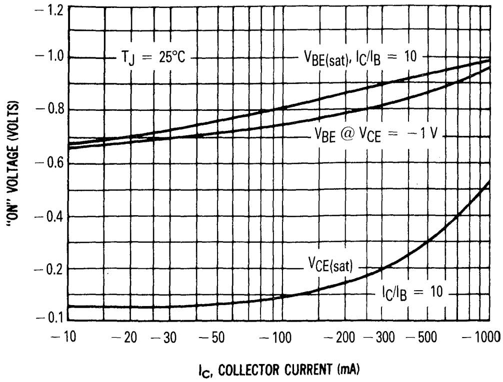


FIGURE 4 — TEMPERATURE COEFFICIENTS

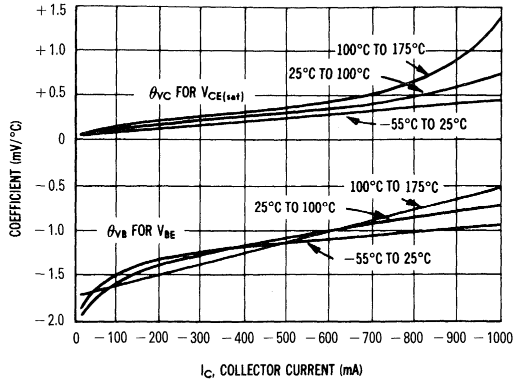
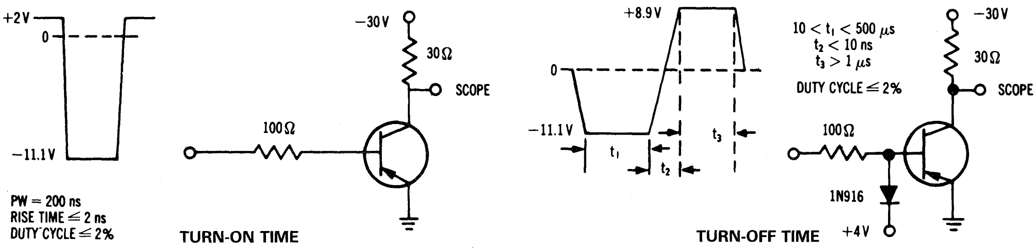
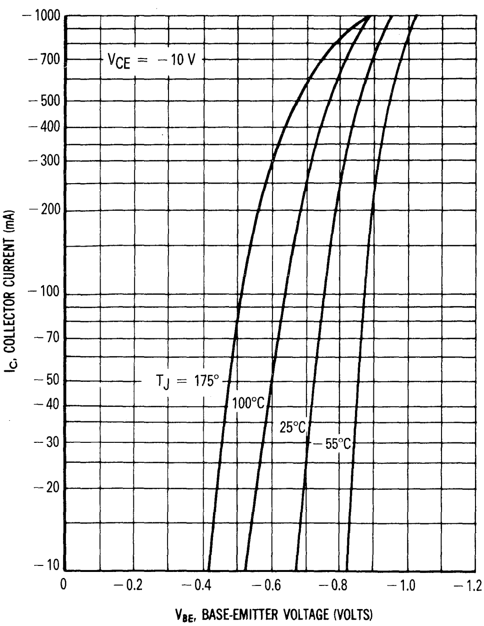


FIGURE 5 — SWITCHING TIME EQUIVALENT TEST CIRCUITS



LARGE SIGNAL CHARACTERISTICS

FIGURE 6 — TRANSCONDUCTANCE



"OFF" CONDITION CHARACTERISTICS

FIGURE 7 — TRANSCONDUCTANCE

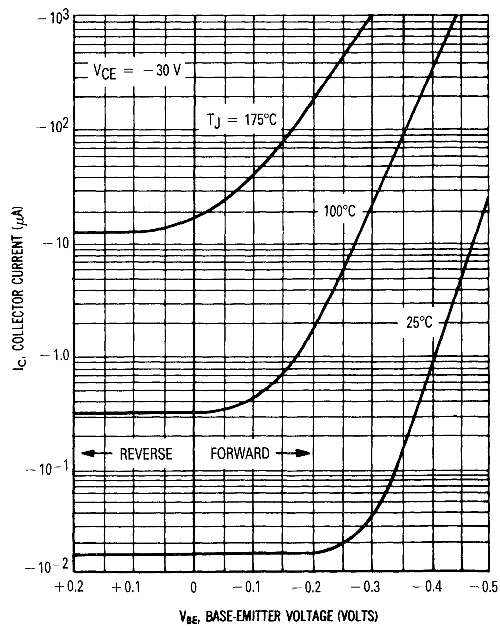


FIGURE 8 — INPUT ADMITTANCE

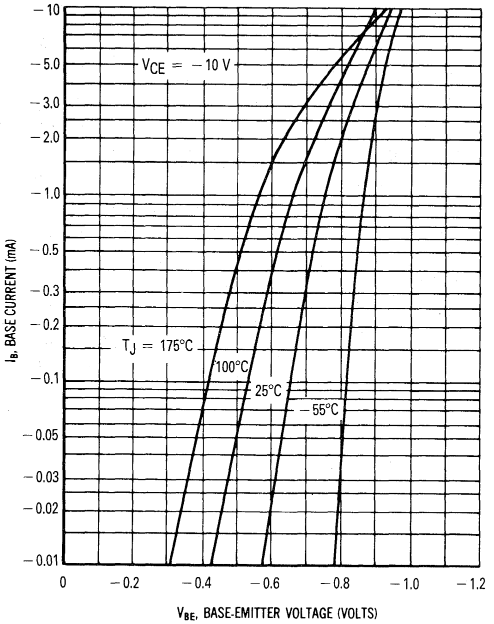
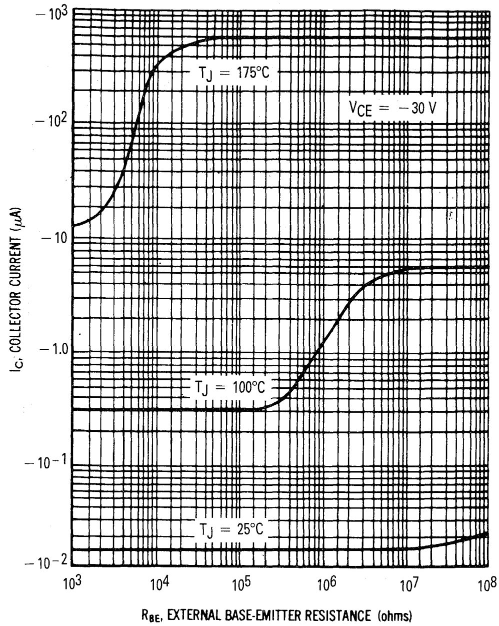


FIGURE 9 — EFFECT OF BASE-EMITTER RESISTANCE



3

SWITCHING CHARACTERISTICS

— T_J = 25°C
- - T_J = 150°C

FIGURE 10 — TURN-ON TIME

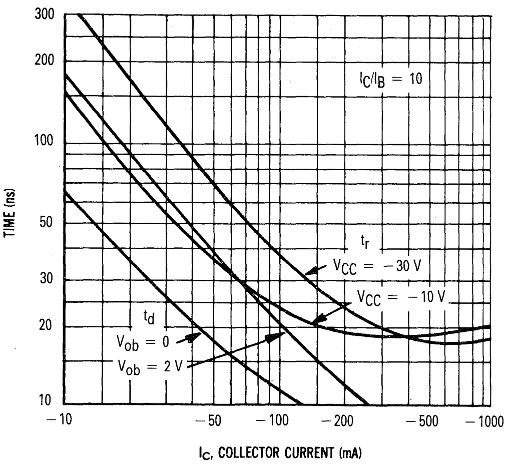
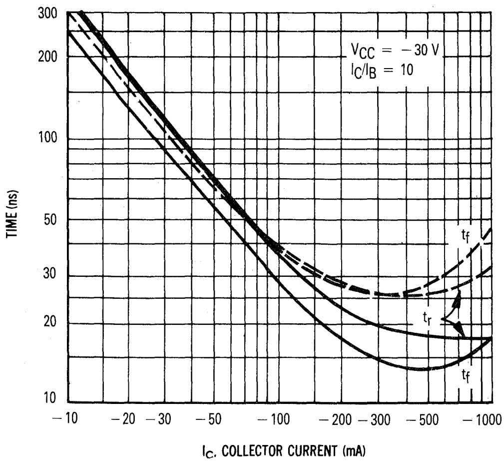


FIGURE 11 — RISE AND FALL TIME



3

FIGURE 12 — STORAGE TIME

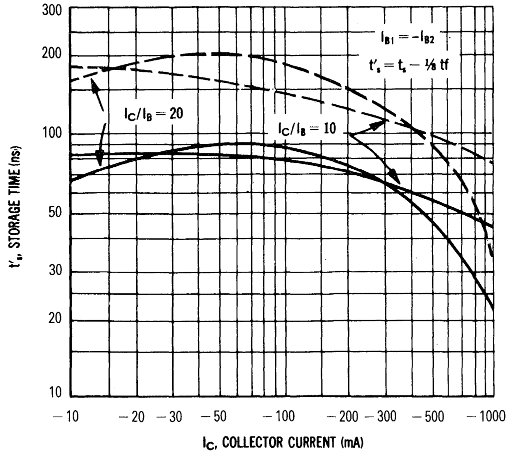


FIGURE 13 — FALL TIME

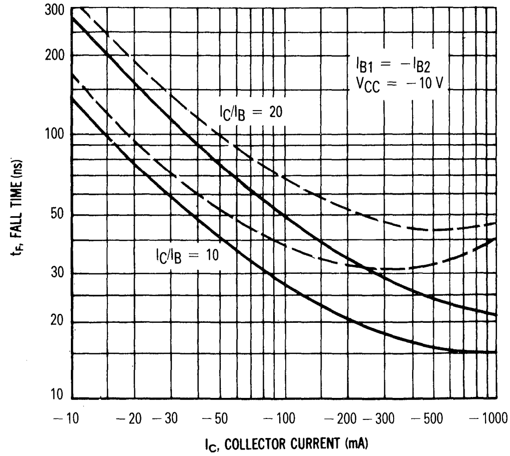


FIGURE 14 — CHARGE DATA

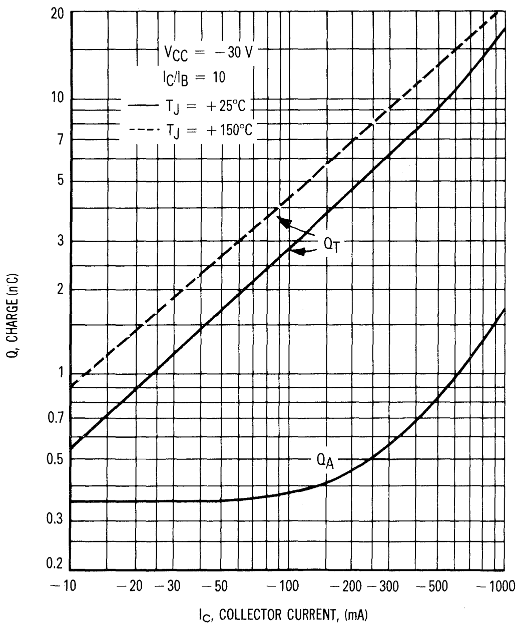


FIGURE 15 — CAPACITANCE

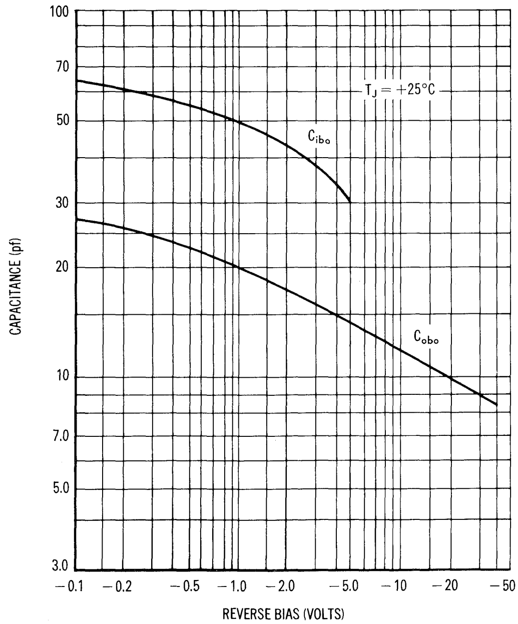
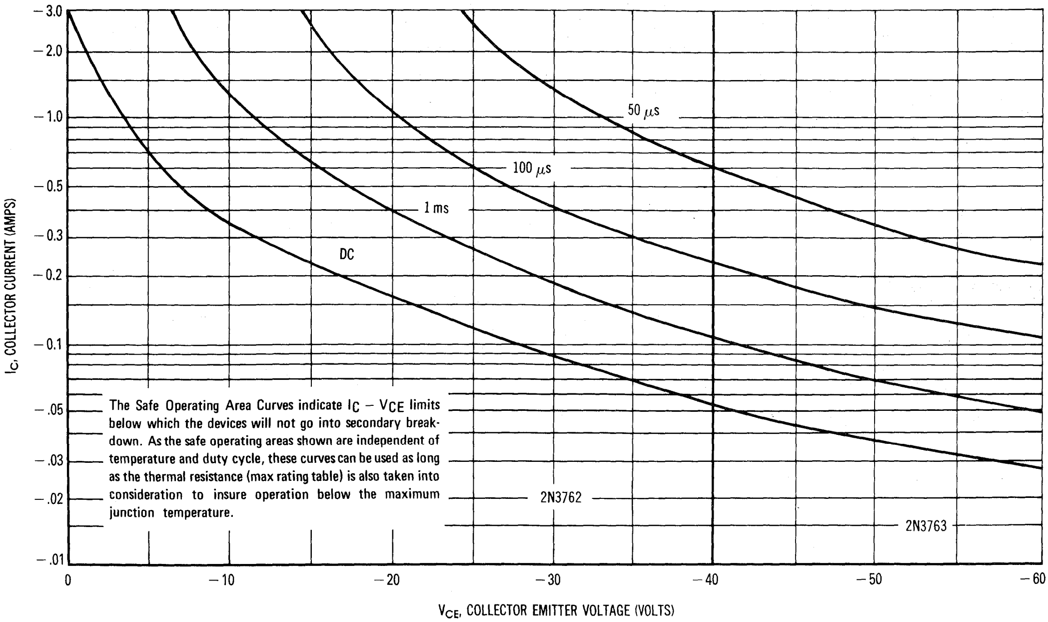
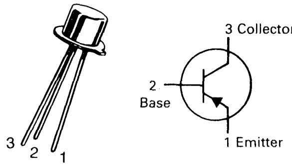


FIGURE 16 — ACTIVE REGION SAFE OPERATING AREAS



2N3799★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



AMPLIFIER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Characteristic	Symbol	Max	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
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 6.86	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 Ambient	$R_{\theta JA}$	0.49	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/mW

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	—	—	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_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	—	−20	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 = −100 μAdc, V_{CE} = −5.0 Vdc) (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, T_A = −55°C) (I_C = −500 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)(1)	h_{FE}	 75 225 300 150 300 300 250	 — — — — — — —	 — — — — 900 — —	—
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
Base-Emitter On Voltage (I_C = −100 μAdc, V_{CE} = −5.0 Vdc)	$V_{BE(on)}$	—	—	−0.7	Vdc

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

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)	f_T				MHz
(I_C = −500 μAdc, V_{CE} = −5.0 Vdc, f = 20 MHz)		30	—	—	
(I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)		100	—	500	
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	8.0	pF
Input Impedance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{ie}	10	—	40	k ohms
Voltage Feedback Ratio (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{re}	—	—	25	$X 10^{-4}$
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{fe}	300	—	900	—
Output Admittance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{oe}	5.0	—	60	μmhos
Noise Figure (I_C = −100 μAdc, V_{CE} = −10 Vdc, R_G = 3.0 k ohms),	NF				dB
f = 100 Hz, B.W. = 20 Hz		—	2.5	4.0	
Spot f = 1.0 kHz, B.W. = 200 Hz		—	0.8	1.5	
Noise f = 10 kHz, B.W. = 2.0 kHz		—	0.8	1.5	
f = 1.0 kHz		—	1.5	2.5	

(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.

3

SPOT NOISE FIGURE
(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 1 — SOURCE RESISTANCE EFFECTS, f = 1.0 kHz

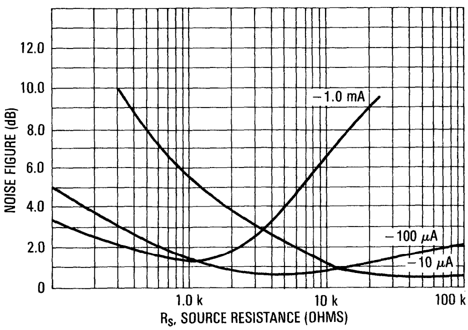


FIGURE 2 — SOURCE RESISTANCE EFFECTS, f = 10 Hz

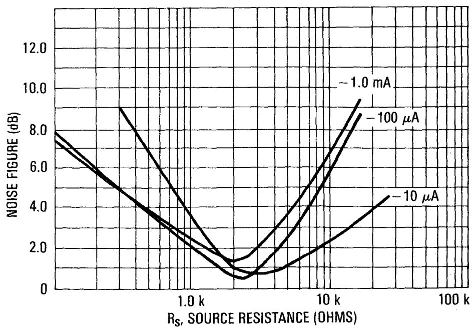


FIGURE 3 — FREQUENCY EFFECTS

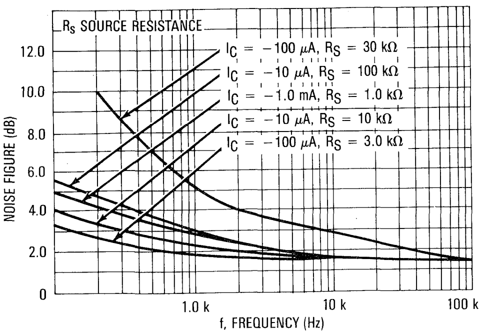
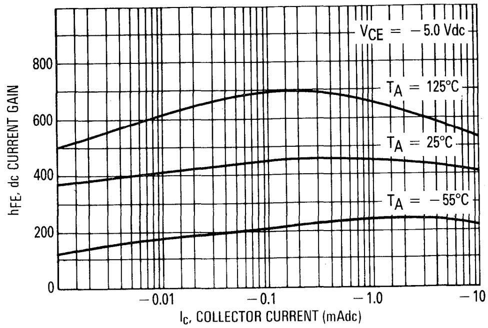


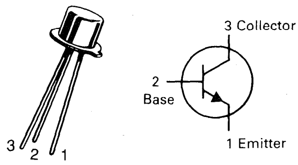
FIGURE 4 — TYPICAL CURRENT GAIN CHARACTERISTICS — 2N3799



3

2N3947★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

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	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	$R_{\theta JC}$	0.15	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/mW

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)	$V_{(BR)CEO}$	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 ($V_{CE} = 40$ Vdc, $V_{EB} = 3.0$ Vdc) ($V_{CE} = 40$ Vdc, $V_{EB} = 3.0$ Vdc, $T_A = 150°C$)	I_{CEX}	 — —	 0.010 15	μAdc
Base Cutoff Current ($V_{CE} = 40$ Vdc, $V_{EB} = 3.0$ Vdc)	I_{BL}	—	.025	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)(1) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	h_{FE}	 60 90 100 40	 — — 300 —	—
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)	$V_{BE(sat)}$	 0.6 —	 0.9 1.0	—
SMALL-SIGNAL CHARACTERISTICS				
Current Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	4.0	pF

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

Characteristic	Symbol	Min	Max	Unit
Input Capacitance (V_{EB} = 1.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	h_{ie}	2.0	12	kohms
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	h_{re}	—	20	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	h_{fe}	100	700	—
Output Admittance (I_C = 10 mA, V_{CE} = 10 V, f = 1.0 kHz)	h_{oe}	5.0	50	μmhos
Collector Base Time Constant (I_C = 10 mA, V_{CE} = 20 V, f = 31.8 MHz)	$rb'C_c$	—	200	ps
Noise Figure (I_C = 100 μA, V_{CE} = 5.0 V, R_g = 1.0 kΩ, f = 1.0 kHz)	NF	—	5.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	V_{CC} = 3.0 Vdc, V_{BE} = −0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mA	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	V_{CC} = 3.0 V, I_C = 10 mA, I_{B1} = I_{B2} = 1.0 mAdc	t_s	—	375	ns
Fall Time		t_f	—	75	ns

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

TYPICAL SWITCHING CHARACTERISTICS

(T_A = 25°C unless otherwise noted)

FIGURE 1 — DELAY AND RISE TIME

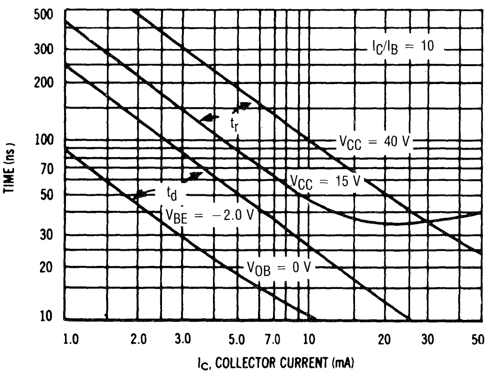


FIGURE 2 — RISE TIME

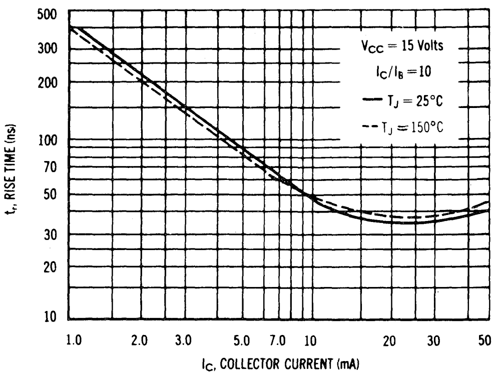


FIGURE 3 — STORAGE AND FALL TIMES

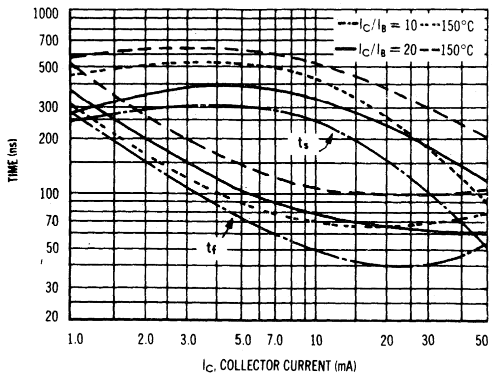


FIGURE 4 — TURN-ON TIME EQUIVALENT TEST CIRCUIT

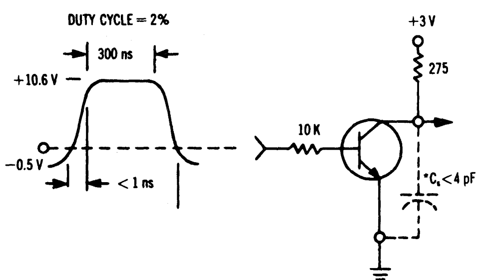
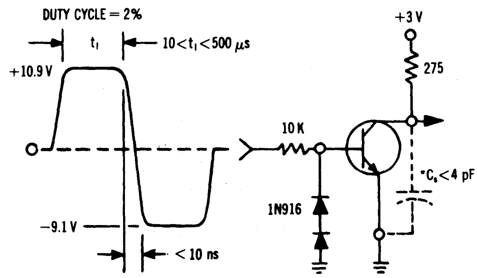


FIGURE 5 — TURN-OFF TIME EQUIVALENT TEST CIRCUIT

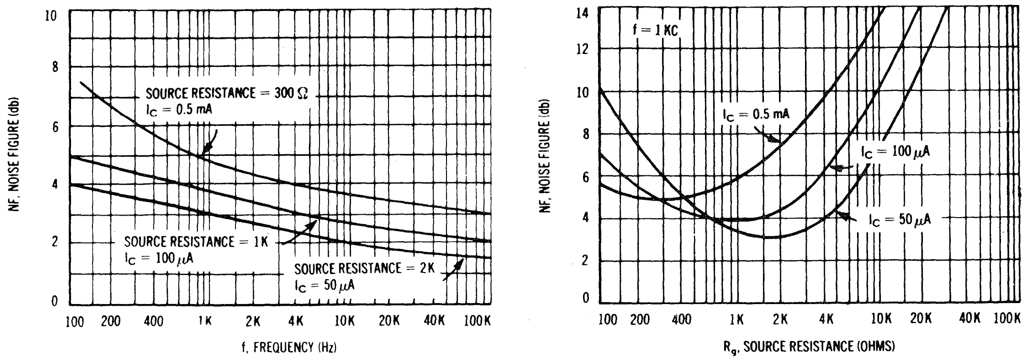


*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS

3

AUDIO SMALL-SIGNAL CHARACTERISTICS

FIGURE 6 — NOISE FIGURE VARIATIONS
V_{CE} = 5.0 V, T_A = 25°C



h PARAMETERS
V_{CE} = 10 V, T_A = 25°C, f = 1.0 kc

FIGURE 7 — CURRENT GAIN

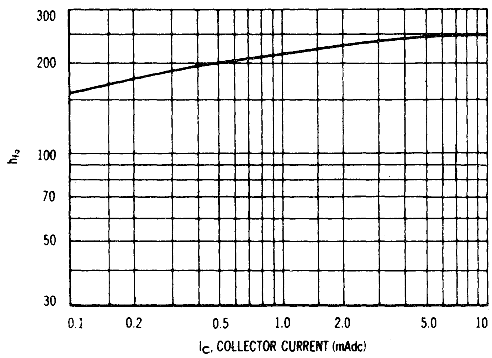


FIGURE 8 — OUTPUT CAPACITANCE

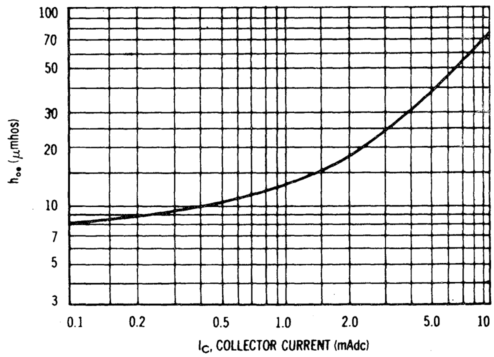


FIGURE 9 — INPUT IMPEDANCE

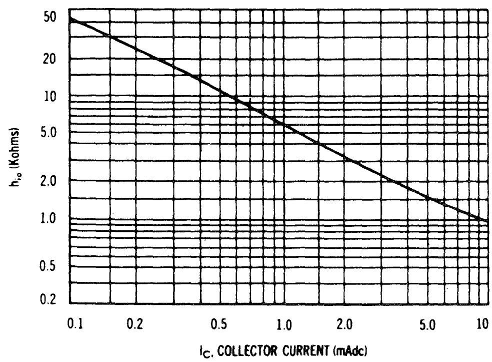


FIGURE 10 — VOLTAGE FEEDBACK RATIO

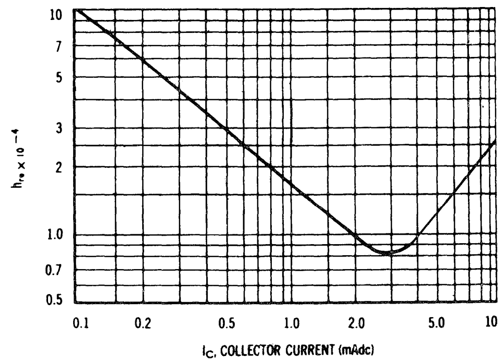


FIGURE 11 — CURRENT GAIN CHARACTERISTICS

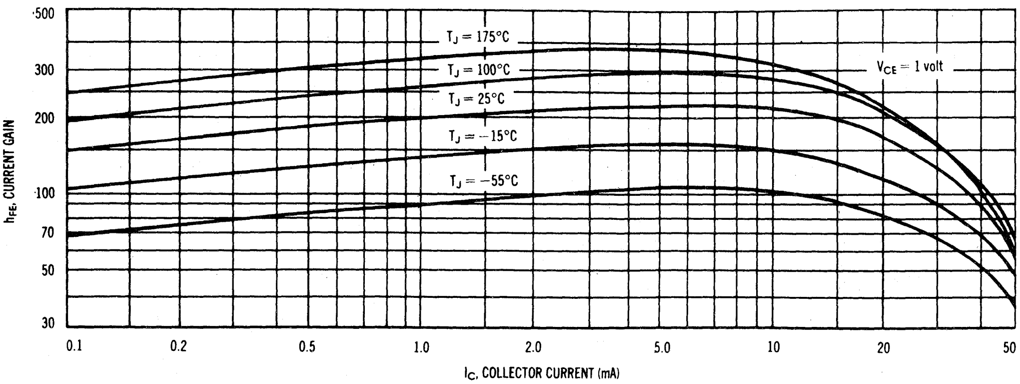


FIGURE 12 — CAPACITANCE

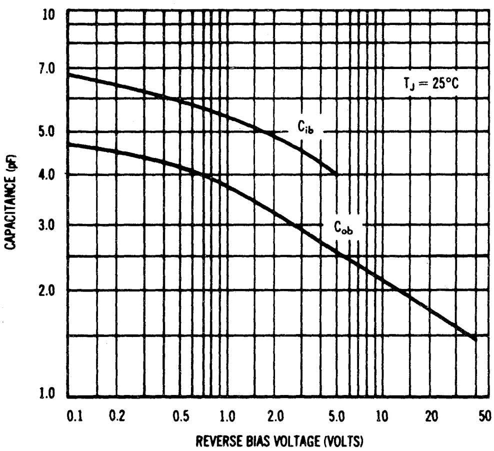
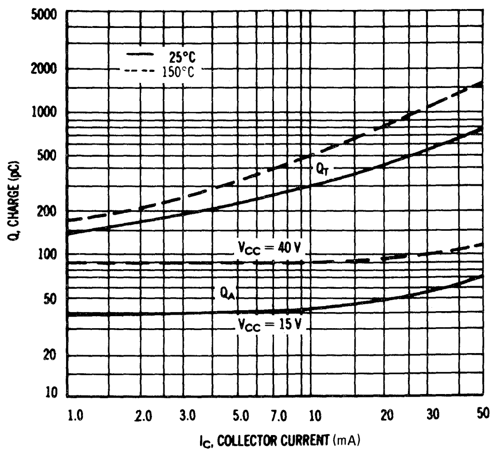
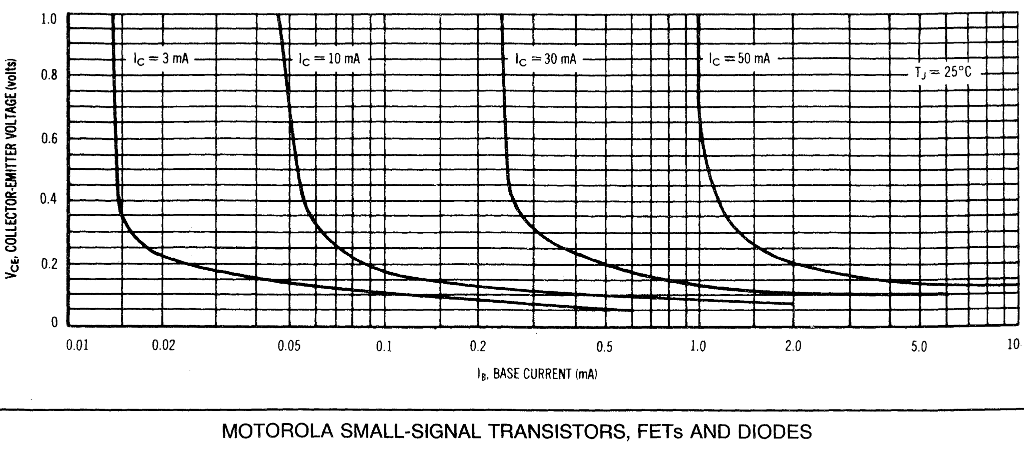


FIGURE 13 — CHARGE DATA



3

FIGURE 14 — COLLECTOR SATURATION REGION



3

FIGURE 15 — "ON" VOLTAGES

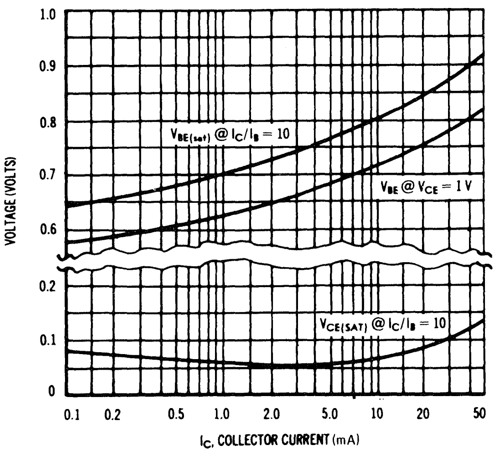
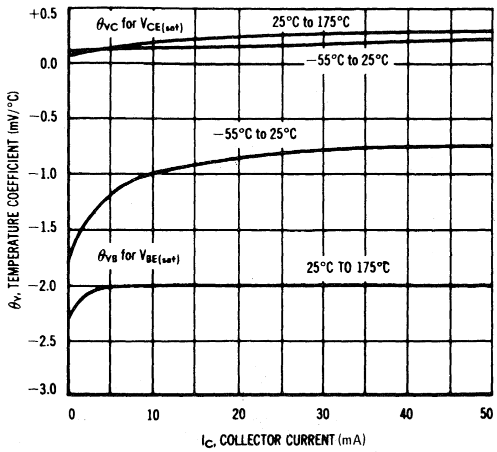
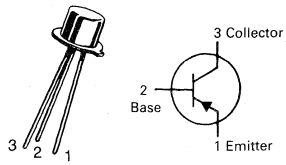


FIGURE 16 — TEMPERATURE COEFFICIENTS



2N3963, 2N3964★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3799 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3964	2N3963	Unit
Collector-Emitter Voltage	V_{CEO}	−45	−80	V
Collector-Base Voltage	V_{CBO}	−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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

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)	2N3963 2N3964	$V_{(BR)CEO}$	−80 −45	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = −10 μA)	2N3963 2N3964	$V_{(BR)CES}$	−80 −45	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μA)	2N3963 2N3964	$V_{(BR)CBO}$	−80 −45	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μA		$V_{(BR)EBO}$	−6.0	—	Vdc
Collector Cutoff Current (V_{CE} = −40 V) (V_{CE} = −70 V)	2N3964 2N3963	I_{CBO}	— —	−10 −10	nAdc
Collector Cutoff Current (V_{CE} = −70 V) (V_{CE} = −40 V)	2N3963 2N3964	I_{CES}	— —	−10 −10	nAdc
Emitter Cutoff Current (V_{EB} = −4.0 V)		I_{EBO}	—	−10	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = −10 μA, V_{CE} = −5.0 V)	2N3963 2N3964		100 250	300 500	
(I_C = −100 μA, V_{CE} = −5.0 V)	2N3963 2N3964		100 250	— —	
(I_C = −1.0 mA, V_{CE} = −5.0)	2N3963 2N3964		100 250	450 600	
(I_C = −10 μA, V_{CE} = −5.0, T_A = −55°C)	2N3963 2N3964		40 100	— —	

(continued)

3

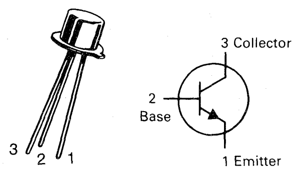
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
DC Current Gain continued					
(I_C = −1.0 mA, V_{CE} = −5.0 V, T_A = 100°C))	2N3963		—	600	
	2N3964		—	800	
(I_C = −1.0 μA, V_{CE} = −5.0 V)	2N3963		60	—	
	2N3964		180	—	
(I_C = −10 μA, V_{CE} = −5.0 V)	2N3963		100	—	
	2N3964		200	—	
(I_C = −50 mA, V_{CE} = −5.0)(1)	2N3963		90	—	
	2N3964		180	—	
(I_C = −50 mA, V_{CE} = −5.0, T_A = −55°C)(1)	2N3963		45	—	
	2N3964		90	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			
(I_C = −10 mA, I_B = −0.5 mA)(1)			—	−0.25	V
(I_C = −50 mA, I_B = −5.0 mA)(1)			—	−0.4	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			
(I_C = −10 mA, I_B = −0.5 mA)(1)			—	0.9	V
(I_C = −50 mA, I_B = −5.0 mA)(1)			—	0.95	V
SMALL-SIGNAL CHARACTERISTICS					
Ouput Capacitance (V_{CB} = −5.0 V, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = −0.5 V, f = 1.0 MHz)		C_{ibo}	—	15	pF
Input Impedance		h_{ie}			kΩ
(I_C = −1.0 mA, V_{CE} = −5.0 V, f = 1.0 kHz)	2N3963		2.5	17	
	2N3964		6.0	20	
Voltage Feedback Ratio (I_C = −1.0 mA, V_{CE} = −5.0, f = 1.0 kHz)		h_{re}	—	10	10^{-4}
Small Signal Current Gain		h_{fe}			
(I_C = −1.0 mA, V_{CE} = −5.0 V, f = 1.0 kHz)	2N3963		100	550	—
	2N3964		250	700	—
Magnitude of Forward Current Transfer Ratio, Common-Emitter		$\|h_{fe}\|$			
(I_C = −0.5 mA, V_{CE} = −5.0 V, f = 20 MHz)	2N3963		2.0	8.0	—
	2N3964		2.5	8.0	—
Output Admittance		h_{oe}			μmhos
(I_C = −1.0 mA, V_{CE} = −5.0, f = 1.0 kHz)	2N3963		5.0	40	
	2N3964		5.0	50	
Noise Figure		NF			dB
(I_C = −20 mA, V_{CE} = −5.0 V, BW = 15.7 kHz)	2N3963		—	3	
	2N3964		—	2	
(I_C = −20 μA, V_{CE} = −5.0 V, BW = 1.5 kHz,	2N3963		—	3	
f = 10 kHz, R_S = 10 kΩ)	2N3964		—	2	
(I_C = −20 μA, V_{CE} = −5.0 V, BW = 150 Hz,	2N3963		—	3	
f = 1.0 kHz, R_S = 10 kΩ)	2N3964		—	2	
(I_C = −20 μA, V_{CE} = −5.0 V, BW = 15 Hz,	2N3963		—	10	
f = 100 Hz, R_S = 10 hΩ)	2N3964		—	4	
(I_C = −20 μA, V_{CE} = −5.0 V, BW = 2.0 Hz,	2N3964		—	8	
f = 10 Hz, R_S = 10 kΩ)					

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

2N4014

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4014	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 — Peak	I_C	1.0 2.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.4 8.0	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 Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

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	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\ \mu$Adc, $V_{BE} = 0$)	$V_{(BR)CES}$	80	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 100°C$)	I_{CBO}	 — —	 0.12 —	 1.7 120	μAdc
Collector Cutoff Current ($V_{CE} = 80$ Vdc, $V_{EB} = 0$)	I_{CES}	—	0.15	10	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) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 300$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 800$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 30 60 30 40 35 20 20 25	 — — — — — — — —	 — 150 — — — — — —	—

(continued)

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

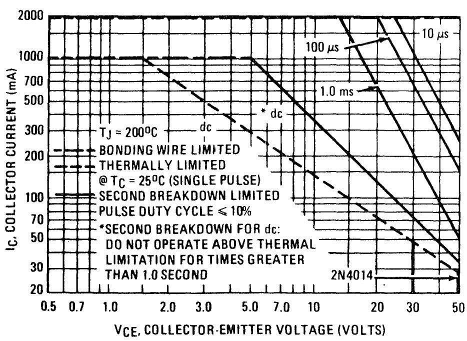
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.17	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.19	0.26	
(I_C = 300 mAdc, I_B = 30 mAdc)		—	0.25	0.40	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.30	0.52	
(I_C = 800 mAdc, I_B = 80 mAdc)		—	0.43	0.80	
(I_C = 1.0 mAdc, I_B = 100 mAdc)		—	0.55	0.95	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	—	0.76	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	—	0.86	
(I_C = 300 mAdc, I_B = 30 mAdc)		—	—	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)		0.8	—	1.1	
(I_C = 800 mAdc, I_B = 80 mAdc)		—	—	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)		—	—	1.7	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, 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}	—	—	10	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	55	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8,10)	t_d	—	5.0	10	ns
Rise Time		t_r	—	15	30	
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9,10)	t_s	—	30	50	ns
Fall Time		t_f	—	20	25	ns
Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)	t_{on}	—	20	35	ns
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10)	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

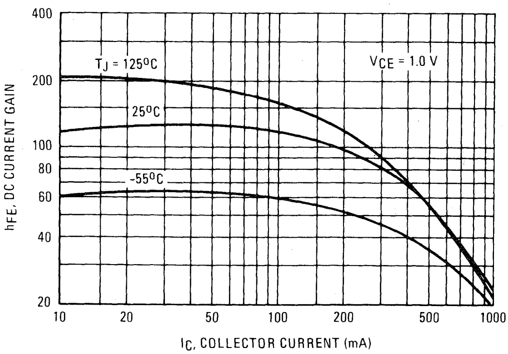


FIGURE 3 – "ON" VOLTAGES

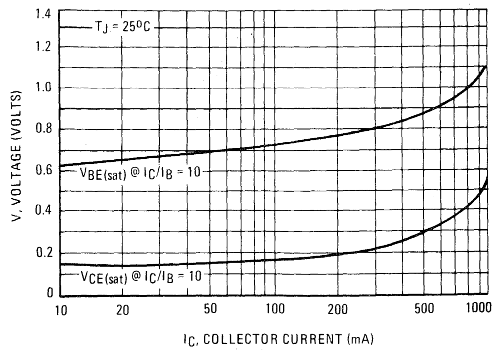


FIGURE 4 – COLLECTOR SATURATION REGION

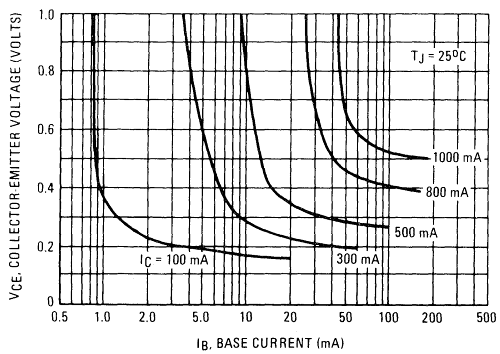
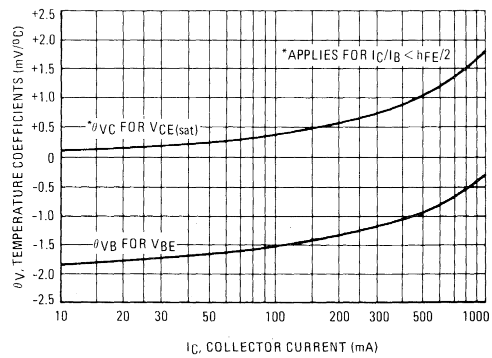


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

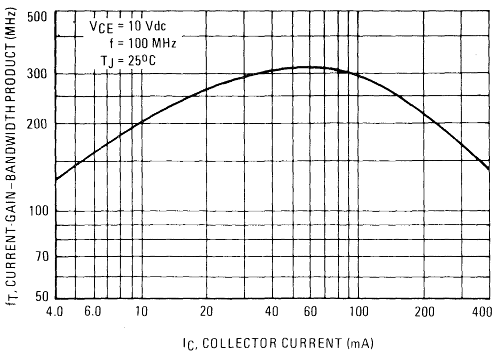


FIGURE 7 – CAPACITANCE

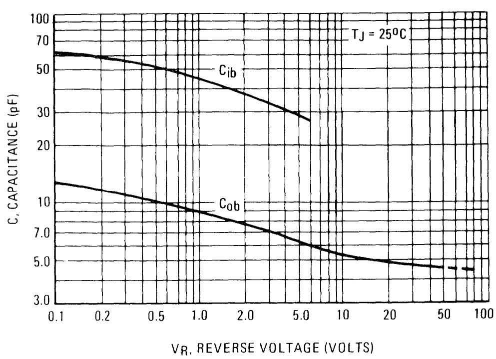


FIGURE 8 — TURN-ON TIME

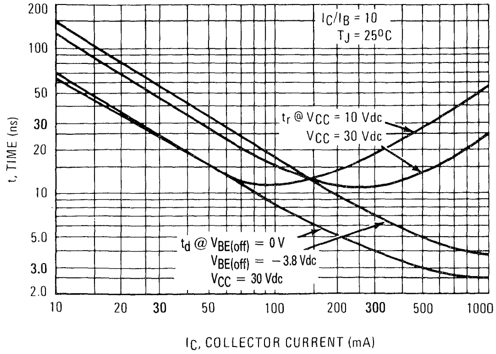


FIGURE 9 — TURN-OFF TIME

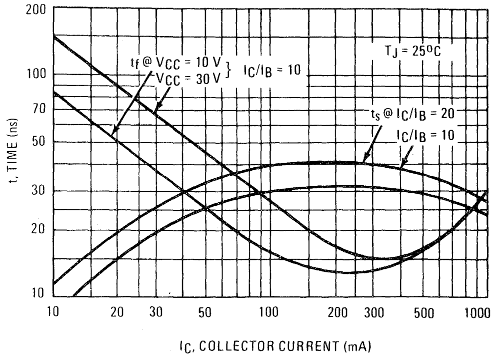
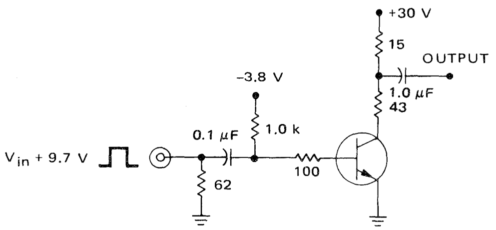
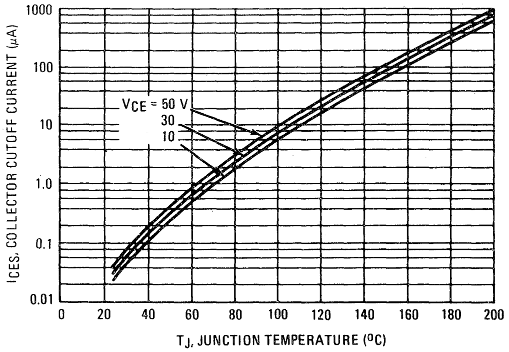


FIGURE 10 — SWITCHING TIME TEST CIRCUIT



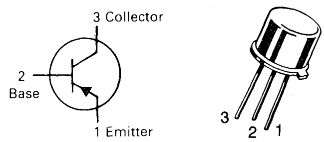
t_r ≤ 1.0 ns
P.W. ≥ 200 ns
Duty Cycle ≤ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope

FIGURE 11 — COLLECTOR CUTOFF CURRENT



2N4032
2N4033

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

Refer to 2N4405 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N4032	2N4033	Unit
Collector-Emitter Voltage	V_{CEO}	−60	−80	Vdc
Collector-Base Voltage	V_{CBO}	−60	−80	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	−5.0	Vdc
		2N4032	2N4033	
Collector Current — Continuous	I_C	−1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.56		W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8		W 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 Ambient	$R_{\theta JA}$	140	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°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)	 2N4032 2N4033	$V_{(BR)CEO}$	 −60 −80	 — —	V
Collector-Base Breakdown Voltage (I_C = −10 μA)	 2N4032 2N4033	$V_{(BR)CBO}$	 −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)	 2N4032 2N4033 2N4032 2N4033	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)(1)	 2N4032,33	h_{FE}	 40	 —	—
(I_C = −100 μA, V_{CE} = −5.0 V)	2N4032,33		75	—	
(I_C = −100 mA, V_{CE} = −5.0 V)(1)	2N4032,33		100	300	
(I_C = −500 mA, V_{CE} = −5.0 V)(1)	2N4032,33		70	—	
(I_C = −1.0 A, V_{CE} = −5.0 V)F(1)	2N4032 2N4033		40 25	— —	

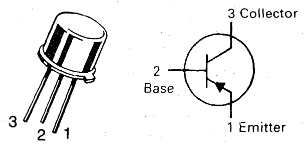
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			V
(I_C = −150 mA, I_B = −15 mA)			—	−0.15	
(I_C = −500 mA, I_B = −50 mA)			—	−0.50	
(I_C = −1.0 A, I_B = −100 mA)	2N4032		—	−1.0	
Base-Emitter Saturation Voltage(1) (I_C = −150 mA, I_B = −15 mA)		$V_{BE(sat)}$	—	−0.9	V
Base-Emitter On Voltage		$V_{BE(on)}$			V
(I_C = −1.0 A, V_{CE} = −1.0 V)	2N4032		—	−1.2	
(I_C = −500 mA, V_{CE} = −0.5 V)(1)			—	−1.1	
SMALL-SIGNAL CHARACTERISTICS					
Ouput Capacitance (V_{CE} = −10 V, f = 1.0 MHz)		C_{obo}	—	20	pF
Input Capacitance (V_{EB} = −0.5 V, f = 1.0 MHz)		C_{ibo}	—	110	pF
Small Signal Current Gain (I_C = −50 mA, V_{CE} = −10 V, f = 100 MHz)		h_{fe}	1.5	5.0	—
SWITCHING CHARACTERISTICS					
Storage Time (I_C = −500 mA, I_{B1} = I_{B2} = −50 mA)		t_s	—	350	ns
Turn-On Time (I_C = −500 mA, I_{B1} = −50 mA)		t_{on}	—	100	ns
Fall Time (I_C = −500 mA, I_{B1} = I_{B2} = −50 mA)		t_f	—	50	ns

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

2N4036
2N4037

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4036	2N4037	Unit
Collector-Emitter Voltage	V_{CEO}	−65	−40	Vdc
Collector-Base Voltage	V_{CBO}	−90	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−7.0	−7.0	Vdc
Base Current	I_B	−0.5		Adc
Collector Current — Continuous	I_C	−1.0		Adc
Continuous Power Dissipation at or Below T_C = 25°C Linear Derating Factor	P_D	 5.0 28.6	 5.0 28.6	 Watts mW/°C
Continuous Power Dissipation at or Below T_A = 25°C Linear Derating Factor	P_D	 1.0 5.72	 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	$R_{\theta JC}$	35	35	°C/W

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = −100 mAdc, I_B = 0)(1)	2N4036 2N4037	$V_{CEO(sus)}$	−65 −40	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −0.1 mAdc)	2N4037	$V_{(BR)CBO}$	−60	—	Vdc
Collector Cutoff Current (V_{CE} = −85 V, V_{EB} = −1.5 V) (V_{CE} = −30 V, V_{EB} = −1.5 V, T_C = 150°C)	2N4036 2N4037	I_{CEX}	— —	−0.1 −100	mAdc
Collector Cutoff Current (V_{CB} = −90 V, I_E = 0) (V_{CB} = −60 V, I_E = 0)	2N4036 2N4037	I_{CBO}	— —	−1.0 −0.25	μAdc
Emitter Cutoff Current (V_{EB} = −7.0 Vdc, I_C = 0) (V_{EB} = −5.0 Vdc, I_C = 0)	2N4036 2N4037	I_{EBO}	— —	−10 −1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −10 V) (I_C = −1.0 mAdc, V_{CE} = −10 V)	2N4036 2N4037	h_{FE}	20 15	— —	—
(I_C = −150 mAdc, V_{CE} = −10 V)(1)	2N4036 2N4037		40 50	140 250	
(I_C = −150 mAdc, V_{CE} = −2.0 V)(1)	2N4036		20	200	
(I_C = −500 mAdc, V_{CE} = −10 V)(1)	2N4036		20	—	
Collector-Emitter Saturation Voltage (I_C = −150 mA, I_B = −15 mA)(1)	2N4036 2N4037	$V_{CE(sat)}$	— —	−0.65 −1.4	V
Base-Emitter Saturation Voltage (I_C = −150 mA, I_B = −15 mA)(1)	2N4036	$V_{BE(sat)}$	—	−1.4	V
Base-Emitter On Voltage (I_C = −150 mA, V_{CE} = −10 V)(1)	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	—
SWITCHING CHARACTERISTICS					
Rise Time (I_{B1} = −15 mA)	2N4036	t_r	—	70	ns
Storage Time (I_{B2} = −15 mA)	2N4036	t_s	—	600	ns
Fall Time (I_{B2} = −15 mA)	2N4036	t_f	—	100	ns
Turn-On Time (I_{B1} = I_{B2})	2N4036	t_{on}	—	110	ns
Turn-Off Time (I_{B1} = I_{B2})	2N4036	t_{off}	—	700	ns

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

FIGURE 1 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

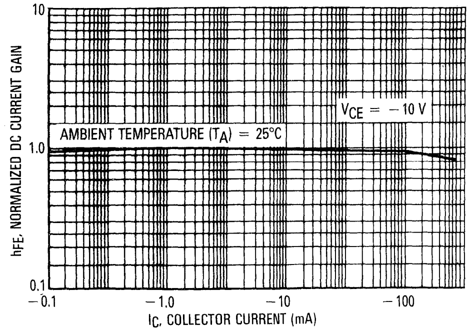


FIGURE 2 — DISSIPATION DERATING CURVE

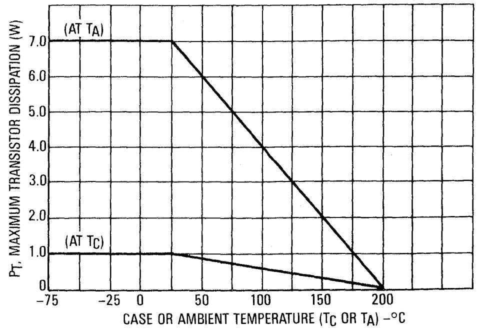


FIGURE 3 — TYPICAL COLLECTOR-CUTOFF CURRENT versus JUNCTION TEMPERATURE

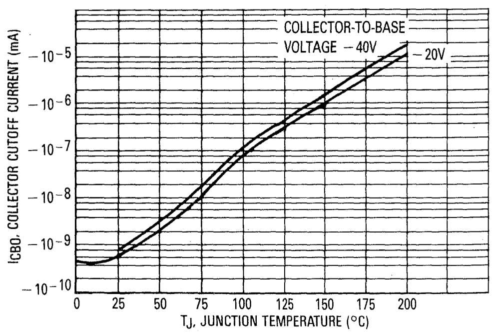


FIGURE 4 — TYPICAL SATURATION-VOLTAGE CHARACTERISTICS

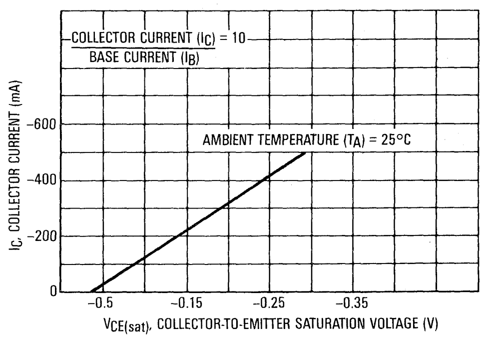


FIGURE 5 — TYPICAL SMALL-SIGNAL BETA CHARACTERISTICS

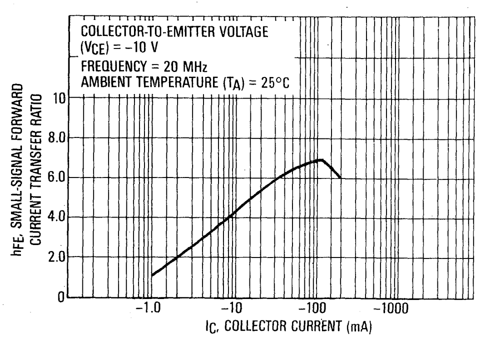
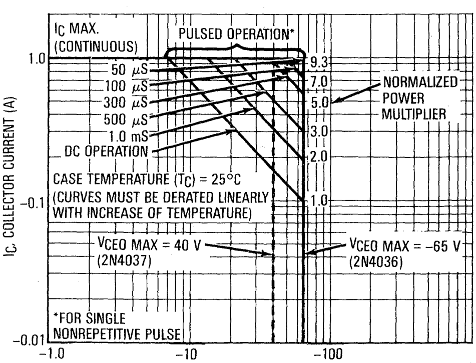
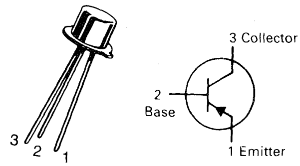


FIGURE 6 — MAXIMUM SAFE OPERATING AREAS (SOA)



2N4208

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

PNP SILICON

3

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}	−4.5	Vdc
Collector Current — Continuous	I_C	−50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.72	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.7 4.0	Watts mW/°C
Operating and Storage Jucntion Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

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

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage(1) (I_C = −3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−12	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	Vdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0) (V_{CE} = −6.0 Vdc, V_{BE} = 0, T_A = 125°C)	I_{CES}	— —	−10 −5.0	nAdc μAdc
Base Current (V_{CE} = −6.0 Vdc, V_{BE} = 0)	I_B	—	−1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −0.5 Vdc) (I_C = −10 mAdc, V_{CE} = −0.3 Vdc)(1) (I_C = −10 mAdc, V_{CE} = −0.3 Vdc, T_A = −55°C)(1) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc)(1)	h_{FE}	 15 30 12 30	 — 120 — —	—
Collector-Emitter Saturation Voltage (I_C = −1.0 mAdc, I_B = −0.1 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −50 mAdc, I_B = −5.0 mAdc)(1)	$V_{CE(sat)}$	 — — —	 −0.13 −0.15 −0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −1.0 mAdc, I_B = − 0.1 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −50 mAdc, I_B = −5.0 mAdc)(1)	$V_{BE(sat)}$	 — −0.75 —	 −0.8 −0.95 −1.5	Vdc

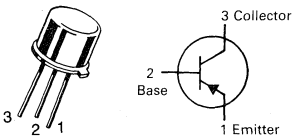
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)		f_T	700	—	MHz
Output Capacitance (V_{CB} = −5.0 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}	—	3.5	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −1.5 Vdc, V_{BE} = 0, I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	15	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	(V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	20	ns
Storage Time		t_s	—	20	ns
Fall Time		t_f	—	10	ns
Storage Time (I_C ≈ −10 mAdc, I_{B1} ≈ −10 mAdc, I_{B2} ≈ −10 mAdc)		t_s	—	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%
(2) f_T is defined as the freqency at which $|h_{fe}|$ extrapolates to unity.

2N4405

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

3

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	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.75 50	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 Ambient	$R_{\theta JA}$	140	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°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 mAdc, I_B = 0)	$V_{(BR)CEO}$	−80	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −60 Vdc, I_E = 0)	I_{CBO}	—	−25	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	−25	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −5.0 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc)(1) (I_C = −150 mAdc, V_{CE} = −5.0 Vdc)(1) (I_C = −500 mAdc, V_{CE} = −5.0 Vdc)(1)	h_{FE}	 75 100 100 50	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −150 mAdc, I_B = −15 mAdc)(1) (I_C = −500 mAdc, I_B = −50 mAdc)(1)	$V_{CE(sat)}$	 — — —	 −0.15 −0.2 −0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −500 mAdc, I_B = −50 mAdc)(1)	$V_{BE(sat)}$	 — −0.85	 −0.8 −1.2	Vdc
Base-Emitter On Voltage (I_C = −150 mAdc, V_{CE} = −1.0 Vdc)(1)	$V_{BE(on)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	200	600	MHz
Collector-Base Capacitance (I_C = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	10	pF
Emitter-Base Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	75	pF

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

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −30 Vdc, $V_{BE(off)}$ = +2.0 Vdc, I_C = −500 mAdc, I_{B1} = −50 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = −30 Vdc, I_C = −500 mAdc, I_{B1} = I_{B2} = −50 mAdc)	t_s	—	175	ns
Fall Time		t_f	—	35	ns

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

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON

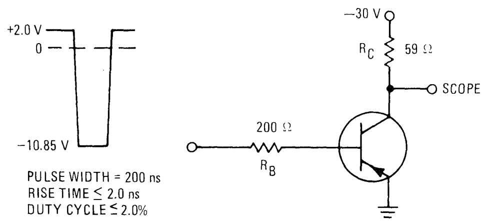
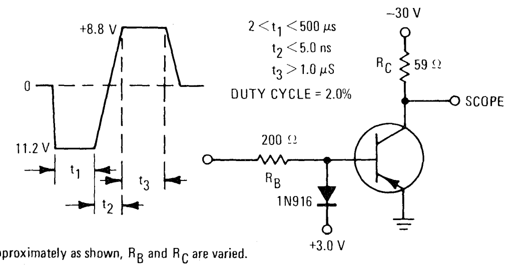


FIGURE 2 — TURN-OFF



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

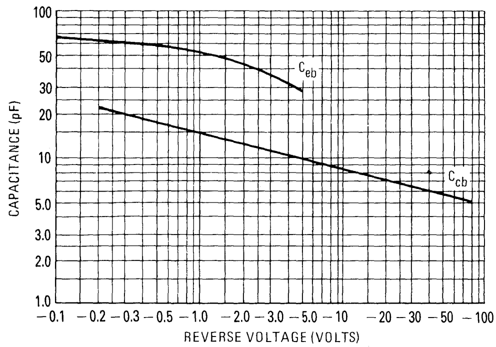


FIGURE 4 — CHARGE DATA

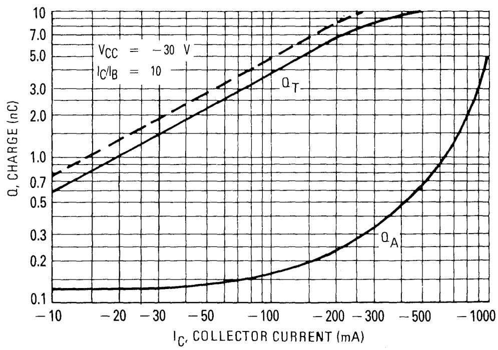


FIGURE 5 — DELAY TIME

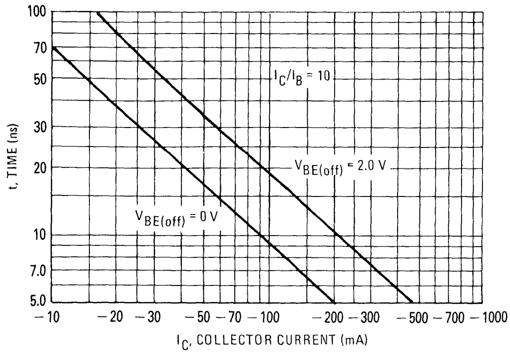


FIGURE 6 — RISE TIME

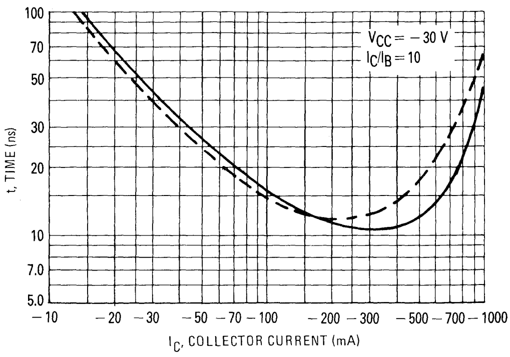


FIGURE 7 — STORAGE TIME

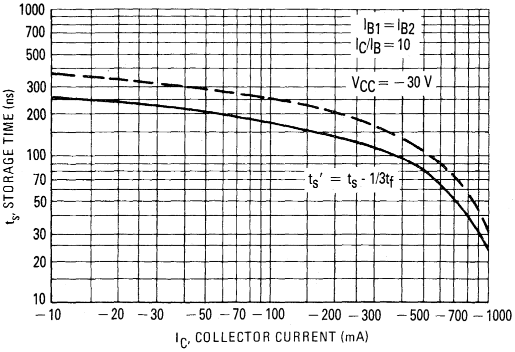
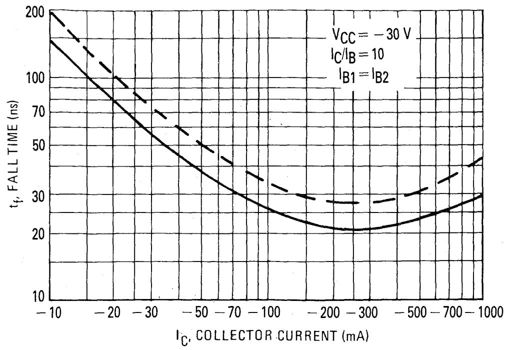


FIGURE 8 — FALL TIME



3

SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE

$V_{CE} = 10$ Vdc, $T_A = 25°C$

FIGURE 9 — FREQUENCY EFFECTS

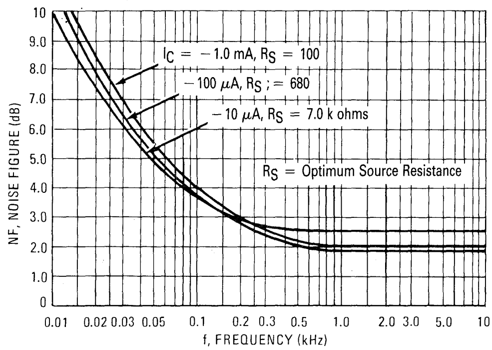
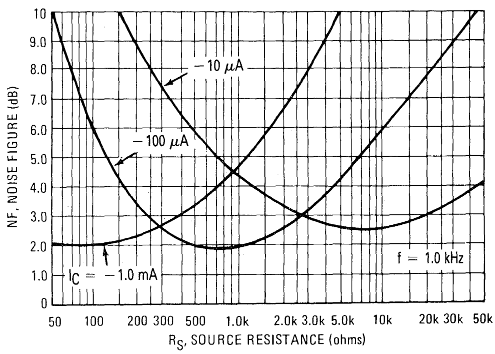


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

$V_{CE} = 10$ Vdc, f = 1.0 kHz, $T_A = 25°C$

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

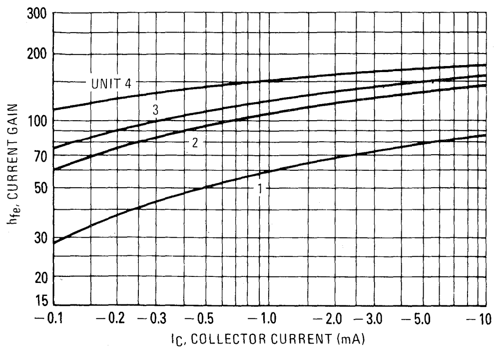
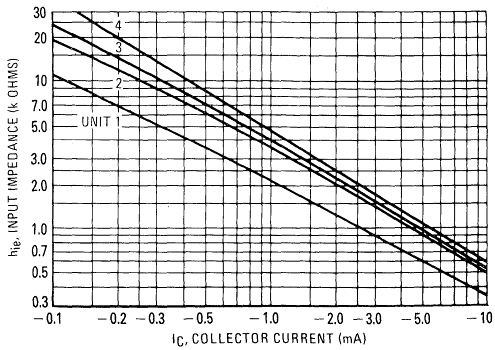


FIGURE 12 — INPUT IMPEDANCE



3

FIGURE 13 — VOLTAGE FEEDBACK RATIO

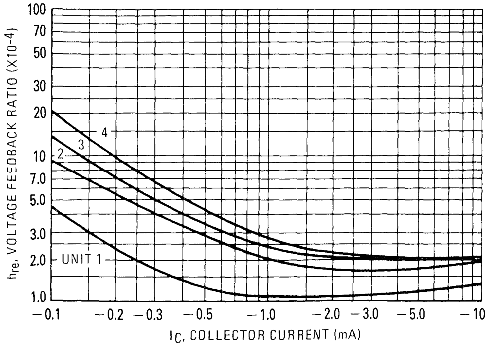
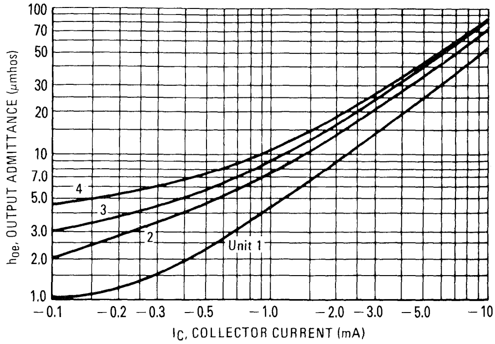


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

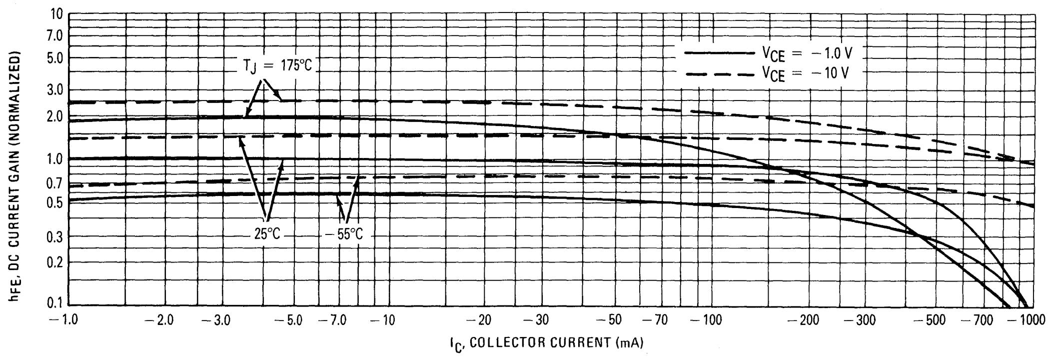


FIGURE 16 — COLLECTOR SATURATION REGION

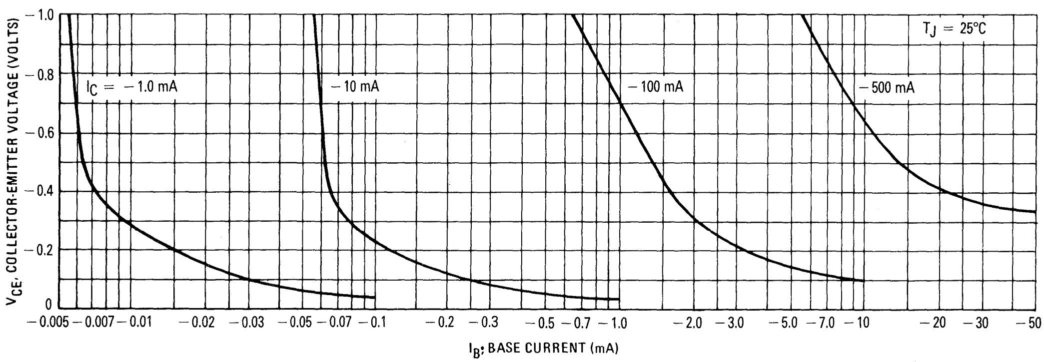


FIGURE 17 — "ON" VOLTAGES

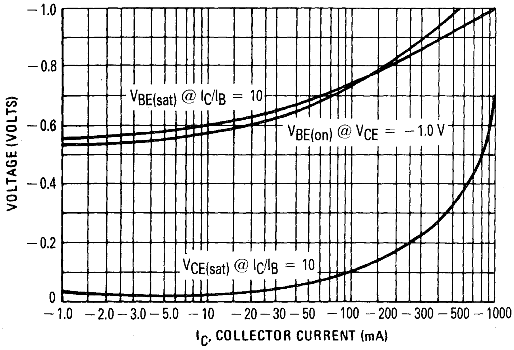
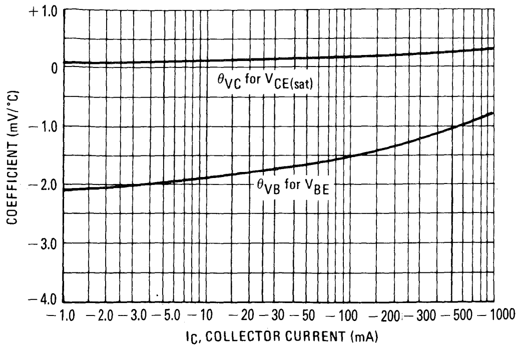
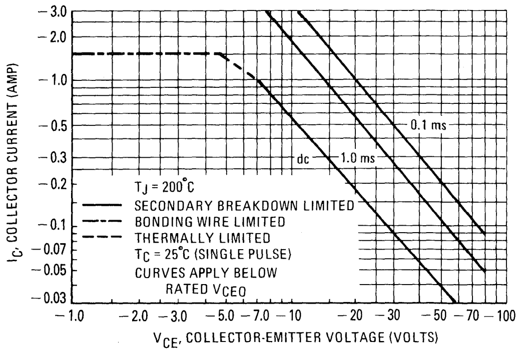


FIGURE 18 — TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

FIGURE 19 — SAFE OPERATING AREA

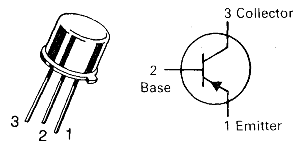


The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 19 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 200°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.

2N4407

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CBO}	−80	Vdc
Collector-Base Voltage	V_{CEO}	−80	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−2.0	Amps
Total Device Dissipation @ T_A = 25°C* Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C* Derate above 25°C	P_D	8.75 50	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 Ambient	$R_{\theta JA}$	140	°C/W
Thermal Resistance to Case	$R_{\theta JC}$	20	°C/W

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

Characteristic	Symbol	Min	Max	Uni
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−80	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −60 Vdc, I_E = 0)	I_{CBO}	—	−25	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	−25	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = −10 mAdc, V_{CE} = −5.0 Vdc) (I_C = −150 mAdc, V_{CE} = −5.0 Vdc) (I_C = −500 mAdc, V_{CE} = −5.0 Vdc) (I_C = −1.0 Adc, V_{CE} = −5.0 Vdc) (I_C = −1.5 Adc, V_{CE} = −5.0 Vdc)	h_{FE}	 80 80 80 30 10	 — — 240 — —	—
Collector-Emitter Saturation Voltage (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) (I_C = −1.5 Adc, I_B = −150 mAdc)	$V_{CE(sat)}$	 — — — —	 −0.2 −0.4 −0.7 −1.5	Vdc
Base-Emitter Saturation Voltage (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc) (I_C = −1.5 Adc, I_B = −150 mAdc)	$V_{BE(sat)}$	 — −0.9 —	 −0.9 −1.3 −1.5	Vdc
Base-Emitter On Voltage (I_C = −500 mAdc, V_{CE} = −1.0 Vdc)	$V_{BE(on)}$	—	−1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	150	750	MHz
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	15	pF
Emitter-Base Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	160	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Indicates Data in addition to JEDEC Requirements.

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

Characteristics		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −30 Vdc, $V_{BE(off)}$ = +2.0 Vdc, I_C = −1.0 Adc, I_{B1} = −100 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	60	ns
Storage Time	(V_{CC} = −30 Vdc, I_C = −1.0 Adc, I_{B1} = I_{B2} = −100 mAdc)	t_s	—	175	ns
Fall Time		t_f	—	50	ns

STATIC CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

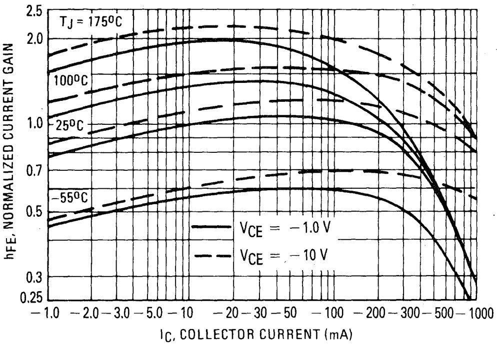


FIGURE 2 — COLLECTOR SATURATION REGION

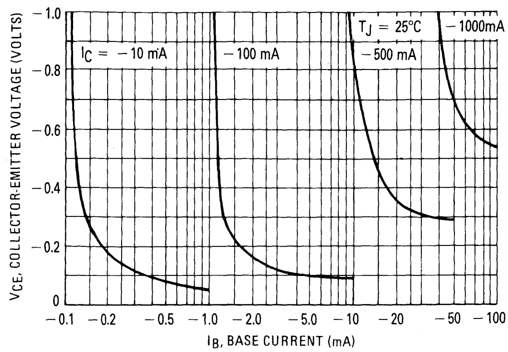


FIGURE 3 — "ON" VOLTAGES

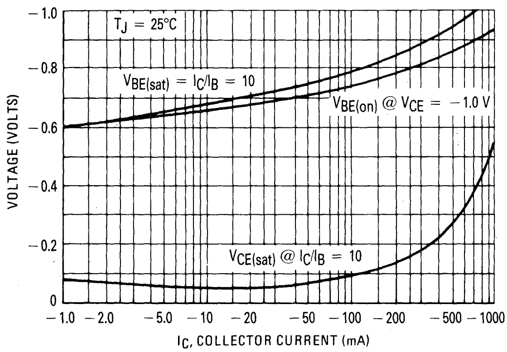


FIGURE 4 — TEMPERATURE COEFFICIENTS

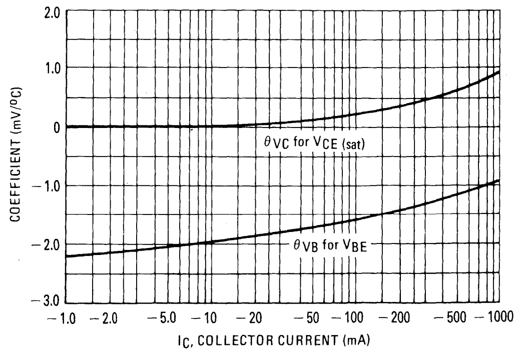
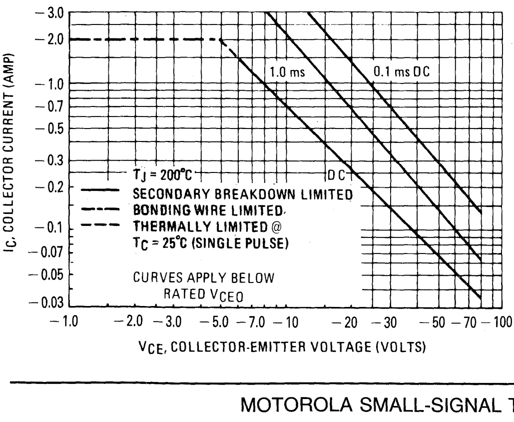


FIGURE 5 — SAFE OPERATING AREA



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°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. 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 6 — CAPACITANCES

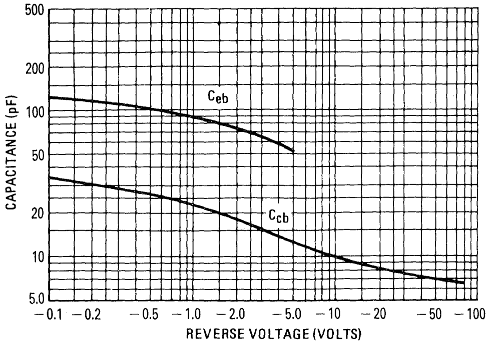


FIGURE 7 — CHARGE DATA

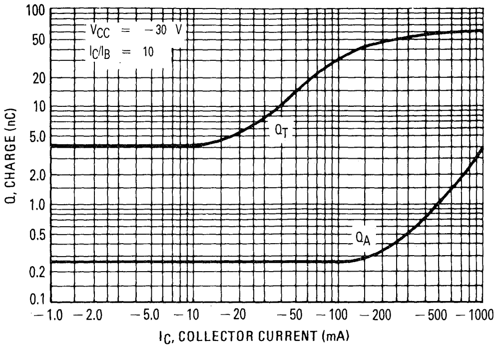


FIGURE 8 — TURN-ON TIME

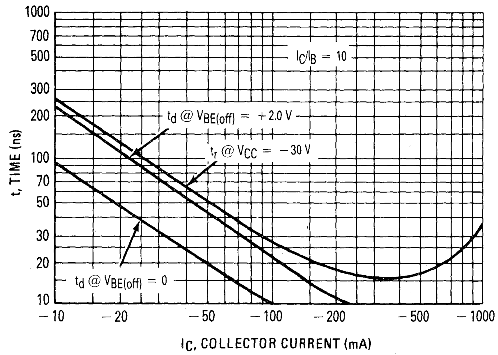
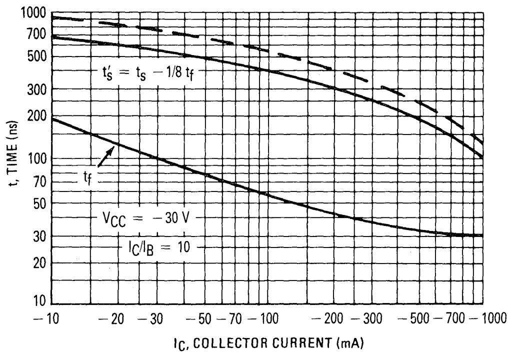


FIGURE 9 — TURN-OFF TIME



SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 10 — TURN-ON TIME

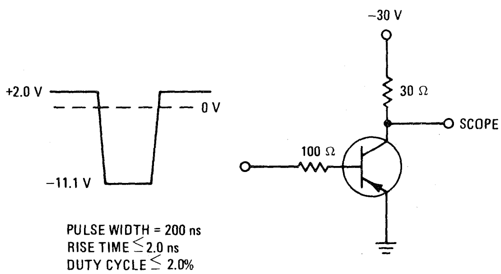
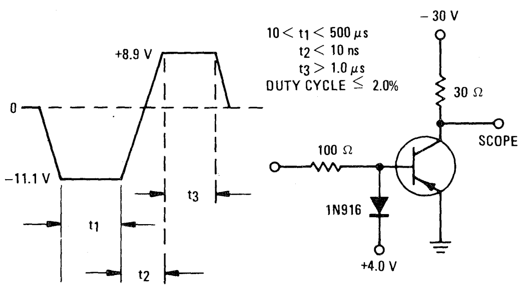
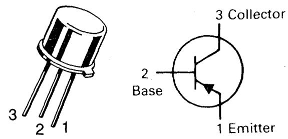


FIGURE 11 — TURN-OFF TIME



2N4931

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	2N4931	Unit
Collector-Emitter Voltage	V_{CEO}	−250	Vdc
Collector-Base Voltage	V_{CBO}	−250	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	1.0 5.71	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 Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	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 mAdc, I_B = 0)	$V_{(BR)CEO}$	−250	—	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = −100 μAdc)	$V_{(BR)CBO}$	−250	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −150 Vdc, I_E = 0)	I_{CBO}	—	−1.0	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	−1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc)(1) (I_C = −30 mAdc, V_{CE} = −10 Vdc)(1)	h_{FE}	 20 20 20	 200 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−5.0	Vdc
Base-Emitter On Voltage (I_C = −10 mAdc, V_{CE} = −10 Vdc)	$V_{BE(on)}$	—	−1.0	Vdc

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

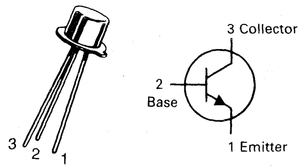
Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −20 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	20	200	MHz
Collector-Base Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	20	pF
Emitter-Base Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	400	pF

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

3

2N6431★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

3

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}	6.0	Vdc
Collector Current — Continuous	I_C	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.86	mW mW/°C
Total Device Dissipation @ T_A = 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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

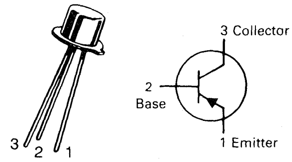
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	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} = 200 Vdc)	I_{CBO}	—	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)(1) (I_C = 30 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	 25 40 50	 — — 200	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)(1)	$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)(1)	$V_{BE(sat)}$	—	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 ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N6433★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	2N6433	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
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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

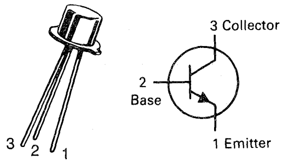
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−300	—	Vdc
Collector-Base Breakdown Voltage (I_C = −0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	−300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc)	I_{CBO}	—	−0.25	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 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)(1) (I_C = −30 mAdc, V_{CE} = −10 Vdc)(1)	h_{FE}	 25 40 30	 — — 150	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)(1)	$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)(1)	$V_{BE(sat)}$	—	−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}	—	6.0	pF

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

BC107, A, B thru BC109, C

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTORS
NPN SILICON

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 (1) $T_A = 25°C$ Derate above 25°C	P_D	0.6 3.43			Watt mW/°C
Total Device Dissipation (1) $T_C = 25°C$ $T_C = 100°C$ Derate above 25°C	P_D	1 5.7			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	$R_{\theta JC}$	175	°C/W

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Base Leakage Current		I_{CBO}				
($I_E = 0$, $V_{CB} = 45$ V)	BC107				15	nA
($I_E = 0$, $V_{CB} = 45$ V, $T_{Amb} = 125°C$)	BC107				4	μA
($I_E = 0$, $V_{CB} = 25$ V)	BC108/109				15	nA
($I_E = 0$, $V_{CB} = 25$ V, $T_{Amb} = 125°C$)	BC108/109				4	μA
Emitter Base Breakdown Voltage		$V_{(BR)EBO}$				V
($I_E = 10$ μA, $I_C = 0$)	BC107		6			
	BC108/109		5			
Collector Emitter Breakdown Voltage		$V_{(BR)CEO}$				V
($I_C = 2$ mA, $I_E = 0$)	BC107		45			
	BC108/109		25			
ON CHARACTERISTICS						
DC Current gain		h_{FE}				
($V_{CE} = 5$ V, $I_C = 2$ mA)	BC107		110		450	
	BC108		110		800	
	BC109		200		800	
	BC107A		110		220	
	BC107B, BC108B		200		450	
	BC109C		420		800	
($V_{CE} = 5$ V, $I_C = 10$ μA)	BC107B, BC108B		40			
	BC109C		100			
Base Emitter Saturation Voltage(1)		$V_{BE(sat)}$				V
($I_C = 10$ mA, $I_B = 0.5$ mA)				0.7	0.83	
($I_C = 100$ mA, $I_B = 5$ mA)				1.0	1.05	
Collector Emitter Saturation Voltage(1)		$V_{CE(sat)}$				V
($I_C = 10$ mA, $I_B = 0.5$ mA)					0.25	
($I_C = 100$ mA, $I_B = 5$ mA)					0.60	
Base Emitter on Voltage		$V_{BE(on)}$				V
($I_C = 2$ mA, $V_{CE} = 5$ V)			0.55		0.70	
($I_C = 10$ mA, $V_{CE} = 5$ V)(1)					0.77	
Collector Knee Voltage		$V_{CE(K)}$				V
($I_C = 10$ mA, $I_B =$ the value for which $I_C = 11$ mA at $V_{CE} = 1$ V)				0.4	0.6	
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)		NF				dB
F = 1.0 KHz	BC109				4	
F = 1 kHz, ΔF = 200 Hz	BC109				4	
	BC107/108				10	

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

Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)		C_{obo}	–	–	4.5	pF
h_{21e} Parameters		h_{21e}				–
(V_{CE} = 5.0 V, I_C = 2.0 mA, f = 1.0 kHz)	BC107/108		125	–	500	
	BC109		240	–	900	
	BC107A		125	–	260	
	BC107B, BC108B		240	–	500	
	BC109C		450	–	900	
h_{11e} Parameters		h_{11e}				KΩ
(V_{CE} = 5.0 V, I_C = 2.0 mA, f = 1.0 kHz)	BC107A		1.6	–	4.5	
	BC107B, BC108B		3.2	–	8.5	
	BC109C		6.0	–	15	
h_{22e} Parameters		h_{22e}				μhos
(V_{CE} = 5.0 V, I_C = 2.0 mA, f = 1.0 kHz)	BC107A		–	–	30	
	BC107B, BC108B		–	–	60	
	BC109C		–	–	110	

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

3

FIGURE 1 — EMITTER-BASE CAPACITANCE COLLECTOR-BASE CAPACITANCE

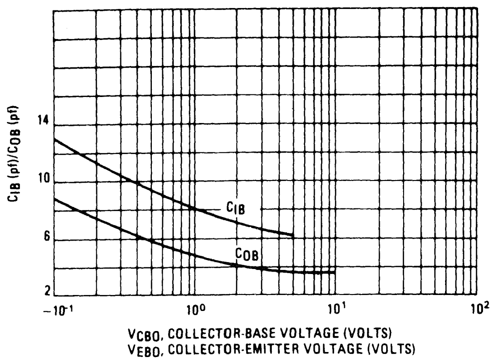


FIGURE 2 — CURRENT GAIN — BANDWIDTH PRODUCT

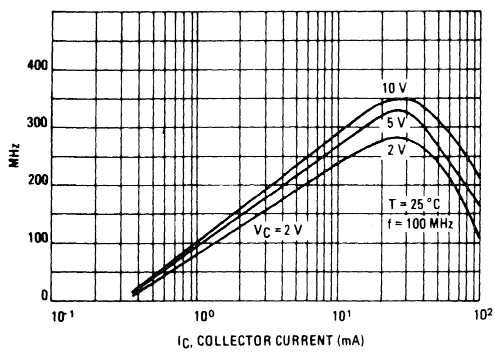
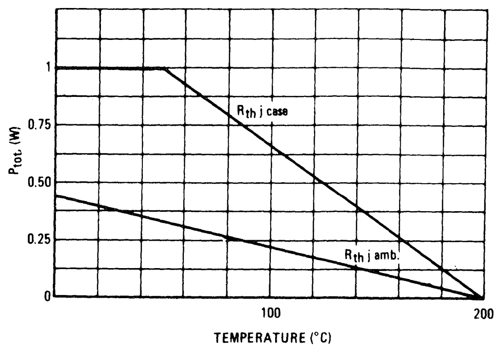
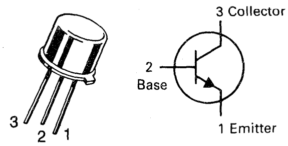


FIGURE 3 — TOTAL PERMISSIBLE POWER DISSIPATION



BC140-10, -16
BC141-10, -16

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to 2N3019 for graphs.

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 Ambient	$R_{\theta JA}$	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

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

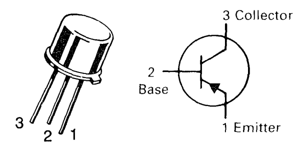
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current (I_E = 0, V_{CE} = 60 V)	 T_A = 150°C	I_{CES}		100 100	nA µA
Collector-Emitter Breakdown Voltage (I_{CES} = 100 µA, I_E = 0)	BC140 Series BC141 Series	$V_{(BR)CES}$	80 100		V
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mA, I_B = 0)	BC140 Series BC141 Series	$V_{(BR)CEO}$	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) for BC140, 141, -10 for BC140, 141, -16		h_{FE}	 63 100	 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 = 2.0%.

3

BC160-16
BC161-16

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTORS

PNP SILICON

Refer to 2N4405 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 160–16	BC 161–16	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CBO}	−40	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−1.0		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 Ambient	$R_{\theta JA}$	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

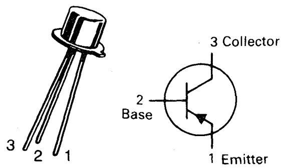
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current I_E = 0, V_{CES} = −40 V for BC160–16 V_{CES} = −60 V for BC161–16 V_{CES} = −40 V for BC160–16 T_{Amb} = 150°C V_{CES} = −60 V for BC161–16 T_{Amb} = 150°C	I_{CES}		 −100 −100 −100 −100	 nA μA
Collector-Emitter Breakdown Voltage I_C = −100 μA, I_E = 0 for BC160–16 for BC161–16	$V_{(BR)CES}$	 −40 −60		V
Collector-Emitter Breakdown Voltage(1) I_C = −10 mA, I_B = 0 for BC160–16 for BC161–16	$V_{(BR)CEO}$	 −40 −60		V
Emitter-Base Breakdown Voltage I_E = −100 μA, I_C = 0	$V_{(BR)EBO}$	−5.0		V
ON CHARACTERISTICS				
DC Current Gain(1) I_C = −100 mA, V_{CE} = −1.0 V for BC160, BC161, -16	h_{FE}	100	250	
Collector-Emitter Saturation Voltage(1) (I_C = −1.0 A, I_B = −0.1 A)	$V_{CE(sat)}$		−1.0	V
Base-Emitter Saturation Voltage(1) (I_C = −1.0 A, V_{CE} = −1.0 V)	$V_{BE(on)}$		−1.7	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} = −10 V, f = 1.0 MHz)	C_{ib}		180	pF
Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz)	C_{obo}		30	pF
Turn On Time (I_C = −100 mA, I_{B1} = −5.0 μA)	T_{on}		500	ns
Turn Off Time (I_C = −100 mA, I_{B1} = I_{B2} = −5.0 μA)	T_{off}		650	ns

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 2.0%.

BC177,A,B

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTORS

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−45	Vdc
Collector-Emitter Voltage	V_{CES}	−50	Vdc
Collector-Base Voltage	V_{CBO}	−50	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 3.43	Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.0 5.7	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	$R_{\theta JC}$	175	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
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			V
Collector Emitter Breakdown Voltage (I_C = −2.0 mA, I_E = 0)	$V_{(BR)CEO}$	−45			V
Emitter Base Breakdown Voltage (I_E = −10 μA, I_C = 0)	$V_{(BR)EBO}$	−5.0			V
ON CHARACTERISTICS					
DC Current Gain — BC177 (I_C = −2.0 mA, V_{CE} = −5.0 V) — A Group B Group	h_{FE}	120 120 180		460 220 460	
Collector Emitter Saturation Voltage(1) (I_C = −10 mA, I_B = −0.5 mA) (I_C = −100 mA, I_B = −5.0 mA)	$V_{CE(sat)}$			 −0.2 −0.6	V
Base Emitter Saturation Voltage(1) (I_C = −10 mA, I_B = −0.5 mA) (I_C = −100 mA, I_B = −5.0 mA)	$V_{BE(sat)}$		 −0.7 −0.9	 −0.8	V
Base Emitter on Voltage (I_C = −2.0 mA, V_{CE} = −5.0 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} = −1.0 V)	$V_{CE(K)}$		 −0.4	 −0.6	V
DYNAMIC CHARACTERISTICS					
Transition Frequency (V_{CE} = −5.0 V, I_C = −10 mA, f = 100 MHz)	f_T	200	300		MHz
Noise Figure (V_{CE} = −5.0 V, I_C = −0.2 mA, R_g = 2 KΩ) F = 1.0 kHz F = 1.0 kHz, F = 200 Hz	NF			 4.0 4.0 10	dB

3

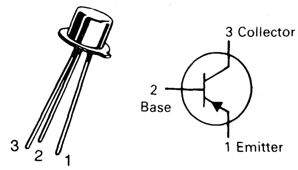
ELECTRICAL CHARACTERISTICS *(continued)* (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = −10 V, f = 1.0 MHz)		C_{obo}		3.5	4.0	pF
h_{21e} Parameters (V_{CE} = −5.0 V, I_C = −2.0 mA, f = 1.0 kHz)	BC177 A Group B Group	h_{21e}	125 125 240		500 260 500	
h_{11e} Parameters (V_{CE} = −5.0 V, I_C = −2.0 mA, f = 1.0 kHz)	 A Group B Group	h_{11e}	 1.6 3.2		 4.5 8.5	KΩ
h_{22e} Parameters (V_{GE} = −5.0 V, I_C = −2.0 mA, f = 1.0 kHz)	 A Group B Group	h_{22e}			 30 60	μmhos

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

BC393

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTOR

PNP

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−180	Vdc
Collector-Base Voltage	V_{CBO}	−180	Vdc
Emitter-Base Voltage	V_{EBO}	−6	Vdc
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 10.0	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	$R_{\theta JC}$	125	°C/W

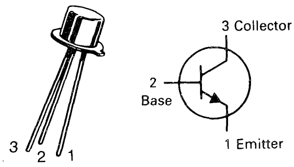
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mA, I_B = 0)	$V_{(BR)CEO}$	−180			Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−180			Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−6			Vdc
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(1)					
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 = −1.0 mAdc)	$V_{CE(sat)}$		−0.15	−0.3	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{BE(sat)}$		−0.7	−0.9	Vdc
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 = 1.0 MHz)	C_{obo}	—	3.5	7	pF
Input Capacitance (I_C = 0, V_{EB} = −0.5 Vdc, f = 1.0 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%.

BC394

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTOR

NPN

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	180	Vdc
Collector-Base Voltage	V_{CBO}	180	Vdc
Emitter-Base Voltage	V_{EBO}	6	Vdc
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 10.0	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	$R_{\theta JC}$	125	°C/W

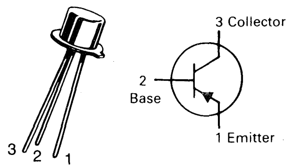
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	180			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	180			Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6			Vdc
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(1)					
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 = 1.0 mAdc)	$V_{CE(sat)}$		0.15	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$		0.7	0.9	Vdc
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 = 1.0 MHz)	C_{obo}	—	3.5	7	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1.0 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%.

BCY70 thru BCY72

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BCY 70	BCY 71	BCY 72	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−45	−25	Vdc
Collector-Base Voltage	V_{CBO}	−50	−45	−25	Vdc
Emitter-Base Voltage	V_{EBO}		−5.0		Vdc
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 3.43		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	$R_{\theta JC}$	292	°C/W

Refer to 2N3799 for graphs.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$				Vdc
($I_C = -2.0$ mA, $I_B = 0$)	BCY70		−40			
	BCY71		−45			
	BCY72		−25			
Collector-Base Leakage Current		I_{CBO}				
($I_E = 0$, $V_{CB} = -50V$)	BCY70				−0.5	μA
($I_E = 0$, $V_{CB} = -45V$)	BCY71				−0.5	
($I_E = 0$, $V_{CB} = -25V$)	BCY72				−0.5	
($I_E = 0$, $V_{CB} = -40V$, $T_{Amb} = 100°C$)	BCY70				−2.0	
($I_E = 0$, $V_{CB} = -40V$, $T_{Amb} = 100°C$)	BCY71				−2.0	
($I_E = 0$, $V_{CB} = -20V$, $T_{Amb} = 100°C$)	BCY72				−2.0	
($I_E = 0$, $V_{CB} = -40V$)	BCY70				−10	nA
($I_E = 0$, $V_{CB} = -40V$)	BCY71				−50	
($I_E = 0$, $V_{CB} = -20V$)	BCY72				−50	
Emitter-Base Leakage Current		I_{EBO}				
($V_{EB} = -5.0$ V, $I_C = 0$)					−0.5	μA
($V_{EB} = -4.0$ V, $I_C = 0$)					−10	nA
($V_{EB} = -4.0$ V, $I_C = 0$, $T_{Amb} = 100°C$)					−2.0	μA
Collector-Emitter Leakage Current		I_{CEX}				nA
($V_{CE} = -50$ V, $V_{EB} = -3.0$ V)	BCY70				−20	

3

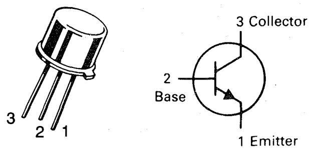
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(V_{CE} = −1.0 V, I_C = −10 μA)	BCY71		40			
(V_{CE} = −1.0 V, I_C = −100 μA)	BCY70		40			
	BCY71		80			
(V_{CE} = −1.0 V, I_C = −1.0 mA)	BCY70		45			
	BCY71		90			
	BCY72		40			
(V_{CE} = −1.0 V, I_C = −10 mA)(1)	BCY70		50			
	BCY71		100		600	
	BCY72		50			
(V_{CE} = −1.0 V, I_C = −50 mA)(1)	BCY70		15			
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				V
(I_C = −50 mA, I_B = −5.0 mA)	BCY70/71				−1.2	
(I_C = −10 mA, I_B = −1.0 mA)	BCY70/71		−0.6		−0.9	
Collector-Emitter, Saturation Voltage(1)		$V_{CE(sat)}$				V
(I_C = −50 mA, I_B = −5.0 mA)					−0.50	
(I_C = −10 mA, I_B = −1.0 mA)					−0.25	
DYNAMIC CHARACTERISTICS						
Transition Frequency		f_T				MHz
(I_C = −10 mA, f = 100 MHz, V_{CE} = −20 V)	All types		250			
(I_C = −100 μA, f = 20 MHz, V_{CE} = −20 V)	BCY71 only		15			
Noise Figure		NF				dB
(V_{CE} = −5.0 V, I_C = −100 μA, Rg = 2.0 KΩ, f = 1.0 kHz						
	BCY70/72				6.0	
	BCY71				2.0	
Switching Times						ns
(I_C = −10 mA, I_{B1} = I_{B2} = −1.0 mA)	BCY70/72	t_{on}			65	
	BCY70/72	t_{off}			420	
	BCY70/72	t_d			35	
	BCY70/72	t_r			35	
	BCY70/72	t_s			350	
	BCY70/72	t_f			80	
h parameters		h_{12e}	—		20 X 10^{-4}	—
(V_{CE} = −10 V, I_C = −1.0 mA, f = 1.0 kHz)	BCY71	h_{21e}	100		400	—
		h_{22e}	10		60	μs
		h_{11e}	2.0		12	KΩ
Common Base Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz)		C_{ob}			6.0	pF
Input Capacitance (V_{EB} = −1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}			8.0	pF

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

BF258

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	250	Vdc
Collector-Emitter Voltage	V_{CER}	250	Vdc
Collector-Base Voltage	V_{CBO}	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	0.1	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	$R_{\theta JC}$	35	°C/W

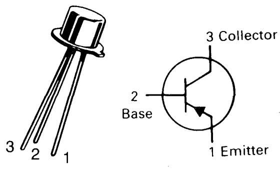
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, I_B = 0)	$V_{(BR)CEO}$	250	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	250	—	—	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)	I_{CBO}	—	1.0	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	80	—	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 6.0 mAdc)	$V_{CE(sat)}$	—	0.1	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain-Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	—	110	—	MHz
Reverse Transfer Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}	—	3.5	—	pF
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	5.5	—	pF

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

BFW43

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−150	Vdc
Collector-Base Voltage	V_{CBO}	−150	Vdc
Emitter-Base Voltage	V_{EBO}	−6.0	Vdc
Collector Current — Continuous	I_C	−0.1	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 2.28	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.4 8.0	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 Ambient	$R_{\theta JA}$	438	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°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 = −2.0 mA, I_B = 0)	$V_{(BR)CEO}$	−150			Vdc
Collector Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−150			Vdc
Emitter Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−6.0			Vdc
Collector Cutoff Current (V_{CB} = −100 V, I_E = 0)	I_{CBO}			−10	nA
Collector Emitter Cutoff Current (V_{CB} = −100 V, I_B = 0) T_A = 125°C	I_{CEO}			−10	μA
ON CHARACTERISTICS					
DC Current Gain (I_C = −1.0 mA, V_{CE} = −10 V) (I_C = −10 mA, V_{CE} = −10 V)(1) (I_C = −10 μA, V_{CE} = −10 V, T_A = −55°C)	h_{FE}	 40 40 	 30		
Collector Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1 mAdc)	$V_{CE(sat)}$		−0.15	−0.5	Vdc
Base Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1 mAdc)	$V_{BE(sat)}$		−0.7	−0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 20 MHz)	f_T	60	110	200	MHz
Output Capacitance (I_E = 0, V_{CB} = −20 Vdc, f = 1.0 MHz)	C_{obo}	—	3.5	7.0	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

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 1 – CURRENT-GAIN–BANDWIDTH PRODUCT

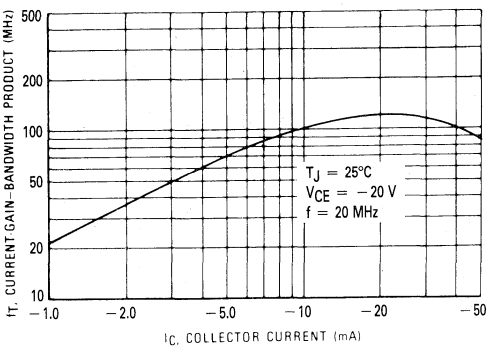


FIGURE 2 – TURN-ON TIME

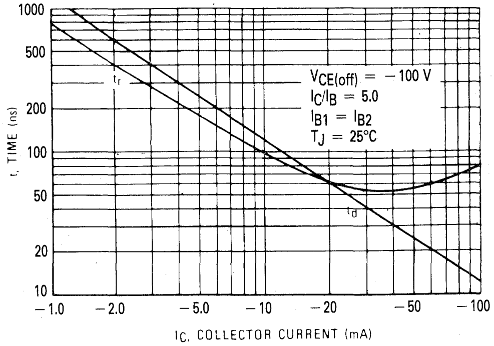


FIGURE 3 – TURN-OFF TIME

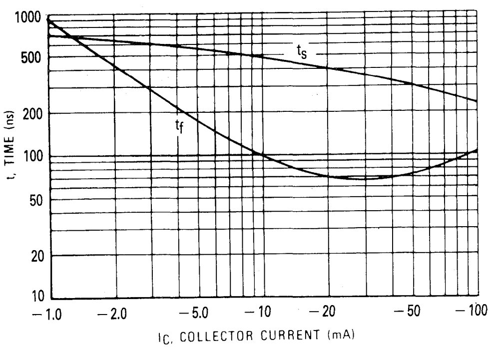
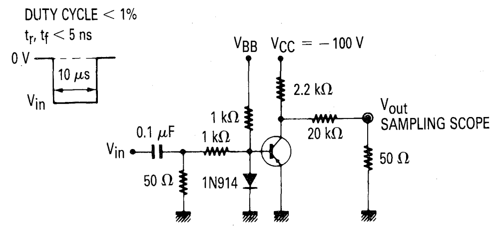


FIGURE 4 – SWITCHING TIME TEST CIRCUIT

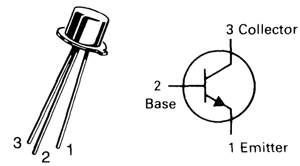


	V_{in}	V_{BB}
t_{on}	−10.6 V	
t_{off}	−20 V	+9.2 V

3

BSS71 thru BSS73

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTORS
NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BSS 71	BSS 72	BSS 73	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	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	$R_{\theta JC}$	70	°C/W

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$				Vdc
(I_C = 10 mA, I_B = 0)	BSS71		200	—	—	
	BSS72		250	—	—	
	BSS73		300	—	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$				Vdc
(I_C = 100 μAdc, I_E = 0)	BSS71		200	—	—	
	BSS72		250	—	—	
	BSS73		300	—	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$				Vdc
(I_E = 100 μAdc, I_C = 0)	BSS71		6	—	—	
	BSS72		6	—	—	
	BSS73		6	—	—	
Collector Cutoff Current		I_{CBO}				nA
(V_{CB} = 150 V, I_E = 0)	BSS71		—	—	50	
(V_{CB} = 200 V, I_E = 0)	BSS72		—	—	50	
(V_{CB} = 250 V, I_E = 0)	BSS73		—	—	50	
Collector-Emitter Cutoff Current		I_{CEO}				nA
(V_{CE} = 150 V, I_B = 0)	BSS71		—	—	500	
(V_{CE} = 200 V, I_B = 0)	BSS72		—	—	500	
(V_{CE} = 300 V, I_B = 0)	BSS73		—	—	500	
Emitter-Cutoff Current		I_{EBO}				nA
(V_{EB} = 5.0 Vdc, I_C = 0)	ALL		—	—	50	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = 0.1 mA, V_{CE} = 1 V)	BSS71		20	40	—	—
(I_C = 1 mA, V_{CE} = 10 V)	ALL		30	45	—	
(I_C = 10 mA, V_{CE} = 10 V)(1)	ALL		50	120	—	
(I_C = 30 mA, V_{CE} = 10 V)(1)	ALL		40	140	250	
(I_C = 100 mA, V_{CE} = 10 V)(1)	BSS73		—	35	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	ALL		—	0.15	0.3	
(I_C = 30 mAdc, I_B = 3 mAdc)	ALL		—	0.25	0.4	
(I_C = 50 mAdc, I_B = 5 mAdc)	ALL		—	0.35	0.5	
(I_C = 100 mAdc, I_B = 20 mAdc)	BSS73		—	0.25	—	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	ALL		—	0.7	0.8	
(I_C = 30 mAdc, I_B = 3 mAdc)	ALL		—	0.8	0.9	
(I_C = 50 mAdc, I_B = 5 mAdc)	ALL		—	0.85	1.0	
(I_C = 100 mAdc, I_B = 10 mAdc)	BSS73		—	0.9	—	

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_t	50	70	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1 MHz)	C_{ob}	—	3.5	—	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1 MHz)	C_{ib}	—	45	—	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

FIGURE 1 — DC CURRENT GAIN

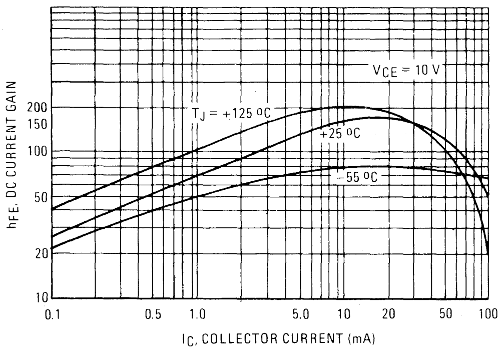


FIGURE 2 — CAPACITANCES

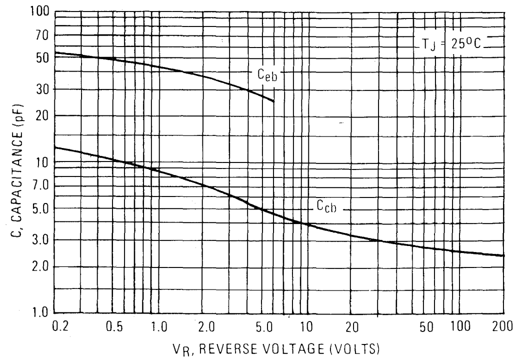


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT

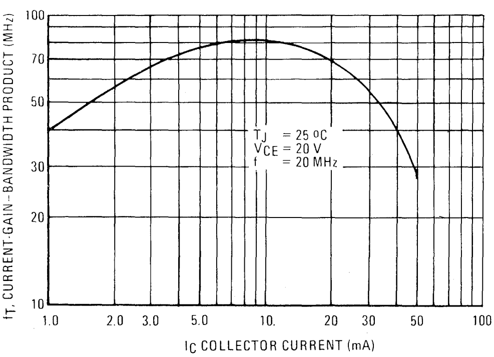


FIGURE 4 — ACTIVE-REGION SAFE OPERATING AREA

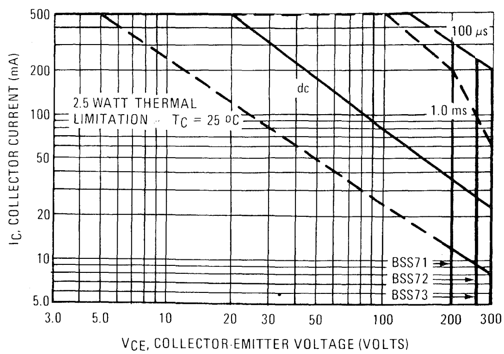


FIGURE 5 — "ON" VOLTAGES

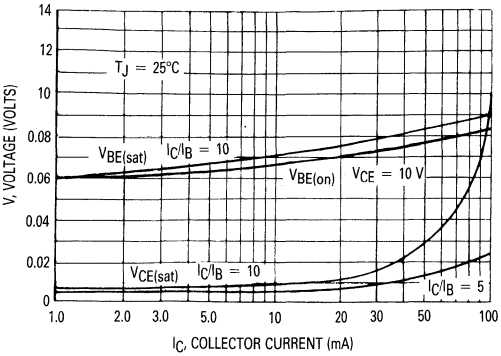
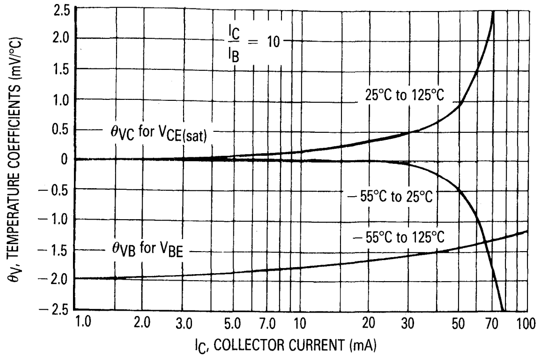


FIGURE 6 — TEMPERATURE COEFFICIENTS



3

FIGURE 7 — TURN-ON TIME

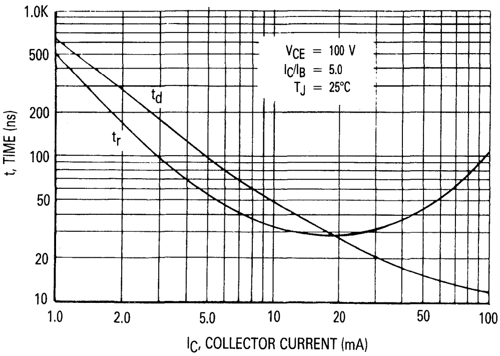


FIGURE 8 — TURN-OFF TIME

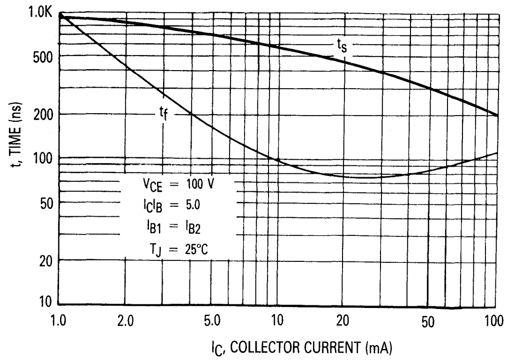
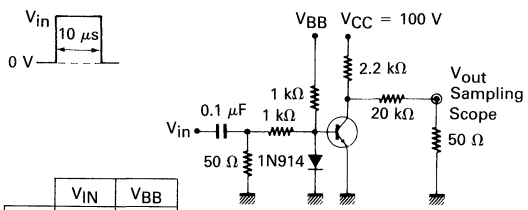


FIGURE 9 — SWITCHING TIME TEST CIRCUIT

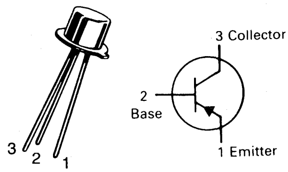
Duty Cycle < 1%
t_r, t_f < 5 ns



	V_{IN}	V_{BB}
t_{on}	10.6 V	
t_{off}	20 V	−9.2 V

BSS74 thru BSS76

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BSS 74	BSS 75	BSS 76	Unit
Collector-Emitter Voltage	V_{CEO}	−200	−250	−300	Vdc
Collector-Base Voltage	V_{CBO}	−200	−250	−300	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0			Vdc
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	$R_{\theta JC}$	70	°C/W

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$				Vdc
(I_C = −10 mA, I_B = 0)	BSS74		−200	—	—	
	BSS75		−250	—	—	
	BSS76		−300	—	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$				Vdc
(I_C = −100 μAdc, I_E = 0)	BSS74		−200	—	—	
	BSS75		−250	—	—	
	BSS76		−300	—	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$				Vdc
(I_E = −100 μAdc, I_C = 0)	BSS74		−6	—	—	
	BSS75		−6	—	—	
	BSS76		−6	—	—	
Collector Cutoff Current		I_{CBO}				nA
(V_{CB} = −150 V, I_E = 0)	BSS74		—	—	−50	
(V_{CB} = −200 V, I_E = 0)	BSS75		—	—	−50	
(V_{CB} = −250 V, I_E = 0)	BSS76		—	—	−50	
Collector-Emitter Cutoff Current		I_{CEO}				nA
(V_{CE} = −150 V, I_B = 0)	BSS74		—	—	−500	
(V_{CE} = −200 V, I_B = 0)	BSS75		—	—	−500	
(V_{CE} = −300 V, I_B = 0)	BSS76		—	—	−500	
Emitter-Cutoff Current		I_{EBO}				nA
(V_{EB} = −5.0 Vdc, I_C = 0)	ALL		—	—	−50	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = −0.1 mA, V_{CE} = −1.0 V)	BSS74		20	40	—	—
(I_C = −1.0 mA, V_{CE} = −10 V)	ALL		30	45	—	
(I_C = −10 mA, V_{CE} = −10 V)(1)	ALL		35	50	—	
(I_C = −30 mA, V_{CE} = −10 V)(1)	ALL		35	55	150	
(I_C = −100 mA, V_{CE} = −10 V)(1)	BSS76		—	40	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = −10 mAdc, I_B = −1.0 mAdc)	ALL		—	−0.15	−0.3	
(I_C = −30 mAdc, I_B = −3.0 mAdc)	ALL		—	−0.25	−0.4	
(I_C = −50 mAdc, I_B = −5.0 mAdc)	ALL		—	−0.35	−0.5	
(I_C = −100 mAdc, I_B = −20 mAdc)	BSS76		—	−0.40	—	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = −10 mAdc, I_B = −1.0 mAdc)	ALL		—	−0.7	−0.8	
(I_C = −30 mAdc, I_B = −3.0 mAdc)	ALL		—	−0.8	−0.9	
(I_C = −50 mAdc, I_B = −5.0 mAdc)	ALL		—	−0.85	−1.0	
(I_C = −100 mAdc, I_B = −10 mAdc)	BSS76		—	−0.9	—	

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

3

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

Characteristic	Symbol	Min	Typ	Max	Unit
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 = 1.0 MHz)	C_{ob}	—	3.5	—	pF
Input Capacitance (I_C = 0, V_{EB} = −0.5 Vdc, f = 1.0 MHz)	C_{ib}	—	45	—	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

FIGURE 1 — DC CURRENT GAIN

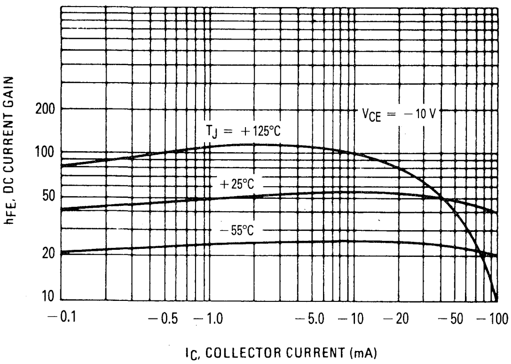


FIGURE 2 — CAPACITANCES

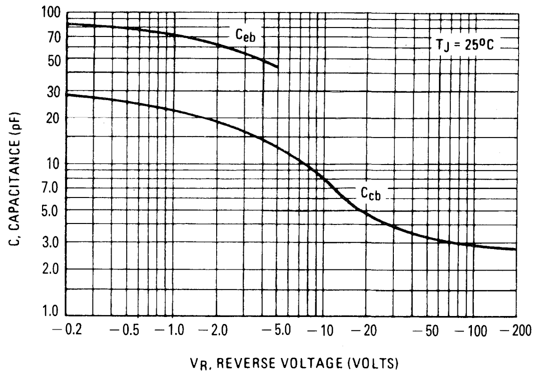


FIGURE 3 — "ON" VOLTAGES

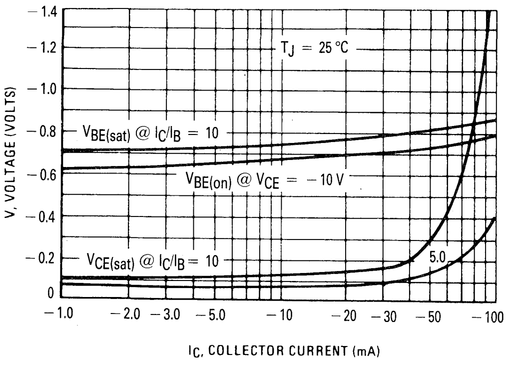
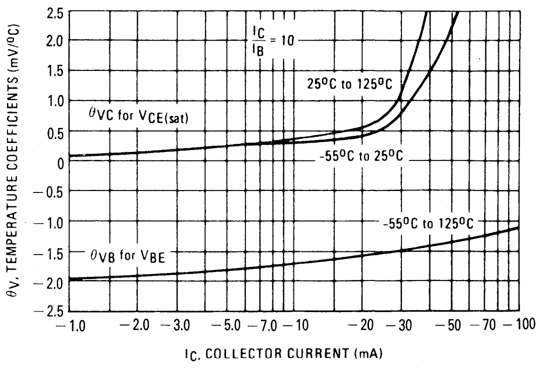


FIGURE 4 — TEMPERATURE COEFFICIENTS



3

FIGURE 5 — CURRENT-GAIN—BANDWIDTH PRODUCT

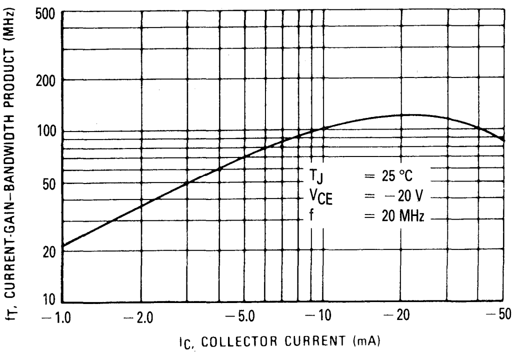


FIGURE 6 — TURN-ON TIME

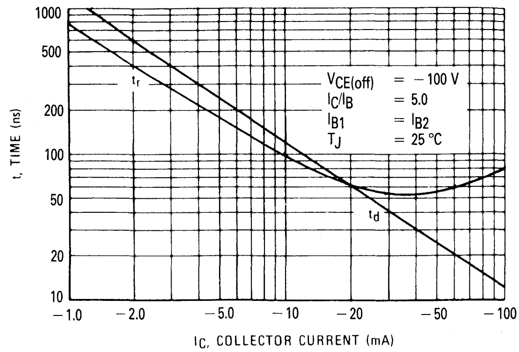


FIGURE 7 — TURN-OFF TIME

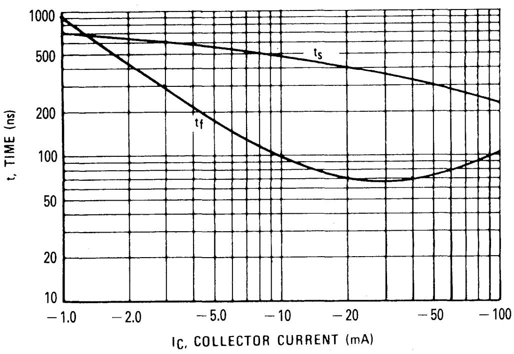


FIGURE 8 — SWITCHING TIME TEST CIRCUIT

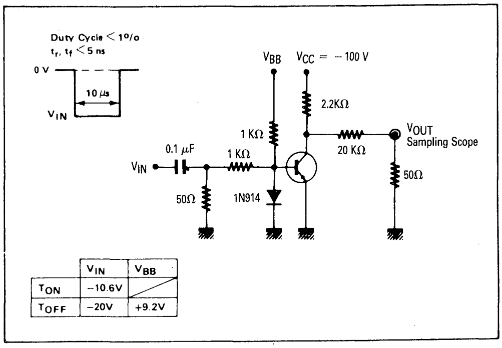
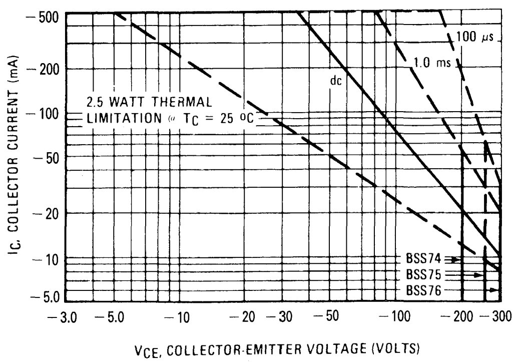


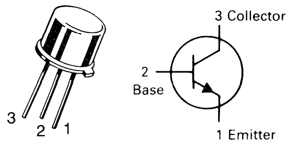
FIGURE 9 — ACTIVE-REGION SAFE OPERATING AREA



3

BSS78

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	250	Vdc
Collector-Base Voltage	V_{CBO}	250	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	1.0	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	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

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 mA, I_B = 0)	$V_{(BR)CEO}$	250	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	250	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 200 V, I_E = 0)	I_{CBO}	—	—	50	nA
Collector-Emitter Cutoff Current (V_{CE} = 200 V, I_B = 0)	I_{CEO}	—	—	500	nA
Emitter-Base Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mA, V_{CE} = 1.0 V) (I_C = 1.0 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V)(1) (I_C = 30 mA, V_{CE} = 10 V)(1) (I_C = 100 mA, V_{CE} = 10 V)(1)	h_{FE}	 20 30 50 40 —	 40 45 120 140 35	 — — — 250 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	 — — — —	 0.15 0.25 0.35 0.25	 0.3 0.4 0.5 —	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 — — — —	 0.7 0.8 0.85 0.9	 0.8 0.9 1.0 —	Vdc

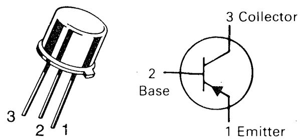
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	70	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1 MHz)	C_{ob}	—	3.5	—	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1 MHz)	C_{ib}	—	45	—	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

BSV16-10

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4405 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−60	Vdc
Collector-Emitter Voltage	V_{CES}	−60	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°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	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

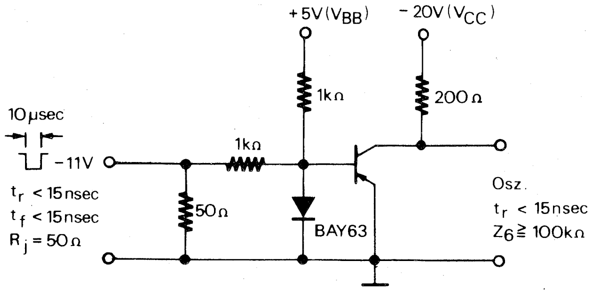
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current (V_{CE} = −60 V) (V_{CE} = −60 V, T_A = 150°C) (V_{CE} = −60 V, V_{BE} = −0.2 V, T_A = 100°C)	I_{CES}	 — — —	 −50 −50 −50	 nA μA
Emitter Cutoff Current (V_{EB} = −4.0 V)	I_{EBO}	—	−50	nA
Collector-Emitter Breakdown Voltage (I_C = −50 mA)(1)	$V_{(BR)CEO}$	−60	—	V
Collector-Emitter Breakdown Voltage (I_C = −10 μA)	$V_{(BR)CES}$	−60	—	V
Emitter-Base Breakdown Voltage (I_E = −10 μA)	$V_{(BR)EBO}$	−5.0	—	V
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = −1.0 V, I_C = −0.1 mA) (V_{CE} = −1.0 V, I_C = −100 mA)(1) (V_{CE} = −1.0 V, I_C = −500 mA)(1)	h_{FE}	 20 63 25	 — 160 —	—
Base-Emitter Voltage (V_{CE} = −1.0 V, I_C = −100 mA)(1) (V_{CE} = −1.0 V, I_C = −500 mA)(1)	$V_{BE(on)}$	 — −0.7	 −1.0 −1.4	V
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, I_E = 0, f = 1.0 MHz)	C_{ob}	—	25	pF
Small-Signal Current Gain (I_C = −1.0 mA, V_{CE} = −5.0V, f = 1.0 MHz)	h_{fe}	20	—	—
Turn On Time (Fig. 1) (I_C = −100 mA, I_{B1} = I_{B2} = −5.0 mA) Storage Time (Fig. 1) (I_C = −100 mA, I_{B1} = I_{B2} = −5.0 mA)	t_{on} t_s	— —	500 500	ns
Fall Time (Fig. 1) (I_C = −100 mA, I_{B1} = I_{B2} = −5.0 mA)	t_f	—	150	ns

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 2%.

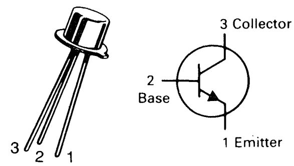
FIGURE 1 — SWITCHING TIME CIRCUIT



3

BSX20

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTOR

NPN SILICON

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	500	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	$R_{\theta JC}$	146	°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 mAdc, I_B = 0) (I_C = 10 mAdc, R_{BE} = 10 Ω)	 $V_{(BR)CEO}$ $V_{(BR)CER}$	 15 20		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_j = 150°C)	I_{CBO}		 400 30	 nAdc μAdc
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 1.0	μAdc
Cutoff Current (V_{CE} = 15 Vdc, V_{EB} = 3.0 V, T_j = 55°C)	I_{CEX} I_{BEX}		0.6 0.6	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_j = −55°C) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 20 10	 120	
Base-Emitter On Voltage (I_C = 30 μAdc, V_{CE} = 20 Vdc, T_j = 100°C)	$V_{BE(on)}$		0.35	Vdc
Emitter-Collector Saturation Voltage(1) (I_C = 10 mAdc, I_B = 0.3 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$		 0.30 0.25 0.60	Vdc
Emitter-Base 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	 0.85 1.50	Vdc

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

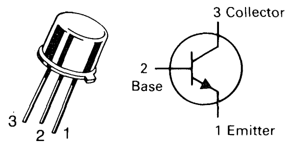
Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current Gain-Bandwidth Product (I_C = 10 mA, V_{CE} = 10 V, f = 100 MHz)	f_T	500		MHz
Output Capacitance (V_{CB} = 5.0 V, I_E = 0, f = 1.0 MHz)	C_{obo}		4.0	pF
Input Capacitance (V_{EB} = 1.0 V, I_C = 0, f = 1.0 MHz)	C_{ibo}		4.5	pF
Time (I_C = 10 mA, I_{B1} = I_{B2} = 10 mA)	t_s		1.3	ns
Turn-On Time	t_{on}			ns
(I_C = 10 mA, I_{B1} = 3.0 mA)			12	
(I_C = 100 mA, I_{B1} = 40 mA)			7.0	
Turn-Off Time	t_{off}			ns
(I_C = 10 mA, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA)			18	
(I_C = 100 mA, I_{B1} = 40 mA, I_{B2} = −20 mA)			21	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

3

CV12253

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Base Voltage	V_{CBO}	65	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	P_D	0.6 3.43	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	$R_{\theta JA}$	292	°C/W

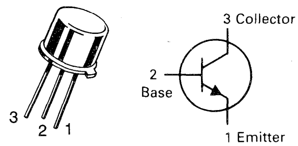
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 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)(1) ($h_{21e}(3)$ I_C = 150 mA, V_{CE} = 0.75 V)(1) ($h_{21e}(4)$ I_C = 50 mA, V_{CE} = 0.4 V)(1)	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 = 20 MHz)	f_T	60		MHz
Storage Time (V_{CC} = 45 V, I_C = 100 mA, I_{B1} = I_{B2} = 10 mA)	t_s	172	550	ns
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)	C_{ob}		20	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 2%.

MM3001

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS
NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	150	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	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 Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

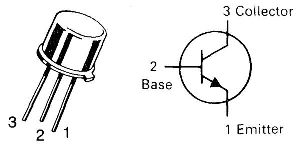
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	150	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 75$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$)	I_{CBO}	—	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	150	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	7.0	pF

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

MM3725★

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

3

MAXIMUM RATINGS

Rating	Symbol	MM3725	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	500	mAdc
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 Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

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	—	—	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	80	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0 T_A = 100°C) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — — — —	 0.12 — — —	 1.7 — 120 —	μAdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{EB} = 0) (V_{CE} = 50 Vdc, V_{EB} = 0)	I_{CES}	 — —	 0.15 —	 10 —	μAdc
Base Current (V_{CE} = 50 V, V_{EB} = 0) (V_{CE} = 80 V, V_{EB} = 0)	I_B	—	—	10	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 = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 300 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 800 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 800 mA, V_{CE} = 2.0 V) (I_C = 1.0 Adc, V_{CE} = 5.0 V)	h_{FE}	 30 60 30 40 35 20 25 30 20 25	 — — — — — — — — — —	— 150 — — — — — — — —	—

3

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

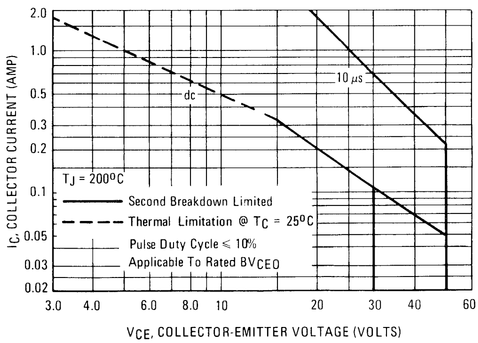
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.17	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.19	0.26	
(I_C = 300 mAdc, I_B = 30 mAdc)		—	0.25	0.40	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.30	0.52	
(I_C = 800 mAdc, I_B = 80 mAdc)		—	0.43	0.80	
(I_C = 1.0 mAdc, I_B = 100 mAdc)		—	0.55	0.95	
Base-Emitter Saturation Voltage(1)	$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	—	0.76	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	—	0.86	
(I_C = 300 mAdc, I_B = 30 mAdc)		—	—	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)		0.8	—	1.1	
(I_C = 800 mAdc, I_B = 80 mAdc)		—	—	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)		—	—	1.7	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, 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}	—	—	10	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	55	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 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 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10)	t_s	—	35	50	ns
Fall Time		t_f	—	20	25	ns
Turn-Off Time		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

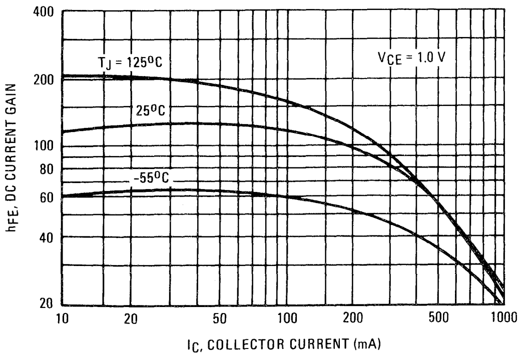


FIGURE 3 – "ON" VOLTAGES

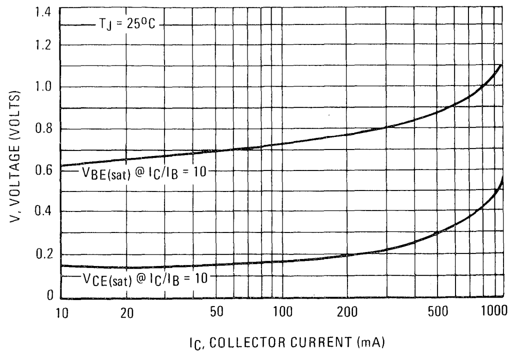


FIGURE 4 – COLLECTOR SATURATION REGION

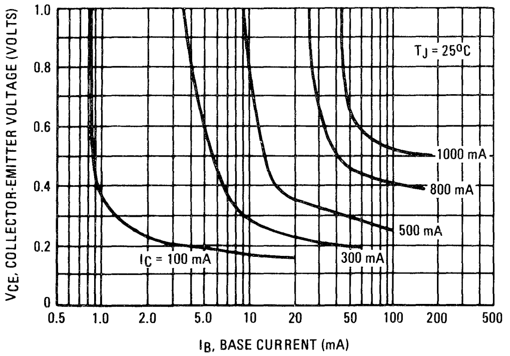
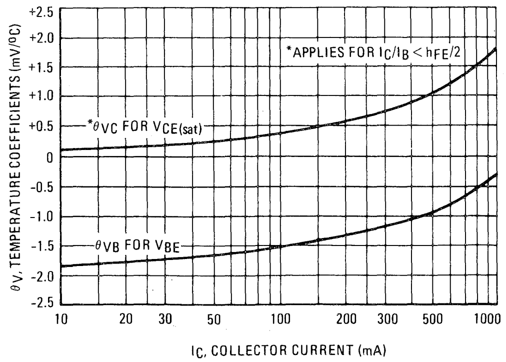


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

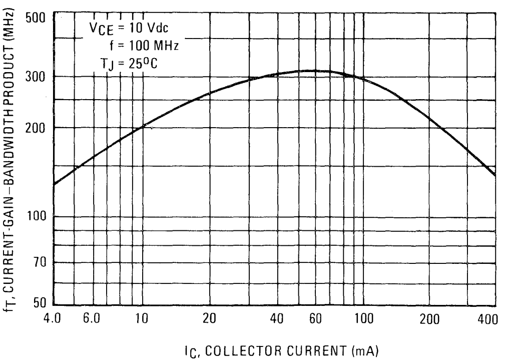


FIGURE 7 – CAPACITANCE

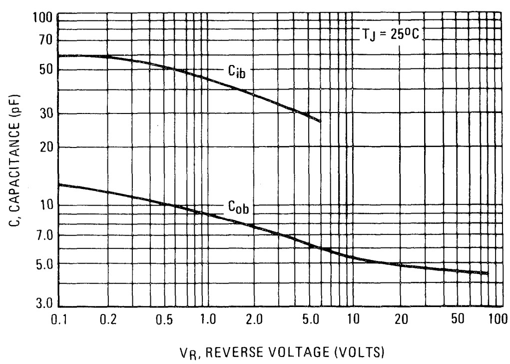


FIGURE 8 — TURN-ON TIME

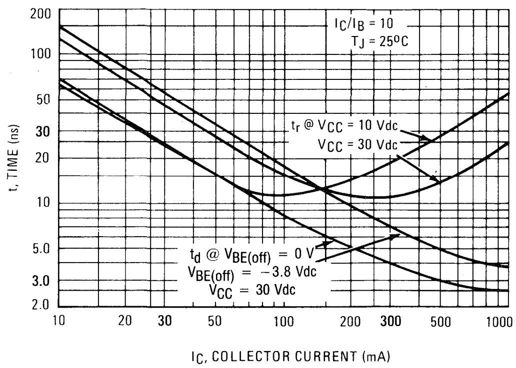
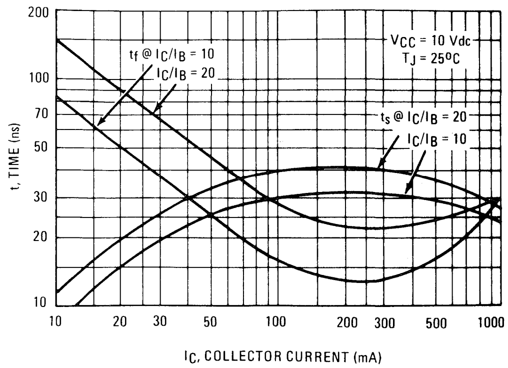


FIGURE 9 — TURN-OFF TIME



3

FIGURE 10 — SWITCHING TIME TEST CIRCUIT

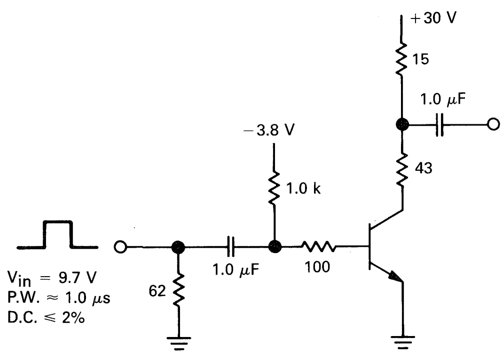
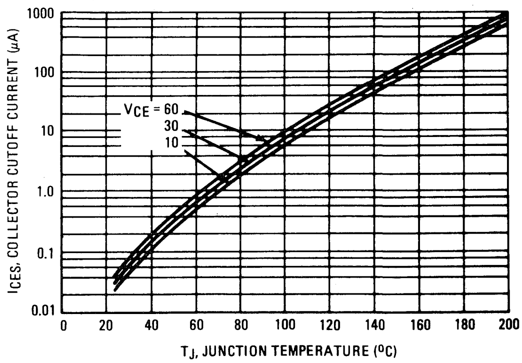
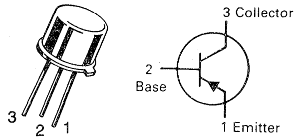


FIGURE 11 — COLLECTOR CUTOFF CURRENT



MM4001

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−150	Vdc
Collector-Base Voltage	V_{CBO}	−150	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−500	mAdc
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 Ambient	$R_{\theta JA}$	292	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	°C/W

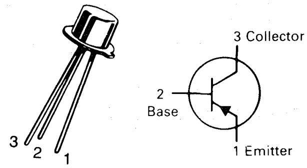
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−150	—	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = −100 μAdc)	$V_{(BR)CBO}$	−150	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −75 Vdc, I_E = 0)	I_{CBO}	—	−1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = −10 mAdc, V_{CE} = −10 Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−0.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	10	pF

(1) Pluse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM4209★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

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	−50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.72	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.7 4.0	Watts mW/°C
Operating and Storage Jucntion Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

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

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage(1) (I_C = −3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−15	—	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_{CE} = −8.0 Vdc, V_{BE} = 0) (V_{CE} = −8.0 Vdc, V_{BE} = 0, T_A = 125°C)	I_{CES}	— —	−10 −5.0	nAdc μAdc
Base Current (V_{CE} = −8.0 Vdc, V_{BE} = 0)	I_B	—	−1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −0.5 Vdc) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc)(1) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc, T_A = −55°C)(1) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc)(1)	h_{FE}	 30 35 15 25	 — 120 — —	—
Collector-Emitter Saturation Voltage (I_C = −1.0 mAdc, I_B = −0.1 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −50 mAdc, I_B = −5.0 mAdc)(1)	$V_{CE(sat)}$	 — — —	 −0.15 −0.18 −0.6	Vdc
Base-Emitter Saturation Voltage (I_C = −1.0 mAdc, I_B = − 0.1 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −50 mAdc, I_B = −5.0 mAdc)(1)	$V_{BE(sat)}$	 — −0.75 —	 −0.8 −0.95 −1.5	Vdc

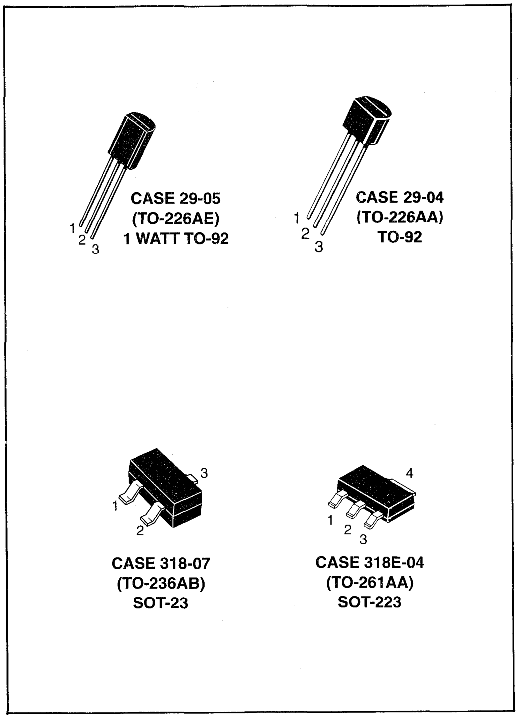
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)		f_T	850	—	MHz
Output Capacitance (V_{CB} = −5.0 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}	—	3.5	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −1.5 Vdc, V_{BE} = 0, I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	15	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	(V_{CC} = −1.5 Vdc, V_{BE} = 0, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	20	ns
Storage Time		t_s	—	20	ns
Fall Time		t_f	—	10	ns
Storage Time (I_C ≈ −10 mAdc, I_{B1} ≈ −10 mAdc, I_{B2} ≈ −10 mAdc)		t_s	—	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%
(2) f_T is defined as the freqency at which $|h_{fe}|$ extrapolates to unity.

Field-Effect Transistors

4



The data sheets on the following pages are designed to emphasize those FETs that by virtue of widespread industry use, ease of manufacture, and low relative cost, merit first consideration for new equipment design.

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 any 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. Additionally, it is very important to keep FET devices in their antistatic shipping containers and away from static-generating materials.

NOTE: All SOT-23 package devices have had a "T1" suffix added to the device title.

EMBOSSED TAPE AND REEL

SOT-23 and SOT-223 packages are available only in Tape and Reel. Use the appropriate suffix indicated below to order any of the SOT-23 and SOT-223 packages. (See Section 7 on Packaging for additional information).

SOT-23: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SOT-223: available in 12 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/1000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/4000 unit reel.

RADIAL TAPE IN FAN FOLD BOX OR REEL

TO-92 packages are available in both bulk shipments and in Radial Tape in Fan Fold Boxes or Reels. Fan Fold Boxes and Radial Tape Reel are the best methods for capturing devices for automatic insertion in printed circuit boards.

TO-92: available in Fan Fold Box
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Fan Fold box.

available in 365 mm Radial Tape Reel
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Radial Tape Reel.

*Refer to Section 7 on Packaging for Style code characters and additional information on ordering requirements.

DEVICE MARKINGS/DATE CODE CHARACTERS

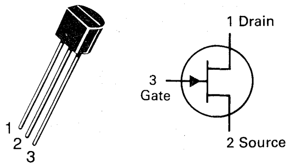
The SOT-23 package has a device marking and a date code etched on the device. The generic example below depicts both the device marking and a representation of the date code that appears on the SOT-23 package.

ABCD

The "D" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

2N5457★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFETs
GENERAL PURPOSE

N-CHANNEL — DEPLETION

★This is a Motorola designated preferred device.

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 @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	125	°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-Source Breakdown Voltage ($I_G = -10\ \mu Adc, V_{DS} = 0$)	$V_{(BR)GSS}$	−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}	 — —	 — —	 −1.0 −200	nAdc
Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	$V_{GS(off)}$	−0.5	—	−6.0	Vdc
Gate Source Voltage ($V_{DS} = 15$ Vdc, $I_D = 100\ \mu Adc$)	V_{GS}	—	−2.5	—	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	1.0	3.0	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance Common Source* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{fs}\|$	1000	—	5000	μmhos
Output Admittance Common Source* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{os}\|$	—	10	50	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	1.5	3.0	pF

(1) Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

FIGURE 1 — NOISE FIGURE versus FREQUENCY

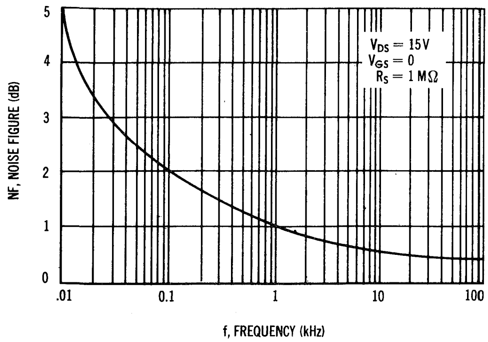
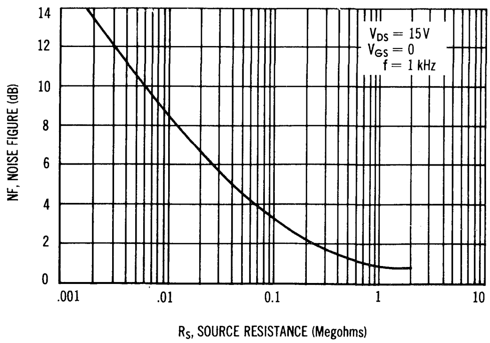


FIGURE 2 — NOISE FIGURE versus SOURCE RESISTANCE



4

FIGURE 3 — TYPICAL DRAIN CHARACTERISTICS $V_{GS(off)} \cong -1.2$ VOLTS

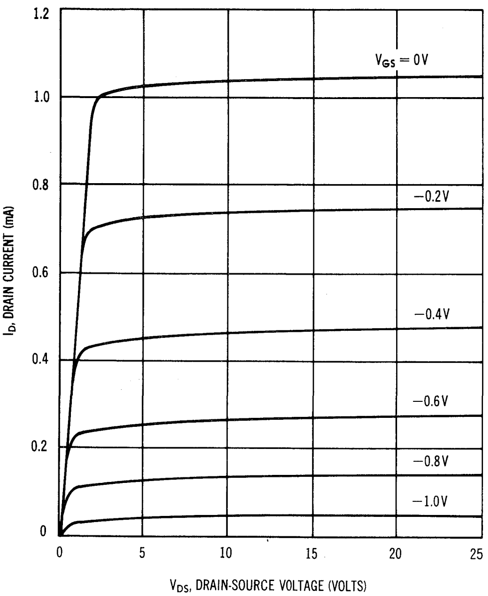


FIGURE 4 — COMMON SOURCE TRANSFER CHARACTERISTICS $V_{GS(off)} \cong -1.2$ VOLTS

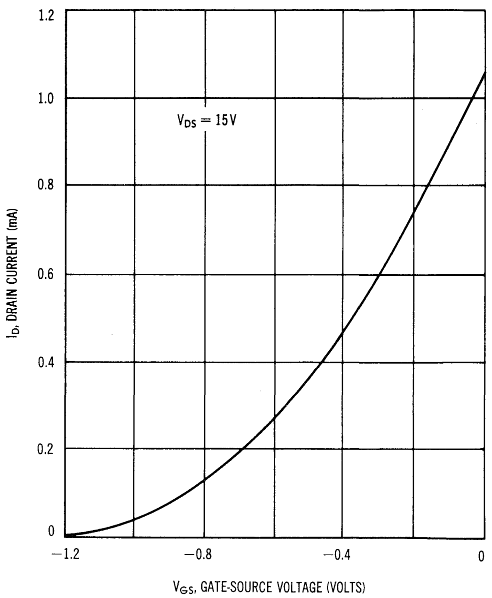


FIGURE 5 — TYPICAL DRAIN CHARACTERISTICS $V_{GS(off)} \cong -3.5$ VOLTS

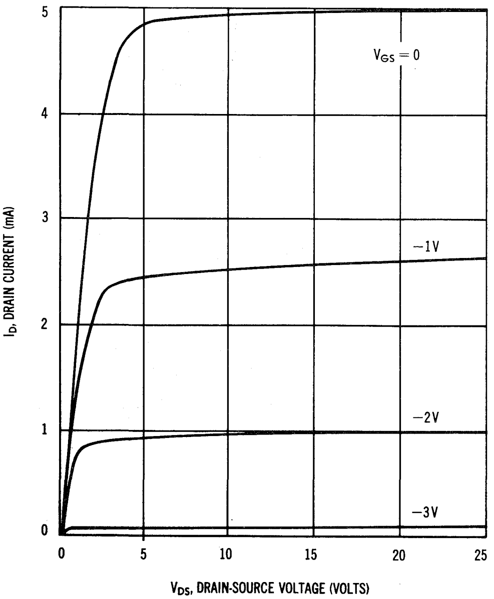


FIGURE 6 — COMMON SOURCE TRANSFER CHARACTERISTICS $V_{GS(off)} \cong -3.5$ VOLTS

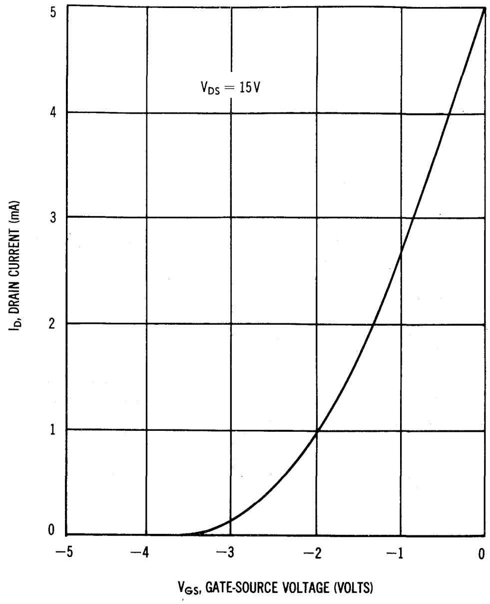


FIGURE 7 — TYPICAL DRAIN CHARACTERISTICS $V_{GS(off)} \cong -5.8$ VOLTS

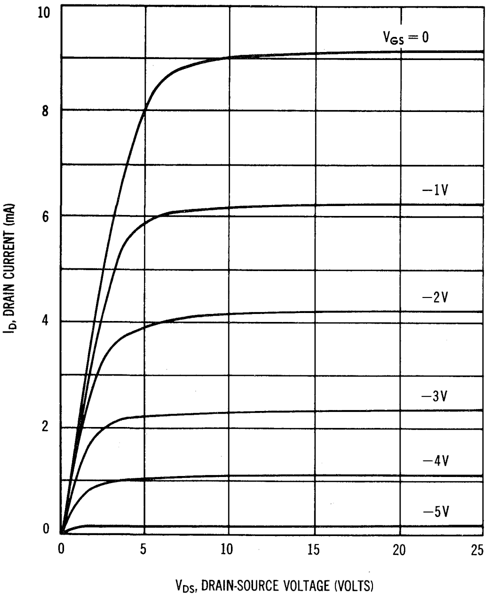
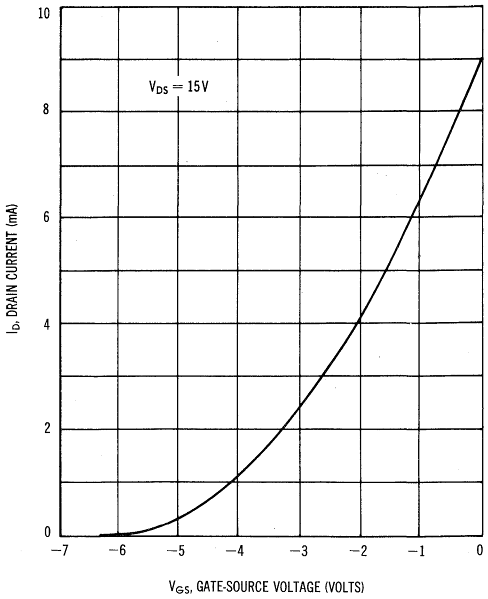


FIGURE 8 — COMMON SOURCE TRANSFER CHARACTERISTICS $V_{GS(off)} \cong -5.8$ VOLTS

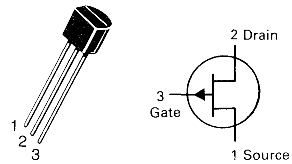


NOTES:

1. 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).
2. Figures 8, 9, 10: Data taken in a standard printed circuit with a TO-18 type socket mounting and 1/4" lead length.

2N5460 thru 2N5462★

CASE 29-04, STYLE 7
TO-92 (TO-226AA)



JFET AMPLIFIERS

P-CHANNEL — DEPLETION

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW 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
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	 2N5460, 2N5461, 2N5462	$V_{(BR)GSS}$	 40	 —	 —	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 30 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C) (V_{GS} = 30 Vdc, V_{DS} = 0, T_A = 100°C)	 2N5460, 2N5461, 2N5462 2N5460, 2N5461, 2N5462	I_{GSS}	 — —	 — —	 5.0 1.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	 2N5460 2N5461 2N5462	$V_{GS(off)}$	 0.75 1.0 1.8	 — — —	 6.0 7.5 9.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.1 mAdc) (V_{DS} = 15 Vdc, I_D = 0.2 mAdc) (V_{DS} = 15 Vdc, I_D = 0.4 mAdc)	 2N5460 2N5461 2N5462	V_{GS}	 0.5 0.8 1.5	 — — —	 4.0 4.5 6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5460 2N5461 2N5462	I_{DSS}	 −1.0 −2.0 −4.0	 — — —	 −5.0 −9.0 −16	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5460 2N5461 2N5462	$\lvert y_{fs}\rvert$	 1000 1500 2000	 — — —	 4000 5000 6000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\lvert y_{os}\rvert$	—	—	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.0	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 15 Vdc, 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 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	—	60	115	nV/$\sqrt{Hz}$

DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 1 — $V_{GS(off)}$ = 2.0 VOLTS

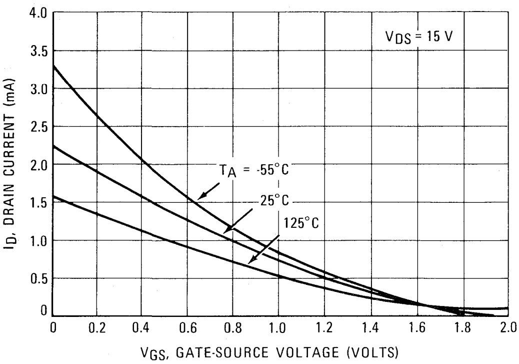


FIGURE 2 — $V_{GS(off)}$ = 4.0 VOLTS

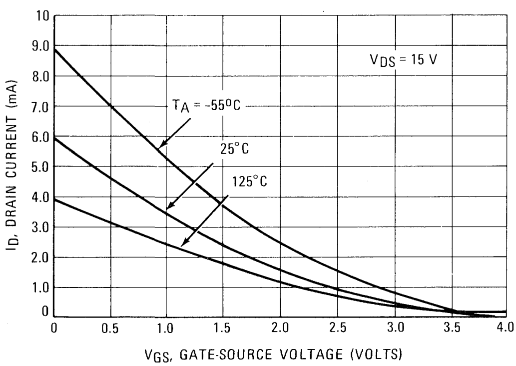
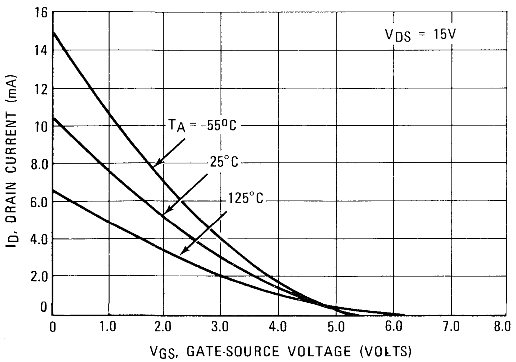


FIGURE 3 — $V_{GS(off)}$ = 5.0 VOLTS



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 4 — $V_{GS(off)}$ = 2.0 VOLTS

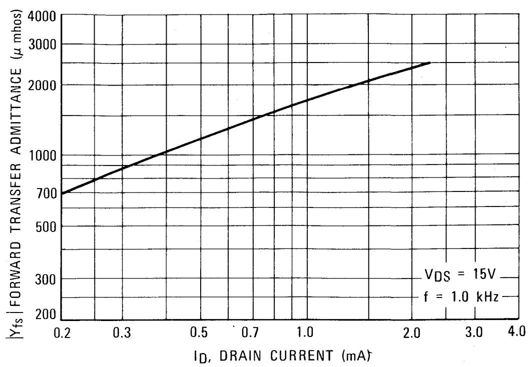


FIGURE 5 — $V_{GS(off)}$ = 4.0 VOLTS

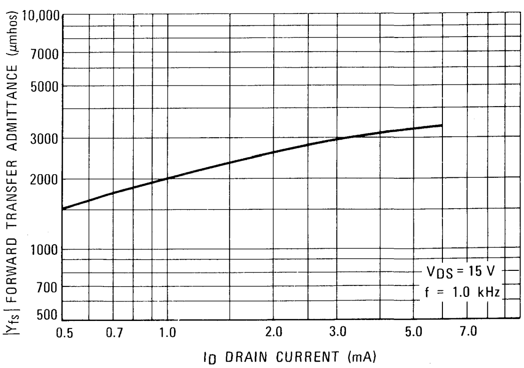
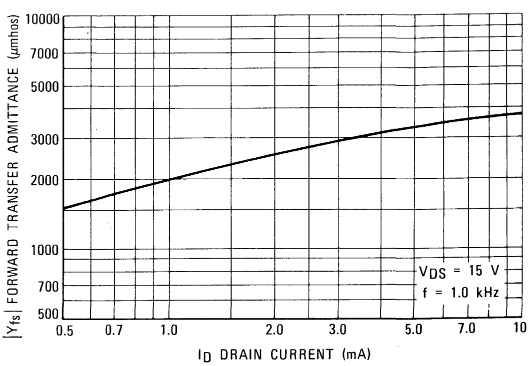


FIGURE 6 — $V_{GS(off)}$ = 5.0 VOLTS



4

FIGURE 7 — OUTPUT RESISTANCE VERSUS DRAIN CURRENT

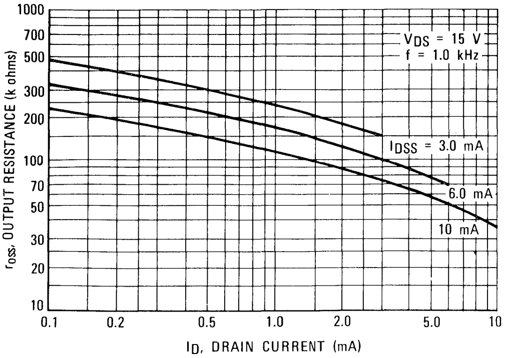
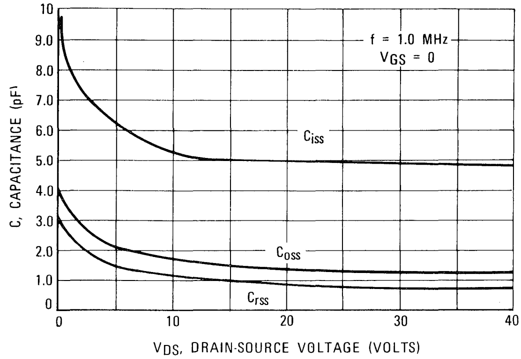


FIGURE 8 — CAPACITANCE VERSUS DRAIN-SOURCE VOLTAGE



4

FIGURE 9 — NOISE FIGURE VERSUS FREQUENCY

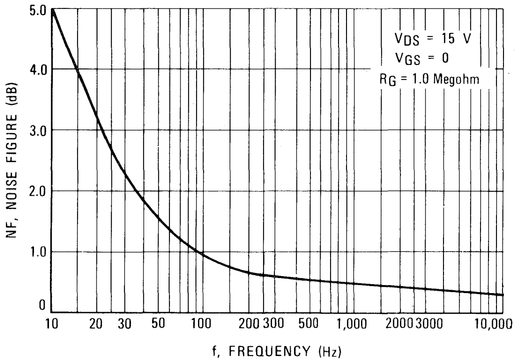


FIGURE 10 — NOISE FIGURE VERSUS SOURCE RESISTANCE

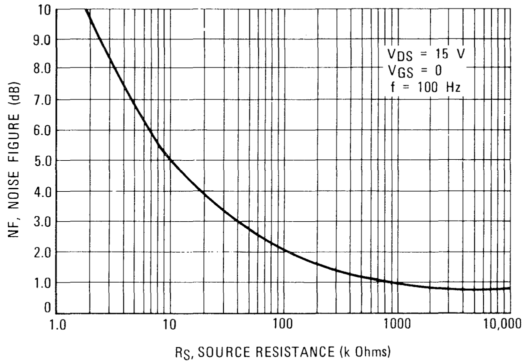
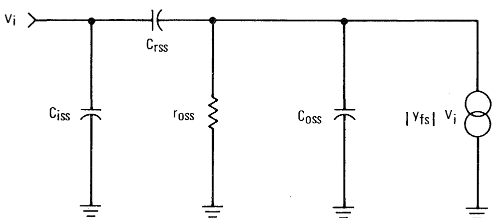


FIGURE 11 — EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source
y Parameters for Frequencies
Below 30 MHz

$y_{is} = j\omega C_{iss}$

$y_{os} = j\omega C_{osp}{}^{*} + 1/r_{oss}$

$y_{fs} = |y_{fs}|$

$y_{rs} = -j\omega C_{rss}$

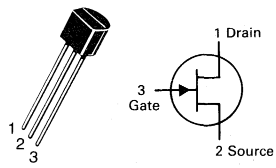
*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

NOTE:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%).

2N5484
2N5486★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
VHF/UHF AMPLIFIERS
N-CHANNEL — DEPLETION

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
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	350 2.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

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	—	—	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 −1.0 −0.2	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 2N5484 2N5486	$V_{GS(off)}$	 −0.3 −2.0	 — —	 −3.0 −6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N5484 2N5486	I_{DSS}	 1.0 8.0	 — —	 5.0 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5484 2N5486	$\|y_{fs}\|$	 3000 4000	 — —	 6000 8000	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	 2N5484 2N5486	$Re(y_{is})$	 — —	 — —	 100 1000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5484 2N5486	$\|y_{os}\|$	 — —	 — —	 50 75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	 2N5484 2N5486	$Re(y_{os})$	 — —	 — —	 75 100	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	 2N5484 2N5486	$Re(y_{fs})$	 2500 3500	 — —	 — —	μmhos

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

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	–	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	–	1.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	–	–	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure		NF				dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)			–	–	2.5	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, R_G ≈ 1.0 k ohm, f = 100 MHz)	2N5484		–	–	3.0	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, R_G ≈ 1.0 k ohm, f = 200 MHz)	2N5484		–	4.0	–	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, R_G ≈ 1.0 k ohm, f = 100 MHz)	2N5486		–	–	2.0	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, R_G ≈ 1.0 k ohm, f = 400 MHz)	2N5486		–	–	4.0	
Common Source Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	2N5484		16	–	25	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 200 MHz)	2N5484		–	14	–	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz)	2N5486		18	–	30	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz)	2N5486		10	–	20	

4

POWER GAIN

FIGURE 1 — EFFECTS OF DRAIN CURRENT

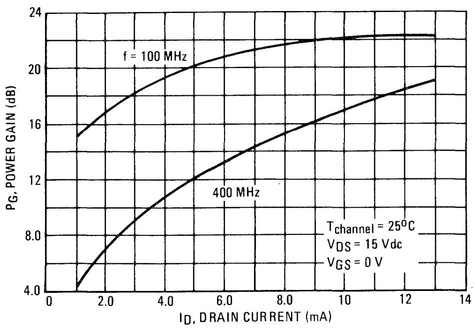
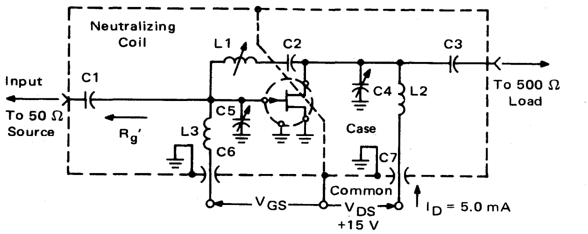


FIGURE 2 — 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



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**

Adjust V_{GS} for I_D = 50 mA, V_{GS} < 0 Volts

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

*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).

4

NOISE FIGURE

($T_{channel}$ = 25°C)

FIGURE 3 — EFFECTS OF DRAIN-SOURCE VOLTAGE

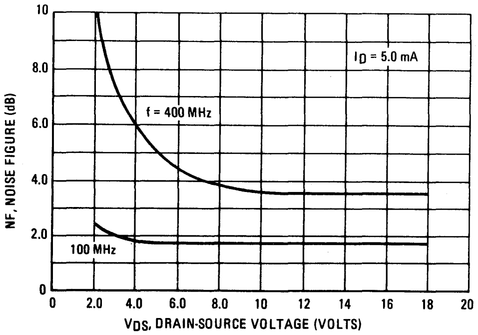
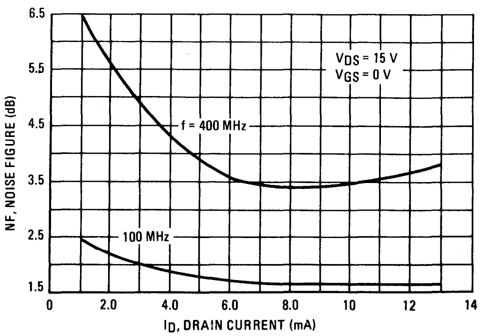
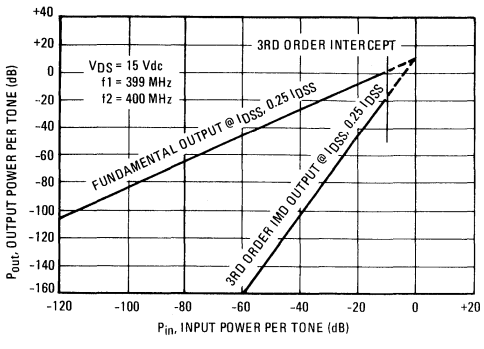


FIGURE 4 — EFFECTS OF DRAIN CURRENT



INTERMODULATION CHARACTERISTICS

FIGURE 5 — THIRD ORDER INTERMODULATION DISTORTION



COMMON SOURCE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 6 — INPUT ADMITTANCE (y_{is})

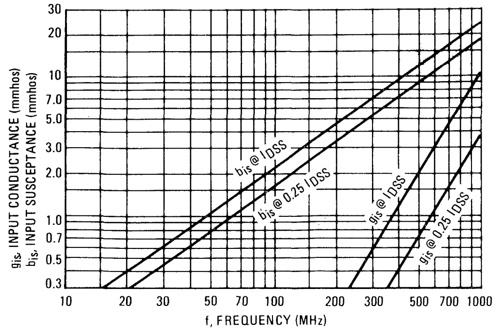


FIGURE 7 — REVERSE TRANSFER ADMITTANCE (y_{rs})

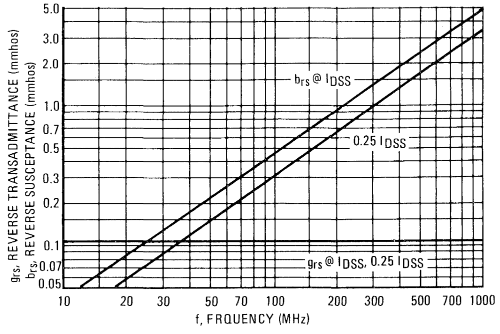


FIGURE 8 — FORWARD TRANSADMITTANCE (y_{fs})

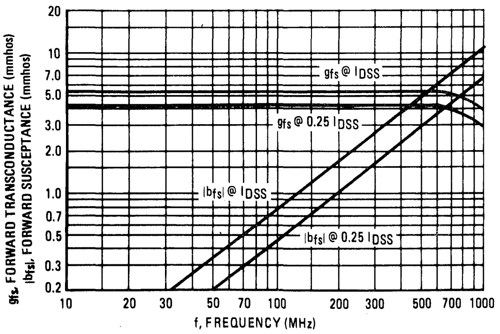
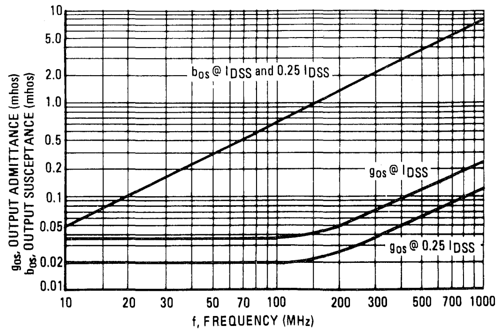


FIGURE 9 — OUTPUT ADMITTANCE (y_{os})



COMMON SOURCE CHARACTERISTICS

S-PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 10 – S_{11s}

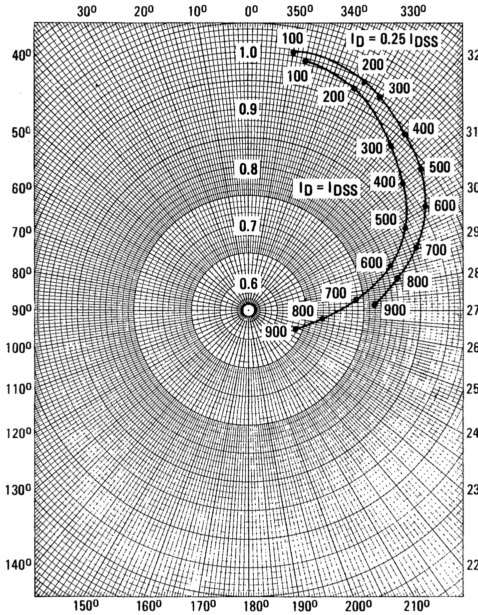


FIGURE 11 – S_{12s}

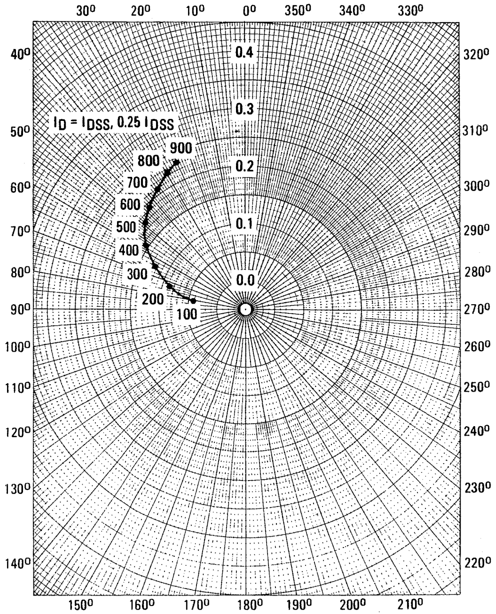


FIGURE 12 – S_{21s}

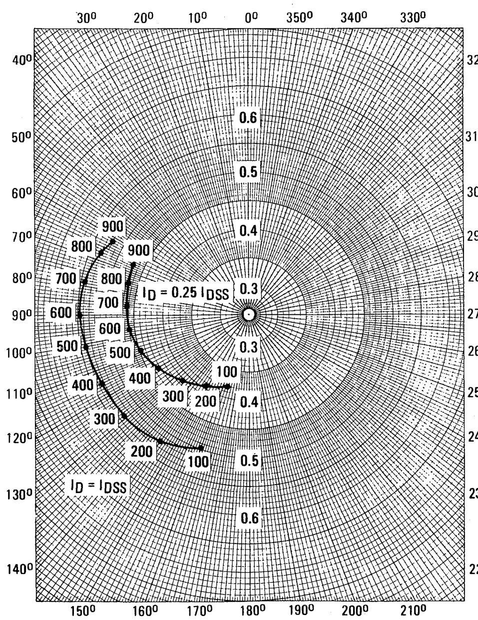
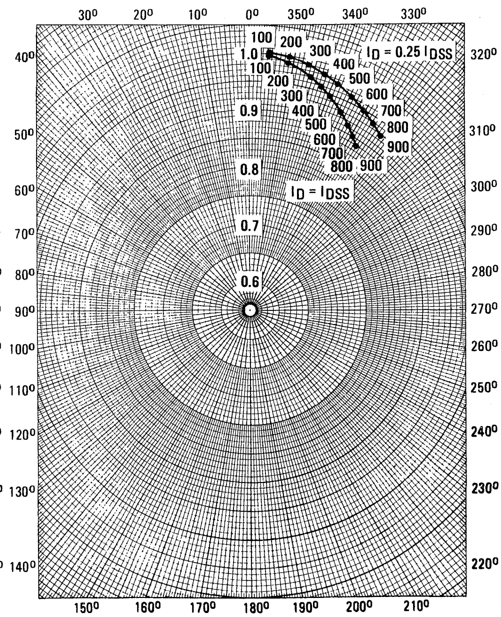


FIGURE 13 – S_{22s}



4

COMMON GATE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 14 — INPUT ADMITTANCE (y_{ig})

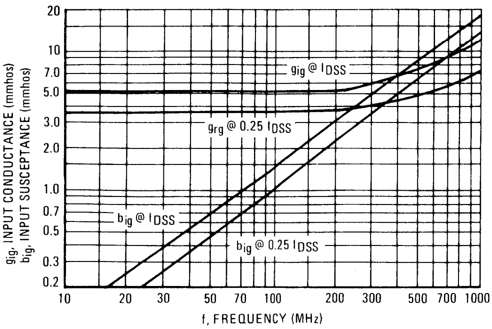


FIGURE 15 — REVERSE TRANSFER ADMITTANCE (y_{rg})

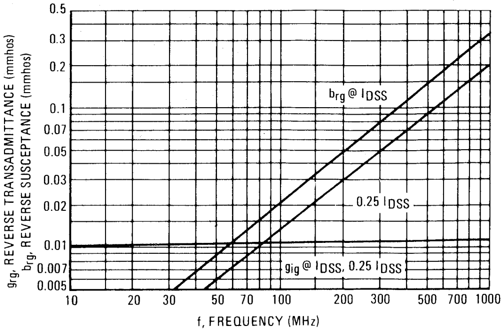


FIGURE 16 — FORWARD TRANSFER ADMITTANCE (y_{fg})

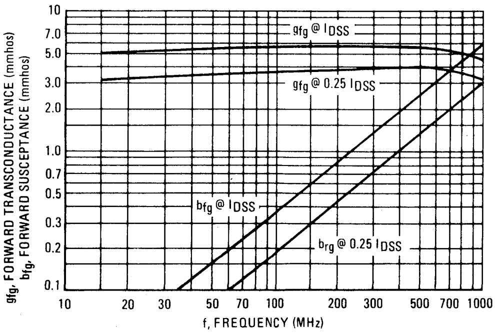
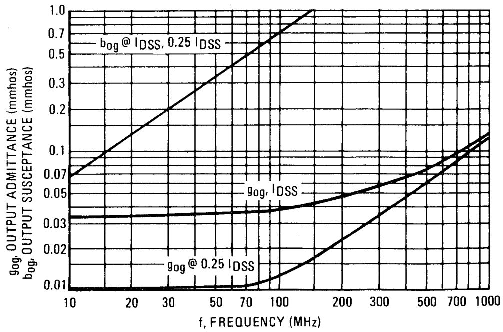


FIGURE 17 — OUTPUT ADMITTANCE (y_{og})



COMMON GATE CHARACTERISTICS

S-PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 18 – S_{11g}

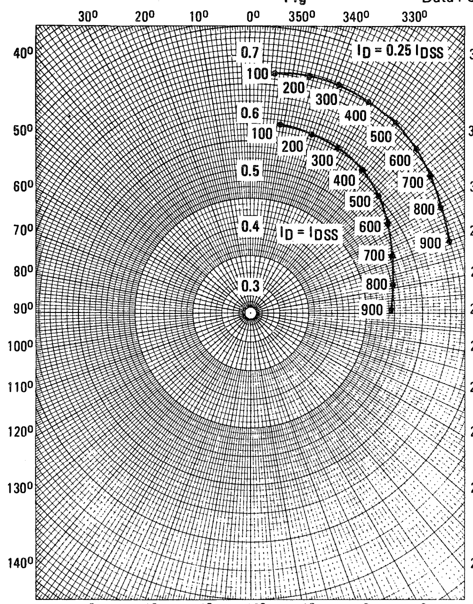


FIGURE 19 – S_{12g}

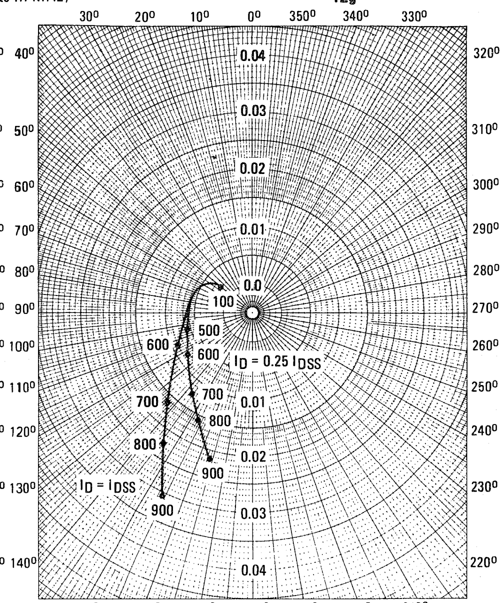


FIGURE 20 – S_{21g}

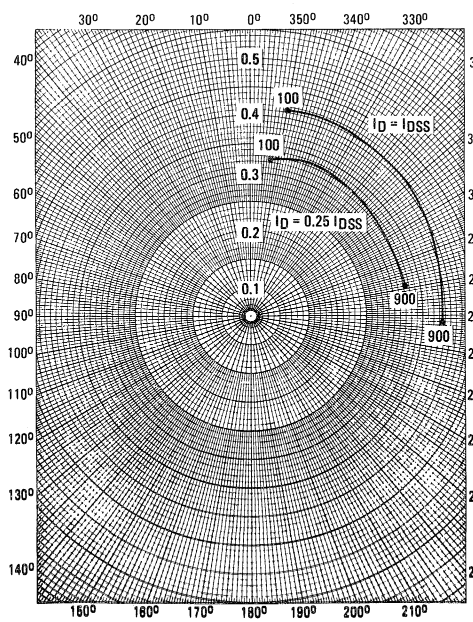
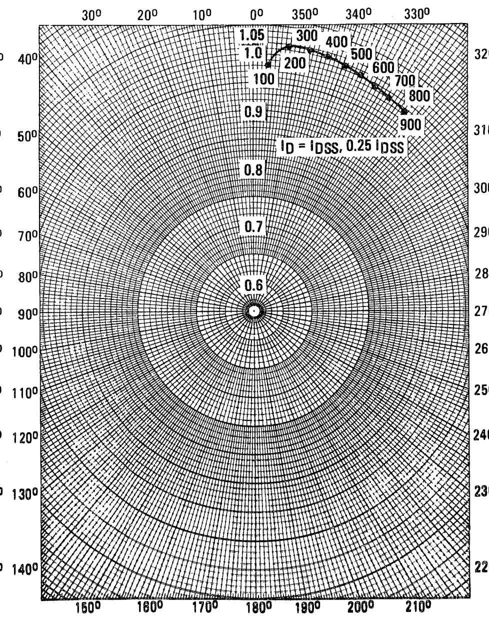


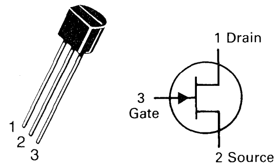
FIGURE 21 – S_{22g}



4

2N5555

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
SWITCHING

N-CHANNEL — DEPLETION

Refer to 2N5484 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}	10	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	350 2.8	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.)

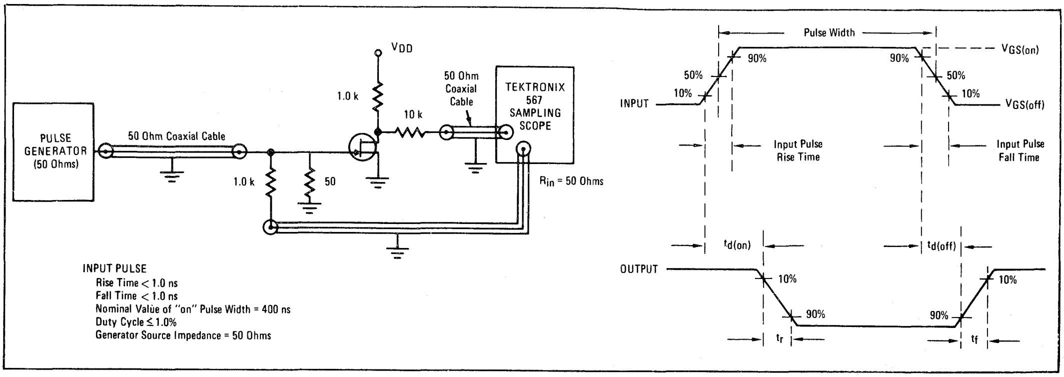
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	1.0	nAdc
Drain Cutoff Current ($V_{DS} = 12$ Vdc, $V_{GS} = -10$ V) ($V_{DS} = 12$ Vdc, $V_{GS} = -10$ V, $T_A = 100°C$)	$I_{D(off)}$	 — —	 10 2.0	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	15	—	mAdc
Gate-Source Forward Voltage ($I_{G(f)} = 1.0$ mAdc, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc
Drain-Source On-Voltage ($I_D = 7.0$ mAdc, $V_{GS} = 0$)	$V_{DS(on)}$	—	1.5	Vdc
Static Drain-Source On Resistance ($I_D = 0.1$ 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 kHz)	$r_{ds(on)}$	—	150	Ohms
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 10$ Vdc, f = 1.0 MHz)	C_{rss}	—	1.2	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Delay Time	($V_{DD} = 10$ Vdc, $I_{D(on)} = 7.0$ mAdc,	$t_{d(on)}$	—	5.0	ns
Rise Time	$V_{GS(on)} = 0$, $V_{GS(off)} = -10$ Vdc) (See Figure 1)	t_r	—	5.0	ns
Turn-Off Delay Time	($V_{DD} = 10$ Vdc, $I_{D(on)} = 7.0$ mAdc,	$t_{d(off)}$	—	15	ns
Fall Time	$V_{GS(on)} = 0$, $V_{GS(off)} = -10$ Vdc) (See Figure 1)	t_f	—	10	ns

*Pulse Test: Pulse Width < 300 μs, Duty Cycle < 3.0%.

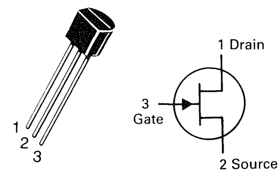
FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



4

2N5640

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFETs
SWITCHING

N-CHANNEL — DEPLETION

Refer to MPF4391 for graphs.

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	350 2.8	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} = −6.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −6.0 Vdc, T_A = 100°C)	$I_{D(off)}$	 — —	 1.0 1.0	 nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	I_{DSS}	5.0	—	mAdc
Drain-Source On-Voltage (I_D = 3.0 mAdc, V_{GS} = 0)	$V_{DS(on)}$	—	0.5	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	$r_{DS(on)}$	—	100	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	—	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

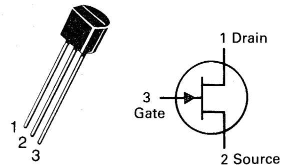
SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
Turn-On Delay Time	V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc, R_G' = 50 ohms	$I_{D(on)}$ = 3.0 mAdc	$t_{d(on)}$	—	8.0	ns
Rise Time		$I_{D(on)}$ = 3.0 mAdc	t_r	—	10	ns
Turn-Off Delay Time		$I_{D(on)}$ = 3.0 mAdc	$t_{d(off)}$	—	15	ns
Fall Time		$I_{D(on)}$ = 3.0 mAdc	t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

2N5668 thru 2N5670

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
VHF AMPLIFIERS

N-CHANNEL — DEPLETION

Refer to 2N5484 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
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

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

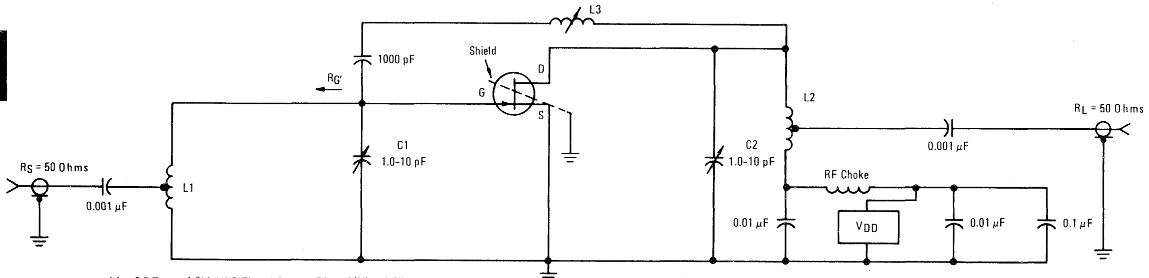
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 2.0 2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 2N5668 2N5669 2N5670	$V_{GS(off)}$	 −0.2 −1.0 −2.0	 — — —	 −4.0 −6.0 −8.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N5668 2N5669 2N5670	I_{DSS}	 1.0 4.0 8.0	 — — —	 5.0 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5668 2N5669 2N5670	$\|y_{fs}\|$	 1500 2000 3000	 — — —	 6500 6500 7500	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		$Re(y_{is})$	—	125	800	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5668 2N5669 2N5670	$\|y_{os}\|$	 — — —	 — — —	 20 50 75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N5668 2N5669 2N5670	$Re(y_{os})$	 — — —	 10 25 35	 50 100 150	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N5668 2N5669 2N5670	$Re(y_{fs})$	 1000 1600 2500	 — — —	 — — —	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	4.7	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.0	3.0	pF

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

Characteristic	Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	1.4	4.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz at R_G' = 1.0 k ohm)	NF	—	—	2.5	dB
Common Source Power Gain (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	G_{ps}	16	—	—	dB

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

100 MHz, POWER GAIN AND NOISE FIGURE TEST CIRCUIT



L1 ≈ 8.5 Turns of #14 AWG Tinned Copper; Dia. ≈ 3/8", ≈ 0.9" Long. Tapped at ≈ 2-1/2 Turns (adjust to give R_G' = 1.0 k ohm); Parallel Resistance = 40 k ohms; tunes at ≈ 8.0 pF.

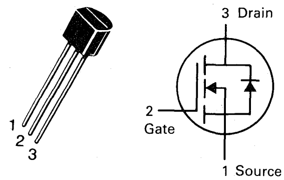
L2 ≈ 13.5 Turns #16 AWG Tinned Copper; Dia. ≈ 3/8", ≈ 1.2" Long. Tapped at ≈ 5 Turns; Parallel Resistance = 40 k ohms; tunes at ≈ 4.0 pF.

L3 ≈ 17 Turns of #28 AWG Enameled Copper Wire, Close Wound on 9/32" Ceramic Form, Tuning Provided by a Powdered Iron Slug.

4

2N7000★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	60	Vdc
Gate-Source Voltage	V_{GS}	±40	Vdc
Drain Current Continuous Pulsed	 I_D I_{DM}	 200 500	mAdc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	$V_{(BR)DSS}$	60	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 48 V, V_{GS} = 0) (V_{DS} = 48 V, V_{GS} = 0, T_J = 125°C)	I_{DSS}	 — —	 1.0 1.0	 μAdc mA
Gate-Body Leakage Current, Forward (V_{GSF} = 15 Vdc, V_{DS} = 0)	I_{GSSF}	—	−10	nAdc
ON CHARACTERISTICS*				
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	3.0	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 0.5 Adc) (V_{GS} = 4.5 V, I_D = 75 mA)	$r_{DS(on)}$	 — —	 5.0 6.0	Ohm
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 0.5 Adc) (V_{GS} = 4.5 V, I_D = 75 mA)	$V_{DS(on)}$	 — —	 2.5 0.45	Vdc
On-State Drain Current (V_{GS} = 4.5 V, V_{DS} = 10 V)	$I_{d(on)}$	75	—	mA
Forward Transconductance (V_{DS} = 10 V, I_D = 200 mA)	g_{fs}	100	—	μmhos
DYNAMIC CHARACTERISTICS				
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	25	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	5.0	pF
SWITCHING CHARACTERISTICS*				
Turn-On Delay Time (V_{DD} = 15 V, I_D = 500 mA, R_{gen} = 25 ohms, R_L = 25 ohms)	t_{on}	—	10	ns
Turn-Off Delay Time (V_{DD} = 15 V, I_D = 500 mA, R_{gen} = 25 ohms, R_L = 25 ohms)	t_{off}	—	10	ns

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

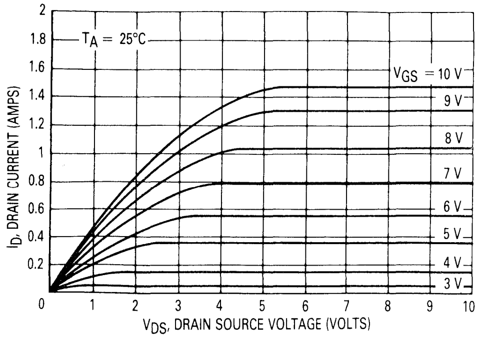


Figure 1. Ohmic Region

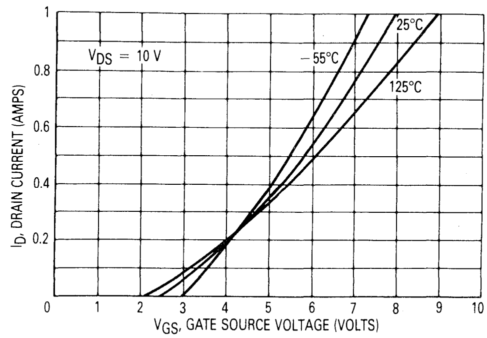


Figure 2. Transfer Characteristics

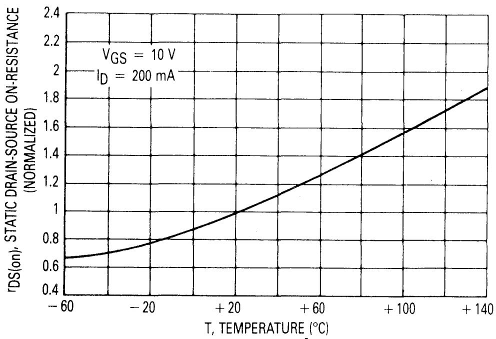


Figure 3. Temperature versus Static Drain-Source On-Resistance

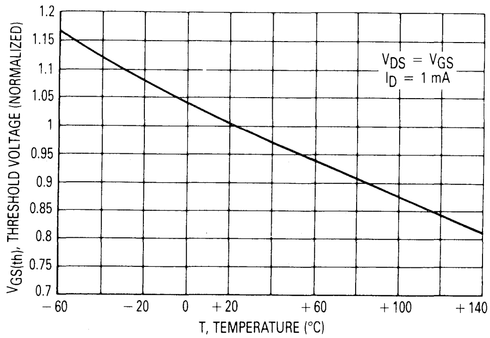
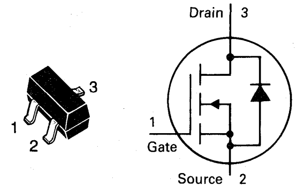


Figure 4. Temperature versus Gate Threshold Voltage

2N7002LT1★

CASE 318-07 STYLE 21
SOT-23 (TO-236AB)



TMOS FET TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N7000 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	60	Vdc
Drain Current — Continuous T_C = 25°C(1) T_C = 100°C(1) — Pulsed(2)	I_D I_D I_{DM}	±115 ±75 ±800	mA
Gate-Source Voltage	V_{GS}	±40	Vdc
Total Power Dissipation T_C = 25°C T_C = 100°C Derate above 25°C ambient	P_D	200 80 1.6	mW mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	625	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

2N7002LT1 = 702

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)	$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current (V_{GS} = 0, V_{DS} = 60 V) T_J = 25°C T_J = 125°C	I_{DSS}	 — —	 — —	 1.0 500	μAdc
Gate-Body Leakage Current Forward (V_{GS} = 20 Vdc)	I_{GSSF}	—	—	100	nAdc
Gate-Body Leakage Current Reverse (V_{GS} = −20 Vdc)	I_{GSSR}	—	—	−100	nAdc

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μA)	$V_{GS(th)}$	1.0	—	2.5	Vdc
On-State Drain Current (V_{DS} ⩾ 2.0 $V_{DS(on)}$, V_{GS} = 10 V)	$I_{D(on)}$	500	—	—	mA
Static Drain-Source On-State Voltage (V_{GS} = 10 V, I_D = 500 mA) (V_{GS} = 5.0 V, I_D = 50 mA)	$V_{DS(on)}$	 — —	 — —	 3.75 .375	Vdc
Static Drain-Source On-State Resistance (V_{GS} = 10 V, I_D = 500 mA) T_C = 25°C T_C = 125°C (V_{GS} = 5.0 V, I_D = 50 mA) T_C = 25°C T_C = 125°C	$r_{DS(on)}$	 — — — —	 — — — —	 7.5 13.5 7.5 13.5	Ohms
Forward Transconductance (V_{DS} ⩾ 2.0 $V_{DS(on)}$, I_D = 200 mA)	g_{FS}	80	—	—	mmhos

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

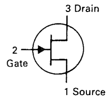
Characteristic		Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	—	50	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	—	25	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	—	5.0	pF
SWITCHING CHARACTERISTICS*						
Turn-On Delay Time	(V_{DD} = 25 V, I_D ≅ 500 mA, R_G = 25 Ω, R_L = 50 Ω)	$t_{d(on)}$	—	—	30	ns
Turn-Off Delay Time		$t_{d(off)}$	—	—	40	ns
BODY-DRAIN DIODE RATINGS						
Diode Forward On-Voltage (I_S = 11.5 mA, V_{GS} = 0 V)		V_{SD}	—	—	−1.5	V
Source Current Continuous (Body Diode)		I_S	—	—	−115	mA
Source Current Pulsed		I_{SM}	—	—	−800	mA

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

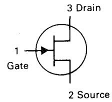
BF244,A,B

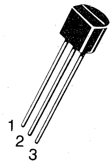
CASE 29-04, STYLE 22
TO-92 (TO-226AA)



BF245,A,B,C

CASE 29-04, STYLE 23
TO-92 (TO-226AA)





JFET
VHF/UHF AMPLIFIERS

N-CHANNEL — DEPLETION

Refer to 2N5484 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
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	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

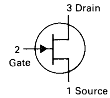
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-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)	BF245(1), BF244(2) BF245A, BF244A BF245B, BF244B BF245C	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)	BF245(1), BF244(2) BF245A, BF244A BF245B, BF244B BF245C	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)		$F_{(Yfs)}$		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 gfs is 0.7 of its value at 1 KHz.

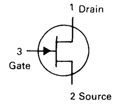
BF246A,B

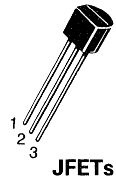
CASE 29-04, STYLE 22
TO-92 (TO-226AA)



BF247B

CASE 29-04, STYLE 5
TO-92 (TO-226AA)





JFETs SWITCHING

N-CHANNEL — DEPLETION

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

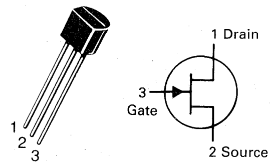
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1 μA, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	—	V
Gate-Source (V_{DS} = 15 V, I_D = 200 μA)	BF246A BF246B, BF247B	V_{GS}	−1.5 −3	— —	−4 −7	V
Gate-Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)		$V_{GS(off)}$	0.6	—	14.5	V
Gate Cutoff Current (V_{GS} = 15 V, V_{DS} = 0)		I_{GSS}	—	—	5	nA
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	BF246A BF246B, BF247B	I_{DSS}	30 60		80 140	mA
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 V, I_D = 10 mA, f = 1 kHz)		$\|Y_{fs}\|$	8	23		mmhos
Reverse Transfer Capacitance (V_{DS} = 15 V, I_D = 10 mA, f = 1 kHz)		C_{rss}		3.3		pF
Input Capacitance (V_{DS} = 15 V, I_D = 10 mA, f = 1 MHz)		C_{in}		6		pF
Output Capacitance (V_{DS} = 15 V, I_D = 10 mA, f = 1 MHz)		C_{out}		5		pF
Cutoff Frequency (V_{DS} = 15 V, V_{GS} = 0)		$F_{(Yfs)}$		450		MHz

BF256B,C

CASE 29-04, STYLE 23
TO-92 (TO-226AA)



JFET
VHF/UHF AMPLIFIERS

N-CHANNEL — DEPLETION

Refer to 2N5484 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
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	350 2.8	mW mW/°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-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	—	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 200 μA)	$V_{GS(off)}$	−0.5	—	−7.5	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	5	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current) (V_{DS} = 15 Vdc, V_{GS} = 0) BF256B BF256C	I_{DSS}	6 11	— —	13 18	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	$\|Y_{fs}\|$	4.5	5	—	mmhos
Reverse Transfer Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1Vdc, f = 1 MHz)	C_{rss}	—	0.7	—	pF
Output Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1 MHz)	C_{oss}	—	1.0	—	pF
Noise Figure (V_{DS} = 10 Vdc, R_s = 47Ω, f = 800 MHz)	N_F	—	7.5	—	db
Cut-off Frequency(2) (V_{DS} = 15 Vdc, V_{GS} = 0)	f_{gfs}	—	1000	—	MHz
Power Gain (V_{DS} = 15 Vdc, R_s = 47 Ω, f =800 MHz)	G_p	—	11	—	dB

(1) The frequency at which gfs is 0.7 of its value at 1 kHz.

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

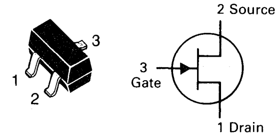
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BFR30LT1 = M1; BFR31LT1 = M2

BFR30LT1
BFR31LT1

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET AMPLIFIERS

N-CHANNEL

Refer to 2N5457 for graphs.

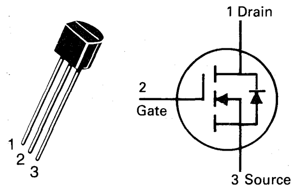
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate Reverse Current (V_{GS} = 10 Vdc, V_{DS} = 0)		I_{GSS}	—	0.2	nAdc
Gate Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 10 Vdc)	BFR30 BFR31	$V_{GS(off)}$	— —	5.0 2.5	Vdc
Gate Source Voltage (I_D = 1.0 mAdc, V_{DS} = 10 Vdc)	BFR30 BFR31	V_{GS}	−0.7 —	−3.0 −1.3	Vdc
(I_D = 50 μAdc, V_{DS} = 10 Vdc)	BFR30 BFR31		— —	−4.0 −2.0	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0)	BFR30 BFR31	I_{DSS}	4.0 1.0	10 5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transconductance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 kHz)	BFR30 BFR31	$\lvert Y_{fs} \rvert$	1.0 1.5	4.0 4.5	mAdc
(I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 kHz)	BFR30 BFR31		0.5 0.75	— —	
Output Admittance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 kHz)	BFR31	$\lvert Y_{os} \rvert$	40	25	μAdc
(I_D = 200 μAdc, V_{DS} = 10 Vdc)	BFR31		20	15	
Input Capacitance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)		C_{iss}	—	5.0	pF
(I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)			—	4.0	
Reverse Transfer Capacitance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)		C_{rss}	—	1.5	pF
(I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)			—	1.5	

Note: "LT1" must be used when ordering SOT-23 devices.

BS107,A★

CASE 29-04, STYLE 30
TO-92 (TO-226AA)



TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

★BS107A is a Motorola designated preferred device.

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_A = 25°C Derate above 25°C	P_D	350	mW
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°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 130 V, V_{GS} = 0)	I_{DSS}	—	—	30	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSX}$	200	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})	$V_{GS(Th)}$	1.0	—	3.0	Vdc
Static Drain-Source On Resistance BS107 (V_{GS} = 2.6 V, I_D = 20 mA) (V_{GS} = 10 V, I_D = 200 mA) BS107A (V_{GS} = 10 Vdc) (I_D = 100 mA) (I_D = 250 mA)	$r_{DS(on)}$	 — — — —	 — — 4.5 4.8	 28 14 6.0 6.4	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	6.0	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	30	—	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 250 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 ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

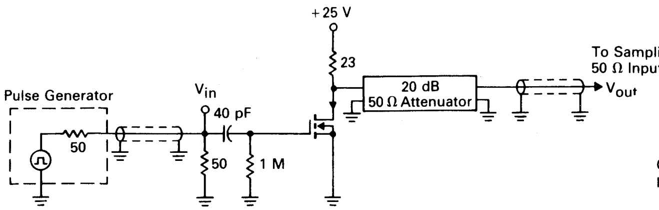


FIGURE 1 — SWITCHING TEST CIRCUIT

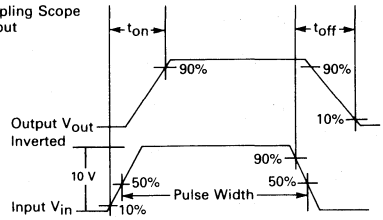


FIGURE 2 — SWITCHING WAVEFORMS

4

FIGURE 3 — ON VOLTAGE versus TEMPERATURE

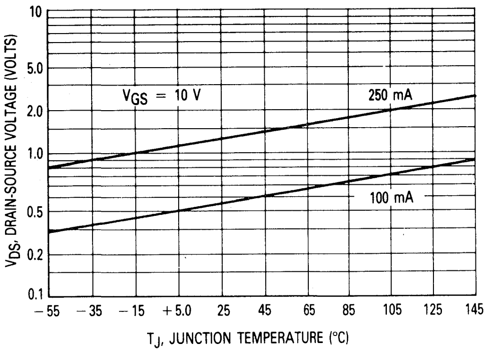


FIGURE 4 — CAPACITANCE VARIATION

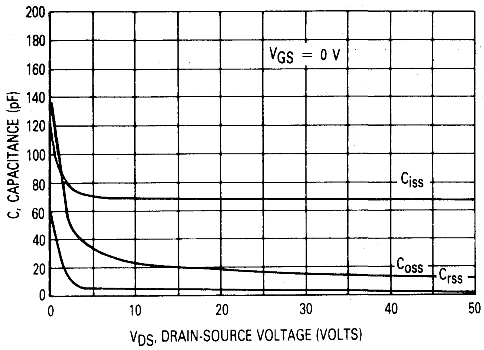


FIGURE 5 — TRANSFER CHARACTERISTIC

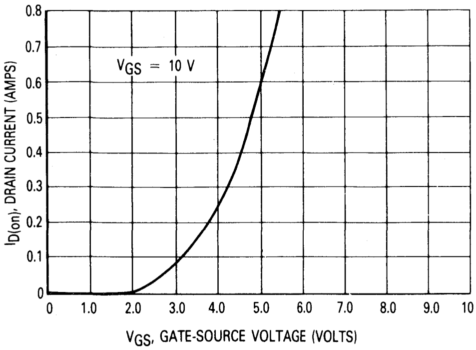


FIGURE 6 — OUTPUT CHARACTERISTIC

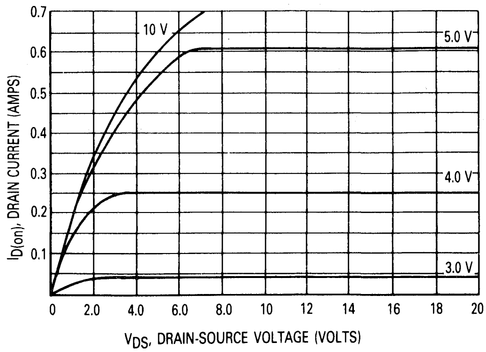
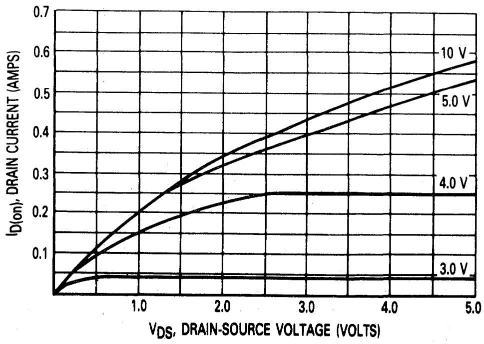


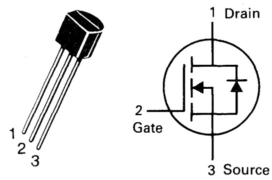
FIGURE 7 — SATURATION CHARACTERISTIC



4

BS170★

CASE 29-04, STYLE 30
TO-92 (TO-226AA)



TMOS FET
SWITCHING

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

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	Adc
Total Device Dissipation @ T_A = 25°C	P_D	350	mW
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	nAdc
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

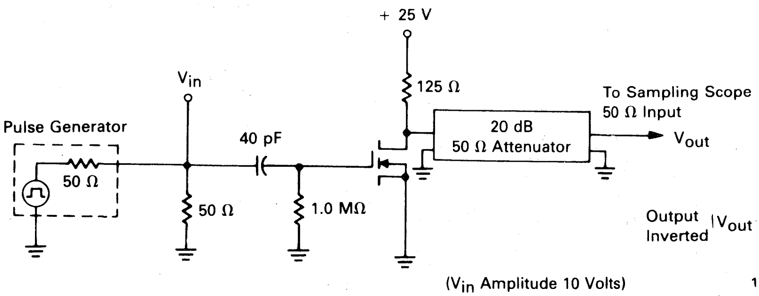


FIGURE 2 — SWITCHING WAVEFORMS

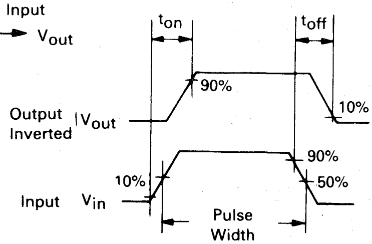


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

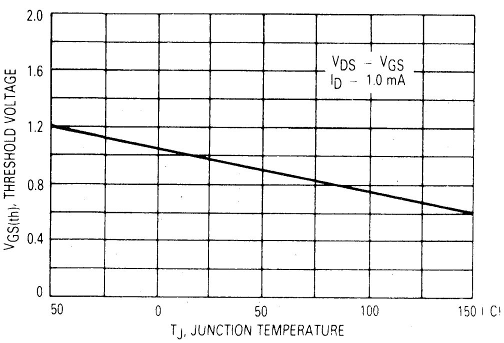


FIGURE 4 — ON-REGION CHARACTERISTICS

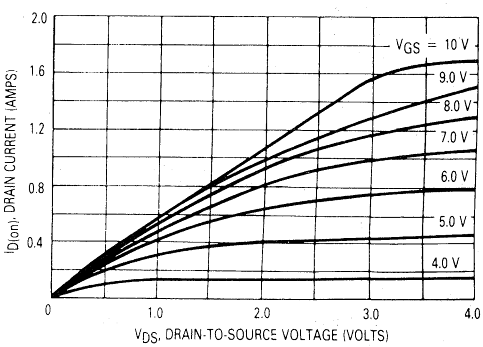


FIGURE 5 — OUTPUT CHARACTERISTICS

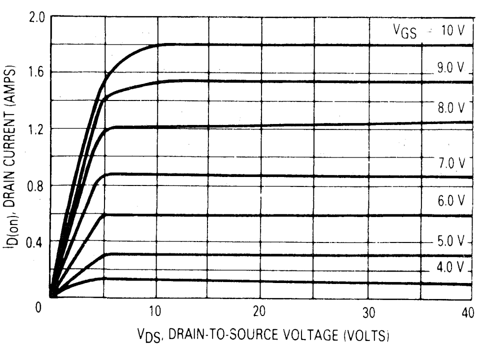
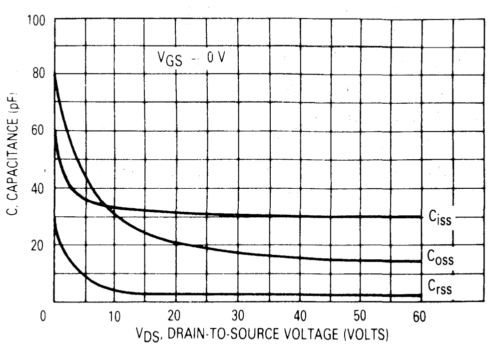
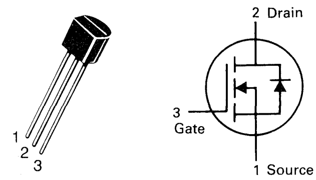


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



BSS89

CASE 29-04, STYLE 7
TO-92 (TO-226AA)



TMOS FET
TRANSISTOR
N-CHANNEL — ENHANCEMENT

Refer to BS107 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	200	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current — Continuous (1) — Pulsed (2)	I_D I_{DM}	400 800	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to 150	°C
Thermal Resistance Junction to Ambient	θ_{JA}	208	°C/W

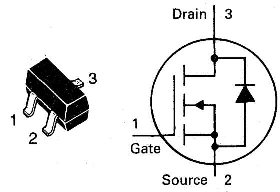
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 0.5 mA)	$V_{(BR)DSS}$	200	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 200 V, V_{GS} = 0)	I_{DSS}	—	0.1	60	μAdc
Gate-Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	0.01	100	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})	$V_{GS(th)}$	1.0	—	2.7	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 100 mA) (I_D = 300 mA) (I_D = 500 mA)	$V_{DS(on)}$	 — — —	 0.45 1.2 3.0	 0.6 1.8 —	Vdc
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)	$I_{D(on)}$	500	700	—	mA
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc) (I_D = 150 mA) (I_D = 300 mA) (I_D = 500 mA)	$r_{DS(on)}$	 — — —	 4.5 — 6.0	 6.0 6.0 —	Ohms
Forward Transconductance (V_{DS} = 25 V, I_D = 300 mA)	g_{fs}	140	400	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	72	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	15	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	2.8	—	pF
SWITCHING CHARACTERISTICS*					
Turn-On Time (See Figure 1)	t_{on}	—	6.0	—	ns
Turn-Off Time (See Figure 1)	t_{off}	—	12	—	ns

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BSS123LT1★

CASE 318-07, STYLE 21
SOT-23 (TO-236AB)



TMOS FET TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N7000 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	100	Vdc
Gate-Source Voltage	V_{GS}	±35	Vdc
Drain Current			Adc
Continuous (1)	I_D	0.17	
Pulsed (2)	I_{DM}	0.68	

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

BSS123LT1 = SA

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

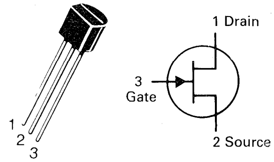
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 250 μA)	$V_{(BR)DSS}$	100	—	—	Vdc
Zero Gate Voltage Drain Current (V_{GS} = 0, V_{DS} = 100 V) T_J = 25°C	I_{DSS}	—	—	15	μAdc
T_J = 125°C		—	—	60	
Gate-Body Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	—	2.8	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 100 mA)	$r_{DS(on)}$	—	5.0	6.0	Ohms
Forward Transconductance (V_{DS} = 25 V, I_D = 100 mA)	g_{fs}	80	—	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	20	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	9.0	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	4.0	—	pF
SWITCHING CHARACTERISTICS*					
Turn-On Delay Time (V_{CC} = 30 V, I_C = 0.28 A, V_{GS} = 10 V, R_{GS} = 50 Ω)	$t_{d(on)}$	—	20	—	ns
Turn-Off Delay Time (V_{CC} = 30 V, I_C = 0.28 A, V_{GS} = 10 V, R_{GS} = 50 Ω)	$t_{d(off)}$	—	40	—	ns
REVERSE DIODE					
Diode Forward On-Voltage (I_D = 0.34 A, V_{GS} = 0 V)	V_{SD}	—	—	1.3	V

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

J111 thru J113

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
CHOPPER TRANSISTORS

N-CHANNEL — DEPLETION

Refer to MPF4391 for graphs.

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	350 2.8	mW mW/°C
Lead Temperature	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

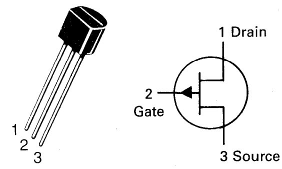
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

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)	J111 J112 J113	$V_{GS(off)}$	−3.0 −1.0 −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)	J111 J112 J113	I_{DSS}	20 5.0 2.0	— — —	mA
Static Drain-Source On Resistance (V_{DS} = 0.1 V)	J111 J112 J113	$r_{DS(on)}$	— — —	30 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 μs, Duty Cycle = 3.0%.

J174 thru J177★

CASE 29-04, STYLE 30
TO-92 (TO-226AA)



JFET
CHOPPER TRANSISTORS

P-CHANNEL — DEPLETION

★These are Motorola designated preferred devices.

Refer to MPF970 for graphs.

4

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

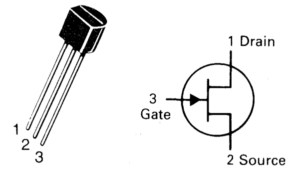
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

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)	J174 J175 J176 J177	$V_{GS(off)}$	5.0 3.0 1.0 0.8	10 6.0 4.0 2.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = −15 V)	J174 J175 J176 J177	I_{DSS}*	−2.0 −7.0 −2.0 −1.5	−100 −60 −25 −20	mA
Static Drain-Source On Resistance (V_{DS} ≤ −0.1 Volt)	J174 J175 J176 J177	$r_{DS(on)}$	— — — —	85 125 250 300	Ω

*Pulse Width = 300 μs, Duty Cycle ≤ 3.0%.

J202
J203

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFETs
LOW FREQUENCY/LOW NOISE

N-CHANNEL — DEPLETION

Refer to 2N5457 for graphs.

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 @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

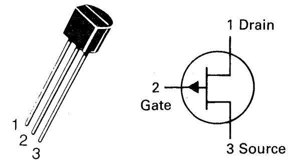
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu A$)		$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current ($V_{GS} = -20$ V)		I_{GSS}	—	−100	pA
Gate Source Cutoff Voltage ($V_{DS} = 20$ V, $I_D = 10$ nA)	J202 J203	$V_{GS(off)}$	−0.8 −2.0	−4.0 −10.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 20$ V)	J202 J203	I_{DSS}*	0.9 4.0	4.5 20.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 20$ V, f = 1.0 kHz)	J202 J203	$\|y_{fs}\|$*	1000 1500	— —	µmhos

*Pulse Width ≤ 2.0 ms.

J270

CASE 29-04, STYLE 30
TO-92 (TO-226AA)



JFET
CHOPPER TRANSISTOR

P-CHANNEL — DEPLETION

Refer to MPF970 for graphs.

4

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.)

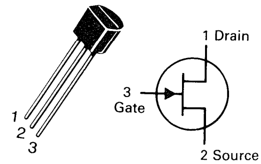
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μA)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Volts)	I_{GSS}	—	200	pA
Gate Source Cutoff Voltage (V_{DS} = −15 V, I_D = −1.0 nA)	$V_{GS(off)}$	0.5	2.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = −15 V)	I_{DSS}*	−2.0	−15	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = −15 V, f = 1.0 kHz)	$\|y_{fs}\|$	6000	15000	μmhos
Output Admittance (V_{DS} = −15 V, f = 1.0 kHz)	$\|y_{os}\|$	—	200	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.

4

J300

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
HIGH FREQUENCY AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N5484 for graphs.

MAXIMUM RATINGS

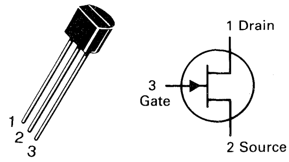
Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−25	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Temperature Range	T_{stg}	−65 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 = −1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −15 V, V_{DS} = 0)	I_{GSS}	—	500	pA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 mA)	$V_{GS(off)}$	−1.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	I_{DSS}	6.0	30	mA
Gate-Source Forward Voltage (V_{DS} = 0, I_G = 1.0 mA)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 kHz)	$\|y_{fs}\|$	4500	9000	μmhos
Output Admittance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 kHz)	$\|y_{os}\|$	—	200	μmhos
Input Capacitance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 MHz)	C_{iss}	—	5.5	pF
Reverse Transfer Capacitance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 MHz)	C_{rss}	—	1.7	pF

J304
J305

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
HIGH FREQUENCY
AMPLIFIERS

N-CHANNEL — DEPLETION

Refer to 2N5484 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	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	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}	−65 to +150	°C

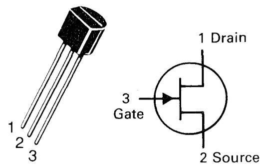
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{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)	J304 J305	$V_{GS(off)}$	−2.0 −0.5	−6.0 −3.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	J304 J305	I_{DSS}	5.0 1.0	15 8.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Output Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)		$\lvert y_{os} \rvert$	—	50	μmhos
Forward Transconductance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	J304 J305	$Re(y_{fs})$	4500 3000	7500 —	μmhos

4

J308 thru J310★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
VHF/UHF AMPLIFIERS

N-CHANNEL — DEPLETION

★These are Motorola designated preferred devices.

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 @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	−65 to +125	°C
Storage 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-Source Breakdown Voltage ($I_G = -1.0\ \mu A$, $V_{DS} = 0$)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current ($V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 25°C$) ($V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = +125°C$)		I_{GSS}	 — —	 — —	 −1.0 −1.0	 nA μA
Gate Source Cutoff Voltage ($V_{DS} = 10$ V, $I_D = 1.0$ nA)	 J308 J309 J310	$V_{GS(off)}$	 −1.0 −1.0 −2.0	 — — —	 −6.5 −4.0 −6.5	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 10$ V, $V_{GS} = 0$)	 J308 J309 J310	I_{DSS}	 12 12 24	 — — —	 60 30 60	mA
Gate-Source Forward Voltage ($V_{DS} = 0$, $I_G = 1.0$ mA)		$V_{GS(f)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Common-Source Input Conductance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 100 MHz)	 J308 J309 J310	$Re(y_{is})$	 — — —	 0.7 0.7 0.5	 — — —	mmhos
Common-Source Output Conductance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 100 MHz)		$Re(y_{os})$	—	0.25	—	mmhos
Common-Gate Power Gain ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 100 MHz)		G_{pg}	—	16	—	dB
Common-Source Forward Transconductance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 100 MHz)		$Re(y_{fs})$	—	12	—	mmhos
Common-Gate Input Conductance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 100 MHz)		$Re(y_{ig})$	—	12	—	mmhos
Common-Source Forward Transconductance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 1.0 kHz)	 J308 J309 J310	g_{fs}	 8000 10000 8000	 — — —	 20000 20000 18000	μmhos
Common-Source Output Conductance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 1.0 kHz)		g_{os}	—	—	250	μmhos

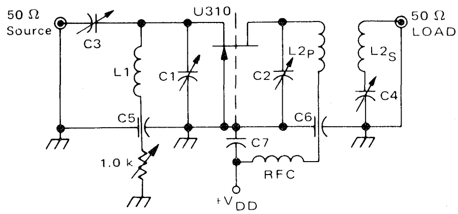
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common-Gate Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308	g_{fg}	—	13000	—	μmhos
	J309		—	13000	—	
	J310		—	12000	—	
Common-Gate Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308	g_{og}	—	150	—	μmhos
	J309		—	100	—	
	J310		—	150	—	
Gate-Drain Capacitance (V_{DS} = 0, V_{GS} = −10 V, f = 1.0 MHz)		C_{gd}	—	1.8	2.5	pF
Gate-Source Capacitance (V_{DS} = 0, V_{GS} = −10 V, f = 1.0 MHz)		C_{gs}	—	4.3	5.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 10 V, I_D = 10 mA, f = 450 MHz)		NF	—	1.5	—	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 V, I_D = 10 mA, f = 100 Hz)		$\bar{e}_n$	—	10	—	nV/√Hz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

4

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 #FA5C.
RFC = 0.33 μH Miller #9230-30.
L1 = One Turn #16 Cu, 1/4" I.D. (Air Core).
$L2_P$ = One Turn #16 Cu, 1/4" I.D. (Air Core).
$L2_S$ = One Turn #16 Cu, 1/4" I.D. (Air Core).

4

FIGURE 2 – DRAIN CURRENT and TRANSFER CHARACTERISTICS versus GATE-SOURCE VOLTAGE

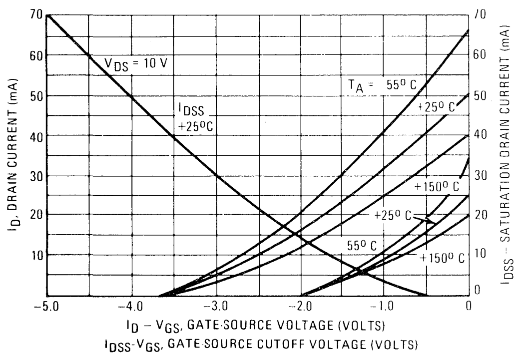


FIGURE 3 – FORWARD TRANSCONDUCTANCE versus GATE-SOURCE VOLTAGE

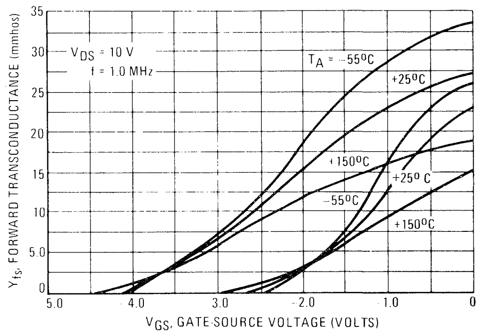


FIGURE 4 – COMMON-SOURCE OUTPUT ADMITTANCE and FORWARD TRANSCONDUCTANCE versus DRAIN CURRENT

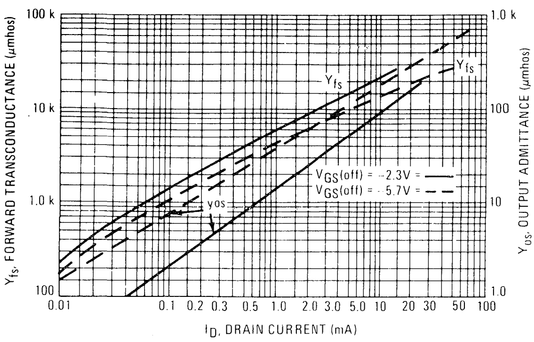


FIGURE 5 – ON RESISTANCE and JUNCTION CAPACITANCE versus GATE-SOURCE VOLTAGE

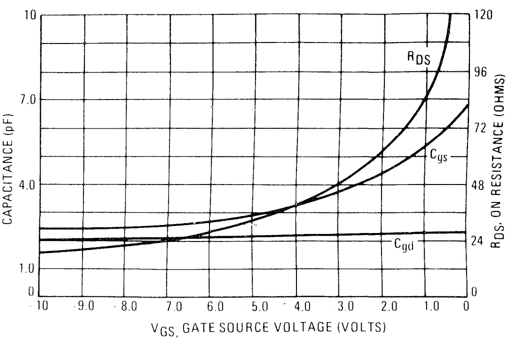


FIGURE 6 – COMMON-GATE Y PARAMETER MAGNITUDE versus FREQUENCY

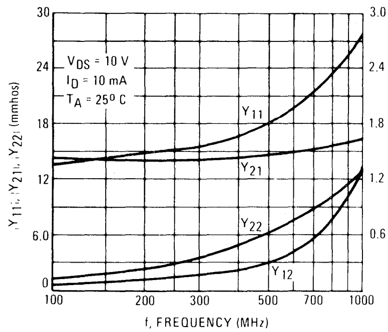


FIGURE 7 – COMMON-GATE S PARAMETER MAGNITUDE versus FREQUENCY

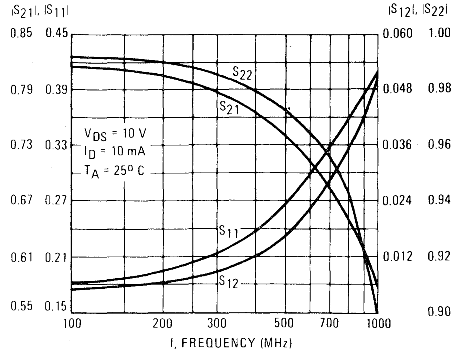


FIGURE 8 – COMMON-GATE Y PARAMETER PHASE-ANGLE versus FREQUENCY

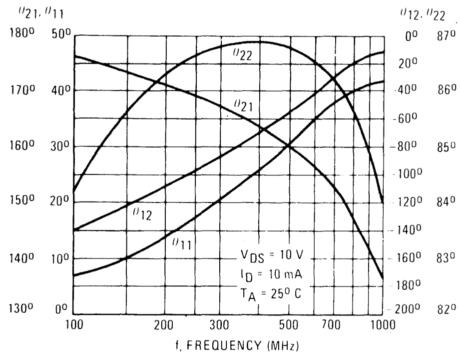


FIGURE 9 – S PARAMETER PHASE-ANGLE versus FREQUENCY

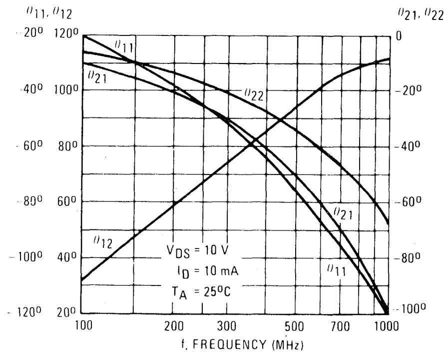


FIGURE 10 – NOISE FIGURE and POWER GAIN versus DRAIN CURRENT

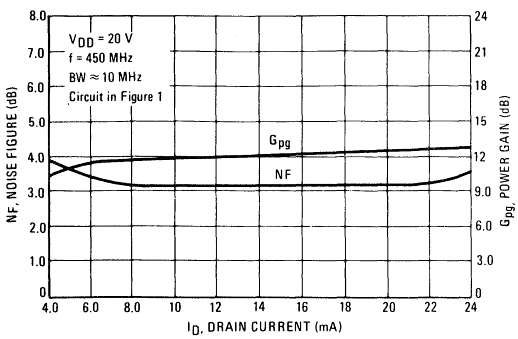
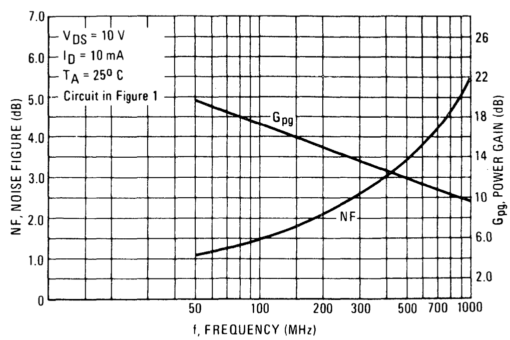
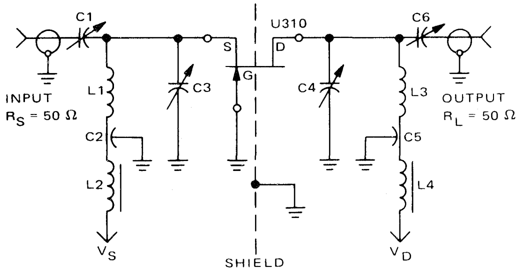


FIGURE 11 – NOISE FIGURE and POWER GAIN versus FREQUENCY



4

FIGURE 12 – 450 MHz IMD EVALUATION AMPLIFIER



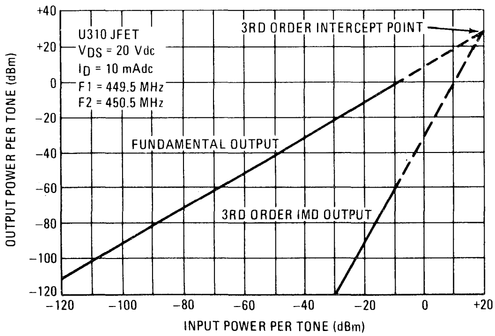
B_W (3dB) – 36.5 MHz
I_D – 10 mAdc
V_{DS} – 20 Vdc
Device case grounded
IM test tones – f1 = 449.5 MHz, f2 = 450.5 MHz

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 Vk200 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.

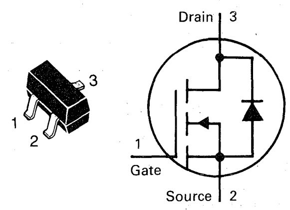
FIGURE 13 – TWO TONE 3RD ORDER INTERCEPT POINT



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.

MMBF170LT1

CASE 318-07, STYLE 21
SOT-23 (TO-236AB)



TMOS FET TRANSISTOR

N-CHANNEL

Refer to 2N7000 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage	V_{DGS}	60	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current — Continuous Pulsed	I_D I_{DM}	0.5 0.8	Adc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF170LT1 = 6Z

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	—	Vdc
Gate-Body Leakage Current, Forward (V_{GSF} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	10	nAdc
ON CHARACTERISTICS*				
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	3.0	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 200 mA)	$r_{DS(on)}$	—	5.0	Ohm
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 0)	$I_{D(off)}$	—	0.5	μA
DYNAMIC CHARACTERISTICS				
Input Capacitance (V_{DS} = 10 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{iss}	—	60	pF
SWITCHING CHARACTERISTICS*				
Turn-On Delay Time — (V_{DD} = 25 V, I_D = 500 mA, R_{gen} = 50 Ohms) Figure 1	$t_{d(on)}$	—	10	ns
Turn-Off Delay Time — (V_{DD} = 25 V, I_D = 500 mA, R_{gen} = 50 Ohms) Figure 1	$t_{d(off)}$	—	10	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

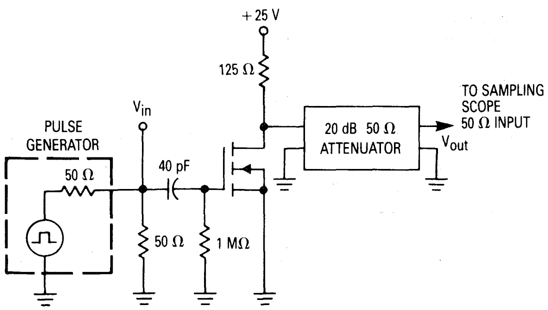
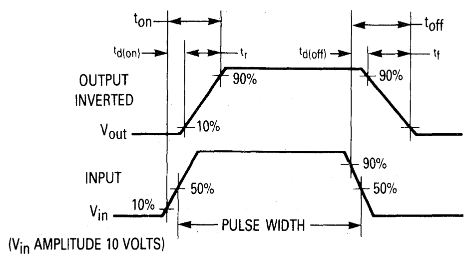


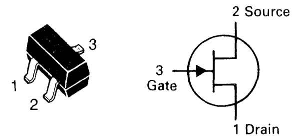
Figure 1. Switching Test Circuit

SWITCHING WAVEFORM



MMBF4391LT1 thru MMBF4393LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET SWITCHING TRANSISTORS

N-CHANNEL

★These are Motorola designated preferred devices.

Refer to MPF4391 for graphs.

4

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 FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF4391LT1 = 6J; MMBF4392LT1 = 6K; MMBF4393LT1 = 6G

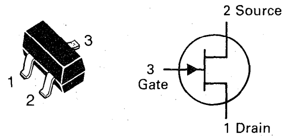
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

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		I_{GSS}			
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 25°C)			—	1.0	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)			—	0.20	μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	MMBF4391	$V_{GS(off)}$	−4.0	−10	Vdc
	MMBF4392		−2.0	−5.0	
	MMBF4393		−0.5	−3.0	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	MMBF4391	I_{DSS}	50	150	mAdc
	MMBF4392		25	75	
	MMBF4393		5.0	30	
Drain Current		I_D			
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)			—	1.0	nAdc
(V_{DS} = 15, V_{GS} = 12 Vdc, T_A = 100°C)			—	1.0	μAdc
Drain-Source On-Voltage		$V_{DS(on)}$			Vdc
(I_D = 12 mAdc, V_{GS} = 0)	MMBF4391		—	0.4	
(I_D = 6.0 mAdc, V_{GS} = 0)	MMBF4392		—	0.4	
(I_D = 3.0 mAdc, V_{GS} = 0)	MMBF4393		—	0.4	
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	MMBF4391	$r_{DS(on)}$	—	30	Ohms
	MMBF4392		—	60	
	MMBF4393		—	100	
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

Note: "LT1" must be used when ordering SOT-23 devices.

MMBF4416LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
VHF/UHF AMPLIFIER TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5484 for graphs.

4

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF4416LT1 = M6A

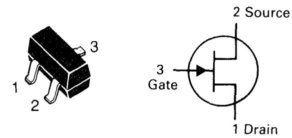
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

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} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)	I_{GSS}	 — —	 1.0 200	 nAdc nAdc
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
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{GS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	15	μAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	4500	7500	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	0.8	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, $R_g \approx$ 1000 Ω, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, $R_g \approx$ 1000 Ω, f = 400 MHz)	NF	 — —	 2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 400 MHz)	G_{ps}	 18 10	 — —	dB

4

MMBF4856LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
SWITCHING

N-CHANNEL — DEPLETION

★This is a Motorola designated preferred device.

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	V
Reverse Gate-Source Voltage	$V_{GS(R)}$	−25	V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF4856LT1 = AAA

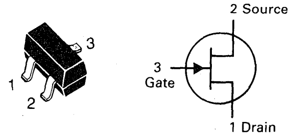
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (V_{DS} = 0, I_D = 1.0 μA)		$V_{(BR)GSS}$	−40	—	V
Gate Reverse Current (V_{DS} = 0 V, V_{GS} = 20 V)		I_{GSS}	—	0.5	nA
Gate Source Cutoff Voltage (V_{DS} = 15, I_D = 0.5 nA)		$V_{GS(OFF)}$	−4.0	−10	V
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{GS} = 0, V_{DS} = 15 V)		I_{DSS}	50	—	mA
Drain Cutoff Current (V_{DS} = 15 V, V_{GS} = 10 V)		$I_{D(off)}$	—	0.25	nA
Drain Source On Voltage (V_{GS} = 0, I_D = 20 mA)		$V_{DS(on)}$	—	0.75	V
Drain Source On Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)		$r_{DS(on)}$	—	25	Ω
Input Capacitance	V_{DS} = 0, V_{GS} = −10 V, f = 1.0 MHz	C_{iss}	—	18	pF
Reverse Transfer Capacitance		C_{rss}	—	8	
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	V_{DD} = 10 V, $I_{D(on)}$ = 20 mA, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 V	t_d	—	6	nS
Rise Time		t_r	—	3	
Turn-Off Time		t_{off}	—	25	

(1) Pulse Test; Pulse Width < 300 μs, Duty Cycle ≤ 2%.

MMBF4860LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
SWITCHING TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to MPF4391 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

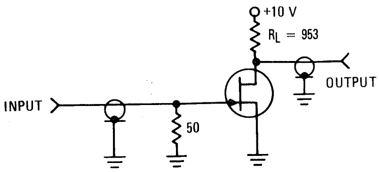
MMBF4860LT1 = M6F

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

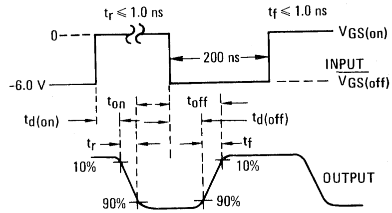
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current	I_{GSS}			
($V_{GS} = 15$ Vdc, $V_{DS} = 0$)		—	0.5	nAdc
($V_{GS} = 15$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)		—	2.0	μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 0.5$ nAdc)	$V_{GS(off)}$	−2.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	20	100	mAdc
Drain Cutoff Current	$I_{D(off)}$			
($V_{DS} = 15$ Vdc, $V_{GS} = 10$ Vdc)		—	0.25	nAdc
($V_{DS} = 15$ Vdc, $V_{GS} = 10$ Vdc, $T_A = 150°C$)		—	0.5	μAdc
Drain-Source On-Voltage ($I_D = 10$ mAdc, $V_{GS} = 0$)	$V_{DS(on)}$	—	0.5	Vdc
Static Drain-Source On Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)	$r_{DS(on)}$	—	40	Ohms
Input Capacitance ($V_{DS} = 0$, $V_{GS} = 10$ Vdc, f = 1.0 MHz)	C_{iss}	—	18	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 10$ Vdc, f = 1.0 MHz)	C_{rss}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time ($V_{DD} = 10$ Vdc, $I_{D(on)} = 20$ mAdc) ($V_{G(on)} = 0$, $V_{GS(off)} = 10$ Vdc)	t_d	—	6.0	ns
Rise Time ($V_{DD} = 10$ Vdc, $I_{D(on)} = 10$ mAdc) ($V_{GS(on)} = 0$, $V_{GS(off)} = 6.0$ Vdc) (Figure 1)	t_r	—	4.0	ns
Turn-Off Time ($V_{DD} = 10$ Vdc, $I_{D(on)} = 5.0$ mAdc) ($V_{GS(on)} = 0$, $V_{GS(off)} = 4.0$ Vdc) (Figure 1)	t_{off}	—	50	ns

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



TEST CIRCUIT



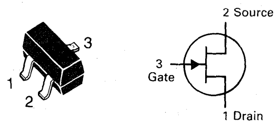
VOLTAGE WAVEFORMS

NOTES: 1. The input waveforms are supplied by a generator with the following characteristics:
Z_{out} = 50 ohms, Duty Cycle ≈ 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.

4

MMBF5457LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
GENERAL PURPOSE TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5457 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	$V_{GS(r)}$	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF5457LT1 = 6D

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

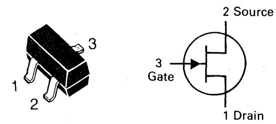
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current	I_{GSS}				nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0)		—	—	1.0	
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)		—	—	200	
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	$V_{GS(off)}$	0.5	—	−6.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 100 μAdc)	V_{GS}	—	−2.5	—	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	1.0	—	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	1000	—	5000	μmhos
Reverse Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{rs}\|$	—	10	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.5	3.0	pF

(1) Pulse test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

4

MMBF5459LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5457 for graphs.

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

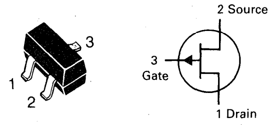
MMBF5459LT1 = 6L

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −10 μA, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	Vdc
Gate 1 Leakage Current (V_{GS} = −15 V, V_{DS} = 0)	I_{G1SS}	—	1.0	nA
Gate 2 Leakage Current (V_{GS} = −15 V, V_{DS} = 0, T_A = 100°C)	I_{G2SS}	—	200	nA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)	$V_{GS(off)}$	−2.0	−8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	I_{DSS}	4.0	16	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	2000	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}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	3.0	pF

MMBF5460LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
GENERAL PURPOSE
TRANSISTOR

P-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

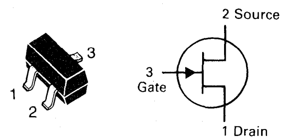
MMBF5460LT1 = 6E

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	—	—	Vdc
Gate Reverse Current	I_{GSS}				
(V_{GS} = 20 Vdc, V_{DS} = 0)		—	—	5.0	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)		—	—	1.0	μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	0.75	—	6.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.1 mAdc)	V_{GS}	0.5	—	4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	−1.0	—	−5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert Y_{fs} \rvert$	1000	—	4000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{os} \rvert$	—	—	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.0	2.0	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 MΩ, f = 100 Hz, BW = 1.0 Hz)	$\bar{e}_n$	—	20	—	$nV/\sqrt{Hz}$

MMBF5484LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5484 for graphs.

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
Continuous Device Dissipation at or Below T_C = 25°C Linear Derating Factor	P_D	200 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

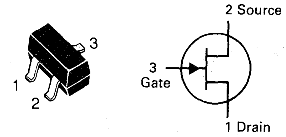
MMBF5484LT1 = 6B

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	—	Vdc
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	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (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 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	G_{ps}	16	25	dB

MMBF5486LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5484 for graphs.

4

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

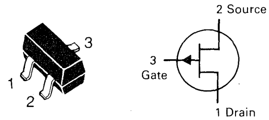
MMBF5486LT1 = 6H

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (V_{DS} = 0, I_G = −1.0 μA)	$V_{(BR)GSS}$	−25	—	Vdc
Gate 1 Leakage Current (V_{GS} = −20 V, V_{DS} = 0)	I_{G1SS}	—	−1.0	nA
Gate 2 Leakage Current (V_{GS} = −20 V, V_{DS} = 0, T_A = 100°C)	I_{G2SS}	—	−0.2	μA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)	$V_{GS(off)}$	−2.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{GS} = 0, V_{DS} = 15 V)	I_{DSS}	8.0	20	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{fs}\|$	4000	8000	μmhos
Input Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{is})$	—	1000	μmhos
Output Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{os}\|$	—	75	μmhos
Output Conductance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{os})$	—	100	μmhos
Forward Transconductance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{fs})$	3500	—	μmhos
Input Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Output Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure	NF			dB
(V_{DS} = 15 V, I_D = 4.0 mA, f = 100 MHz, Y_G = 1.0 μmhos)		—	2.0	
(V_{DS} = 15 V, I_D = 4.0 mA, R_G = 1.0 kΩ, f = 400 MHz, Y_G = 1.0 μmhos)		—	4.0	
(V_{GS} = 0, V_{DS} = 15 V, R_G = 1.0 mΩ, f = 1.0 kHz, Y_G = 1.0 μmhos)		—	2.5	
Common Source Power Gain	G_{ps}			dB
(V_{DS} = 15 V, I_D = 4.0 mA, f = 100 MHz)		18	30	
(V_{DS} = 15 V, I_D = 4.0 mA, f = 400 MHz)		10	20	

MMBFJ175LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
CHOPPER

P-CHANNEL — DEPLETION

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	V
Reverse Gate-Source Voltage	$V_{GS(r)}$	−25	V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBFJ175LT1 = 6W

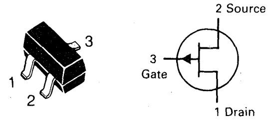
ELECTRICAL CHARACTERISTICS (T_A = 25°C, unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (V_{DS} = 0, I_D = 1.0 μA)		$V_{(BR)GSS}$	30	—	V
Gate Reverse Current (V_{DS} = 0 V, V_{GS} = 20 V)		I_{GSS}	—	1.0	nA
Gate Source Cutoff Voltage (V_{DS} = 15, I_D = 10 nA)		$V_{GS(OFF)}$	3.0	6.0	V
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{GS} = 0, V_{DS} = 15 V)		I_{DSS}	7.0	60	mA
Drain Cutoff Current (V_{DS} = 15 V, V_{GS} = 10 V)		$I_{D(off)}$	—	1.0	nA
Drain Source On Resistance (I_D = 500 μA)		$r_{DS(on)}$	—	125	Ω
Input Capacitance	V_{DS} = 0, V_{GS} = 10 V f = 1.0 MHz	C_{iss}	—	11	pF
Reverse Transfer Capacitance		C_{rss}	—	5.5	

(1) Pulse Test; Pulse Width < 300 μs, Duty Cycle ≤ 2%.

MMBFJ177LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
CHOPPER

P-CHANNEL — DEPLETION

★This is a Motorola designated preferred device.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	V
Reverse Gate-Source Voltage	$V_{GS(r)}$	−25	V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBFJ175LT1 = 6W

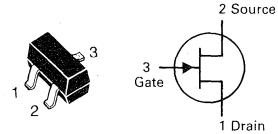
ELECTRICAL CHARACTERISTICS (T_A = 25°C, unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (V_{DS} = 0, I_D = 1.0 μA)		$V_{(BR)GSS}$	30	—	V
Gate Reverse Current (V_{DS} = 0 V, V_{GS} = 20 V)		I_{GSS}	—	1.0	nA
Gate Source Cutoff Voltage (V_{DS} = 15, I_D = 10 nA)		$V_{GS(OFF)}$	0.8	2.5	V
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{GS} = 0, V_{DS} = 15 V)		I_{DSS}	1.5	20	mA
Drain Cutoff Current (V_{DS} = 15 V, V_{GS} = 10 V)		$I_{D(off)}$	—	1.0	nA
Drain Source On Resistance (I_D = 500 μA)		$r_{DS(on)}$	—	300	Ω
Input Capacitance	V_{DS} = 0, V_{GS} = 10 V, f = 1.0 MHz	C_{iss}	—	11	pF
Reverse Transfer Capacitance		C_{rss}	—	5.5	pF

(1) Pulse Test; Pulse Width < 300 μs, Duty Cycle ≤ 2%.

MMBFJ309LT1★
MMBFJ310LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
VHF/UHF AMPLIFIER
TRANSISTOR

N-CHANNEL

★These are Motorola designated preferred devices.

Refer to J309 for graphs.

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBFJ309LT1 = 6U; MMBFJ310LT1 = 6T

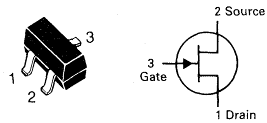
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 V) (V_{GS} = −15 V, T_A = 125°C)		I_{GSS}	 — —	 — —	 −1.0 −1.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 nAdc)	MMBFJ309 MMBFJ310	$V_{GS(off)}$	−1.0 −2.0	—	−4.0 −6.5	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0)	MMBFJ309 MMBFJ310	I_{DSS}	12 24	—	30 60	mAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		$V_{GS(f)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)		$\|Y_{fs}\|$	8.0	—	18	mmhos
Output Admittance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)		$\|y_{os}\|$	—	—	250	μmhos
Input Capacitance (V_{GS} = −10 Vdc, V_{DS} = 0 Vdc, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = −10 Vdc, V_{DS} = 0 Vdc, f = 1.0 MHz)		C_{rss}	—	—	2.5	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 Hz)		$\bar{e}_n$	—	10	—	nV/√Hz

Note: "LT1" must be used when ordering SOT-23 devices.

MMBFU310LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to J310 for graphs.

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

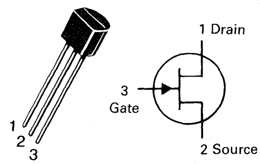
MMBFU310LT1 = 6C

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	—	Vdc
Gate 1 Leakage Current (V_{GS} = −15 V, V_{DS} = 0)	I_{G1SS}	–	−150	pA
Gate 2 Leakage Current (V_{GS} = −15 V, V_{DS} = 0, T_A = 125°C)	I_{G2SS}	—	−150	nA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 nA)	$V_{GS(off)}$	−2.5	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	I_{DSS}	24	60	mA
Gate-Source Forward Voltage (I_G = 10 mA, V_{DS} = 0)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	$\|Y_{fs}\|$	10	18	mmhos
Output Admittance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	$\|y_{os}\|$	—	250	μmhos
Input Capacitance (V_{GS} = −10 V, V_{DS} = 10 V, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = −10 V, V_{DS} = 10 V, f = 1.0 MHz)	C_{rss}	—	2.5	pF

MPF102

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N5484 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°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

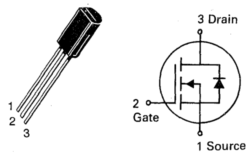
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−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}	 — —	 −2.0 −2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 2.0 nAdc)	$V_{GS(off)}$	—	−8.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.2 mAdc)	V_{GS}	−0.5	−7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	2.0	20	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\|y_{fs}\|$	 2000 1600	 7500 —	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	—	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	—	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	3.0	pF

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

MPF910

MPF910
CASE 29-03, STYLE 22
TO-92 (TO-226AE)



TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to MPF6659 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Gate-Source Voltage	V_{GS}	±15	Vdc
Drain Current — Continuous(1) Pulsed(2)	I_D I_{DM}	0.5 1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C MPF910	P_D	1.0 8.0	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C MFE910	P_D	6.25 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

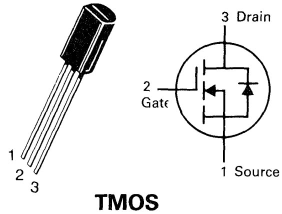
(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 40 V, V_{GS} = 0)	I_{DSS}	—	0.1	10	μAdc
Gate Reverse Current (V_{GS} = 10 V, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	90	—	Vdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.3	1.5	2.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 500 mA)	$V_{DS(on)}$	—	—	2.5	Vdc
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)	$I_{D(on)}$	500	—	—	mA
Forward Transconductance (V_{DS} = 15 V, I_D = 500 mA)	g_{fs}	100	—	—	mmhos

MPF930★
MPF960★
MPF990★

CASE 29-03, STYLE 22
TO-92 (TO-226AE)



TMOS SWITCHING

N-CHANNEL — ENHANCEMENT

★These are Motorola designated preferred devices.

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					Adc
Continuous (1)	I_D		2.0		
Pulsed (2)	I_{DM}		3.0		
Total Device Dissipation	P_D				
@ T_A = 25°C			1.0		Watts
Derate above 25°C			8.0		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 ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage		$V_{(BR)DSX}$				Vdc
(V_{GS} = 0, I_D = 10 μA)	MPF930		35	—	—	
	MPF960		60	—	—	
	MPF990		90	—	—	
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})		$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V)		$V_{DS(on)}$				Vdc
(I_D = 0.5 A)	MPF930		—	0.4	0.7	
	MPF960		—	0.6	0.8	
	MPF990		—	0.6	1.2	
(I_D = 1.0 A)	MPF930		—	0.9	1.4	
	MPF960		—	1.2	1.7	
	MPF990		—	1.2	2.4	
(I_D = 2.0 A)	MPF930		—	2.2	3.0	
	MPF960		—	2.8	3.5	
	MPF990		—	2.8	4.8	
Static Drain-Source On Resistance		$r_{DS(on)}$				Ohms
(V_{GS} = 10 Vdc, I_D = 1.0 Adc)	MPF930		—	0.9	1.4	
	MPF960		—	1.2	1.7	
	MPF990		—	1.2	2.0	
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	70	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	20	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	49	—	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 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

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

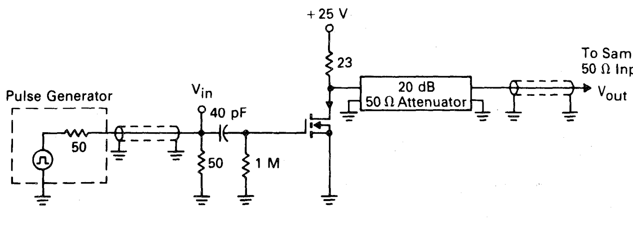


FIGURE 2 — SWITCHING WAVEFORMS

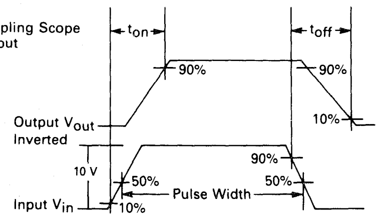


FIGURE 3 — ON VOLTAGE versus TEMPERATURE.

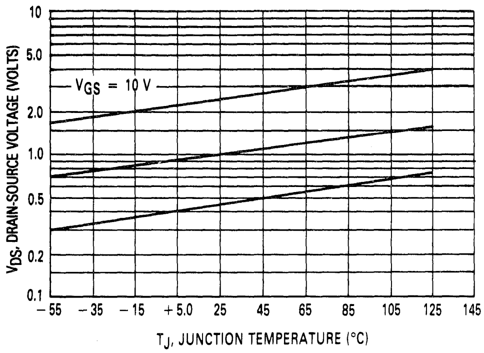


FIGURE 4 — CAPACITANCE VARIATION

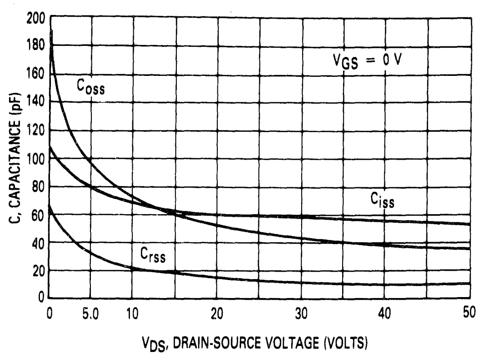


FIGURE 5 — TRANSFER CHARACTERISTIC

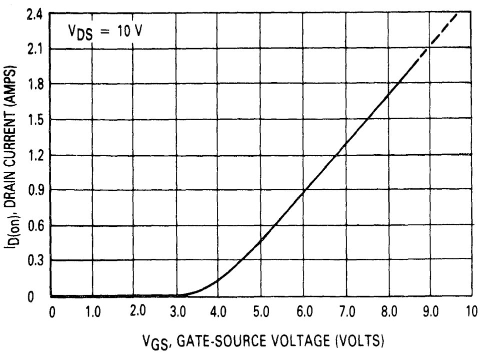


FIGURE 6 — OUTPUT CHARACTERISTIC

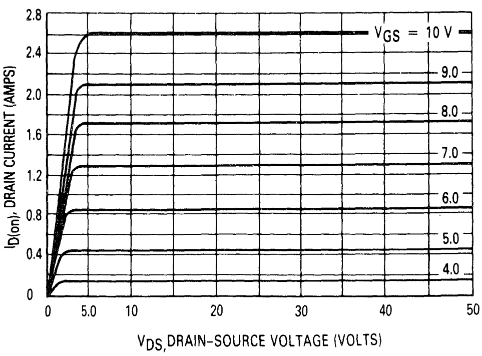
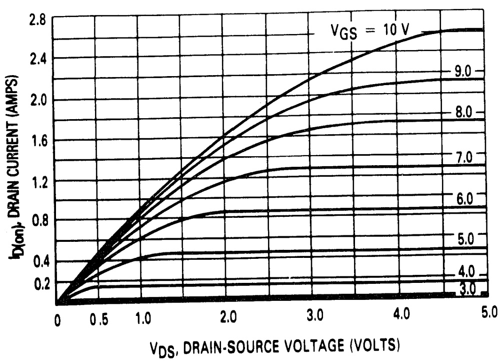


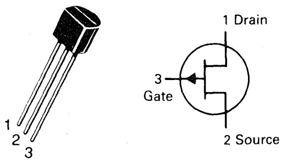
FIGURE 7 — SATURATION CHARACTERISTIC



4

MPF970
MPF971

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET SWITCHING

P-CHANNEL — DEPLETION

4

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 @ T_A = 25°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°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	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°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} = 12 Vdc, T_A = 150°C) (V_{DS} = 15 Vdc, V_{GS} = 7.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 7.0 Vdc, T_A = 150°C)	 MPF970 MPF970 MPF971 MPF971	$I_{D(off)}$	 — — — —	 — — — —	 10 10 10 10	 nAdc μAdc nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 MPF970 MPF971	$V_{GS(off)}$	 5.0 1.0	 — —	 12 7.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	 MPF970 MPF971	I_{DSS}	 −15 −2.0	 — —	 −100 −50	mAdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 0) (I_D = 1.5 mAdc, V_{GS} = 0)		$V_{DS(on)}$	 — —	 — —	 1.5 1.5	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 MPF970 MPF971	$r_{DS(on)}$	 — —	 — —	 100 250	Ohms
SMALL-SIGNAL CHARACTERISTICS						
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 MPF970 MPF971	$r_{ds(on)}$	 — —	 — —	 100 250	Ohms
Input Capacitance (V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz) (V_{GS} = 7.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	 MPF970 MPF971	C_{iss}	 — —	 — —	 12 12	pF
Reverse Transfer Capacitance (V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz) (V_{GS} = 7.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	 MPF970 MPF971	C_{rss}	 — —	 — —	 5.0 5.0	pF

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

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS (See Figure 6, R_K = 0) (1)						
Rise Time		t_r				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	2.0	5.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	3.0	5.0	
Fall Time		t_f				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	9.0	15	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	68	80	
Turn-On Time		t_{on}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	3.5	8.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	5.0	10	
Turn-Off Time		t_{off}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	13	25	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	88	120	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

FIGURE 1 – EFFECT OF I_{DSS} ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE

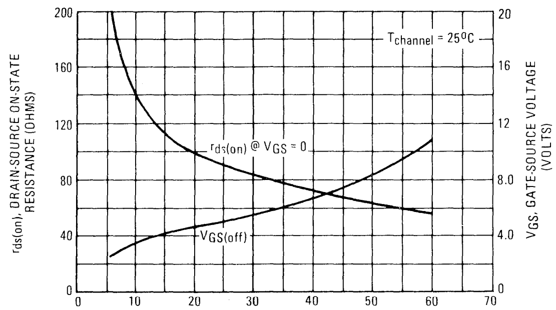


FIGURE 2 – TURN-ON DELAY TIME

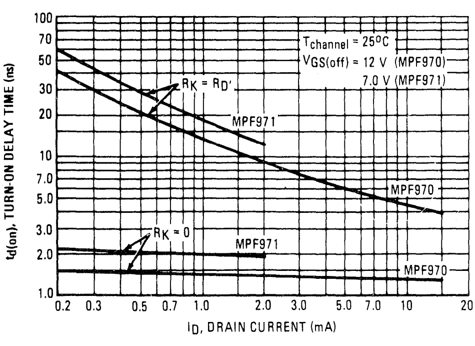


FIGURE 3 – RISE TIME

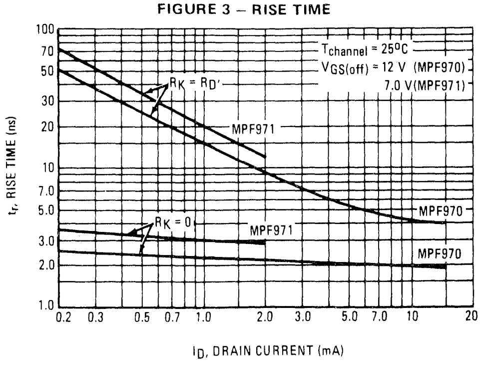


FIGURE 4 – TURN-OFF DELAY TIME

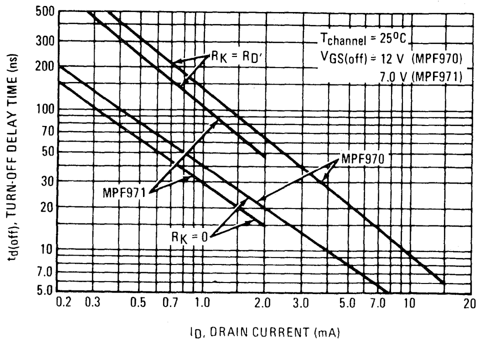
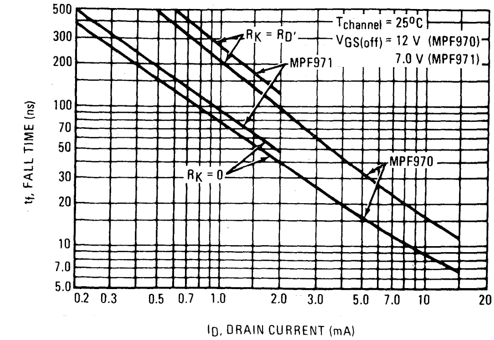
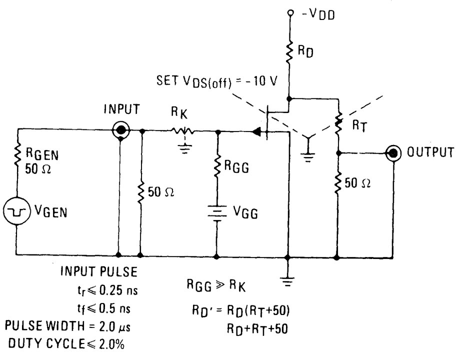


FIGURE 5 – FALL TIME



4

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

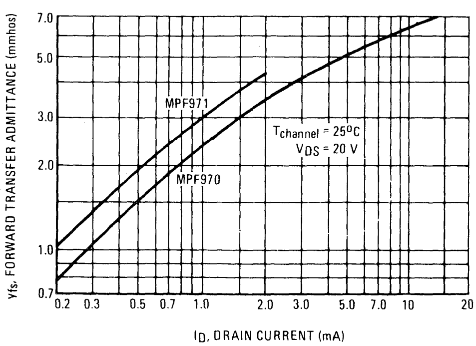


FIGURE 8 – TYPICAL CAPACITANCE

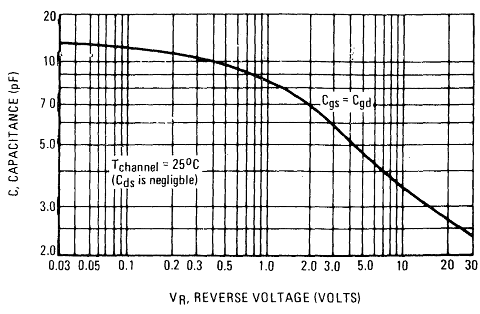


FIGURE 9 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

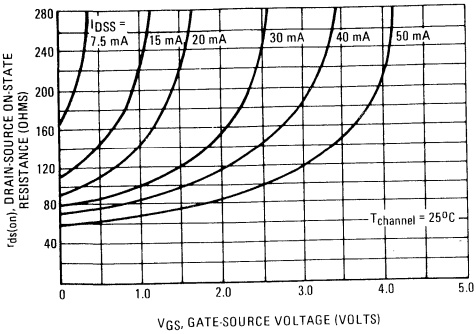


FIGURE 10 – EFFECT OF TEMPERATURE ON DRAIN-SOURCE ON-STATE RESISTANCE

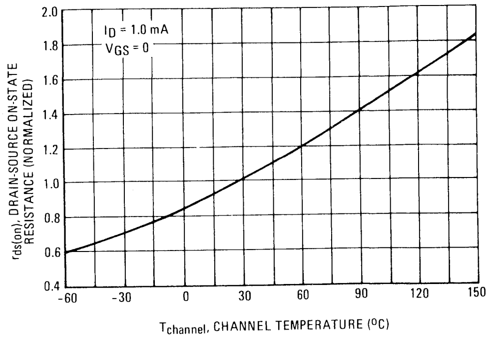
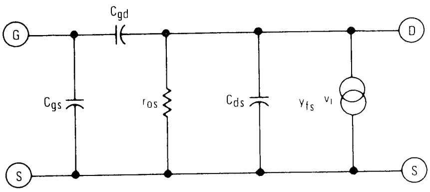


FIGURE 11 – LOW FREQUENCY CIRCUIT MODEL

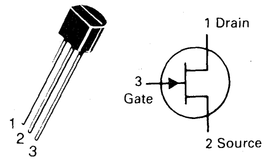


$y_{is} = j\omega C_{iss}$
$y_{os} = 1/r_{oss} + j\omega C_{oss}$
$y_{fs} = y_{fs}$
$y_{rs} = -j\omega C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds}, C_{ds} \approx 0$

MPF3821
MPF3822

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
GENERAL PURPOSE

N-CHANNEL — DEPLETION

Refer to 2N5457 for graphs.

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°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Temperature Range	T_{stg}	−65 to 150	°C

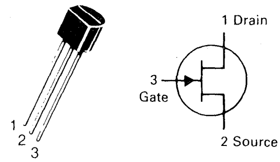
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−50	—	Vdc
Gate Reverse Current (V_{GS} = −30 Vdc, V_{DS} = 0) (V_{GS} = −30 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 −0.1 −100	nAdc
Gate Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 15 Vdc)	 MPF3821 MPF3822	$V_{GS(off)}$	 — —	 −4.0 −6.0	Vdc
Gate Source Voltage (I_D = 50 μAdc, V_{DS} = 15 Vdc) (I_D = 200 μAdc, V_{DS} = 15 Vdc)	 MPF3821 MPF3822	V_{GS}	 −0.5 −1.0	 −2.0 −4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 MPF3821 MPF3822	I_{DSS}	 0.5 2.0	 2.5 10	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 MPF3821 MPF3822 MPF3821 MPF3822	$\lvert y_{fs} \rvert$	 1500 3000 1500 3000	 4500 6500 — —	μmhos
Output Admittance(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 MPF3821 MPF3822	$\lvert y_{os} \rvert$	 — —	 10 20	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	3.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 megohm, f = 10 Hz, Noise Bandwidth = 5.0 Hz)		NF	—	5.0	dB
Equivalent Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 10 Hz, Noise Bandwidth = 5.0 Hz)		e_n	—	200	nv/Hz$^{1/2}$

(1) Pulse Test: Pulse Width ≤ 100 ms, Duty Cycle ≤ 10%.

MPF4392★
MPF4393★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFETs
SWITCHING

N-CHANNEL — DEPLETION

★MPF4392 and MPF4393 are Motorola designated preferred devices.

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 @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	−65 to +150	°C

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	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 0.2	 nAdc µAdc
Drain Cutoff Current ($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc) ($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc, $T_A = 100°C$)		$I_{D(off)}$	 — —	 — —	 1.0 0.1	 nAdc µAdc
Gate Source Voltage ($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	 MPF4392 MPF4393	V_{GS}	 −2.0 −0.5	 — —	 −5.0 −3.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	 MPF4392 MPF4393	I_{DSS}	 25 5.0	 — —	 75 30	mAdc
Drain-Source On-Voltage ($I_D = 6.0$ mAdc, $V_{GS} = 0$) ($I_D = 3.0$ mAdc, $V_{GS} = 0$)	 MPF4392 MPF4393	$V_{DS(on)}$	 — —	 — —	 0.4 0.4	Vdc
Static Drain-Source On Resistance ($I_D = 1.0$ mAdc, $V_{GS} = 0$)	 MPF4392 MPF4393	$r_{DS(on)}$	 — —	 — —	 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $I_D = 25$ mAdc, f = 1.0 kHz) ($V_{DS} = 15$ Vdc, $I_D = 5.0$ mAdc, f = 1.0 kHz)	 MPF4392 MPF4393	$\|y_{fs}\|$	 — —	 17 12	 — —	mmhos
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)	 MPF4392 MPF4393	$r_{ds(on)}$	 — —	 — —	 60 100	Ohms
Input Capacitance ($V_{GS} = 15$ Vdc, $V_{DS} = 0$, f = 1.0 MHz)		C_{iss}	—	6.0	10	pF

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

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Transfer Capacitance		C_{rss}				pF
(V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz)			–	2.5	3.5	
(V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)			–	3.2	–	
SWITCHING CHARACTERISTICS						
Rise Time (See Figure 2)		t_r				ns
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		–	2.0	5.0	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		–	2.5	5.0	
Fall Time (See Figure 4)		t_f				ns
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		–	15	20	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		–	29	35	
Turn-On Time (See Figures 1 and 2)		t_{on}				ns
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		–	4.0	15	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		–	6.5	15	
Turn-Off Time (See Figures 3 and 4)		t_{off}				ns
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		–	20	35	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		–	37	55	

4

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 — TURN-ON DELAY TIME

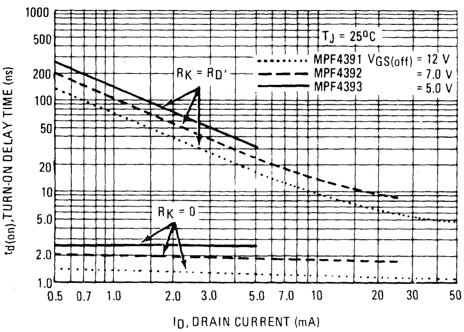


FIGURE 2 — RISE TIME

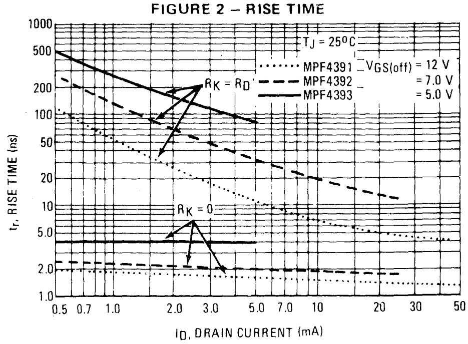


FIGURE 3 — TURN-OFF DELAY TIME

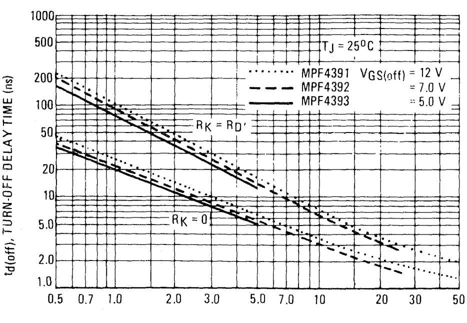
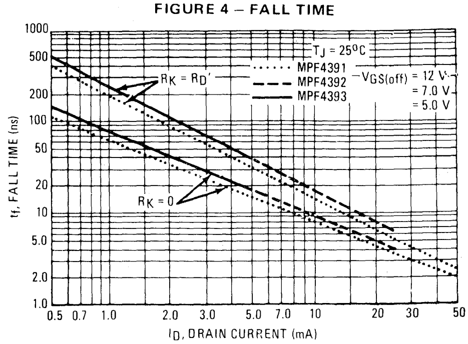
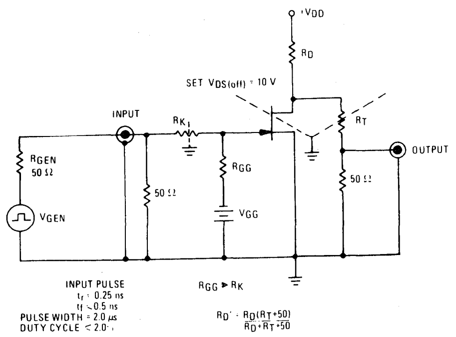


FIGURE 4 — FALL TIME



4

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

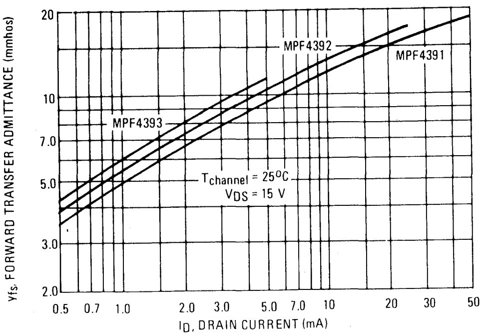


FIGURE 7 – TYPICAL CAPACITANCE

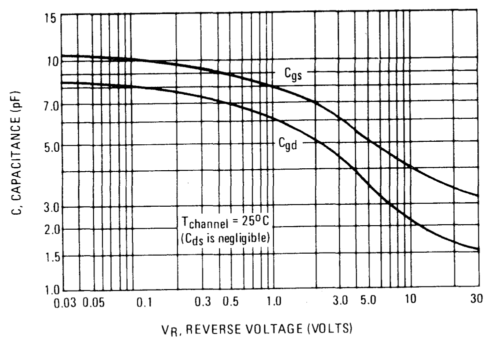


FIGURE 8 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

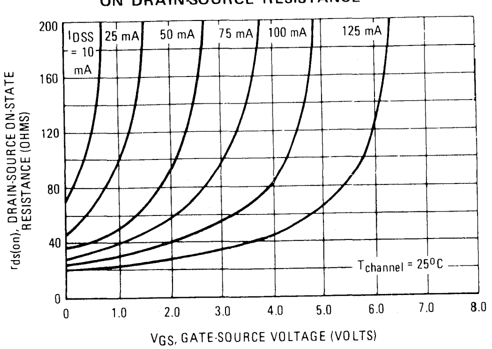


FIGURE 9 – EFFECT OF TEMPERATURE ON DRAIN–SOURCE ON-STATE RESISTANCE

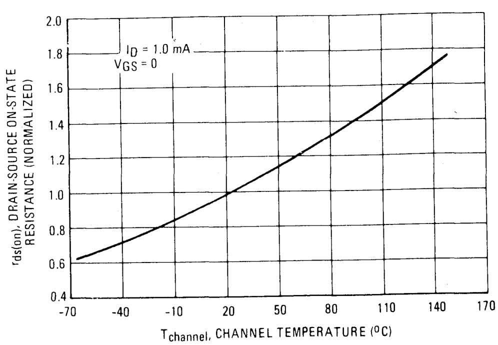
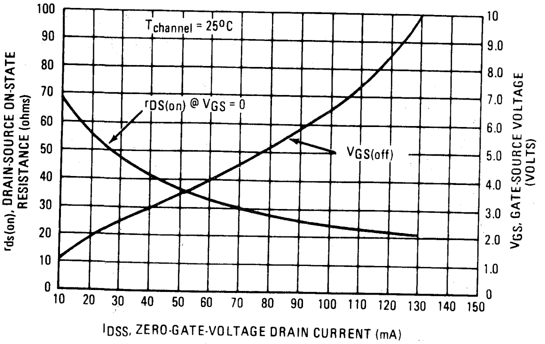


FIGURE 10 – EFFECT OF IDSS ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE



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 ±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

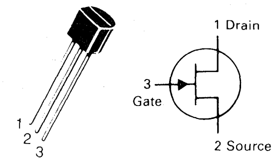
$r_{ds(on)}$ and V_{GS} range for an MPF4392

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.

4

MPF4856
thru
MPF4861★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
SWITCHING

N-CHANNEL — DEPLETION

★These are Motorola preferred devices.

Refer to MPF4391 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	MPF4856 MPF4857 MPF4858	MPF4859 MPF4860 MPF4861	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 +150		°C

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage		$V_{(BR)GSS}$			Vdc
(I_G = 1.0 μAdc, V_{DS} = 0)	MPF4856, MPF4857, MPF4858		−40	—	
	MPF4859, MPF4860, MPF4861		−30	—	
Gate Reverse Current		I_{GSS}			
(V_{GS} = −20 Vdc, V_{DS} = 0)	MPF4856, MPF4857, MPF4858		—	0.25	nAdc
(V_{GS} = −15 Vdc, V_{DS} = 0)	MPF4859, MPF4860, MPF4861		—	0.25	
(V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 150°C)	MPF4856, MPF4857, MPF4858		—	0.5	μAdc
(V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 150°C)	MPF4859, MPF4860, MPF4861		—	0.5	
Gate Source Cutoff Voltage		$V_{GS(off)}$			Vdc
(V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	MPF4856, MPF4859		−4.0	−10	
	MPF4857, MPF4860		−2.0	−6.0	
	MPF4858, MPF4861		−0.8	−4.0	
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 15 Vdc, V_{GS} = −10 Vdc)			—	0.25	nAdc
(V_{DS} = 15 Vdc, V_{GS} = −10 Vdc, T_A = 150°C)			—	0.5	μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1)		I_{DSS}			mAdc
(V_{DS} = 15 Vdc, V_{GS} = 0)	MPF4856, MPF4859		50	—	
	MPF4857, MPF4860		20	100	
	MPF4858, MPF4861		8.0	80	
Drain-Source On-Voltage		$V_{DS(on)}$			Vdc
(I_D = 20 mAdc, V_{GS} = 0)	MPF4856, MPF4859		—	0.75	
(I_D = 10 mAdc, V_{GS} = 0)	MPF4857, MPF4860		—	0.5	
(I_D = 5.0 mAdc, V_{GS} = 0)	MPF4858, MPF4861		—	0.5	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MPF4856, MPF4859		—	25	
	MPF4857, MPF4860		—	40	
	MPF4858, MPF4861		—	60	
Input Capacitance		C_{iss}			pF
(V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	MPF4856 thru MPF4861		—	18	
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	MPF4856 thru MPF4861		—	8.0	

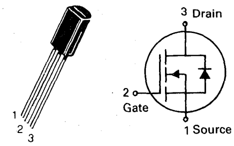
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	Conditions for MPF4856, MPF4859: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc)	MPF4856, MPF4859	$t_{d(on)}$	—	6.0	ns
		MPF4857, MPF4860		—	6.0	
		MPF4858, MPF4861		—	10	
Rise Time	Conditions for MPF4857, MPF4860: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −6.0 Vdc)	MPF4856, MPF4859	t_r	—	3.0	ns
		MPF4857, MPF4860		—	4.0	
		MPF4858, MPF4861		—	10	
Turn-Off Time	Conditions for MPF4858, MPF4861: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −4.0 Vdc)	MPF4856, MPF4859	t_{off}	—	25	ns
		MPF4857, MPF4860		—	50	
		MPF4858, MPF4861		—	100	

4

MPF6659 thru MPF6661★

CASE 29-05, STYLE 22
TO-92 (TO-226AE)



TMOS FET TRANSISTORS

N-CHANNEL — ENHANCEMENT

★MPF6660 and MPF6661 are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	MPF6659	MPF6660	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)	I_D		2.0		Adc
Pulsed (2)	I_{DM}		3.0		
Total Device Dissipation @ T_C = 25°C	P_D		2.5		Watts
Derate above 25°C			20		mW/°C
Total Device Dissipation @ T_A = 25°C	P_D		1.0		Watts
Derate above 25°C			8.0		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°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 15 V, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	MPF6659	$V_{(BR)DSX}$	35	—	—	Vdc
	MPF6660		60	—	—	
	MPF6661		90	—	—	
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(Th)}$	0.8	1.4	2.0	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 1.0 A)	MPF6659	$V_{DS(on)}$	—	—	1.8	Vdc
	MPF6660		—	—	3.0	
	MPF6661		—	—	4.0	
(V_{GS} = 5.0 V, I_D = 0.3 A)	MPF6659		—	0.8	1.5	
	MPF6660		—	0.9	1.5	
	MPF6661		—	0.9	1.6	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	MPF6659	$r_{DS(on)}$	—	—	1.8	Ohms
	MPF6660		—	—	3.0	
	MPF6661		—	—	4.0	
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	30	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	3.6	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	20	—	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	170	—	—	mmhos

ELECTRICAL CHARACTERISTICS (T_A = 25°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 ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

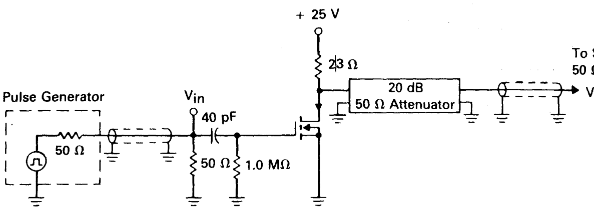


FIGURE 2 — SWITCHING WAVEFORMS

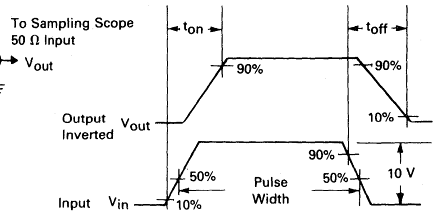


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

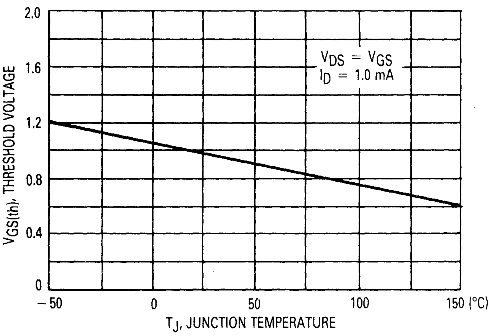


FIGURE 4 — ON-REGION CHARACTERISTICS

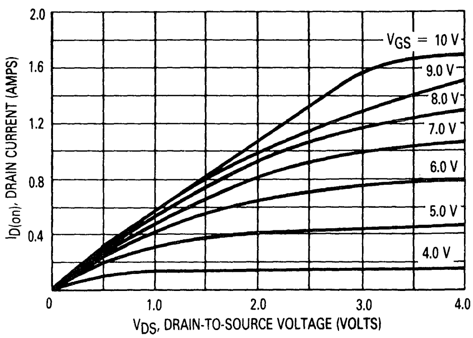


FIGURE 5 — OUTPUT CHARACTERISTICS

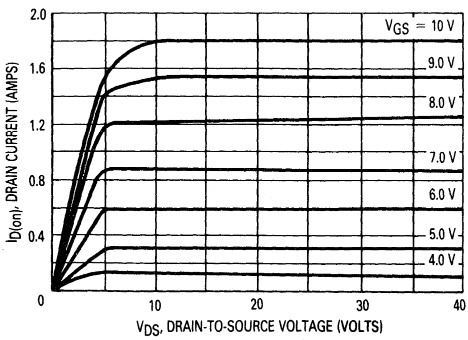


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE

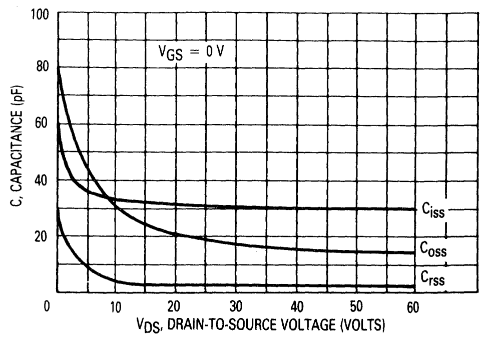
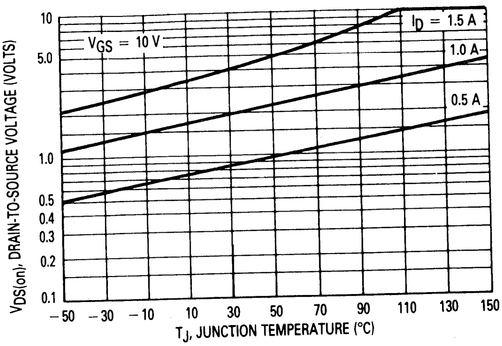


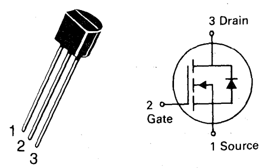
FIGURE 7 — ON-VOLTAGE versus TEMPERATURE



4

VN0300L★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	V
Drain-Gate Voltage	V_{DGR}	60	V
Gate-Source Voltage	V_{GS}	−40	V
Continuous Drain Current	I_D	200	mA
Pulsed Drain Current	I_{DM}	500	mA
Power Dissipation @ T_C = 25°C	P_D	350	mW
Derate above 25°C		2.8	mW/°C
Operating and Storage Temperature	T_J, T_{stg}		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

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

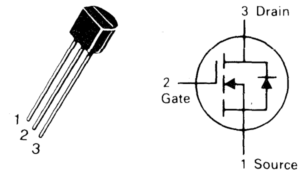
Characteristic	Symbol	Min	Max	Unit
STATIC CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	$V_{(BR)DSS}$	30	—	V
Zero Gate Voltage Drain Current	I_{DSS}			μA
(V_{DS} = 48 V, V_{GS} = 0)		—	10	
(V_{DS} = 48 V, V_{GS} = 0, T_A = 125 °C)		—	500	
Gate-Body Leakage (V_{DS} = 0, V_{GS} = ±30 V)	I_{GSS}		±100	nA
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	2.5	V
On-State Drain Current* (V_{DS} = V_{GS}, I_D = 1.0 mA)	$I_{D(on)}$	1.0	—	A
Drain-Source On Resistance*	$r_{DS(on)}$			Ω
(V_{GS} = 5.0 V, I_D = 0.3 A)		—	3.3	
(V_{GS} = 10 V, I_D = 1.0 A)		—	1.2	
Forward Transconductance* (V_{DS} = 10 V, I_D = 0.5 A)	g_{fs}	200	—	mS

Characteristic	Conditions	Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS					
Input Capacitance	V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz	C_{iss}	—	100	pF
Output Capacitance		C_{oss}	—	95	
Reverse Transfer Capacitance		C_{rss}	—	25	
SWITCHING CHARACTERISTICS					
Turn-On Time	V_{DD} = 25 V, I_D = 1.0 A, R_L = 24 Ω, RG = 25 Ω	t_{on}	—	30	ns
Turn-Off Time		t_{off}	—	30	

* Pulse Test; Pulse width < 300 μs, Duty Cycle ≤ 2%

VN0610LL★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

Refer to BS170 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	60	Vdc
Gate-Source Voltage	V_{GS}	±40	Vdc
Drain Current Continuous Pulsed	 I_D I_{DM}	 190 1000	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 3.2	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

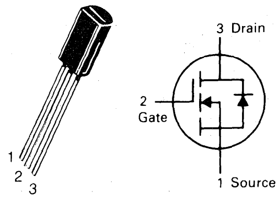
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 48 V, V_{GS} = 0) (V_{DS} = 48 V, V_{GS} = 0, T_J = 125°C)	I_{DSS}	 — —	 10 500	μAdc
Gate-Body Leakage Current, Forward (V_{GSF} = 30 Vdc, V_{DS} = 0)	I_{GSSF}	—	−100	nAdc
ON CHARACTERISTICS*				
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	2.5	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 500 mA) (V_{GS} = 10 Vdc, I_D = 500 mA, T_C = 125°C)	$r_{DS(on)}$	 — —	 5.0 9.0	Ohm
Drain-Source On-Voltage (V_{GS} = 5.0 V, I_D = 200 mA) (V_{GS} = 10 V, I_D = 500 mA)	$V_{DS(on)}$	 — —	 1.5 2.5	Vdc
On-State Drain Current (V_{GS} = 10 V, $V_{DS} \geq 2.0\ V_{DS(on)}$)	$I_{D(on)}$	750	—	mA
Forward Transconductance ($V_{DS} \geq 2.0\ V_{DS(on)}$, I_D = 500 mA)	g_{fs}	100	—	μmhos
DYNAMIC CHARACTERISTICS				
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	25	
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	5.0	
SWITCHING CHARACTERISTICS*				
Turn-On Delay Time (V_{DD} = 15 V, I_D = 600 mA, R_{gen} = 25 ohms, R_L = 23 ohms)	t_{on}	—	10	ns
Turn-Off Delay Time (V_{DD} = 15 V, I_D = 600 mA, R_{gen} = 25 ohms, R_L = 23 ohms)	t_{off}	—	10	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

VN10LM

CASE 29-05, STYLE 22
TO-92 (TO-226AE)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current — Continuous(1) Pulsed(2)	I_D I_{DM}	0.3 1.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−40 to +150	°C

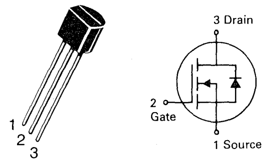
(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle.

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)	$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 45 V, V_{GS} = 0)	I_{DSS}	—	0.1	10	μAdc
Gate-Body Leakage Current (V_{GS} = −15 V, V_{DS} = 0)	$I_{GSS}1$	—	—	100	nAdc
Gate-Body Leakage Current (V_{GS} = 15 V, V_{DS} = 0)	$I_{GSS}2$	—	—	−100	nAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	—	2.5	Vdc
On-State Drain Current (V_{DS} = 15 V, V_{GS} = 10 V)	$I_{D(on)}$	750	—	—	mA
Forward Transconductance (V_{DS} = 15 V, I_D = 500 mA)	g_{fs}	200	—	—	mmhos
Drain-Source On-Voltage (V_{GS} = 5.0 V, I_D = 200 mA)	$V_{DS(on)}1$	—	—	1.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 500 mA)	$V_{DS(on)}2$	—	—	2.5	Vdc
Drain-Source On-Resistance (V_{GS} = 5.0 V, I_D = 200 mA)	$r_{DS(on)}1$	—	—	7.5	Ω
Drain-Source On-Resistance (V_{GS} = 10 V, I_D = 500 mA)	$r_{DS(on)}2$	—	—	5.0	Ω
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	—	60	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	—	25	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{rss}	—	—	5.0	pF
Turn-On Time (V_{DS} = 15 V, R_L = 23 Ω, R_G = 50 Ω, V_{in} = 20 V)	t_{on}	—	—	10	ns
Turn-Off Time (V_{DS} = 15 V, R_L = 23 Ω, R_G = 50 Ω, V_{in} = 20 V)	t_{off}	—	—	10	ns

VN1706L★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	V
Drain-Gate Voltage	V_{DGR}	60	V
Gate-Source Voltage	V_{GS}	−40	V
Continuous Drain Current	I_D	200	mA
Pulsed Drain Current	I_{DM}	500	mA
Power Dissipation @ T_C = 25°C	P_D	350	mW
Derate above 25°C		2.8	mW/°C
Operating and Storage Temperature	T_J, T_{stg}	—	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

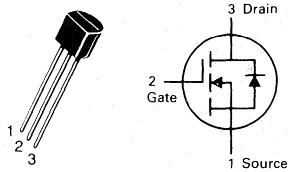
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
STATIC CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)		$V_{(BR)DSS}$	170	—	V
Zero Gate Voltage Drain Current		I_{DSS}			μA
(V_{DS} = 120 V, V_{GS} = 0)			—	10	
(V_{DS} = 120 V, V_{GS} = 0, T_A = 125 °C)			—	500	
Gate-Body Leakage (V_{DS} = 0, V_{GS} = ±15 V)		I_{GSS}	—	±100	nA
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(th)}$	0.8	2.0	V
On-State Drain Current* (V_{GS} = 10 V, V_{DS} ≥ 2.0 $V_{DS(on)}$)		$I_{D(on)}$	1.0	—	A
Drain-Source On Resistance*		$r_{DS(on)}$			Ω
(V_{GS} = 2.5 V, I_D = 0.1 A)			—	10	
(V_{GS} = 10 V, I_D = 0.5 A)			—	6.0	
Forward Transconductance* (V_{DS} = 10 V, I_D = 0.5 A)		g_{fs}	300	—	mS
DYNAMIC CHARACTERISTICS					
Input Capacitance	V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz	C_{iss}	—	125	pF
Output Capacitance		C_{oss}	—	50	
Reverse Transfer Capacitance		C_{rss}	—	20	
SWITCHING CHARACTERISTICS					
Turn-On Time	V_{DD} = 60 V, I_D = 0.1 A, R_L = 150 Ω, R_G = 25 Ω	$t_{(on)}$	—	8.0	ns
		t_r	—	8.0	
Turn-Off Time		$t_{(off)}$	—	18	
		$t_{(f)}$	—	12	

* Pulse Test; Pulse width < 300 μs, Duty Cycle ≤ 2%

VN2222LL★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	60	Vdc
Gate-Source Voltage	V_{GS}	±40	Vdc
Drain Current Continuous Pulsed	 I_D I_{DM}	 150 1000	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 3.2	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)		$V_{(BR)DSS}$	60	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 48 V, V_{GS} = 0) (V_{DS} = 48 V, V_{GS} = 0, T_J = 125°C)		I_{DSS}	 — —	 10 500	μAdc
Gate-Body Leakage Current, Forward (V_{GSF} = 30 Vdc, V_{DS} = 0)		I_{GSSF}	—	−100	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(th)}$	0.6	2.5	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 0.5 Adc) (V_{GS} = 10 Vdc, I_D = 0.5 V, T_C = 125°C)		$r_{DS(on)}$	 — —	 7.5 13.5	Ohm
Drain-Source On-Voltage (V_{GS} = 5.0 V, I_D = 200 mA) (V_{GS} = 10 V, I_D = 500 mA)		$V_{DS(on)}$	 — —	 1.5 3.75	Vdc
On-State Drain Current (V_{GS} = 10 Vdc, V_{DS} ≥ 2.0 $V_{DS(on)}$)		$I_{D(on)}$	750	—	mA
Forward Transconductance (V_{DS} = 10 V, I_D = 500 mA)		g_{fs}	100	—	μmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0 f = 1.0 MHz)	C_{iss}	—	60	pF
Output Capacitance		C_{oss}	—	25	
Reverse Transfer Capacitance		C_{rss}	—	5.0	
SWITCHING CHARACTERISTICS*					
Turn-On Delay Time	(V_{DD} = 15 V, I_D = 600 mA R_{gen} = 25 ohms, R_L = 23 ohms)	t_{on}	—	10	ns
Turn-Off Delay Time		t_{off}	—	10	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

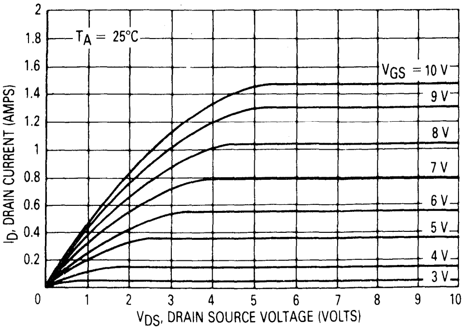


Figure 1. Ohmic Region

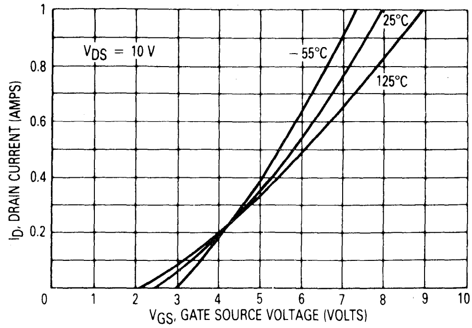


Figure 2. Transfer Characteristics

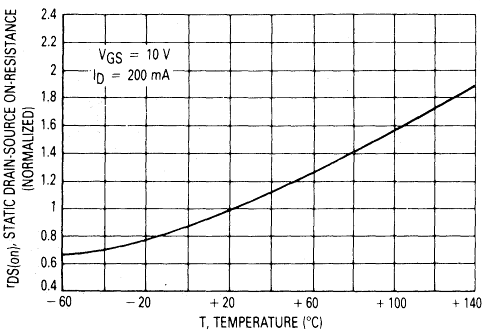


Figure 3. Temperature versus Static Drain-Source On-Resistance

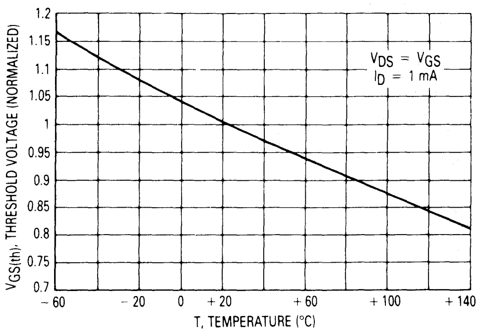
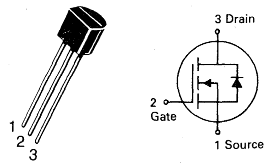


Figure 4. Temperature versus Gate Threshold Voltage

VN2406L★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	V
Drain-Gate Voltage	V_{DGR}	60	V
Gate-Source Voltage	V_{GS}	−40	V
Continuous Drain Current	I_D	200	mA
Pulsed Drain Current	I_{DM}	500	mA
Power Dissipation @ T_C = 25°C	P_D	350	mW
Derate above 25°C		2.8	mW/°C
Operating and Storage Temperature	T_J, T_{stg}		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

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

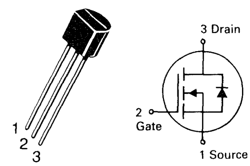
Characteristic	Symbol	Min	Max	Unit
STATIC CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	240	—	V
Zero Gate Voltage Drain Current	I_{DSS}			μA
(V_{DS} = 120 V, V_{GS} = 0)		—	10	
(V_{DS} = 120 V, V_{GS} = 0, T_A = 125 °C)		—	500	
Gate-Body Leakage (V_{DS} = 0, V_{GS} = ±15 V)	I_{GSS}	—	±100	nA
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	2.0	V
On-State Drain Current* (V_{GS} = 10 V, $V_{DS} \geq 2.0\ V_{DS(on)}$)	$I_{D(on)}$	1.0	—	A
Drain-Source On Resistance*	$r_{DS(on)}$			Ω
(V_{GS} = 2.5 V, I_D = 0.1 A)		—	10	
(V_{GS} = 10 V, I_D = 0.5 A)		—	6.0	
Forward Transconductance* (V_{DS} = 10 V, I_D = 0.5 A)	g_{fs}	300	—	mS
DYNAMIC CHARACTERISTICS				
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	125	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	50	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	20	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{DD} = 60 V, I_D = 0.4 A, R_L = 150 Ω, R_G = 25 Ω)	$t_{(on)}$	—	8.0	ns
	t_r	—	8.0	ns
Turn-Off Time (V_{DD} = 60 V, I_D = 0.4 A, R_L = 150 Ω, R_G = 25 Ω)	$t_{(off)}$	—	23	ns
	$t_{(f)}$	—	34	ns

* Pulse Test; Pulse width < 300 μs, Duty Cycle ≤ 2%

4

VN2410L★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	V
Drain-Gate Voltage	V_{DGR}	60	V
Gate-Source Voltage	V_{GS}	−40	V
Continuous Drain Current	I_D	200	mA
Pulsed Drain Current	I_{DM}	500	mA
Power Dissipation @ T_C = 25°C	P_D	350	mW
Derate above 25°C		2.8	mW/°C
Operating and Storage Temperature	T_J, T_{stg}		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

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

Characteristic	Symbol	Min	Max	Unit
STATIC CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	240	—	V
Zero Gate Voltage Drain Current	I_{DSS}			μA
(V_{DS} = 120 V, V_{GS} = 0)		—	10	
(V_{DS} = 120 V, V_{GS} = 0, T_A = 125 °C)		—	500	
Gate-Body Leakage (V_{DS} = 0, V_{GS} = ±15 V)	I_{GSS}	—	±100	nA
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	2.0	V
On-State Drain Current* (V_{GS} = 10 V, V_{DS} ≥ 2.0 $V_{DS(on)}$)	$I_{D(on)}$	1.0	—	A
Drain-Source On Resistance*	$r_{DS(on)}$			
(V_{GS} = 2.5 V, I_D = 0.1 A)		—	10	Ω
(V_{GS} = 10 V, I_D = 0.5 A)			10	
Forward Transconductance* (V_{DS} = 10 V, I_D = 0.5 A)	g_{fs}	300	—	mS

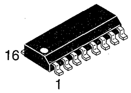
DYNAMIC CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Input Capacitance	V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz	C_{iss}	—	125	pF
Output Capacitance		C_{oss}	—	50	
Reverse Transfer Capacitance		C_{rss}	—	20	

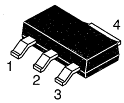
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Time	V_{DD} = 60 V, I_D = 0.4 A, R_L = 150 Ω, R_G = 25 Ω	$t_{(on)}$	—	8.0	ns
		t_r	—	8.0	
Turn-Off Time		$t_{(off)}$	—	23	
		$t_{(f)}$	—	34	

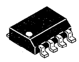
* Pulse Test; Pulse width < 300 μs, Duty Cycle ≤ 2%



CASE 751B-05
(SO-16)



CASE 318E-04
(TO-261AA)



CASE 751-04
(SO-8)

Medium Power TMOS FETs

5

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MMDF2C05E

Motorola Preferred Device

Medium Power Surface Mount Products

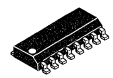
Complementary Half-Bridge TMOS Field Effect Transistors

This new series of complementary TMOS MOSFETs consists of an advanced series of N and P-Channel MOSFET die in a half-bridge configuration. This device is particularly well suited for bridge circuits where diode speed and commutating safe operating area are critical. The MMDF2C05E is designed for use in low voltage, low power motor control applications such as disk drives, tape drives, optical drives, printers and plotters. It can also be used for driving relays and solenoids.

- Low $R_{DS(on)}$
- Specially Designed Leadframe for Maximum Power Dissipation
- SO-16 Surface Mount Package
- Available in 16 mm Embossed Tape
- Simplifies Circuit Design Through Component Count and Board Space Reduction
- Applications Literature; AN1321, Brushless DC Motor Drive Incorporates Small Outline Integrated Circuit Packaged MOSFETs

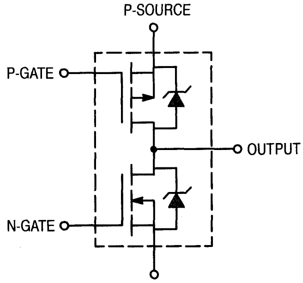
TMOS®

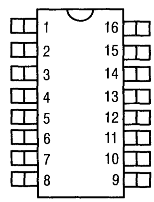
TMOS MOSFET
HALF BRIDGE
50 VOLTS
2 AMPERES



MMDF2C05E
CASE 751B-05, STYLE 7
SO-16

MMDF2C05E SCHEMATIC





MMDF2C05E (TOP VIEW)

PIN 1. N-SOURCE
2. OUTPUT
3. OUTPUT
4. P-GATE
5. OUTPUT
6. OUTPUT
7. OUTPUT
8. P-SOURCE
9. P-SOURCE
10. OUTPUT
11. OUTPUT
12. OUTPUT
13. N-GATE
14. OUTPUT
15. OUTPUT
16. N-SOURCE

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMDF2C05ER1	7″	16 mm embossed tape	500
MMDF2C05ER2	13″	16 mm embossed tape	2500

Preferred devices are Motorola recommended choices for future use and best overall value.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	BV_{DSS}	50	Volts
Gate-to-Source Voltage — Continuous	V_{GS}	±20	Volts
Drain Current — Continuous — Pulsed	I_D I_{DM}	2 10	Amps
Single Pulse Drain-to-Source Avalanche Energy – Starting T_J = 25°C (V_{DD} = 50 V, V_{GS} = 10 V, I_L = 2 Apk) N Channel P Channel	E_{AS}	 220 1140	mJ
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to 150	°C

DEVICE MARKING

MMDF2C05E

THERMAL CHARACTERISTICS

Total Power Dissipation @ T_A = 25°C N Channel Device Only P Channel Device Only	P_D	 2 2	Watts
Derate above 25°C N Channel Device Only P Channel Device Only		 16 16	mW/°C
Thermal Resistance — Junction to Ambient (surface mounted) N Channel Device Only P Channel Device Only	$R_{\theta JA}$	 62.5 62.5	°C/W
Maximum Temperature for Soldering, Time in Solder Bath	T_L	260 5	°C Sec

5

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 250 μA)	$V_{(BR)DSS}$	50	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 50 V, V_{GS} = 0)	I_{DSS}	—	—	250	μAdc
Gate-Body Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)	$V_{GS(th)}$ (N) (P)	2.0 1.5	—	4.0 4.0	Vdc
Drain-to-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	$R_{DS(on)}$	—	—	0.3	Ohms
Forward Transconductance (V_{DS} = 15 V, I_D = 1.0 A)	g_{FS}	—	1.5	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss} (N) (P)	— —	350 425	— —	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss} (N) (P)	— —	150 200	— —	
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss} (N) (P)	— —	50 50	— —	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(continued)

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

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS						
Rise Time	(V_{DD} = 25 V, I_D = 1.0 A, R_L = 25 Ω, V_{gen} = 10 V, R_G = 50 Ω)	t_r (N) (P)	— —	— —	30 50	ns
Fall Time		t_f (N) (P)	— —	— —	25 100	
Turn-On Delay Time		$t_{d(on)}$ (N) (P)	— —	— —	20 20	
Turn-Off Delay Time		$t_{d(off)}$ (N) (P)	— —	— —	40 100	
Total Gate Charge	(V_{DS} = 25 V, I_D = 3.0 A, V_{GS} = 10 V)	Q_g (N) (P)	— —	10 23	15 30	nC
Gate-Source Charge		Q_{gs} (N) (P)	— —	5.5 14	— —	
Gate-Drain Charge		Q_{gd} (N) (P)	— —	4.5 9.0	— —	
SOURCE-DRAIN DIODE CHARACTERISTICS (T_C = 25°C)						
Forward Voltage*	(I_S = 0.5 Rated I_D) dI_S/dt = 100 A/µs V_{GS} = 0	V_{SD} (N) (P)	— —	— —	1.6 2.0	V
Reverse Recovery Time		t_{rr}	—	45	—	ns

*Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

5

TYPICAL ELECTRICAL CHARACTERISTICS

N-CHANNEL

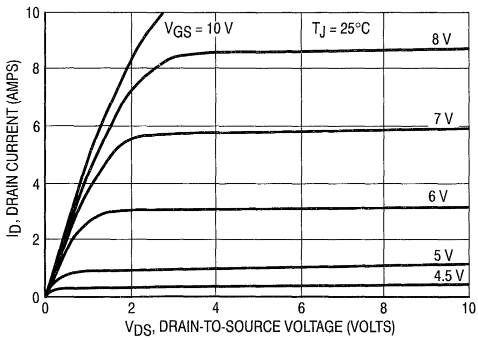


Figure 1. On-Region Characteristics

P-CHANNEL

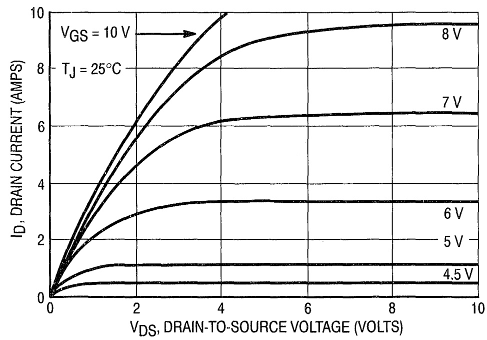


Figure 2. On-Region Characteristics

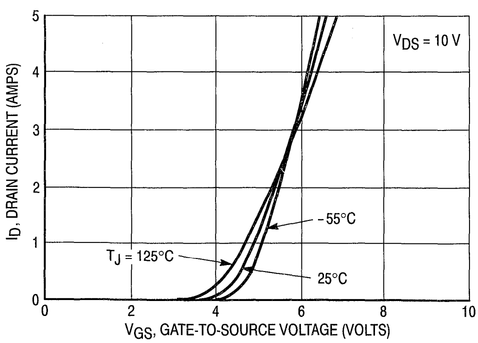


Figure 3. Transfer Characteristics

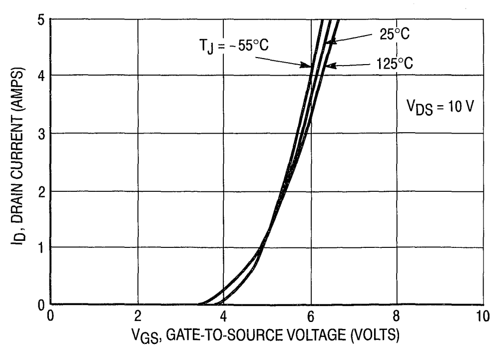


Figure 4. Transfer Characteristics

TYPICAL ELECTRICAL CHARACTERISTICS

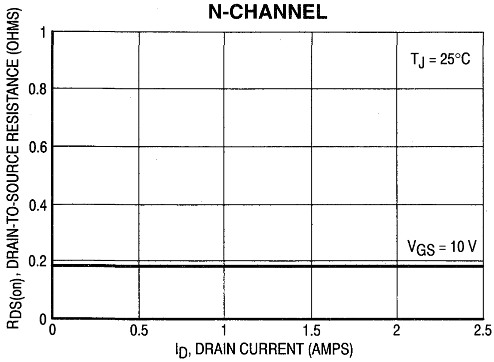


Figure 5. On-Resistance versus Drain Current

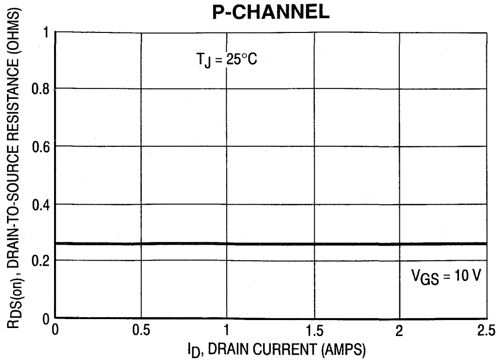


Figure 6. On-Resistance versus Drain Current

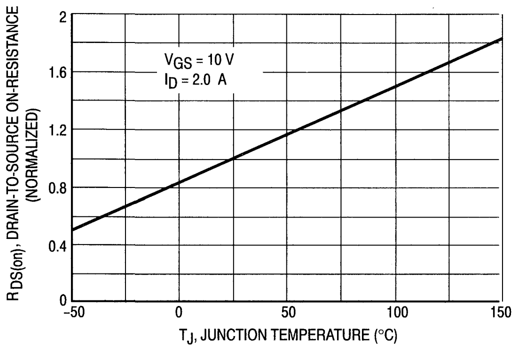


Figure 7. On-Resistance Variation with Temperature

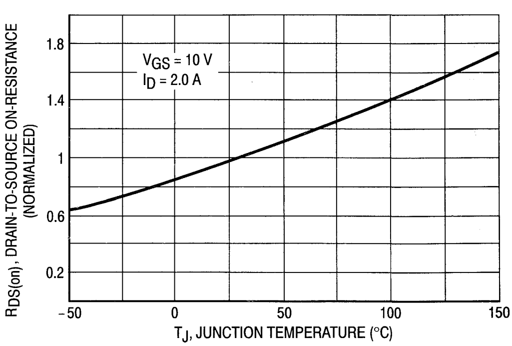


Figure 8. On-Resistance Variation with Temperature

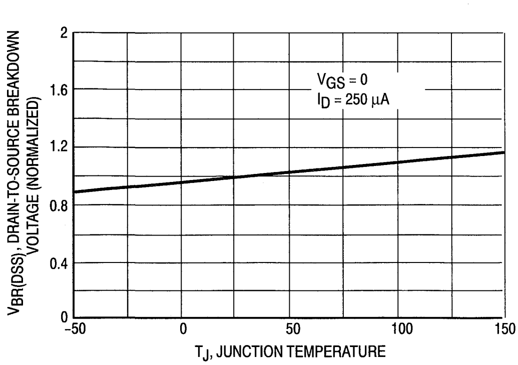


Figure 9. Drain-To-Source Breakdown Voltage Variation

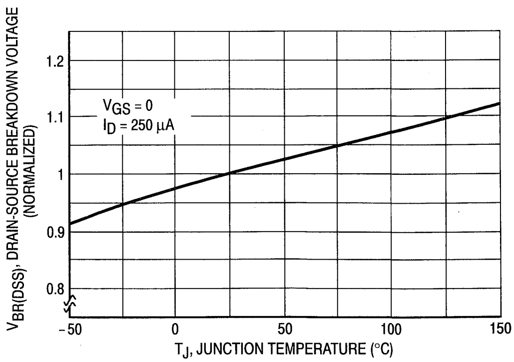


Figure 10. Drain-To-Source Breakdown Voltage Variation

TYPICAL ELECTRICAL CHARACTERISTICS

N-CHANNEL

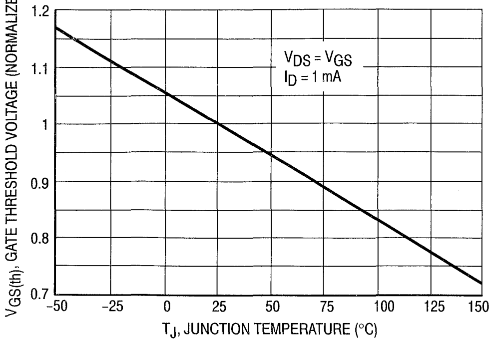


Figure 11. Gate Threshold Voltage Variation with Temperature

P-CHANNEL

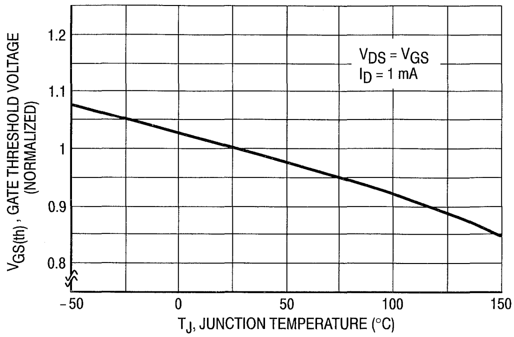


Figure 12. Gate Threshold Voltage Variation with Temperature

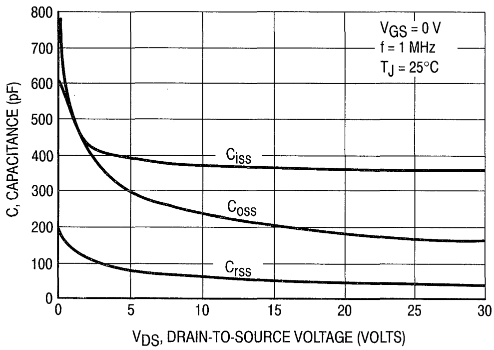


Figure 13. Capacitance Variation

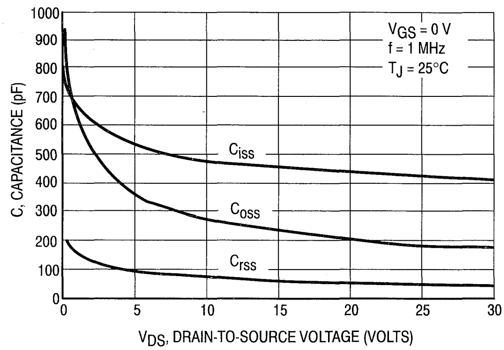


Figure 14. Capacitance Variation

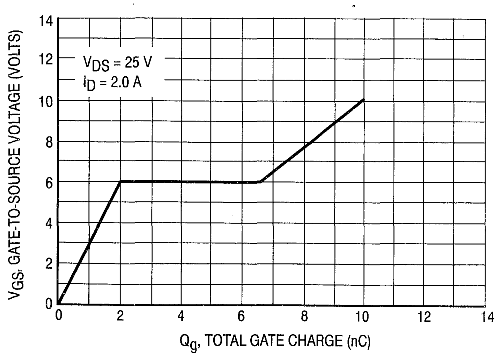


Figure 15. Gate-Charge versus Gate-To-Source Voltage

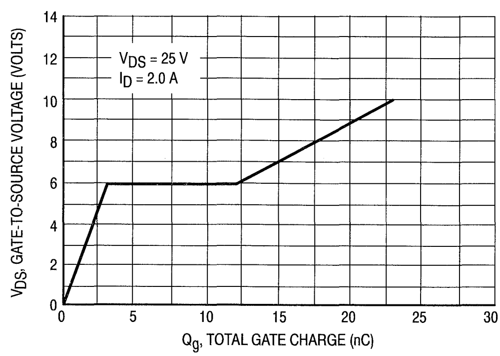


Figure 16. Gate-Charge versus Gate-To-Source Voltage

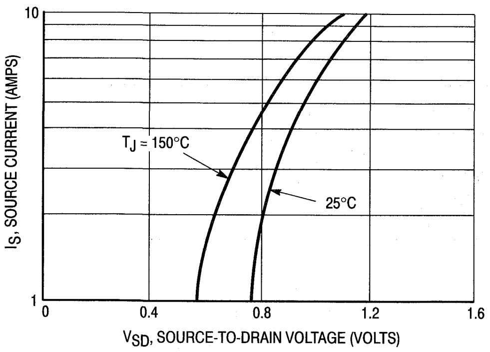


Figure 17. Maximum Rated Switching Safe Operating Area

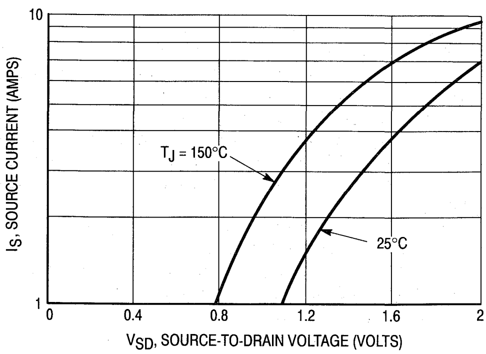


Figure 18. Maximum Rated Switching Safe Operating Area

SAFE OPERATING AREA INFORMATION

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, when it is on, or when it is being turned on. Because these curves include the limitations of simultaneous high voltage and high current up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on a case temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various case temperatures can be determined by using the thermal response curves. Motorola Application Note AN569, "Transient Thermal Resistance-General Data and Its Use" provides detailed instructions.

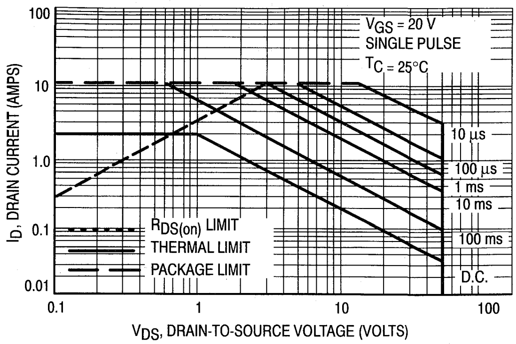


Figure 19. Maximum Rated Forward Biased Safe Operating Area

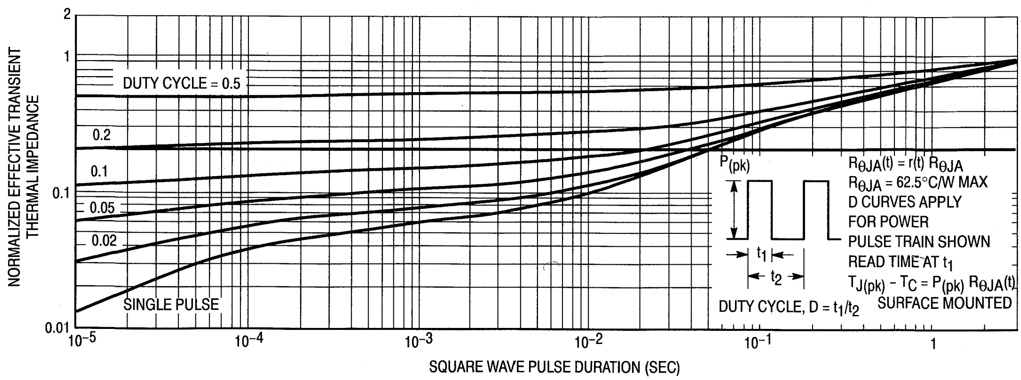


Figure 20. Thermal Response

COMMUTATING SAFE OPERATING AREA (CSOA)

The Commutating Safe Operating Area (CSOA) of Figure 21 defines the limits of safe operation for commutated source-drain current versus re-applied drain voltage when the source-drain diode has undergone forward bias. The curve shows the limitations of I_{FM} and peak V_{DS} for a given rate of change of source current. It is applicable when waveforms similar to those of Figure 22 are present. Full or half-bridge PWM DC motor controllers are common applications requiring CSOA data.

Device stresses increase with the increasing rate of change of source current so dI_S/dt is specified with a maximum value. Higher values of dI_S/dt require an appropriate derating of I_{FM}, peak V_{DS} or both. Ultimately dI_S/dt is limited primarily by device, package, and circuit impedances. Maximum device stress occurs during t_{rr} as the diode goes from conduction to reverse blocking.

$V_{DS(pk)}$ is the peak drain-to-source voltage that the device must sustain during commutation. I_{FM} is the maximum forward source-drain diode current just prior to the onset of commutation.

V_R is specified at 80% of BV_{DSS} to ensure that the CSOA stress is maximized as I_S decays from I_{RM} to zero.

R_{GS} should be minimized during commutation. T_J has only a second order effect on CSOA.

Stray inductances in Motorola's test circuit are assumed to be practical minimums. dV_{DS}/dt in excess of 10 V/ns was attained with dI_S/dt of 400 A/µs.

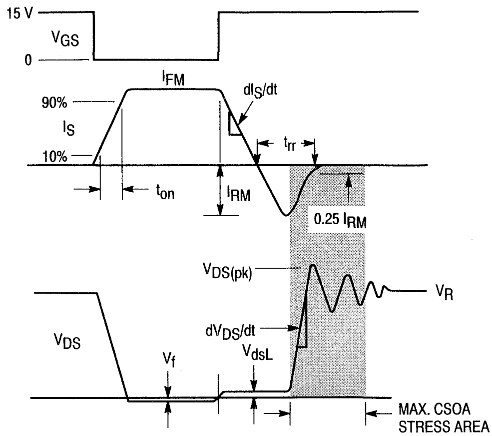


Figure 22. Commutating Waveforms

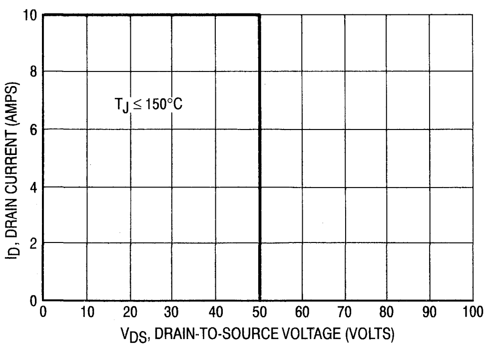


Figure 21. Commutating Safe Operating Area (CSOA)

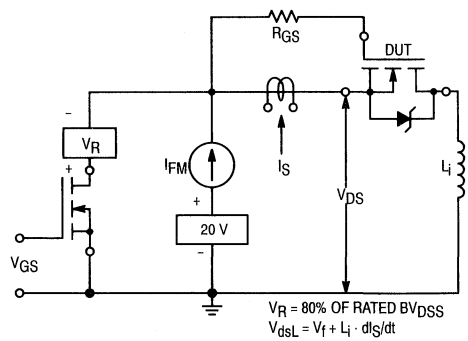


Figure 23. Commutating Safe Operating Area Test Circuit

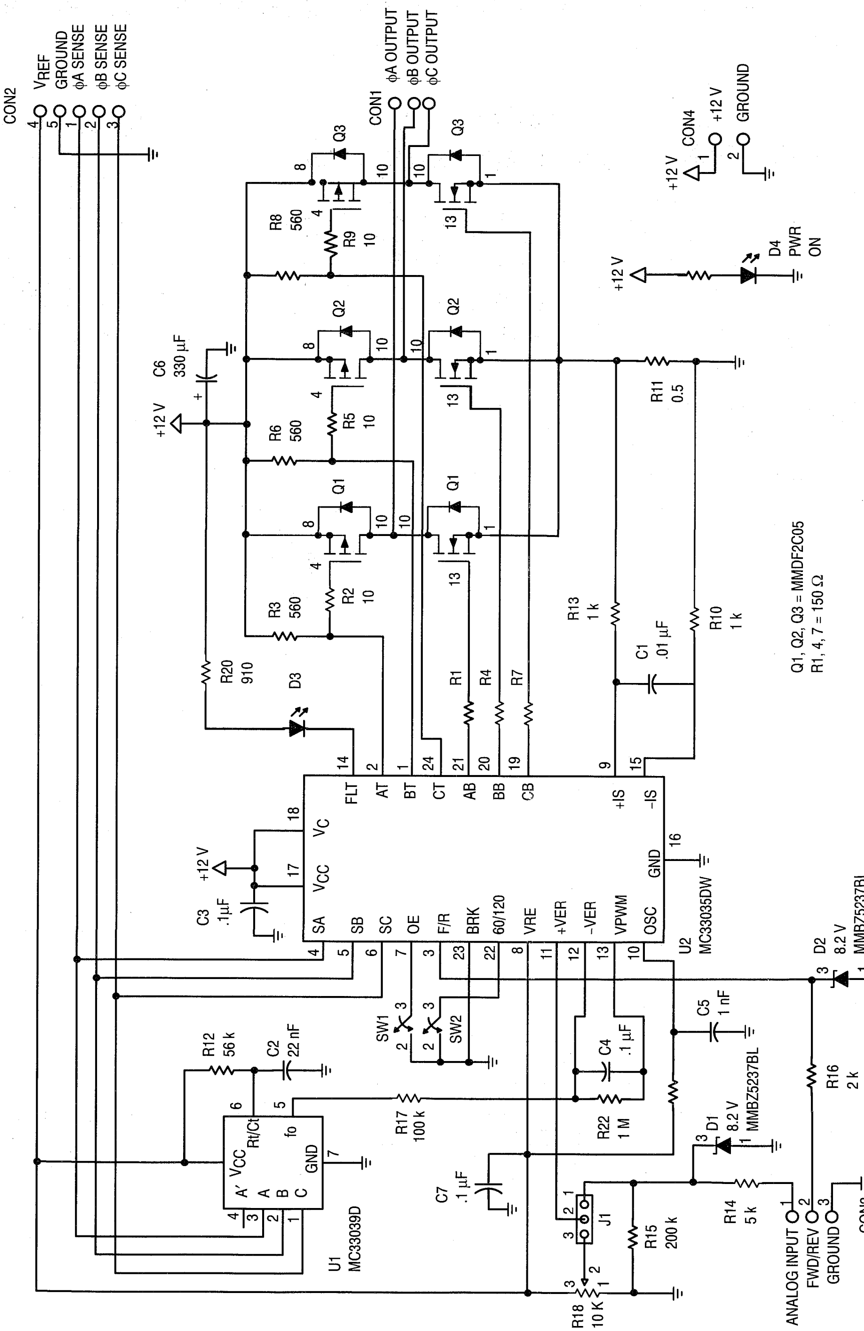


Figure 24. Brushless DC Motor Drive Using MMDF2C05E

5

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MMDF2N02E

Motorola Preferred Device

Medium Power Surface Mount Products
Dual TMOS Field Effect Transistors

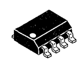
This new series of dual TMOS MOSFETs consists of an advanced series of two independent N-Channel MOSFET die. This device is particularly well suited for bridge circuits where diode speed and commutating safe operating area are critical. The MMDF2N02E is designed for use in low voltage, low power motor control applications such as disk drives, tape drives, optical drives, printers and plotters. It can also be used for driving relays and solenoids.

- Commutating Safe Operating Area Specified for Use in Half and Full Bridge Circuits
- Low $R_{DS(on)}$: 0.1 Ω per Device
- Specially Designed Leadframe for Maximum Power Dissipation
- SO-8 Surface Mount Package
- Available in 12 mm Embossed Tape and Reel
- Simplifies Circuit Design Through Component Count and Board Space Reduction

5

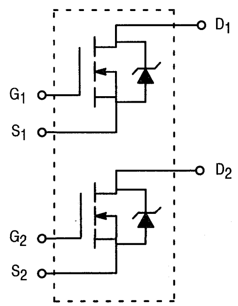
TMOS®

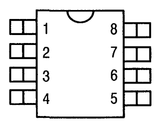
DUAL TMOS MOSFET
20 VOLTS
2.2 AMPERES
$R_{DS(on)}$ = 0.1 OHM



MMDF2N02E
CASE 751-04, STYLE 11
SO-8

MMDF2N02E SCHEMATIC





MMDF2N02E (TOP VIEW)

PIN 1. SOURCE-S1
2. GATE-G1
3. SOURCE-S2
4. GATE-G2
5. DRAIN-D2
6. DRAIN-D2
7. DRAIN-D1
8. DRAIN-D1

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMDF2N02ER1	7″	12 mm embossed tape	500
MMDF2N02ER2	13″	12 mm embossed tape	2500

TMOS is a registered trademark of Motorola Inc.
Thermal Clad is a trademark of the Bergquist Company.

Preferred devices are Motorola recommended choices for future use and best overall value.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	20	Volts
Gate-to-Source Voltage — Continuous	V_{GS}	±20	Volts
Drain Current — Continuous — Pulsed	I_D I_{DM}	2.2 14	Amps
Single Pulse Drain-to-Source Avalanche Energy – Starting T_J = 25°C (V_{DD} = 20 V, V_{GS} = 10 V, I_L = 4 Apk)	E_{AS}	800	mJ
Operating and Storage Temperature Range	T_J, T_{stg}	– 65 to 150	°C

DEVICE MARKING

2N02E

THERMAL CHARACTERISTICS

Total Power Dissipation @ T_A = 25°C Any single die "on" Both die "on" equally	P_D	 1000 1500	mW
Derate above 25°C Any single die "on" Both die "on" equally		 8 12	mW/°C
Thermal Resistance — Junction-to-Ambient (surface mounted) Any single die "on" Both die "on" equally	$R_{\theta JA}$	 125 83	°C/W
Maximum Temperature for Soldering, Time in Solder Bath	T_L	260 5	°C Sec

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 250 μA)	$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 V, V_{GS} = 0)	I_{DSS}	—	—	250	μAdc
Gate-Body Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)	$V_{GS(th)}$	1.0	—	3.0	Vdc
Drain-to-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 2.2 Adc) (V_{GS} = 4.5 Vdc, I_D = 1.0 Adc)	 $R_{DS(on)}$ 1 $R_{DS(on)}$ 2	 — —	 — —	 0.1 0.2	Ohms
Forward Transconductance (V_{DS} = 15 V, I_D = 1.0 A)	g_{FS}	—	4.3	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 20 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	410	—	pF
Output Capacitance (V_{DS} = 20 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	270	—	pF
Reverse Transfer Capacitance (V_{DS} = 20 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	75	—	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(continued)

5

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

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS (See Figures 18 and 19)						
Rise Time	(V_{DD} = 10 V, I_D = 1.0 A, R_L = 10 Ω, V_{gen} = 10 V, R_G = 50 Ω)	t_r	—	—	20	ns
Fall Time		t_f	—	—	50	
Turn-On Delay Time		$t_{d(on)}$	—	—	20	
Turn-Off Delay Time		$t_{d(off)}$	—	—	90	
Total Gate Charge	(V_{DS} = 10 V, I_D = 2.2 A, V_{GS} = 10 V)	Q_g	—	12.5	30	nC
Gate-Source Charge		Q_{gs}	—	9.5	—	
Gate-Drain Charge		Q_{gd}	—	3.0	—	
SOURCE-DRAIN DIODE CHARACTERISTICS (T_C = 25°C)						
Forward Voltage*	(I_S = 2.2 A, V_{GS} = 0 V) (dI_S/dt = 100 A/μs)	V_{SD}	V_{SD}	—	1.6	V
Reverse Recovery Time		t_{rr}	t_{rr}	—	100	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

TYPICAL ELECTRICAL CHARACTERISTICS

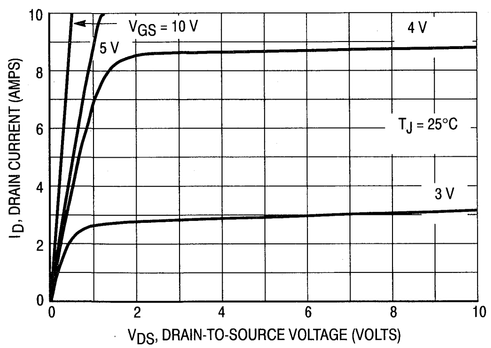


Figure 1. On-Region Characteristics

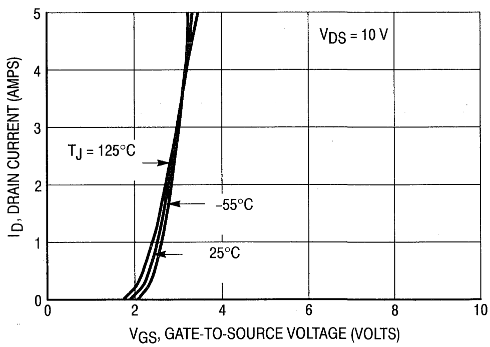


Figure 2. Transfer Characteristics

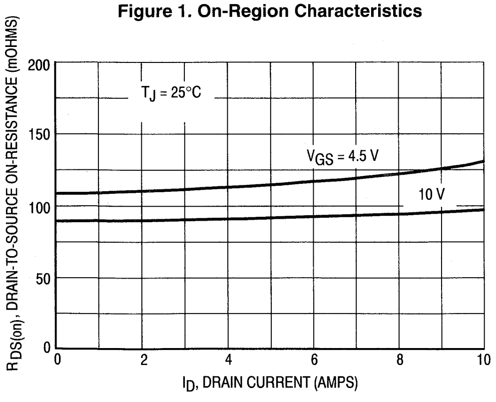


Figure 3. On-Resistance versus Drain Current

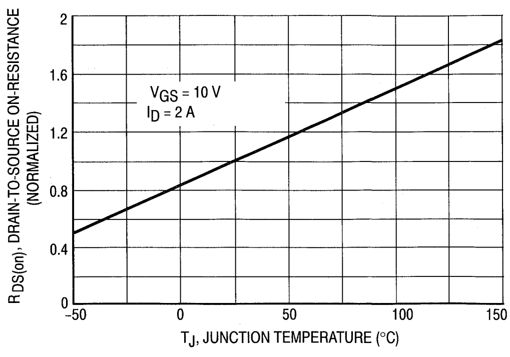


Figure 4. On-Resistance Variation with Temperature

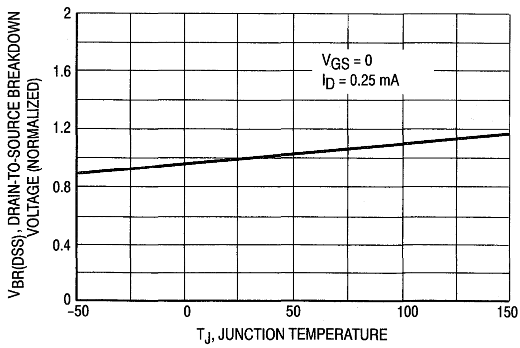


Figure 5. Breakdown Voltage Variation with Temperature

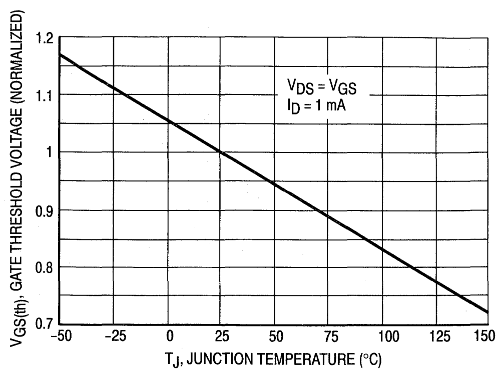


Figure 6. Gate Threshold Voltage Variation with Temperature

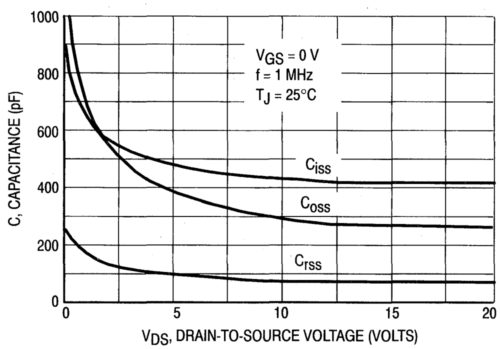


Figure 7. Capacitance Variation

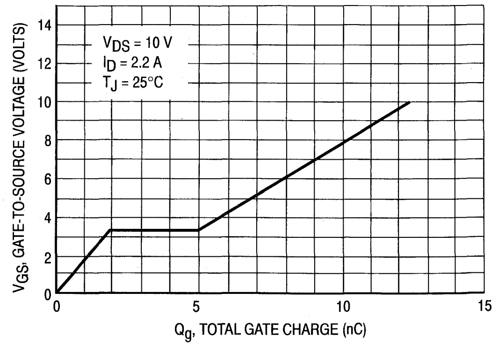
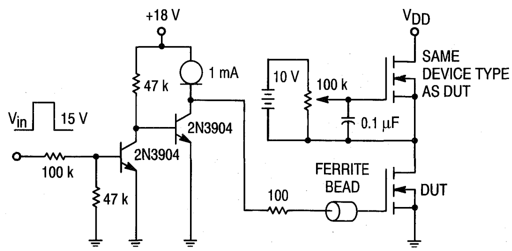


Figure 8. Gate Charge versus Gate-To-Source Voltage



V_{in} = 15 V_{pk}; PULSE WIDTH ≤ 100 µs, DUTY CYCLE ≤ 10%.

Figure 9. Gate Charge Test Circuit

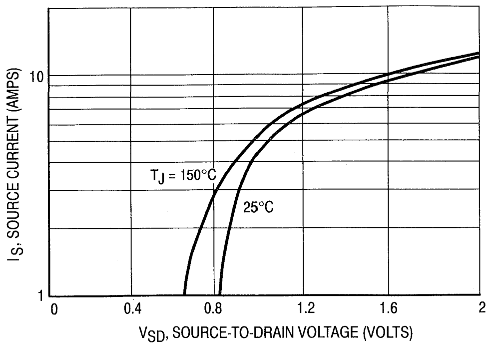


Figure 10. Source-Drain Diode Forward Voltage

SAFE OPERATING AREA INFORMATION

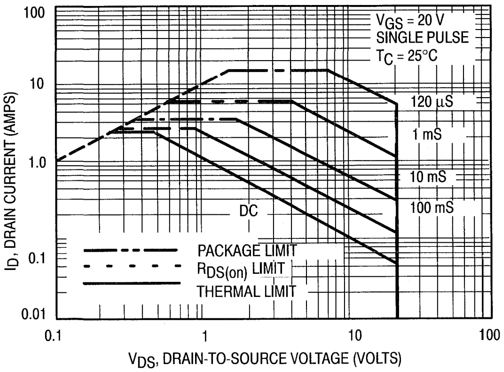


Figure 11. Maximum Rated Forward Biased Safe Operating Area

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, or when it is on, or being turned on. Because these curves include the limitations of simultaneous high voltage and high current, up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on a case temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various case temperatures can be determined by using the thermal response curves. Motorola Application Note, AN569, "Transient Thermal Resistance — General Data and Its Use" provides detailed instructions.

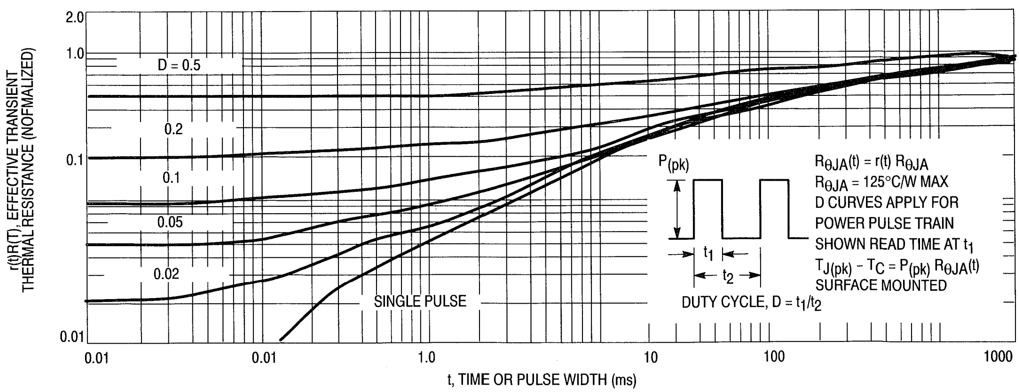


Figure 12. Thermal Response

COMMUTATING SAFE OPERATING AREA (CSOA)

The Commutating Safe Operating Area (CSOA) of Figure 14 defines the limits of safe operation for commutated source-drain current versus re-applied drain voltage when the source-drain diode has undergone forward bias. The curve shows the limitations of I_{FM} and peak V_{DS} for a given rate of change of source current. It is applicable when waveforms similar to those of Figure 13 are present. Full or half-bridge PWM DC motor controllers are common applications requiring CSOA data.

Device stresses increase with increasing rate of change of source current so dI_S/dt is specified with a maximum value. Higher values of dI_S/dt require an appropriate derating of I_{FM}, peak V_{DS} or both. Ultimately dI_S/dt is limited primarily by device, package, and circuit impedances. Maximum device stress occurs during t_{rr} as the diode goes from conduction to reverse blocking.

$V_{DS(pk)}$ is the peak drain-to-source voltage that the device must sustain during commutation; I_{FM} is the maximum forward source-drain diode current just prior to the onset of commutation.

V_R is specified at 80% of BV_{DSS} to ensure that the CSOA stress is maximized as I_S decays from I_{RM} to zero.

R_{GS} should be minimized during commutation. T_J has only a second order effect on CSOA.

Stray inductances in Motorola's test circuit are assumed to be practical minimums. dV_{DS}/dt in excess of 10 V/ns was attained with dI_S/dt of 400 A/µs.

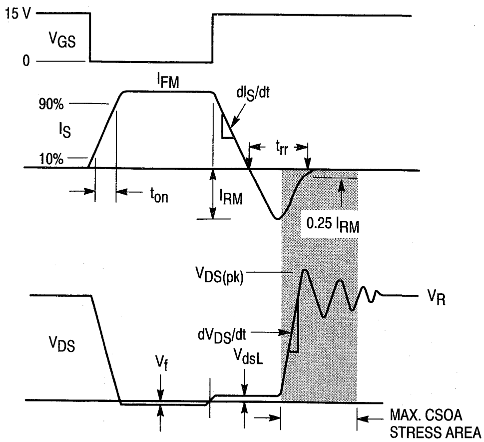


Figure 13. Commutating Waveforms

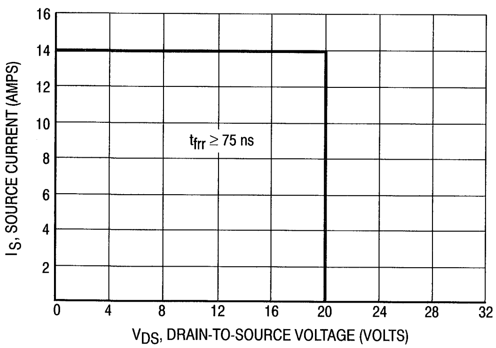


Figure 14. Commutating Safe Operating Area (CSOA)

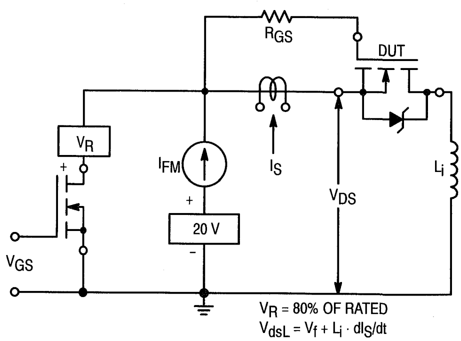


Figure 15. Commutating Safe Operating Area Test Circuit

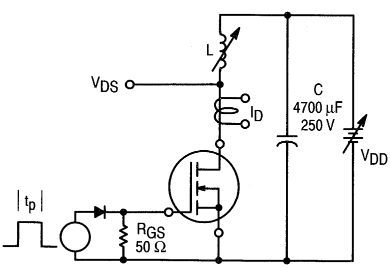


Figure 16. Unclamped Inductive Switching Test Circuit

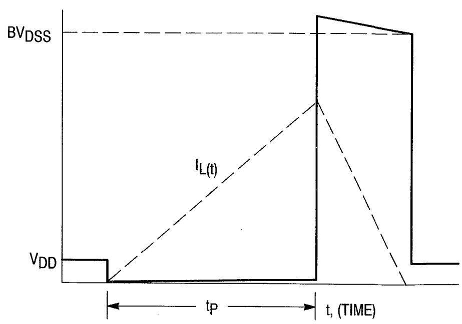


Figure 17. Unclamped Inductive Switching Waveforms

RESISTIVE SWITCHING

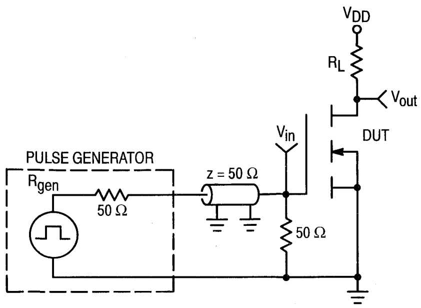


Figure 18. Switching Test Circuit

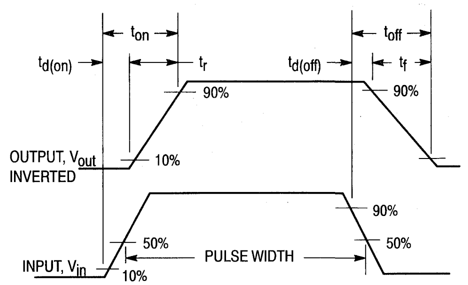


Figure 19. Switching Waveforms

5

Medium Power Field Effect Transistor

N-Channel Enhancement Mode
Silicon Gate TMOS E-FET™
SOT-223 for Surface Mount

MMFT1N10T1

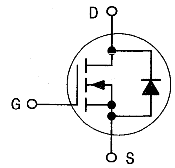
Motorola Preferred Device

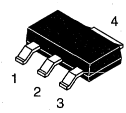
This TMOS medium power field effect transistor is designed for high speed, low loss power switching applications such as switching regulators, converters, solenoid and relay drivers. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- Silicon Gate for Fast Switching Speeds
- $R_{DS(on)}$ = 3.4 Ω Max
- Low Drive Requirement
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use MMFT1N10T1 to order the 7 inch/1000 unit reel.
  Use MMFT1N10T3 to order the 13 inch/4000 unit reel.

TMOS®

MEDIUM POWER
TMOS FET
500 mA
100 VOLTS
$R_{DS(on)}$ = 3.4 OHMS





CASE 318E-04, STYLE 3
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	100	Vdc
Gate-to-Source Voltage — Continuous	V_{GS}	±20	Vdc
Drain Current	I_D	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

T1N10

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a FR-4 glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. = 0.93 sq. in.

Thermal Clad is a trademark of the Bergquist Company
TMOS is a registered trademark of Motorola Inc.
E-FET is a trademark of Motorola Inc.

Preferred devices are Motorola recommended choices for future use and best overall value.

5

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

Characteristics		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 250 μA)		$V_{(BR)DSS}$	100	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 100 V, V_{GS} = 0)		I_{DSS}	—	250	μAdc
Gate-Body Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	—	500	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	2.0	4.0	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 0.25 Adc)		$R_{DS(on)}$	—	3.4	Ohms
On-State Drain Current (V_{GS} = 10 V, V_{DS} = 5.0 V)		$I_{D(on)}$	0.5	—	Adc
Forward Transconductance (V_{DS} = 5.0 V, I_D = 0.25 A)		g_{FS}	0.25	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0 f = 1.0 MHz)	C_{iss}	—	70	pF
Output Capacitance		C_{oss}	—	30	
Transfer Capacitance		C_{rss}	—	10	
SWITCHING CHARACTERISTICS					
Rise Time	(V_{DS} = 50 V, I_D = 0.25 A R_{gen} = 50 ohms, Z_o = 50 ohms)	t_r	—	25	ns
Fall Time		t_f	—	20	
Turn-On Delay Time		$t_{d(on)}$	—	20	
Turn-Off Delay Time		$t_{d(off)}$	—	25	
SOURCE-DRAIN DIODE CHARACTERISTICS					
Diode Forward Voltage	(V_{GS} = 0 I_S = 0.5 A)	V_F	—	1.4	V
Continuous Source Current, Body Diode		I_S	—	0.5	A
Pulsed Source Current, Body Diode		I_{SM}	—	4.0	A

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Medium Power Field Effect Transistor
N-Channel Enhancement Mode
Silicon Gate TMOS E-FET™
SOT-223 for Surface Mount

MMFT1N10ET1

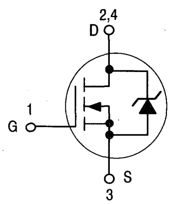
Motorola Preferred Device

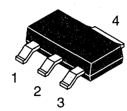
MEDIUM POWER
TMOS FET
1 AMP
100 VOLTS
$R_{DS(on)}$ = 0.25 OHM

5

This advanced E-FET is a TMOS Medium Power MOSFET designed to withstand high energy in the avalanche and commutation modes. This new energy efficient device also offers a drain-to-source diode with a fast recovery time. Designed for low voltage, high speed switching applications in power supplies, dc-dc converters and PWM motor controls, these devices are particularly well suited for bridge circuits where diode speed and commutating safe operating areas are critical and offer additional safety margin against unexpected voltage transients. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- Silicon Gate for Fast Switching Speeds
- Low $R_{DS(on)}$ — 0.25 Ω max
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use the MMFT1N10ET1 to order the 7 inch/1000 unit reel.
  Use the MMFT1N10ET3 to order the 13 inch/4000 unit reel.





CASE 318E-04, STYLE 3
TO-261AA

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	100	Vdc
Gate-to-Source Voltage — Continuous	V_{GS}	±20	
Drain Current — Continuous — Pulsed	I_D I_{DM}	1 4	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to 150	°C
Single Pulse Drain-to-Source Avalanche Energy — Starting T_J = 25°C (V_{DD} = 60 V, V_{GS} = 10 V, Peak I_L= 1 A, L = 0.2 mH, R_G = 25 Ω)	E_{AS}	168	mJ

DEVICE MARKING

1N10

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

*Power rating when mounted on FR-4 glass epoxy printed circuit board using recommended footprint.
TMOS is a registered trademark of Motorola Inc.
E-FET is a trademark of Motorola Inc.
Thermal Clad is a trademark of the Bergquist Company

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage, (V_{GS} = 0, I_D = 250 μA)		$V_{(BR)DSS}$	100	—	—	Vdc
Zero Gate Voltage Drain Current, (V_{DS} = 100 V, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current, (V_{GS} = 20 V, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS						
Gate Threshold Voltage, (V_{DS} = V_{GS}, I_D = 1 mA)		$V_{GS(th)}$	2	—	4.5	Vdc
Static Drain-to-Source On-Resistance, (V_{GS} = 10 V, I_D = 0.5 A)		$R_{DS(on)}$	—	—	0.25	Ohms
Drain-to-Source On-Voltage, (V_{GS} = 10 V, I_D = 1 A)		$V_{DS(on)}$	—	—	0.33	Vdc
Forward Transconductance, (V_{DS} = 10 V, I_D = 0.5 A)		g_{FS}	—	2.2	—	mhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 20 V, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	410	—	pF
Output Capacitance		C_{oss}	—	145	—	
Reverse Transfer Capacitance		C_{rss}	—	55	—	
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	(V_{DD} = 25 V, I_D = 0.5 A V_{GS} = 10 V, R_{gen} = 50 ohms, R_{GS} = 25 ohms)	$t_{d(on)}$	—	15	—	ns
Rise Time		t_r	—	15	—	
Turn-Off Delay Time		$t_{d(off)}$	—	30	—	
Fall Time		t_f	—	32	—	
Total Gate Charge	(V_{DS} = 80 V, I_D = 1 A, V_{GS} = 10 Vdc) See Figures 15 and 16	Q_g	—	7	—	nC
Gate-Source Charge		Q_{gs}	—	1.3	—	
Gate-Drain Charge		Q_{gd}	—	3.2	—	
SOURCE DRAIN DIODE CHARACTERISTICS*						
Forward On-Voltage	I_S = 1 A, V_{GS} = 0	V_{SD}	—	0.8	—	Vdc
Forward Turn-On Time	I_S = 1 A, V_{GS} = 0, dI_S/dt = 400 A/μs, V_R = 50 V	t_{on}	Limited by stray inductance			
Reverse Recovery Time		t_{rr}	—	90	—	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

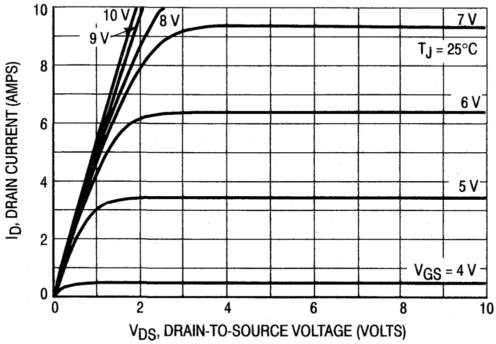


Figure 1. On Region Characteristics

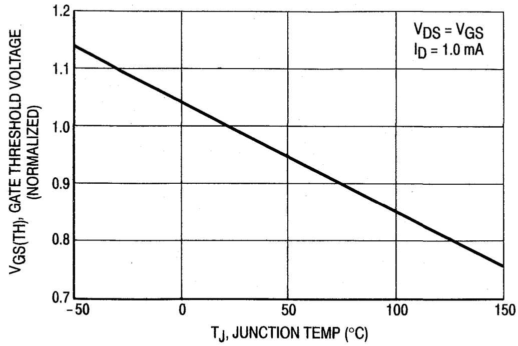


Figure 2. Gate-Threshold Voltage Variation With Temperature

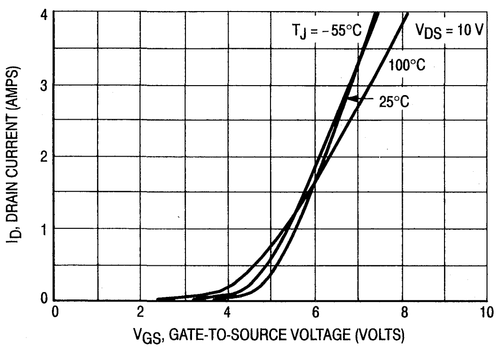


Figure 3. Transfer Characteristics

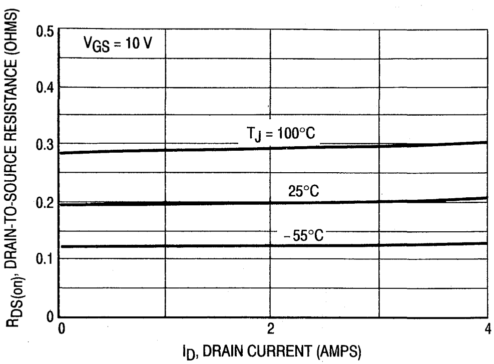


Figure 4. On-Resistance versus Drain Current

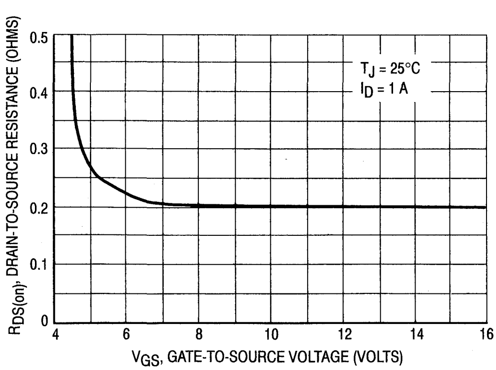


Figure 5. On-Resistance versus Gate-to-Source Voltage

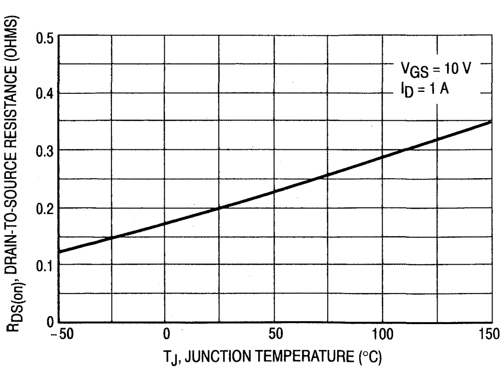


Figure 6. On-Resistance versus Junction Temperature

5

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, or when it is on, or being turned on. Because these curves include the limitations of simultaneous high voltage and high current, up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on an ambient temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various ambient temperatures can be determined by using the thermal response curves. Motorola Application Note, AN569, "Transient Thermal Resistance-General Data and Its Use" provides detailed instructions.

SWITCHING SAFE OPERATING AREA

The switching safe operating area (SOA) is the boundary that the load line may traverse without incurring damage to the MOSFET. The fundamental limits are the peak current, I_{DM} and the breakdown voltage, BV_{DSS}. The switching SOA is applicable for both turn-on and turn-off of the devices for switching times less than one microsecond.

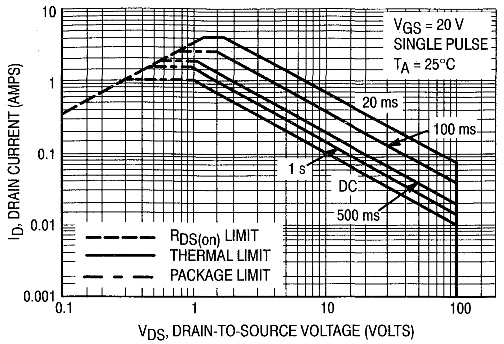


Figure 7. Maximum Rated Forward Biased Safe Operating Area

5

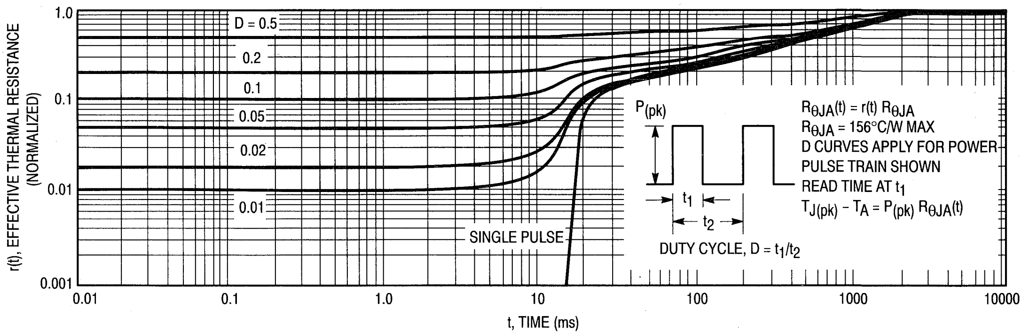


Figure 8. Thermal Response

COMMUTATING SAFE OPERATING AREA (CSOA)

The Commutating Safe Operating Area (CSOA) of Figure 10 defines the limits of safe operation for commutated source-drain current versus re-applied drain voltage when the source-drain diode has undergone forward bias. The curve shows the limitations of I_{FM} and peak V_{DS} for a given rate of change of source current. It is applicable when waveforms similar to those of Figure 9 are present. Full or half-bridge PWM DC motor controllers are common applications requiring CSOA data.

Device stresses increase with increasing rate of change of source current so dI_S/dt is specified with a maximum value. Higher values of dI_S/dt require an appropriate derating of I_{FM}, peak V_{DS} or both. Ultimately dI_S/dt is limited primarily by device, package, and circuit impedances. Maximum device stress occurs during t_{rr} as the diode goes from conduction to reverse blocking.

$V_{DS(pk)}$ is the peak drain-to-source voltage that the device must sustain during commutation; I_{FM} is the maximum forward source-drain diode current just prior to the onset of commutation.

V_R is specified at 80% rated BV_{DSS} to ensure that the CSOA stress is maximized as I_S decays from I_{RM} to zero.

R_{GS} should be minimized during commutation. T_J has only a second order effect on CSOA.

Stray inductances in Motorola's test circuit are assumed to be practical minimums. dV_{DS}/dt in excess of 10 V/ns was attained with dI_S/dt of 400 A/µs.

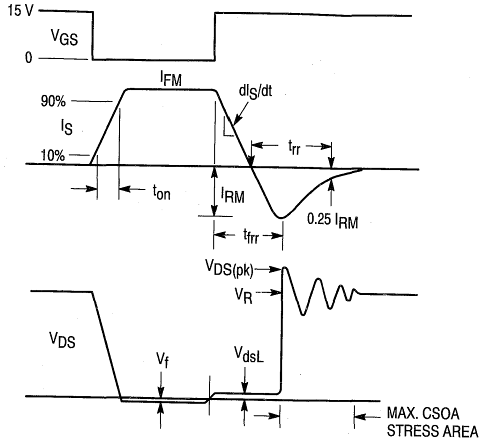


Figure 9. Commutating Waveforms

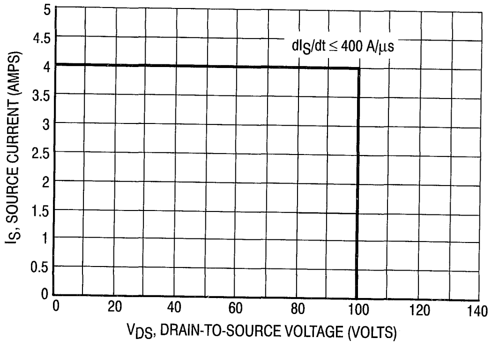


Figure 10. Commutating Safe Operating Area (CSOA)

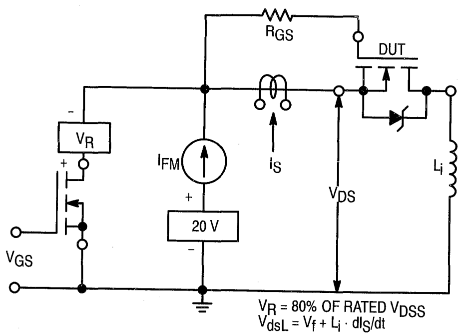


Figure 11. Commutating Safe Operating Area Test Circuit

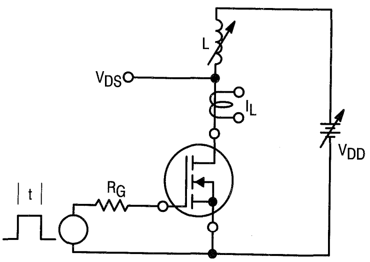


Figure 12. Unclamped Inductive Switching Test Circuit

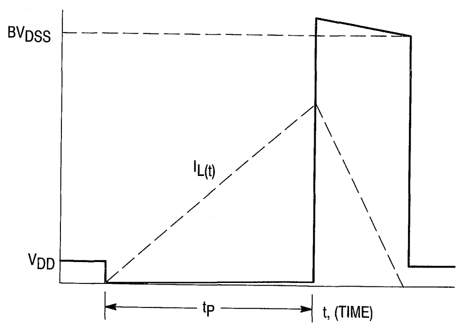


Figure 13. Unclamped Inductive Switching Waveforms

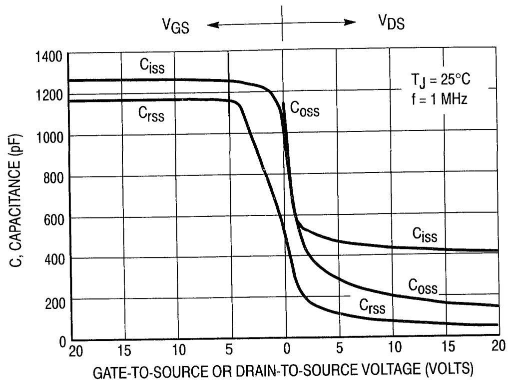


Figure 14. Capacitance Variation With Voltage

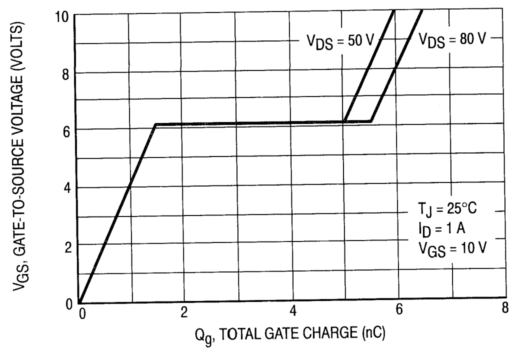


Figure 15. Gate Charge versus Gate-To-Source Voltage

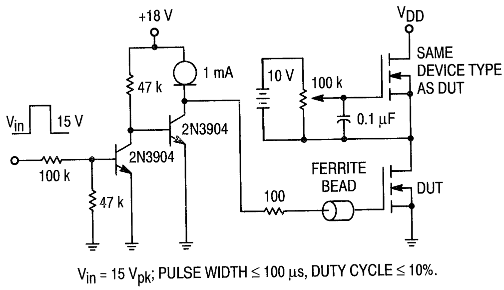


Figure 16. Gate Charge Test Circuit

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

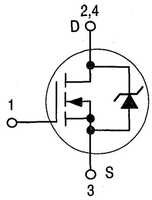
Medium Power Field Effect Transistor
N-Channel Enhancement Mode
Silicon Gate TMOS E-FET™
SOT-223 for Surface Mount

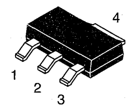
MMFT2N02ELT1

Motorola Preferred Device

MEDIUM POWER
LOGIC LEVEL TMOS FET
1.6 AMP
20 VOLTS
$R_{DS(on)}$ = 0.15 OHM

This advanced E-FET is a TMOS Medium Power MOSFET designed to withstand high energy in the avalanche and commutation modes. This device is also designed with a low threshold voltage so it is fully enhanced with 5 Volts. This new energy efficient device also offers a drain-to-source diode with a fast recovery time. Designed for low voltage, high speed switching applications in power supplies, dc-dc converters and PWM motor controls, these devices are particularly well suited for bridge circuits where diode speed and commutating safe operating areas are critical and offer additional safety margin against unexpected voltage transients. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.





CASE 318E-04, STYLE 3
TO-261AA

- Silicon Gate for Fast Switching Speeds
- Low Drive Requirement to Interface Power Loads to Logic Level ICs, $V_{GS(th)}$ = 2 Volts Max
- Low $R_{DS(on)}$ — 0.15 Ω max
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- SOT-223 Thermal and Mounting Information Provided
- Available in 12 mm Tape and Reel
  Use the MMFT2N02ELT1 to order the 7 inch/1000 unit reel.
  Use the MMFT2N02ELT3 to order the 13 inch/4000 unit reel.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	20	Vdc
Gate-to-Source Voltage — Continuous	V_{GS}	±15	
Drain Current — Continuous — Pulsed	I_D I_{DM}	1.6 6.4	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to 150	°C
Single Pulse Drain-to-Source Avalanche Energy — Starting T_J = 25°C (V_{DD} = 10 V, V_{GS} = 5 V, Peak I_L= 2 A, L = 0.2 mH, R_G = 25 Ω)	E_{AS}	66	mJ

DEVICE MARKING

2N02L

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

*Power rating when mounted on FR-4 glass epoxy printed circuit board using recommended footprint.
TMOS is a registered trademark of Motorola Inc.
E-FET is a trademark of Motorola Inc.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage, (V_{GS} = 0, I_D = 250 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current, (V_{DS} = 20 V, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current, (V_{GS} = 15 V, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS						
Gate Threshold Voltage, (V_{DS} = V_{GS}, I_D = 1 mA)		$V_{GS(th)}$	1	—	2	Vdc
Static Drain-to-Source On-Resistance, (V_{GS} = 5 V, I_D = 0.8 A)		$R_{DS(on)}$	—	—	0.15	Ohms
Drain-to-Source On-Voltage, (V_{GS} = 5 V, I_D = 1.6 A)		$V_{DS(on)}$	—	—	0.32	Vdc
Forward Transconductance, (V_{DS} = 10 V, I_D = 0.8 A)		g_{FS}	—	2.6	—	mhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 15 V, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	580	—	pF
Output Capacitance		C_{oss}	—	430	—	
Reverse Transfer Capacitance		C_{rss}	—	250	—	
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	(V_{DD} = 15 V, I_D = 1.6 A V_{GS} = 5 V, R_{gen} = 50 ohms, R_{GS} = 25 ohms)	$t_{d(on)}$	—	16	—	ns
Rise Time		t_r	—	73	—	
Turn-Off Delay Time		$t_{d(off)}$	—	77	—	
Fall Time		t_f	—	107	—	
Total Gate Charge	(V_{DS} = 16 V, I_D = 1.6 A, V_{GS} = 5 Vdc) See Figures 15 and 16	Q_g	—	20	—	nC
Gate-Source Charge		Q_{gs}	—	1.7	—	
Gate-Drain Charge		Q_{gd}	—	6	—	
SOURCE DRAIN DIODE CHARACTERISTICS*						
Forward On-Voltage	I_S = 1.6 A, V_{GS} = 0	V_{SD}	—	0.9	—	Vdc
Forward Turn-On Time	I_S = 1.6 A, V_{GS} = 0, dI_S/dt = 400 A/μs, V_R = 16 V	t_{on}	Limited by stray inductance			
Reverse Recovery Time		t_{rr}	—	55	—	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

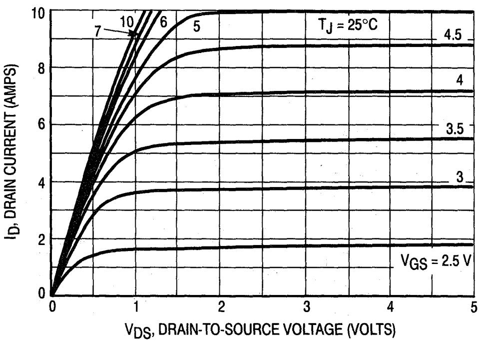


Figure 1. On Region Characteristics

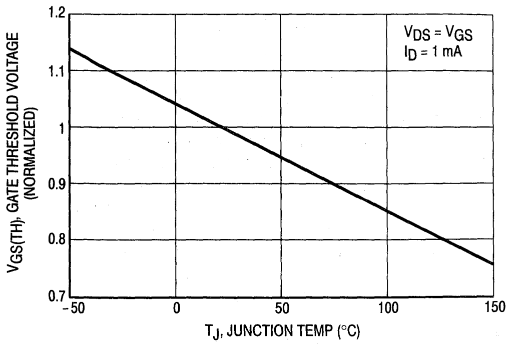


Figure 2. Gate-Threshold Voltage Variation With Temperature

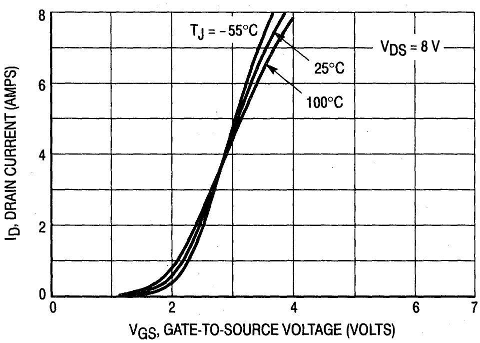


Figure 3. Transfer Characteristics

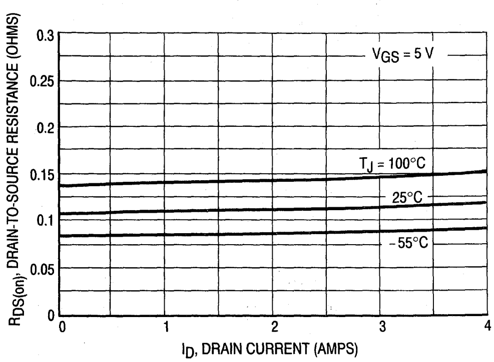


Figure 4. On-Resistance versus Drain Current

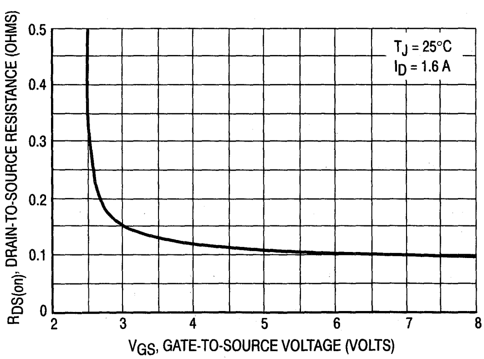


Figure 5. On-Resistance versus Gate-to-Source Voltage

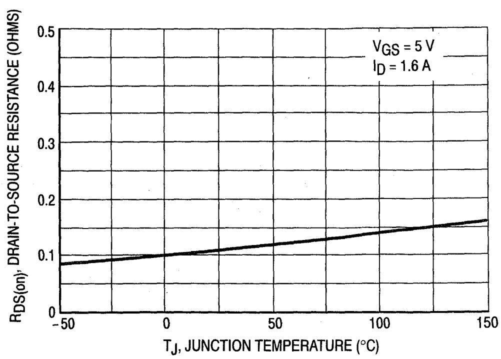


Figure 6. On-Resistance versus Junction Temperature

5

5

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, or when it is on, or being turned on. Because these curves include the limitations of simultaneous high voltage and high current, up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on an ambient temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various ambient temperatures can be determined by using the thermal response curves. Motorola Application Note, AN569, "Transient Thermal Resistance-General Data and Its Use" provides detailed instructions.

SWITCHING SAFE OPERATING AREA

The switching safe operating area (SOA) is the boundary that the load line may traverse without incurring damage to the MOSFET. The fundamental limits are the peak current, I_{DM} and the breakdown voltage, BV_{DSS}. The switching SOA is applicable for both turn-on and turn-off of the devices for switching times less than one microsecond.

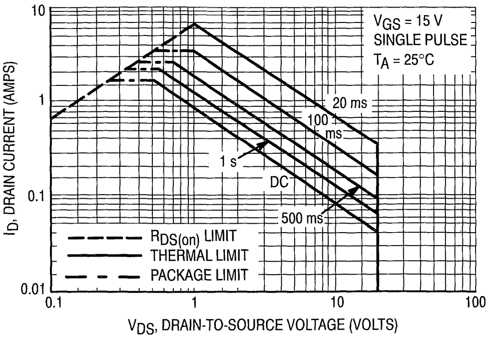


Figure 7. Maximum Rated Forward Biased Safe Operating Area

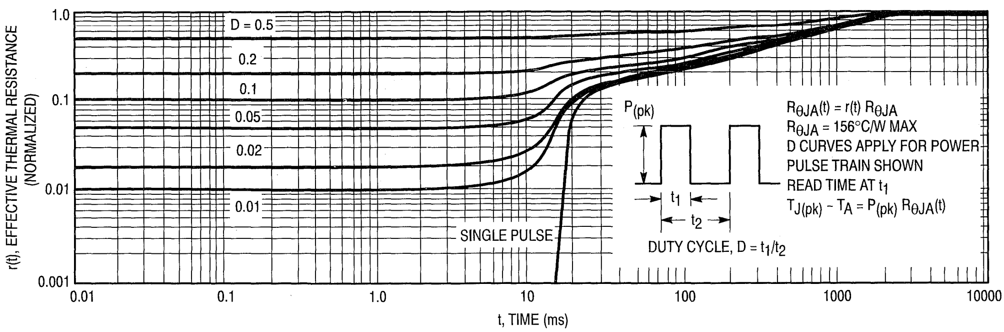


Figure 8. Thermal Response

COMMUTATING SAFE OPERATING AREA (CSOA)

The Commutating Safe Operating Area (CSOA) of Figure 10 defines the limits of safe operation for commutated source-drain current versus re-applied drain voltage when the source-drain diode has undergone forward bias. The curve shows the limitations of I_{FM} and peak V_{DS} for a given rate of change of source current. It is applicable when waveforms similar to those of Figure 9 are present. Full or half-bridge PWM DC motor controllers are common applications requiring CSOA data.

Device stresses increase with increasing rate of change of source current so dI_S/dt is specified with a maximum value. Higher values of dI_S/dt require an appropriate derating of I_{FM}, peak V_{DS} or both. Ultimately dI_S/dt is limited primarily by device, package, and circuit impedances. Maximum device stress occurs during t_{rr} as the diode goes from conduction to reverse blocking.

$V_{DS(pk)}$ is the peak drain-to-source voltage that the device must sustain during commutation; I_{FM} is the maximum forward source-drain diode current just prior to the onset of commutation.

V_R is specified at 80% rated BV_{DSS} to ensure that the CSOA stress is maximized as I_S decays from I_{RM} to zero.

R_{GS} should be minimized during commutation. T_J has only a second order effect on CSOA.

Stray inductances in Motorola's test circuit are assumed to be practical minimums. dV_{DS}/dt in excess of 10 V/ns was attained with dI_S/dt of 400 A/µs.

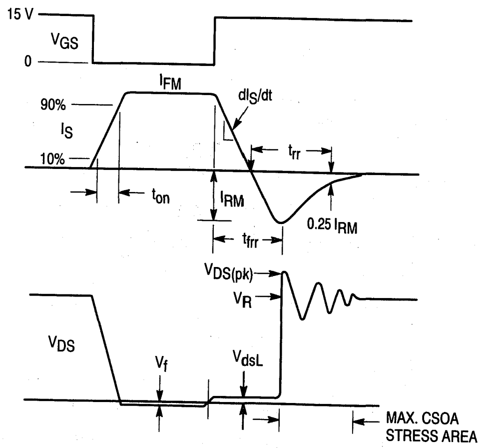


Figure 9. Commutating Waveforms

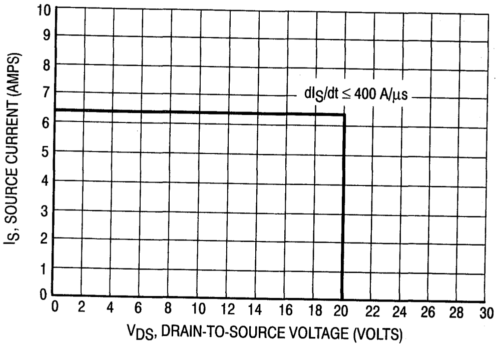


Figure 10. Commutating Safe Operating Area (CSOA)

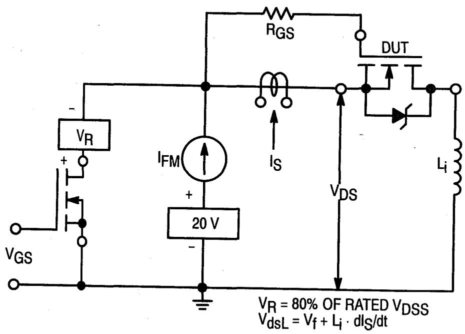


Figure 11. Commutating Safe Operating Area Test Circuit

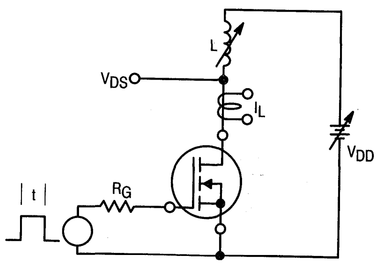


Figure 12. Unclamped Inductive Switching Test Circuit

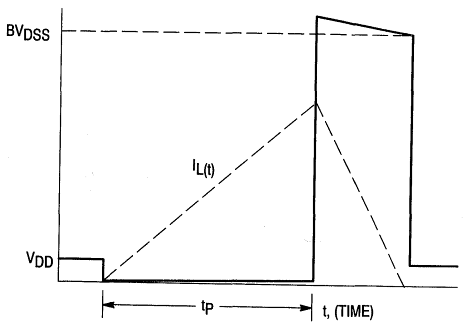


Figure 13. Unclamped Inductive Switching Waveforms

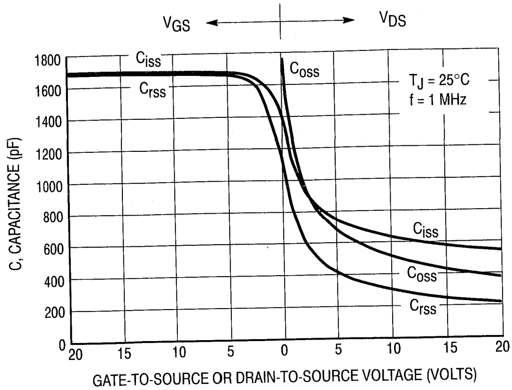


Figure 14. Capacitance Variation With Voltage

5

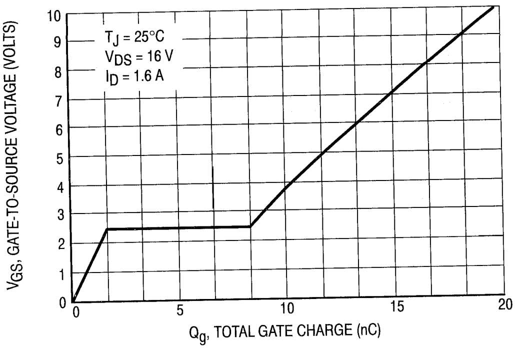
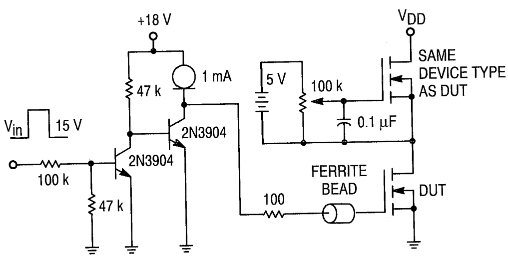


Figure 15. Gate Charge versus Gate-To-Source Voltage



V_{in} = 15 V_{pk}; PULSE WIDTH ≤ 100 μs, DUTY CYCLE ≤ 10%.

Figure 16. Gate Charge Test Circuit

Medium Power Field Effect Transistor

N-Channel Enhancement-Mode Silicon Gate TMOS SOT-223 for Surface Mount

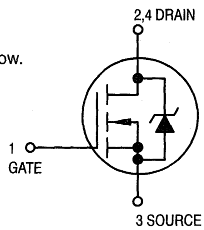
MMFT107T1

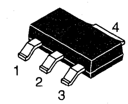
Motorola Preferred Device

MEDIUM POWER TMOS FET 250 mA, 200 VOLTS $R_{DS(on)}$ = 14 OHM MAX

This TMOS medium power field effect transistor is designed for high speed, low loss power switching applications such as switching regulators, dc-dc converters, solenoid and relay drivers. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- Silicon Gate for Fast Switching Speeds
- $R_{DS(on)}$ = 14 Ohm Max
- Low Drive Requirement
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering Eliminating the Possibility of Damage to the Die.
- Available in 12 mm Tape and Reel
  Use MMFT107T1 to order the 7 inch/1000 unit reel
  Use MMFT107T3 to order the 13 inch/4000 unit reel





CASE 318E-04, STYLE 3
TO-261AA

5

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DSS}	200	Volts
Gate-to-Source Voltage — Non-Repetitive	V_{GS}	±20	Volts
Drain Current	I_D	250	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

FT107

THERMAL CHARACTERISTICS

Thermal Resistance — Junction to Ambient	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on FR-4 glass epoxy printed circuit using minimum recommended footprint.

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-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}	—	—	30	nAdc
Gate-Body Leakage Current — Reverse (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	10	nAdc
ON CHARACTERISTICS (1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)		$V_{GS(th)}$	1.0	—	3.0	Vdc
Static Drain-to-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 200 mA)		$R_{DS(on)}$	—	—	14	Ohms
Drain-to-Source On-Voltage (V_{GS} = 10 V, I_D = 200 mA)		$V_{DS(on)}$	—	—	2.8	Vdc
Forward Transconductance (V_{DS} = 25 V, I_D = 250 mA)		g_{fs}	—	300	—	mmhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	—	pF
Output Capacitance		C_{oss}	—	30	—	
Transfer Capacitance		C_{rss}	—	6.0	—	
SOURCE-DRAIN DIODE CHARACTERISTICS						
Diode Forward Voltage	(V_{GS} = 0, I_S = 250 mA)	V_F	—	0.8	—	V
Continuous Source Current, Body Diode		I_S	—	—	250	mA
Pulsed Source Current, Body Diode		I_{SM}	—	—	500	

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

5

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Medium Power Field Effect Transistor

N-Channel Enhancement-Mode Silicon Gate TMOS SOT-223 for Surface Mount

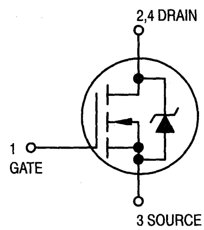
MMFT960T1

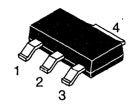
Motorola Preferred Device

MEDIUM POWER
TMOS FET
300 mA
60 VOLTS
$R_{DS(on)}$ = 1.7 OHM MAX

This TMOS medium power field effect transistor is designed for high speed, low loss power switching applications such as switching regulators, dc-dc converters, solenoid and relay drivers. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- Silicon Gate for Fast Switching Speeds
- $R_{DS(on)}$ = 1.7 Ohm Max
- Low Drive Requirement
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering Eliminating the Possibility of Damage to the Die.
- Available in 12 mm Tape and Reel
  Use MMFT960T1 to order the 7 inch/1000 unit reel
  Use MMFT960T3 to order the 13 inch/4000 unit reel





CASE 318E-04, STYLE 3
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	60	Volts
Gate-to-Source Voltage — Non-Repetitive	V_{GS}	±30	Volts
Drain Current	I_D	300	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

FT960

THERMAL CHARACTERISTICS

Thermal Resistance — Junction to Ambient	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a FR-4 glass epoxy printed circuit board using minimum recommended footprint.

TMOS is a registered trademark of Motorola Inc.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)		$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 60 V, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS (1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)		$V_{GS(th)}$	1.0	—	3.5	Vdc
Static Drain-to-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 1.0 A)		$R_{DS(on)}$	—	—	1.7	Ohms
Drain-to-Source On-Voltage		$V_{DS(on)}$				Vdc
(V_{GS} = 10 V, I_D = 0.5 A)			—	—	0.8	
(V_{GS} = 10 V, I_D = 1.0 A)			—	—	1.7	
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	—	600	—	mmhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	65	—	pF
Output Capacitance		C_{oss}	—	33	—	
Transfer Capacitance		C_{rss}	—	7.0	—	
Total Gate Charge	(V_{GS} = 10 V, I_D = 1.0 A, V_{DS} = 48 V)	Q_g	—	3.2	—	nC
Gate-Source Charge		Q_{gs}	—	1.2	—	
Gate-Drain Charge		Q_{gd}	—	2.0	—	

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

5

TYPICAL ELECTRICAL CHARACTERISTICS

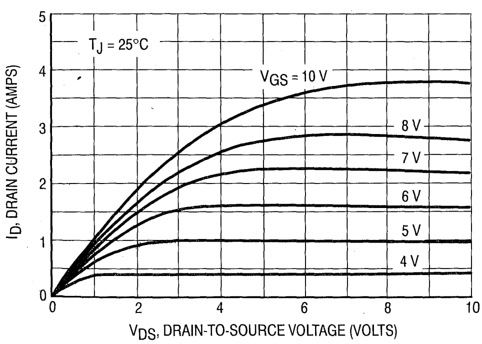


Figure 1. On-Region Characteristics

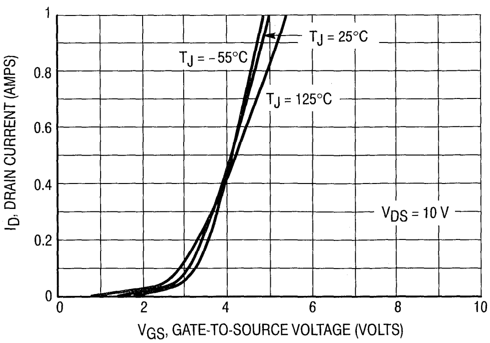


Figure 2. Transfer Characteristics

TYPICAL ELECTRICAL CHARACTERISTICS

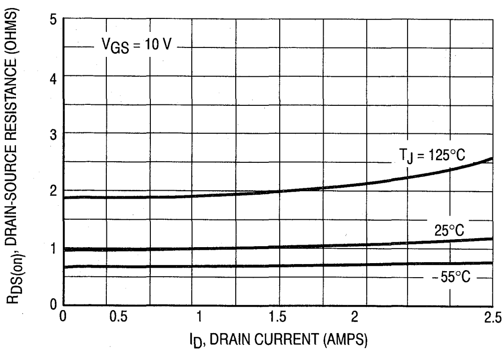


Figure 3. On-Resistance versus Drain Current

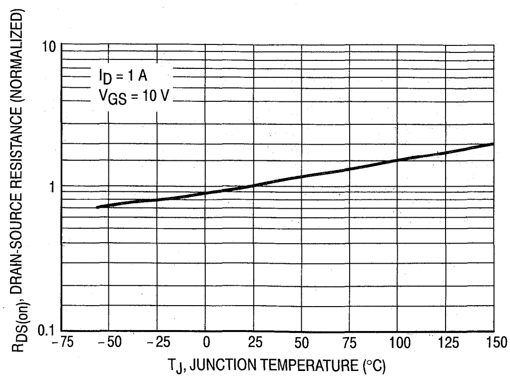


Figure 4. On-Resistance Variation with Temperature

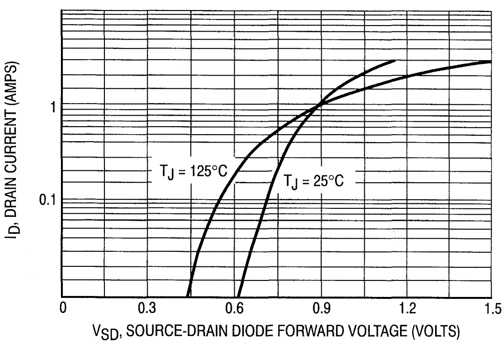


Figure 5. Source-Drain Diode Forward Voltage

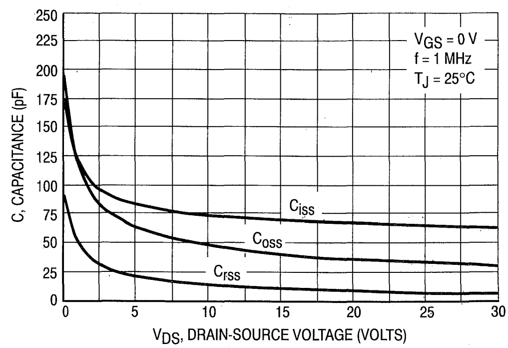


Figure 6. Capacitance Variation

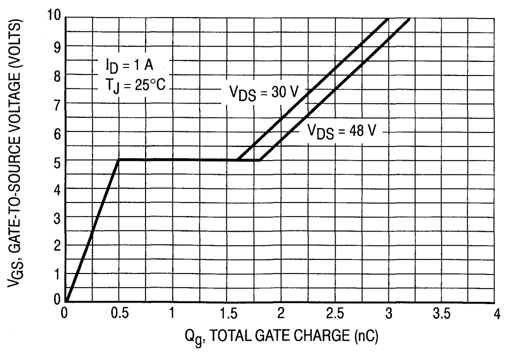


Figure 7. Gate Charge versus Gate-to-Source Voltage

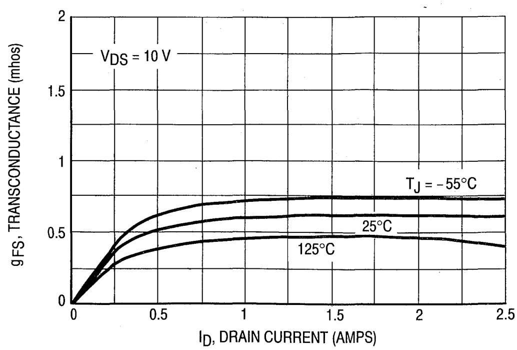


Figure 8. Transconductance

Medium Power Field Effect Transistor
N-Channel Enhancement Mode
Silicon Gate TMOS E-FET™
SOT-223 for Surface Mount

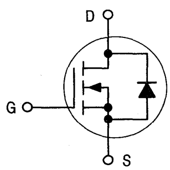
MMFT2406T1

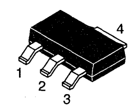
Motorola Preferred Device

**MEDIUM POWER
TMOS FET
700 mA
240 VOLTS
$R_{DS(on)}$ = 6.0 OHM**

This TMOS medium power field effect transistor is designed for high speed, low loss power switching applications such as switching regulators, converters, solenoid and relay drivers. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- Silicon Gate for Fast Switching Speeds
- High Voltage — 240 Vdc
- Low Drive Requirement
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use MMFT2406T1 to order the 7 inch/1000 unit reel.
  Use MMFT2406T3 to order the 13 inch/4000 unit reel.





**CASE 318E-04, STYLE 3
TO-261AA**

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	240	Vdc
Gate-to-Source Voltage — Continuous	V_{GS}	±20	Vdc
Drain Current	I_D	700	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

T2406

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Lead Temperature for Soldering Purposes, 1/16″ from case Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 sq. in.

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristics		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)		$V_{(BR)DSS}$	240	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 120 V, V_{GS} = 0)		I_{DSS}	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	100	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)		$V_{GS(th)}$	0.8	2.0	Vdc
Static Drain-to-Source On-Resistance		$R_{DS(on)}$			Ohms
(V_{GS} = 2.5 Vdc, I_D = 0.1 Adc)			—	10	
(V_{GS} = 10 Vdc, I_D = 0.5 Adc)			—	6.0	
Drain-to-Source On-Voltage (V_{GS} = 10 V, I_D = 0.5 A)		$V_{DS(on)}$	—	3.0	Vdc
Forward Transconductance (V_{DS} = 6.0 V, I_D = 0.5 A)		g_{FS}	300	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0 f = 1.0 MHz)	C_{iss}	—	125	pF
Output Capacitance		C_{oss}	—	50	
Transfer Capacitance		C_{rss}	—	20	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

Medium Power Field Effect Transistor

P-Channel Enhancement Mode
Silicon Gate TMOS E-FET™
SOT-223 for Surface Mount

MMFT2955ET1

Motorola Preferred Device

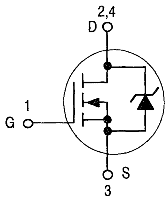
TMOS MEDIUM POWER FET
1.2 AMP
60 VOLTS
$R_{DS(on)}$ = 0.3 OHM

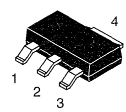
5

This advanced E-FET is a TMOS power MOSFET designed to withstand high energy in the avalanche and commutation modes. This new energy efficient device also offers a drain-to-source diode with a fast recovery time. Designed for low voltage, high speed switching applications in power supplies, converters and PWM motor controls, these devices are particularly well suited for bridge circuits where diode speed and commutating safe operating areas are critical and offer additional safety margin against unexpected voltage transients. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

TMOS®

- Silicon Gate for Fast Switching Speeds
- Low $R_{DS(on)}$ — 0.3 Ω max
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use the MMFT2955ET1 to order the 7 inch/1000 unit reel.
  Use the MMFT2955ET3 to order the 13 inch/4000 unit reel.





CASE 318E-04, STYLE 3
TO-261AA

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	60	Vdc
Gate-to-Source Voltage — Continuous	V_{GS}	±15	
Drain Current — Continuous — Pulsed	I_D I_{DM}	1.2 4.8	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to 150	°C
Single Pulse Drain-to-Source Avalanche Energy — Starting T_J = 25°C (V_{DD} = 25 V, V_{GS} = 10 V, Peak I_L= 1.2 A, L = 0.2 mH, R_G = 25 Ω)	E_{AS}	108	mJ

DEVICE MARKING

2955

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

*Power rating when mounted on FR-4 glass epoxy printed circuit board using recommended footprint.
TMOS is a registered trademark of Motorola Inc.
E-FET is a trademark of Motorola Inc.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage, (V_{GS} = 0, I_D = 250 μA)		$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current, (V_{DS} = 60 V, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current, (V_{GS} = 15 V, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS						
Gate Threshold Voltage, (V_{DS} = V_{GS}, I_D = 1 mA)		$V_{GS(th)}$	2	—	4.5	Vdc
Static Drain-to-Source On-Resistance, (V_{GS} = 10 V, I_D = 0.6 A)		$R_{DS(on)}$	—	—	0.3	Ohms
Drain-to-Source On-Voltage, (V_{GS} = 10 V, I_D = 1.2 A)		$V_{DS(on)}$	—	—	0.48	Vdc
Forward Transconductance, (V_{DS} = 15 V, I_D = 0.6 A)		g_{FS}	—	7.5	—	mhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 20 V, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	460	—	pF
Output Capacitance		C_{oss}	—	210	—	
Reverse Transfer Capacitance		C_{rss}	—	84	—	
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	(V_{DD} = 25 V, I_D = 1.6 A V_{GS} = 10 V, R_{gen} = 50 ohms, R_{GS} = 25 ohms)	$t_{d(on)}$	—	18	—	ns
Rise Time		t_r	—	29	—	
Turn-Off Delay Time		$t_{d(off)}$	—	44	—	
Fall Time		t_f	—	32	—	
Total Gate Charge	(V_{DS} = 48 V, I_D = 1.2 A, V_{GS} = 10 Vdc) See Figures 15 and 16	Q_g	—	18	—	nC
Gate-Source Charge		Q_{gs}	—	2.8	—	
Gate-Drain Charge		Q_{gd}	—	7.5	—	
SOURCE DRAIN DIODE CHARACTERISTICS*						
Forward On-Voltage	I_S = 1.2 A, V_{GS} = 0	V_{SD}	—	1	—	Vdc
Forward Turn-On Time	I_S = 1.2 A, V_{GS} = 0, dI_S/dt = 400 A/μs, V_R = 30 V	t_{on}	Limited by stray inductance			
Reverse Recovery Time		t_{rr}	—	90	—	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

5

5

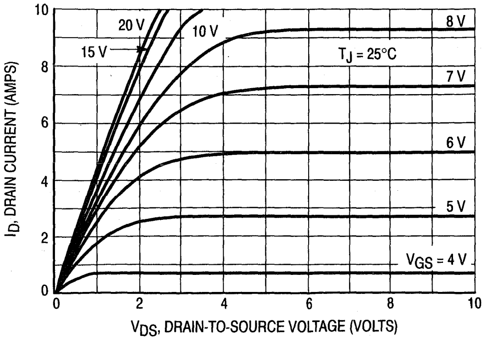


Figure 1. On Region Characteristics

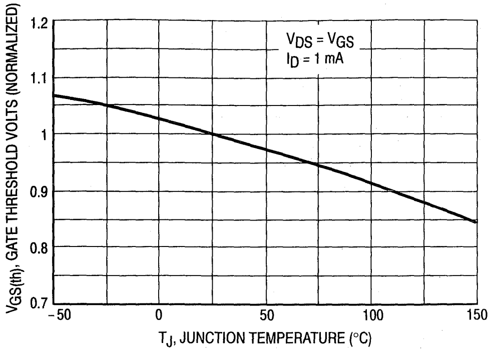


Figure 2. Gate-Threshold Voltage Variation With Temperature

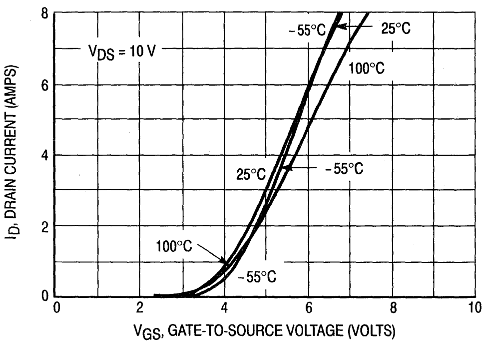


Figure 3. Transfer Characteristics

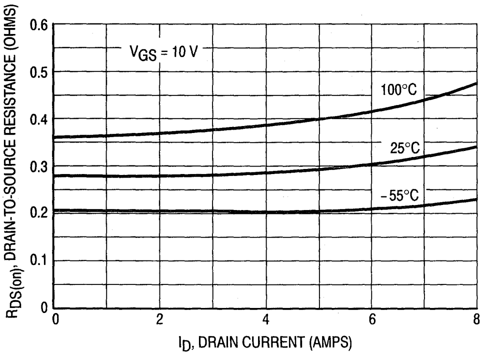


Figure 4. On-Resistance versus Drain Current

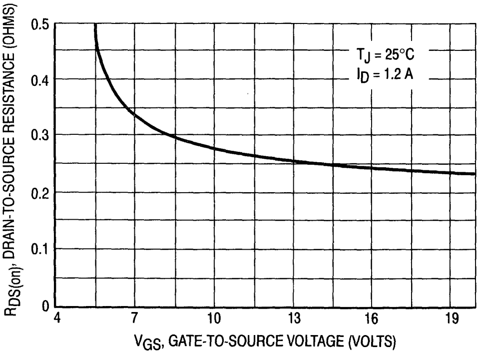


Figure 5. On-Resistance versus Gate-to-Source Voltage

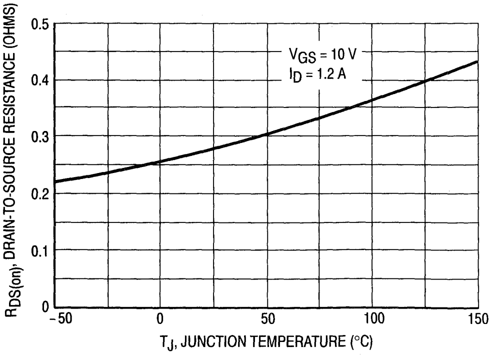


Figure 6. On-Resistance versus Junction Temperature

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, or when it is on, or being turned on. Because these curves include the limitations of simultaneous high voltage and high current, up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on a ambient temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various ambient temperatures can be determined by using the thermal response curves. Motorola Application Note, AN569, "Transient Thermal Resistance-General Data and Its Use" provides detailed instructions.

SWITCHING SAFE OPERATING AREA

The switching safe operating area (SOA) is the boundary that the load line may traverse without incurring damage to the MOSFET. The fundamental limits are the peak current, I_{DM} and the breakdown voltage, BV_{DSS}. The switching SOA is applicable for both turn-on and turn-off of the devices for switching times less than one microsecond.

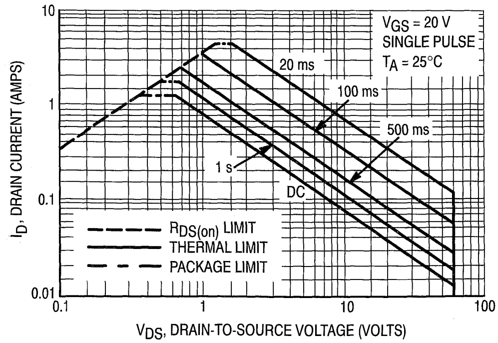


Figure 7. Maximum Rated Forward Biased Safe Operating Area

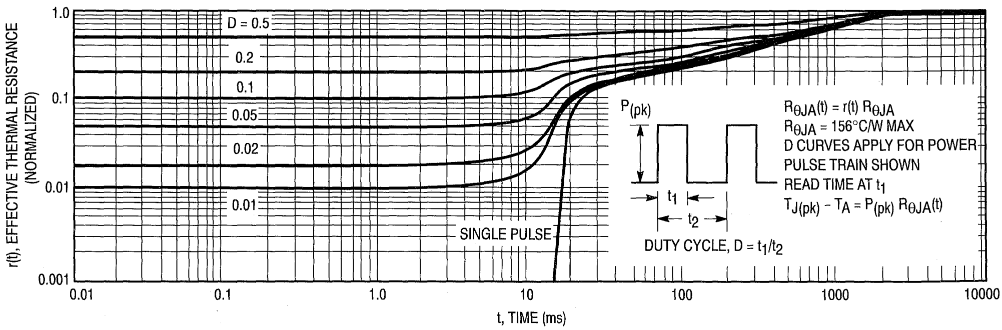


Figure 8. Thermal Response

COMMUTATING SAFE OPERATING AREA (CSOA)

The Commutating Safe Operating Area (CSOA) of Figure 10 defines the limits of safe operation for commutated source-drain current versus re-applied drain voltage when the source-drain diode has undergone forward bias. The curve shows the limitations of I_{FM} and peak V_{DS} for a given rate of change of source current. It is applicable when waveforms similar to those of Figure 9 are present. Full or half-bridge PWM DC motor controllers are common applications requiring CSOA data.

Device stresses increase with increasing rate of change of source current so dI_S/dt is specified with a maximum value. Higher values of dI_S/dt require an appropriate derating of I_{FM}, peak V_{DS} or both. Ultimately dI_S/dt is limited primarily by device, package, and circuit impedances. Maximum device stress occurs during t_{rr} as the diode goes from conduction to reverse blocking.

$V_{DS(pk)}$ is the peak drain-to-source voltage that the device must sustain during commutation; I_{FM} is the maximum forward source-drain diode current just prior to the onset of commutation.

V_R is specified at 80% rated BV_{DSS} to ensure that the CSOA stress is maximized as I_S decays from I_{RM} to zero.

R_{GS} should be minimized during commutation. T_J has only a second order effect on CSOA.

Stray inductances in Motorola's test circuit are assumed to be practical minimums. dV_{DS}/dt in excess of 10 V/ns was attained with dI_S/dt of 400 A/µs.

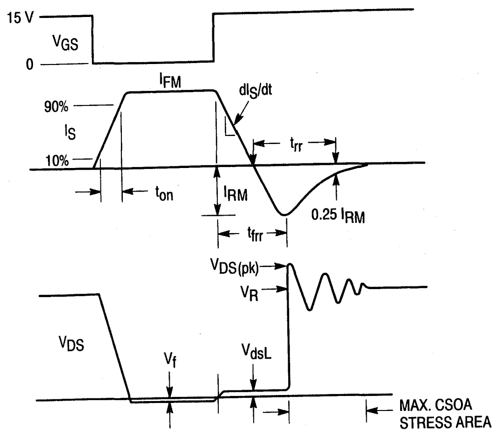


Figure 9. Commutating Waveforms

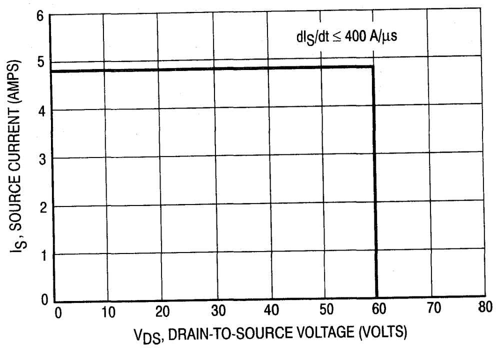


Figure 10. Commutating Safe Operating Area (CSOA)

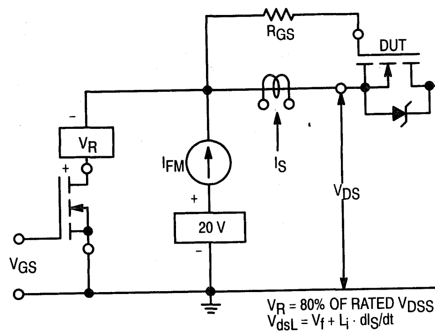


Figure 11. Commutating Safe Operating Area Test Circuit

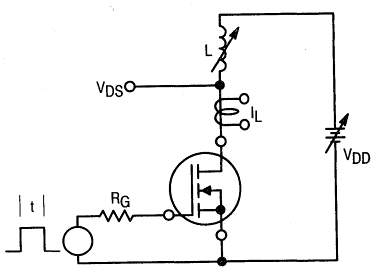


Figure 12. Unclamped Inductive Switching Test Circuit

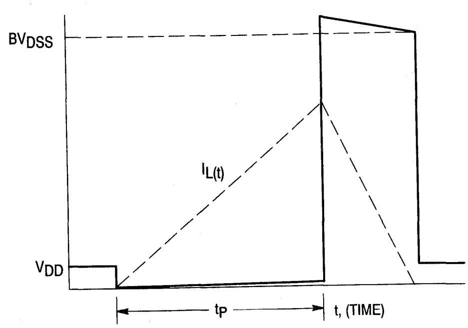


Figure 13. Unclamped Inductive Switching Waveforms

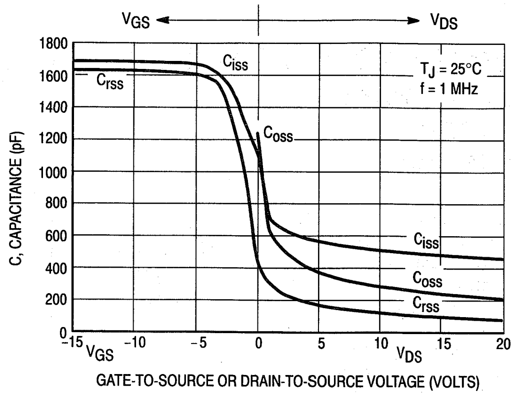


Figure 14. Capacitance Variation

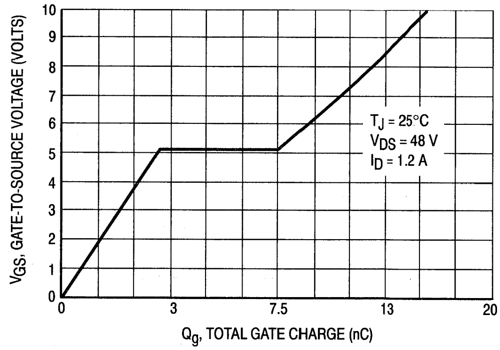
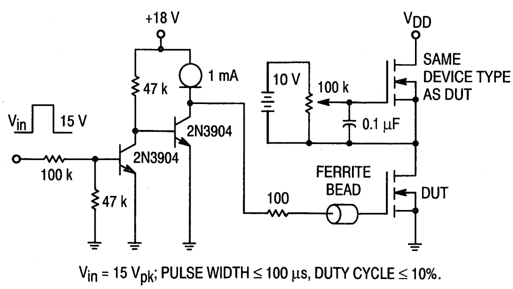


Figure 15. Gate Charge versus Gate-To-Source Voltage



V_{in} = 15 V_{pk}; PULSE WIDTH ≤ 100 µs, DUTY CYCLE ≤ 10%.

Figure 16. Gate Charge Test Circuit

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Medium Power Field Effect Transistor
N-Channel Enhancement Mode
Silicon Gate TMOS E-FET™
SOT-223 for Surface Mount

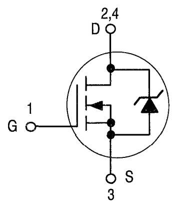
MMFT3055ET1

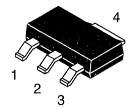
Motorola Preferred Device

MEDIUM POWER
TMOS FET
1.7 AMP
60 VOLTS
$R_{DS(on)}$ = 0.15 OHM

This advanced E-FET is a TMOS Medium Power MOSFET designed to withstand high energy in the avalanche and commutation modes. This new energy efficient device also offers a drain-to-source diode with a fast recovery time. Designed for low voltage, high speed switching applications in power supplies, dc-dc converters and PWM motor controls, these devices are particularly well suited for bridge circuits where diode speed and commutating safe operating areas are critical and offer additional safety margin against unexpected voltage transients. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

TMOS





CASE 318E-04, STYLE 3
TO-261AA

- Silicon Gate for Fast Switching Speeds
- Low $R_{DS(on)}$ — 0.15 Ω max
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use the MMFT3055ET1 to order the 7 inch/1000 unit reel.
  Use the MMFT3055ET3 to order the 13 inch/4000 unit reel.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	60	Vdc
Gate-to-Source Voltage — Continuous	V_{GS}	±20	
Drain Current — Continuous — Pulsed	I_D I_{DM}	1.7 6.8	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C
Single Pulse Drain-to-Source Avalanche Energy — Starting T_J = 25°C (V_{DD} = 60 V, V_{GS} = 10 V, Peak I_L= 1.7 A, L = 0.2 mH, R_G = 25 Ω)	E_{AS}	168	mJ

DEVICE MARKING

3055

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

*Power rating when mounted on FR-4 glass epoxy printed circuit board using recommended footprint.
TMOS is a registered trademark of Motorola Inc.
E-FET is a trademark of Motorola Inc.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage, (V_{GS} = 0, I_D = 250 μA)		$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current, (V_{DS} = 60 V, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current, (V_{GS} = 20 V, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS						
Gate Threshold Voltage, (V_{DS} = V_{GS}, I_D = 1 mA)		$V_{GS(th)}$	2	—	4.5	Vdc
Static Drain-to-Source On-Resistance, (V_{GS} = 10 V, I_D = 0.85 A)		$R_{DS(on)}$	—	—	0.15	Ohms
Drain-to-Source On-Voltage, (V_{GS} = 10 V, I_D = 1.7 A)		$V_{DS(on)}$	—	—	0.34	Vdc
Forward Transconductance, (V_{DS} = 15 V, I_D = 0.85 A)		g_{FS}	—	2.2	—	mhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 20 V, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	430	—	pF
Output Capacitance		C_{oss}	—	225	—	
Reverse Transfer Capacitance		C_{rss}	—	40	—	
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	(V_{DD} = 25 V, I_D = 0.85 A V_{GS} = 10 V, R_{gen} = 50 ohms, R_{GS} = 25 ohms)	$t_{d(on)}$	—	15	—	ns
Rise Time		t_r	—	22	—	
Turn-Off Delay Time		$t_{d(off)}$	—	31	—	
Fall Time		t_f	—	49	—	
Total Gate Charge	(V_{DS} = 48 V, I_D = 1.7 A, V_{GS} = 10 Vdc) See Figures 15 and 16	Q_g	—	12.5	—	nC
Gate-Source Charge		Q_{gs}	—	2	—	
Gate-Drain Charge		Q_{gd}	—	4.5	—	
SOURCE DRAIN DIODE CHARACTERISTICS*						
Forward On-Voltage	I_S = 1.7 A, V_{GS} = 0	V_{SD}	—	0.8	—	Vdc
Forward Turn-On Time	I_S = 1.7 A, V_{GS} = 0, dI_S/dt = 400 A/μs, V_R = 30 V	t_{on}	Limited by stray inductance			
Reverse Recovery Time		t_{rr}	—	50	—	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

5

5

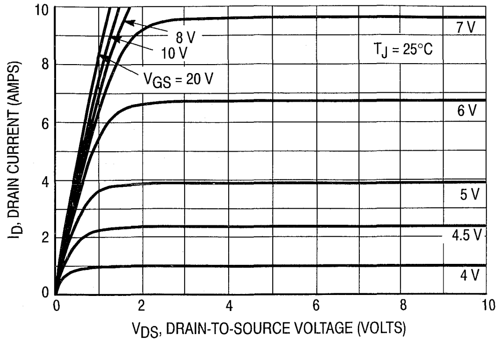


Figure 1. On Region Characteristics

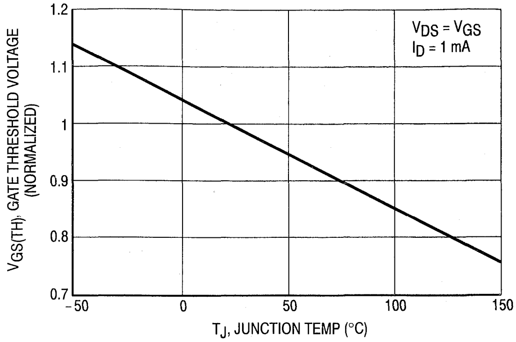


Figure 2. Gate-Threshold Voltage Variation With Temperature

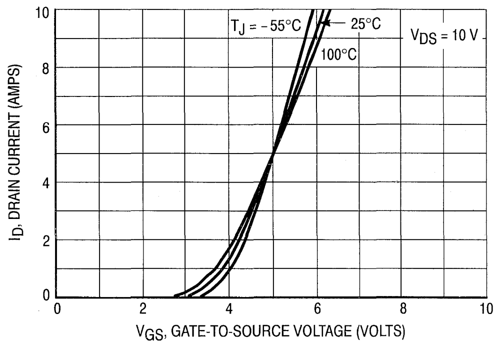


Figure 3. Transfer Characteristics

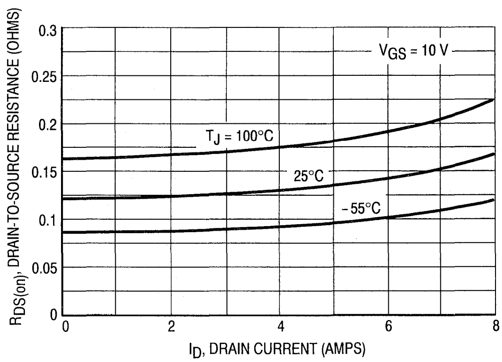


Figure 4. On-Resistance versus Drain Current

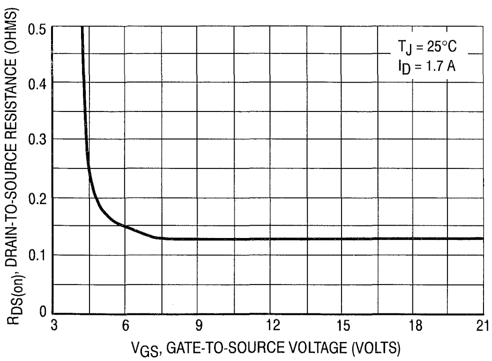


Figure 5. On-Resistance versus Gate-to-Source Voltage

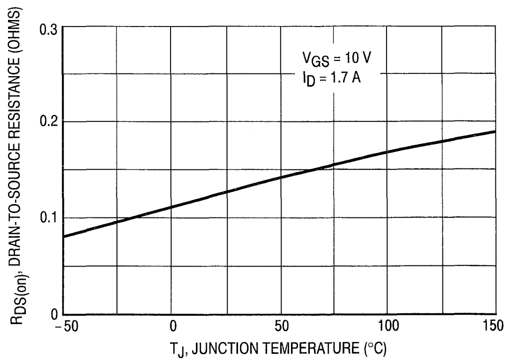


Figure 6. On-Resistance versus Junction Temperature

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, or when it is on, or being turned on. Because these curves include the limitations of simultaneous high voltage and high current, up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on an ambient temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various ambient temperatures can be determined by using the thermal response curves. Motorola Application Note, AN569, "Transient Thermal Resistance-General Data and Its Use" provides detailed instructions.

SWITCHING SAFE OPERATING AREA

The switching safe operating area (SOA) is the boundary that the load line may traverse without incurring damage to the MOSFET. The fundamental limits are the peak current, I_{DM} and the breakdown voltage, BV_{DSS}. The switching SOA is applicable for both turn-on and turn-off of the devices for switching times less than one microsecond.

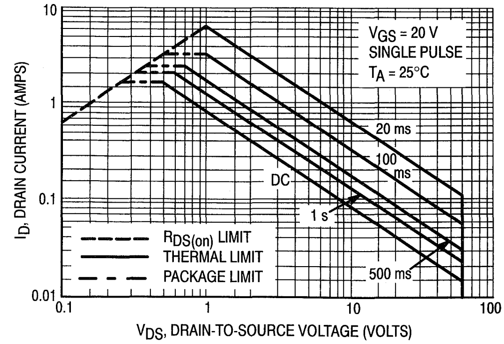


Figure 7. Maximum Rated Forward Biased Safe Operating Area

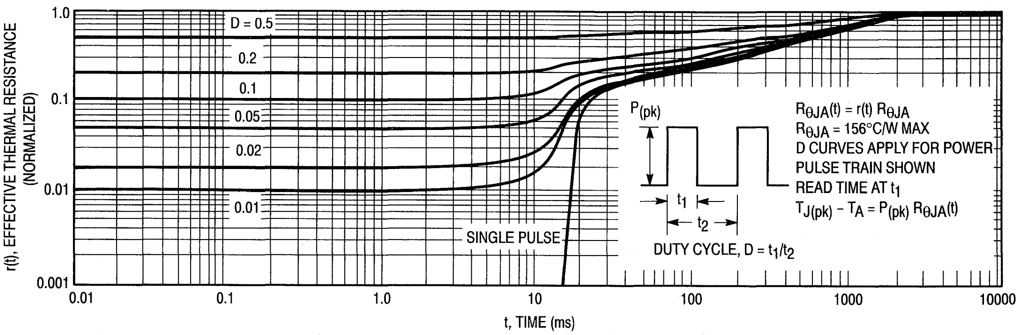


Figure 8. Thermal Response

COMMUTATING SAFE OPERATING AREA (CSOA)

The Commutating Safe Operating Area (CSOA) of Figure 10 defines the limits of safe operation for commutated source-drain current versus re-applied drain voltage when the source-drain diode has undergone forward bias. The curve shows the limitations of I_{FM} and peak V_{DS} for a given rate of change of source current. It is applicable when waveforms similar to those of Figure 9 are present. Full or half-bridge PWM DC motor controllers are common applications requiring CSOA data.

Device stresses increase with increasing rate of change of source current so dI_S/dt is specified with a maximum value. Higher values of dI_S/dt require an appropriate derating of I_{FM}, peak V_{DS} or both. Ultimately dI_S/dt is limited primarily by device, package, and circuit impedances. Maximum device stress occurs during t_{rr} as the diode goes from conduction to reverse blocking.

$V_{DS(pk)}$ is the peak drain-to-source voltage that the device must sustain during commutation; I_{FM} is the maximum forward source-drain diode current just prior to the onset of commutation.

V_R is specified at 80% rated BV_{DSS} to ensure that the CSOA stress is maximized as I_S decays from I_{RM} to zero.

R_{GS} should be minimized during commutation. T_J has only a second order effect on CSOA.

Stray inductances in Motorola's test circuit are assumed to be practical minimums. dV_{DS}/dt in excess of 10 V/ns was attained with dI_S/dt of 400 A/μs.

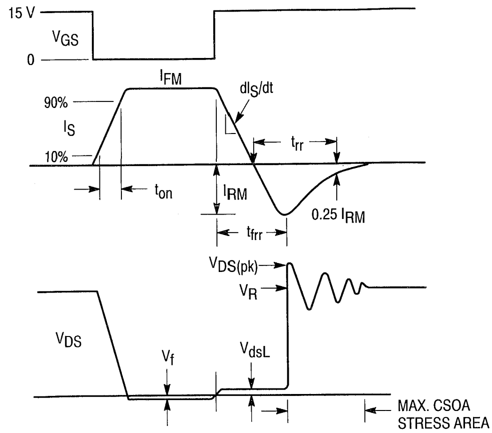


Figure 9. Commutating Waveforms

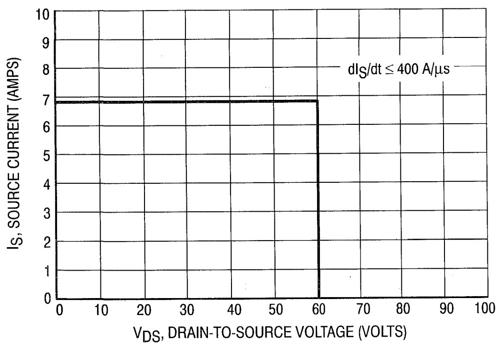


Figure 10. Commutating Safe Operating Area (CSOA)

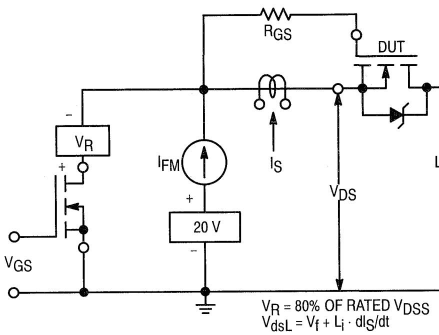


Figure 11. Commutating Safe Operating Area Test Circuit

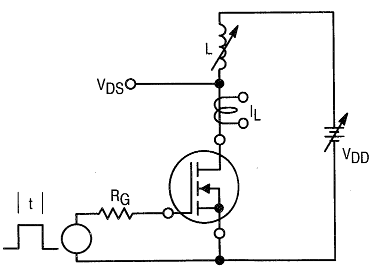


Figure 12. Unclamped Inductive Switching Test Circuit

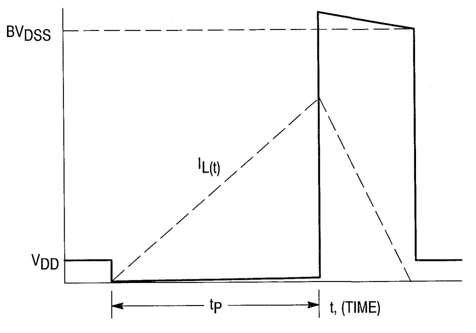


Figure 13. Unclamped Inductive Switching Waveforms

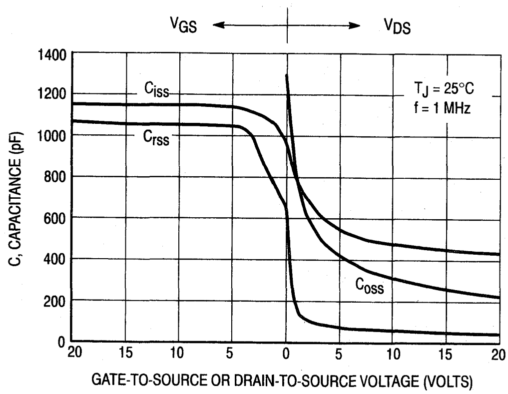


Figure 14. Capacitance Variation With Voltage

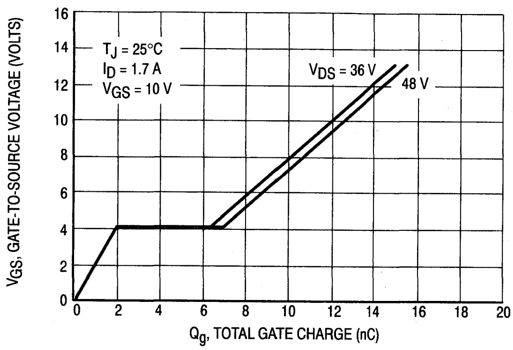
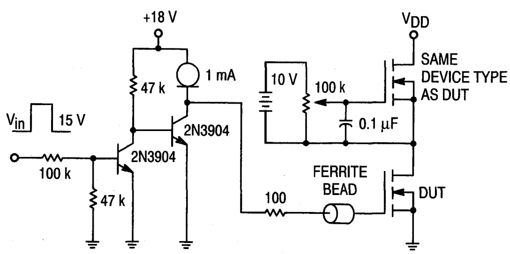


Figure 15. Gate Charge versus Gate-To-Source Voltage



V_{in} = 15 V_{pk}; PULSE WIDTH ≤ 100 µs, DUTY CYCLE ≤ 10%.

Figure 16. Gate Charge Test Circuit

5

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Medium Power Field Effect Transistor
N-Channel Enhancement Mode
Silicon Gate TMOS E-FET™
SOT-223 for Surface Mount

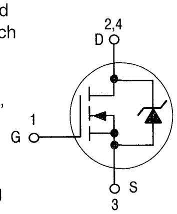
MMFT3055ELT1

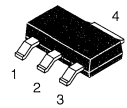
Motorola Preferred Device

MEDIUM POWER
LOGIC LEVEL TMOS FET
1.5 AMP
60 VOLTS
$R_{DS(on)}$ = 0.18 OHM

This advanced E-FET is a TMOS power MOSFET designed to withstand high energy in the avalanche and commutation modes. This device is also designed with a low threshold voltage so it is fully enhanced with 5 Volts. This new energy efficient device also offers a drain-to-source diode with a fast recovery time. Designed for low voltage, high speed switching applications in power supplies, converters and PWM motor controls, these devices are particularly well suited for bridge circuits where diode speed and commutating safe operating areas are critical and offer additional safety margin against unexpected voltage transients. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- Silicon Gate for Fast Switching Speeds
- Low Drive Requirement to Interface Power Loads to Logic Level ICs, $V_{GS(th)}$ = 2 Volts Max
- Low $R_{DS(on)}$ — 0.18 Ω max
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use the MMFT3055ELT1 to order the 7 inch/1000 unit reel.
  Use the MMFT3055ELT3 to order the 13 inch/4000 unit reel.





CASE 318E-04, STYLE 3
TO-261AA

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	60	Vdc
Gate-to-Source Voltage — Continuous	V_{GS}	±15	
Drain Current — Continuous — Pulsed	I_D I_{DM}	1.5 6	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to 150	°C
Single Pulse Drain-to-Source Avalanche Energy — Starting T_J = 25°C (V_{DD} = 25 V, V_{GS} = 5 V, Peak I_L= 1.5 A, L = 0.2 mH, R_G = 25 Ω)	E_{AS}	178	mJ

DEVICE MARKING

3055L

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 5	°C Sec

*Power rating when mounted on FR-4 glass epoxy printed circuit board using recommended footprint.
TMOS is a registered trademark of Motorola Inc.
E-FET is a trademark of Motorola Inc.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage, (V_{GS} = 0, I_D = 250 μA)		$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current, (V_{DS} = 60 V, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current, (V_{GS} = 15 V, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS						
Gate Threshold Voltage, (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(th)}$	1	—	2	Vdc
Static Drain-to-Source On-Resistance, (V_{GS} = 5 V, I_D = 0.75 A)		$R_{DS(on)}$	—	—	0.18	Ohms
Drain-to-Source On-Voltage, (V_{GS} = 5 V, I_D = 1.5 A)		$V_{DS(on)}$	—	—	0.36	Vdc
Forward Transconductance, (V_{DS} = 15 V, I_D = 0.75 A)		g_{FS}	—	2.1	—	mhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	500	—	pF
Output Capacitance		C_{oss}	—	175	—	
Reverse Transfer Capacitance		C_{rss}	—	40	—	
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	(V_{DD}= 25 V, I_D = 6 A V_{GS} = 5 V, R_{gen} = 50 ohms, R_{GS} = 25 ohms)	$t_{d(on)}$	—	20	—	ns
Rise Time		t_r	—	95	—	
Turn-Off Delay Time		$t_{d(off)}$	—	38	—	
Fall Time		t_f	—	50	—	
Total Gate Charge	(V_{DS} = 48 V, I_D = 1.5 A, V_{GS} = 5 Vdc) See Figures 15 and 16	Q_g	—	7	15	nC
Gate-Source Charge		Q_{gs}	—	1.3	—	
Gate-Drain Charge		Q_{gd}	—	6.3	—	
SOURCE DRAIN DIODE CHARACTERISTICS*						
Forward On-Voltage	I_S = 1.5 A, V_{GS} = 0	V_{SD}	—	1.0	—	Vdc
Forward Turn-On Time	I_S = 1.5 A, V_{GS} = 0, dI_S/dt = 400 A/μs, V_R = 30 V	t_{on}	Limited by stray inductance			
Reverse Recovery Time		t_{rr}	—	55	—	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

5

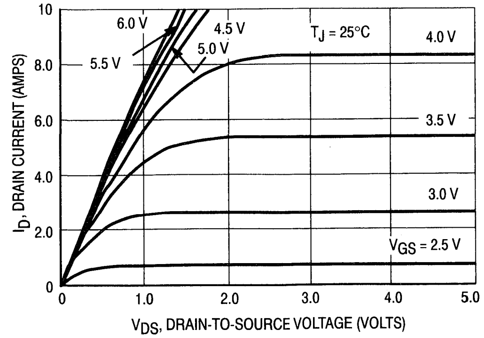


Figure 1. On Region Characteristics

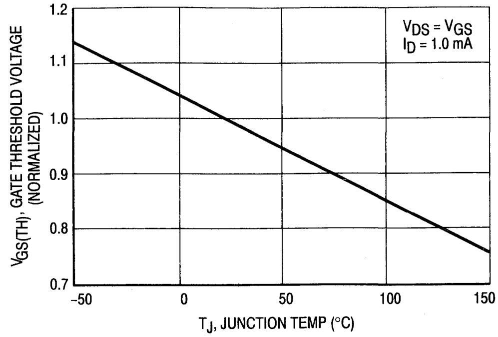


Figure 2. Gate-Threshold Voltage Variation With Temperature

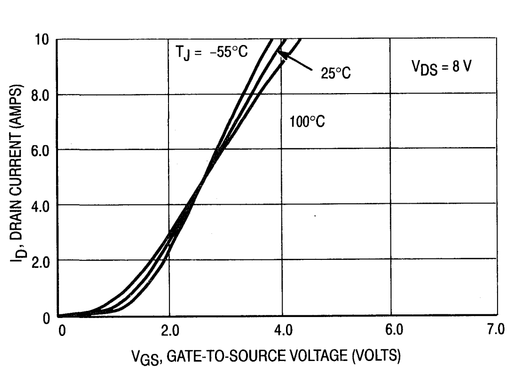


Figure 3. Transfer Characteristics

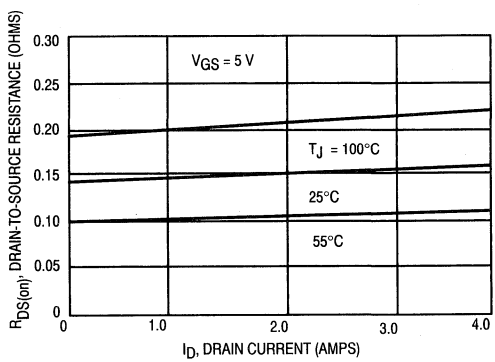


Figure 4. On-Resistance versus Drain Current

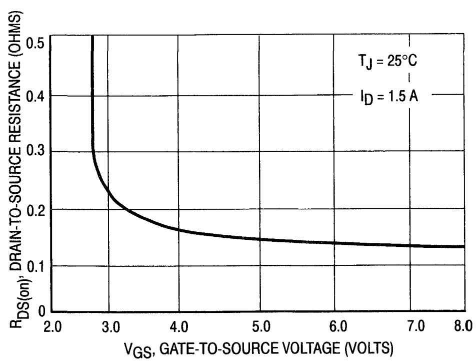


Figure 5. On-Resistance versus Gate-to-Source Voltage

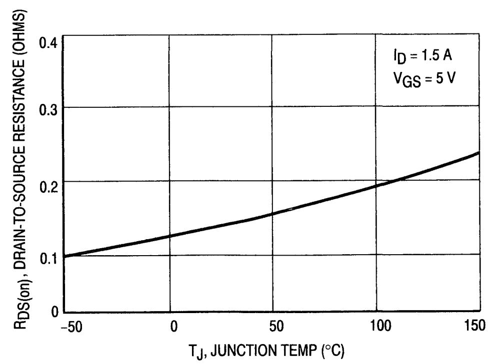


Figure 6. On-Resistance versus Junction Temperature

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, or when it is on, or being turned on. Because these curves include the limitations of simultaneous high voltage and high current, up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on an ambient temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various ambient temperatures can be determined by using the thermal response curves. Motorola Application Note, AN569, "Transient Thermal Resistance-General Data and Its Use" provides detailed instructions.

SWITCHING SAFE OPERATING AREA

The switching safe operating area (SOA) is the boundary that the load line may traverse without incurring damage to the MOSFET. The fundamental limits are the peak current, I_{DM} and the breakdown voltage, BV_{DSS}. The switching SOA is applicable for both turn-on and turn-off of the devices for switching times less than one microsecond.

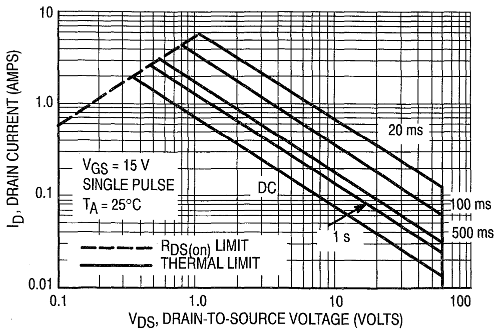


Figure 7. Maximum Rated Forward Biased Safe Operating Area

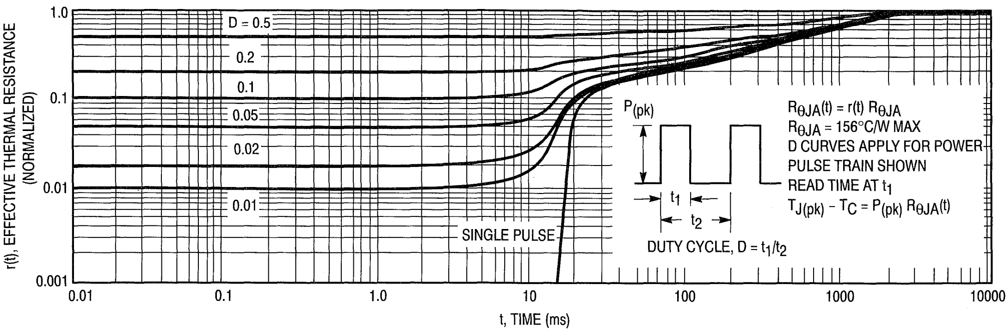


Figure 8. Thermal Response

COMMUTATING SAFE OPERATING AREA (CSOA)

The Commutating Safe Operating Area (CSOA) of Figure 10 defines the limits of safe operation for commutated source-drain current versus re-applied drain voltage when the source-drain diode has undergone forward bias. The curve shows the limitations of I_{FM} and peak V_{DS} for a given rate of change of source current. It is applicable when waveforms similar to those of Figure 9 are present. Full or half-bridge PWM DC motor controllers are common applications requiring CSOA data.

Device stresses increase with increasing rate of change of source current so dI_S/dt is specified with a maximum value. Higher values of dI_S/dt require an appropriate derating of I_{FM}, peak V_{DS} or both. Ultimately dI_S/dt is limited primarily by device, package, and circuit impedances. Maximum device stress occurs during t_{rr} as the diode goes from conduction to reverse blocking.

$V_{DS(pk)}$ is the peak drain-to-source voltage that the device must sustain during commutation; I_{FM} is the maximum forward source-drain diode current just prior to the onset of commutation.

V_R is specified at 80% rated BV_{DSS} to ensure that the CSOA stress is maximized as I_S decays from I_{RM} to zero.

R_{GS} should be minimized during commutation. T_J has only a second order effect on CSOA.

Stray inductances in Motorola's test circuit are assumed to be practical minimums. dV_{DS}/dt in excess of 10 V/ns was attained with dI_S/dt of 400 A/μs.

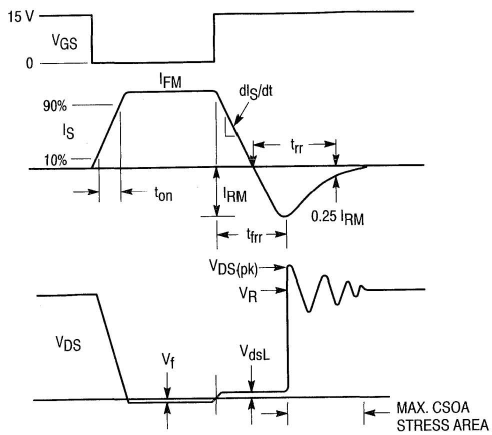


Figure 9. Commutating Waveforms

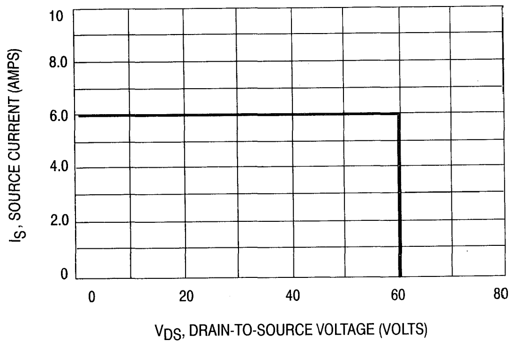


Figure 10. Commutating Safe Operating Area (CSOA)

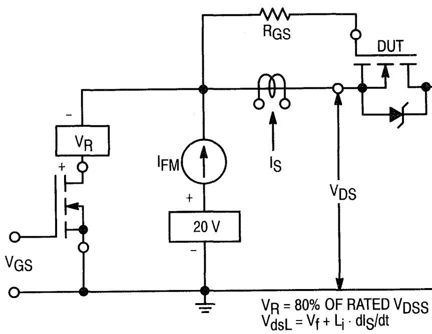


Figure 11. Commutating Safe Operating Area Test Circuit

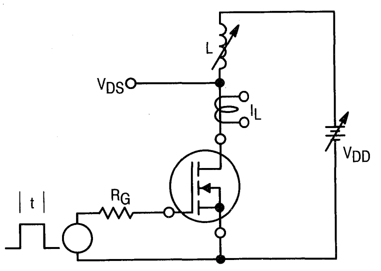


Figure 12. Unclamped Inductive Switching Test Circuit

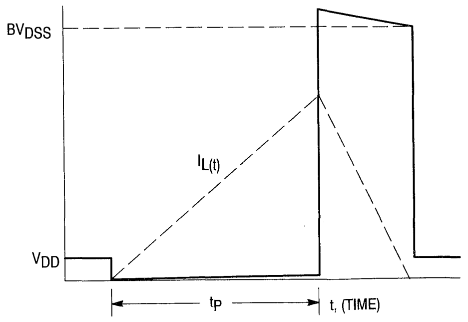


Figure 13. Unclamped Inductive Switching Waveforms

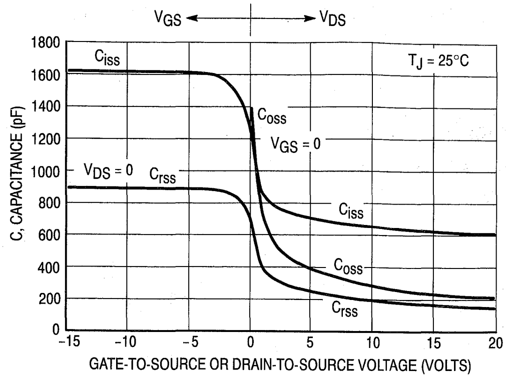


Figure 14. Capacitance Variation With Voltage

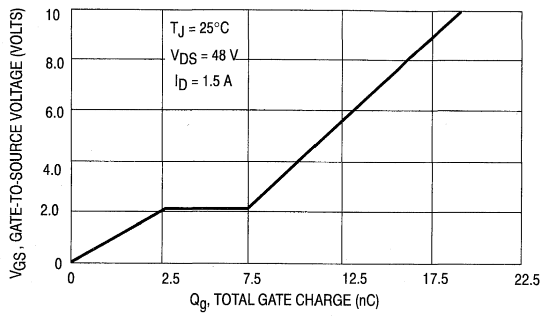
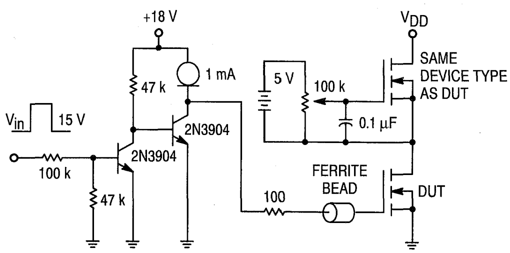


Figure 15. Gate Charge versus Gate-To-Source Voltage



V_{in} = 15 V_{pk}; PULSE WIDTH ≤ 100 μs, DUTY CYCLE ≤ 10%.

Figure 16. Gate Charge Test Circuit

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MMFT3166T1

Motorola Preferred Device

Medium Power Field Effect Transistor

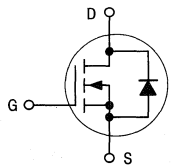
N-Channel Enhancement Mode
Silicon Gate TMOS E-FET™
SOT-223 for Surface Mount

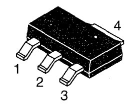
MEDIUM POWER
TMOS FET
1 AMP
60 VOLTS
$R_{DS(on)}$ = 2.0 OHMS

This TMOS medium power field effect transistor is designed for high speed, low loss power switching applications such as switching regulators, converters, solenoid and relay drivers. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

TMOS®

- Silicon Gate for Fast Switching Speeds
- Low $R_{DS(on)}$ — 2.0 Ω Max
- Low Drive Requirement
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering, Eliminating the Possibility of Damage to the Die
- Available in 12 mm Tape and Reel
  Use MMFT3166T1 to order the 7 inch/1000 unit reel.
  Use MMFT3166T3 to order the 13 inch/4000 unit reel.





CASE 318E-04, STYLE 3
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	60	Vdc
Gate-to-Source Voltage — Continuous	V_{GS}	±30	Vdc
Drain Current	I_D	1.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	1.5 12	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

T3166

THERMAL CHARACTERISTICS

Thermal Resistance — Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	83.3	°C/W
Lead Temperature for Soldering Purposes, 1/16″ from case Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 sq. in.

Thermal Clad is a trademark of the Bergquist Company
TMOS is a registered trademark of Motorola Inc.
E-FET is a trademark of Motorola Inc.

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristics		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)		$V_{(BR)DSS}$	60	—	Vdc
Drain-Source Leakage Current (V_{DS} = 30 V, V_{GS} = 1.0 V)		I_{DSX}	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 30 Vdc, V_{DS} = 0)		I_{GSS}	—	50	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage		$V_{GS(th)}$			Vdc
(V_{DS} = V_{GS}, I_D = 1.0 mAdc)			1.6	3.5	
(V_{DS} = V_{GS}, I_D = 10 μAdc)			1.5	3.5	
Static Drain-to-Source On-Resistance		$R_{DS(on)}$			Ohms
(V_{GS} = 10 Vdc, I_D = 0.1 Adc)			—	2.0	
(V_{GS} = 10 Vdc, I_D = 0.5 Adc)			—	2.0	
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0 f = 1.0 MHz)	C_{iss}	—	200	pF
Output Capacitance		C_{oss}	—	200	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

Medium Power Field Effect Transistor

N-Channel Enhancement-Mode Silicon Gate TMOS SOT-223 for Surface Mount

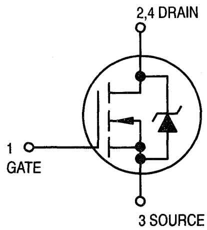
MMFT6661T1

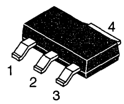
Motorola Preferred Device

**MEDIUM POWER
TMOS FET
500 mA
90 VOLTS
$R_{DS(on)}$ = 4.0 OHM MAX**

This TMOS medium power field effect transistor is designed for high speed, low loss power switching applications such as switching regulators, dc-dc converters, solenoid and relay drivers. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- Silicon Gate for Fast Switching Speeds
- $R_{DS(on)}$ = 4.0 Ohm Max
- Low Drive Requirement, V_{GS} = 2.0 Volts Max
- The SOT-223 Package can be Soldered Using Wave or Reflow. The Formed Leads Absorb Thermal Stress During Soldering Eliminating the Possibility of Damage to the Die.
- Available in 12 mm Tape and Reel
  Use MMFT6661T1 to order the 7 inch/1000 unit reel
  Use MMFT6661T3 to order the 13 inch/4000 unit reel





CASE 318E-04, STYLE 3
TO-261AA

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DS}	90	Vdc
Gate-to-Source Voltage — Non-Repetitive	V_{GS}	±30	Vdc
Drain Current	I_D	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

T6661

THERMAL CHARACTERISTICS

Thermal Resistance — Junction to Ambient	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 5	°C Sec

*Device mounted on FR-4 glass epoxy printed circuit board using minimum recommended footprint.

TMOS is a registered trademark of Motorola Inc.
Thermal Clad is a trademark of the Bergquist Company

Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)		$V_{(BR)DSS}$	90	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 90 V, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS (1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)		$V_{GS(th)}$	0.8	—	2.0	Vdc
Static Drain-to-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)		$R_{DS(on)}$	—	—	4.0	Ohms
Drain-to-Source On-Voltage		$V_{DS(on)}$				Vdc
(V_{GS} = 10 V, I_D = 1.0 A)			—	—	4.0	
(V_{GS} = 5.0 V, I_D = 0.3 A)			—	—	1.6	
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{FS}	—	200	—	mmhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	36	—	pF
Output Capacitance		C_{oss}	—	16	—	
Transfer Capacitance		C_{rss}	—	6.0	—	
Total Gate Charge	(V_{GS} = 10 V, I_D = 1.0 A, V_{DS} = 72 V)	Q_g	—	1.7	—	nC
Gate-Source Charge		Q_{gs}	—	0.34	—	
Gate-Drain Charge		Q_{gd}	—	0.23	—	

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

5

TYPICAL ELECTRICAL CHARACTERISTICS

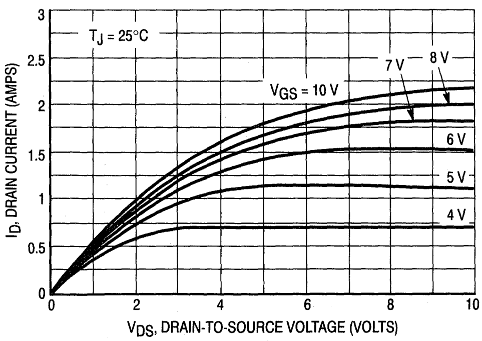


Figure 1. On-Region Characteristics

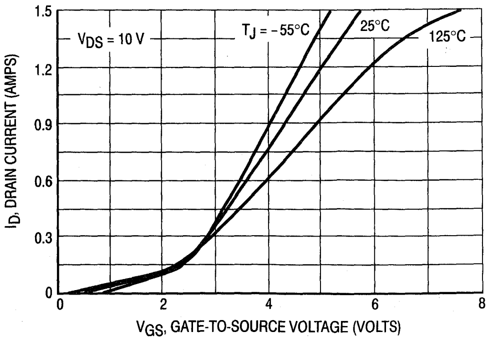


Figure 2. Transfer Characteristics

TYPICAL ELECTRICAL CHARACTERISTICS

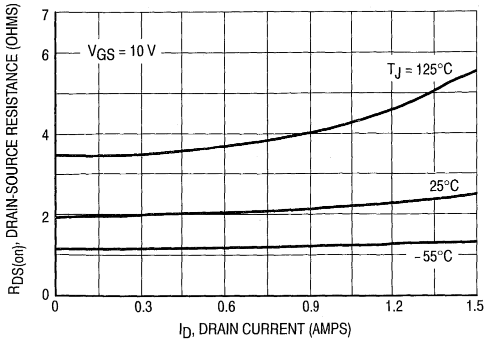


Figure 3. On-Resistance versus Drain Current

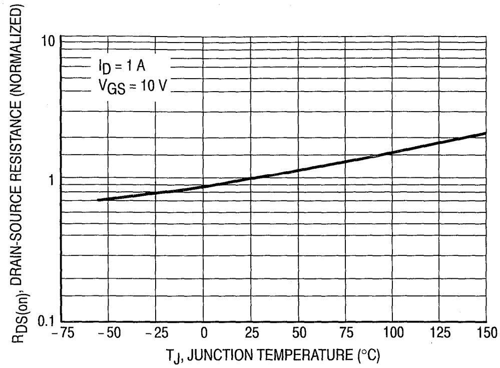


Figure 4. On-Resistance Variation with Temperature

5

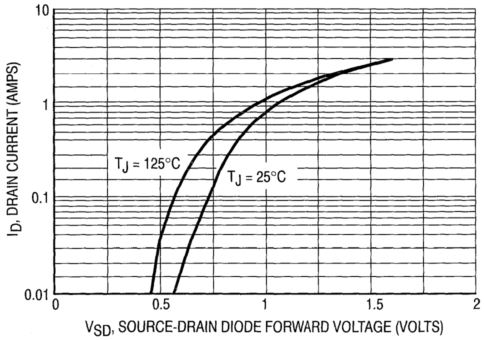


Figure 5. Source-Drain Diode Forward Voltage

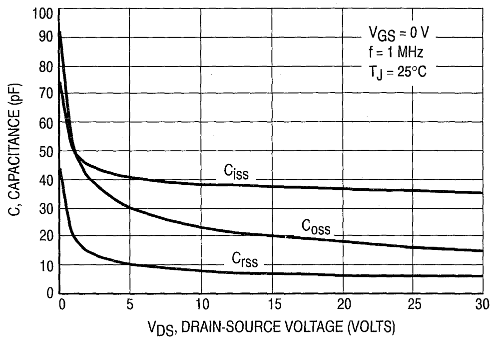


Figure 6. Capacitance versus Drain-Source Voltage

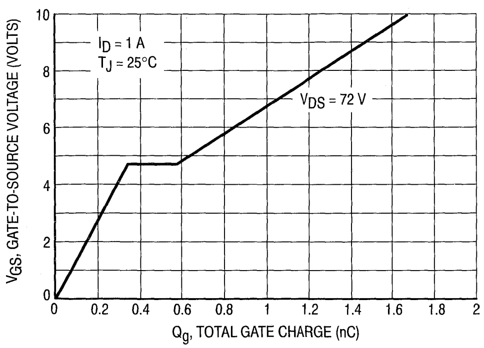


Figure 7. Gate Charge versus Gate-to-Source Voltage

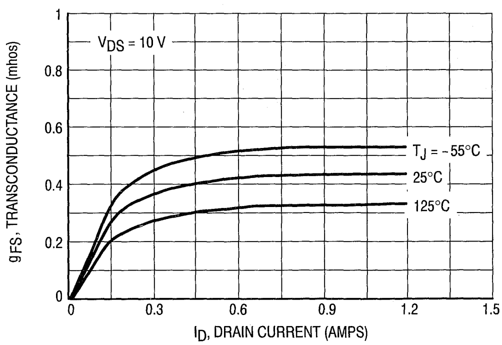
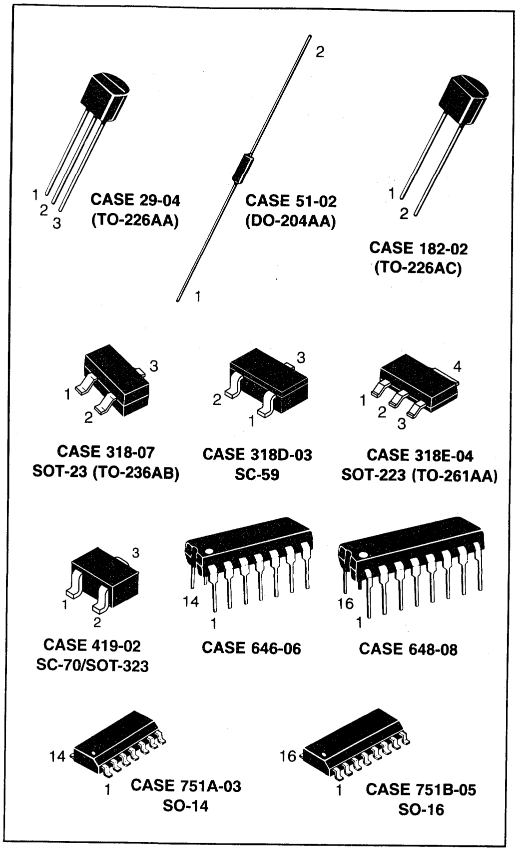


Figure 8. Transconductance



Packaging options include plastic DIPs and surface mount packages. Most SOT-23, SC-59, SC-70/SOT-323 and SOT-223 package devices are only available in Tape and Reel.

NOTE: All SOT-23 package devices have had a "T1" suffix added to the device title.

Small-Signal Tuning and Switching Diodes

6

EMBOSSED TAPE AND REEL

SOT-23, SC-59, SC-70/SOT-323, SOT-223, SO-14 and SO-16 packages are available in Tape and Reel. Use the appropriate suffix indicated below to order any of the SOT-23, SC-59, SC-70/SOT-323, SOT-223, SO-14 and SO-16 packages. (See Section 7 on Packaging for additional information).

SOT-23: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SC-59: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SC-70/ SOT-323: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SOT-223: available in 12 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/1000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/4000 unit reel.

SO-14: available in 16 mm Tape and Reel
Add an "R1" suffix to the device title to order the 7 inch/500 unit reel.
Add an "R2" suffix to the device title to order the 13 inch/2500 unit reel.

SO-16: available in 16 mm Tape and Reel
Add an "R1" suffix to the device title to order the 7 inch/500 unit reel.
Add an "R2" suffix to the device title to order the 13 inch/2500 unit reel.

RADIAL TAPE IN FAN FOLD BOX OR REEL

TO-92 packages are available in both bulk shipments and in Radial Tape in Fan Fold Boxes or Reels. Fan Fold Boxes and Radial Tape Reel are the best methods for capturing devices for automatic insertion in printed circuit boards.

TO-92: available in Fan Fold Box
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Fan Fold box.

available in 365 mm Radial Tape Reel
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Radial Tape Reel.

*Refer to Section 7 on Packaging for Style code characters and additional information on ordering requirements.

DEVICE MARKINGS/DATE CODE CHARACTERS

SOT-23, SC-59 and SC-70/SOT-323 packages have a device marking and a date code etched on the device. The generic example below depicts both the device marking and a representation of the date code that appears on the SC-70/SOT-323, SC-59 and SOT-23 packages.

ABCD

The "D" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

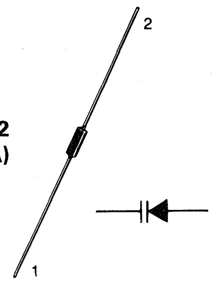
SILICON EPICAP DIODES

. . . are designed for electronic tuning and harmonic-generation applications, and provide solid-state reliability to replace mechanical tuning methods.

- Guaranteed High-Frequency Q
- Guaranteed Wide Tuning Range
- Premium 5% Capacitance Tolerance
- Standard 10% Capacitance Tolerance
- Complete Typical Design Curves

1N5139,A thru 1N5148,A

CASE 51-02 (DO-204AA)



6.8–47 pF EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODES

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Volts
Forward Current	I_F	250	mA
RF Power Input*	P_{in}	5.0	Watts
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_C	2.0 13.3	Watts mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

*The RF power input rating assumes that an adequate heatsink is provided.

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	60	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 55 Vdc, T_A = 25°C) (V_R = 55 Vdc, T_A = 150°C)	I_R	— —	— —	0.02 20	μAdc
Series Inductance (f = 250 MHz, L ≈ 1/16″)	L_S	—	4.0	—	nH
Case Capacitance (f = 1.0 MHz, L ≈ 1/16″)	C_C	—	0.17	—	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	200	—	ppm/°C

	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	α V_R = 4.0 Vdc, f = 1.0 MHz		TR, Tuning Ratio C_4/C_{60} f = 1.0 MHz	
Device	Min	Typ	Max	Min	Min	Typ	Min	Typ
1N5139	6.1	6.8	7.5	350	0.37	0.4	2.7	2.9
1N5139A	6.5	6.8	7.1	350	0.37	0.4	2.7	2.9
1N5140	9.0	10	11	300	0.38	0.41	2.8	3.0
1N5140A	9.5	10	10.5	300	0.38	0.41	2.8	3.0
1N5141	10.8	12	13.2	300	0.38	0.41	2.8	3.0
1N5141A	11.4	12	12.6	300	0.38	0.41	2.8	3.0
1N5142	13.5	15	16.5	250	0.38	0.41	2.8	3.0
1N5142A	14.3	15	15.7	250	0.38	0.41	2.8	3.0
1N5143	16.2	18	19.8	250	0.38	0.41	2.8	3.0
1N5143A	17.1	18	18.9	250	0.38	0.41	2.8	3.0
1N5144	19.8	22	24.2	200	0.43	0.45	3.2	3.4
1N5144A	20.9	22	23.1	200	0.43	0.45	3.2	3.4
1N5145	24.3	27	29.7	200	0.43	0.45	3.2	3.4
1N5145A	25.7	27	28.3	200	0.43	0.45	3.2	3.4
1N5146	29.7	33	36.3	200	0.43	0.45	3.2	3.4
1N5146A	31.4	33	34.6	200	0.43	0.45	3.2	3.4
1N5147	36.1	39	42.9	200	0.43	0.45	3.2	3.4
1N5147A	37.1	39	40.9	200	0.43	0.45	3.2	3.4
1N5148	42.3	47	51.7	200	0.43	0.45	3.2	3.4
1N5148A	44.7	47	49.3	200	0.43	0.45	3.2	3.4

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE
L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter). L = lead length.

2. C_C, CASE CAPACITANCE
C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. C_T, DIODE CAPACITANCE
($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. TR, TUNING RATIO
TR is the ratio of C_T measured at 4.0 Vdc divided by C_T measured at 60 Vdc.

5. Q, FIGURE OF MERIT
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8).

6. α, DIODE CAPACITANCE REVERSE VOLTAGE SLOPE
The diode capacitance, C_T (as measured at V_R = 4.0 Vdc, f = 1.0 MHz) is compared to C_T (as measured at V_R = 60 Vdc, f = 1.0 MHz) by the following equation which defines α.

$$\alpha = \frac{\log C_T(4) - \log C_T(60)}{\log 60 - \log 4}$$

Note that a C_T versus V_R law is assumed as shown in the following equation where C_C is included.

$$C_T = \frac{K}{V\alpha}$$

7. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT

TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = −65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation which defines TC_C:

$$TC_C = \left| \frac{C_T(+85°C) - C_T(-65°C)}{85 + 65} \right| \cdot \frac{10^6}{C_T(25°C)}$$

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE

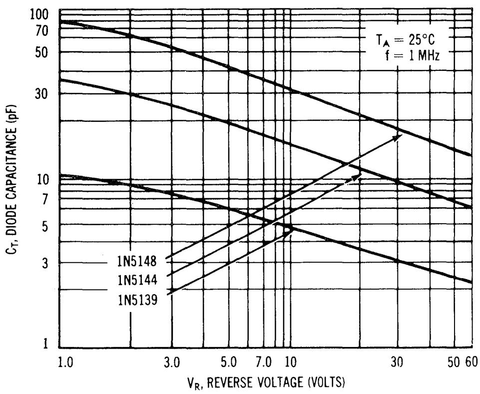


FIGURE 2 — FIGURE OF MERIT versus REVERSE VOLTAGE

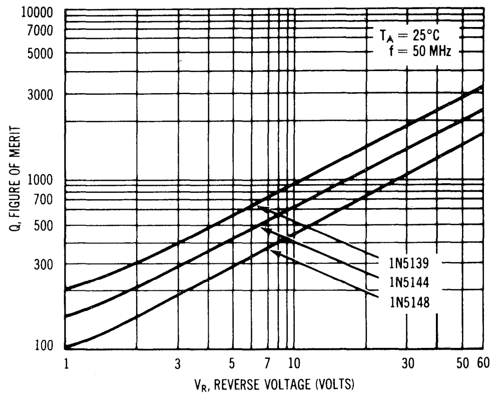


FIGURE 3 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

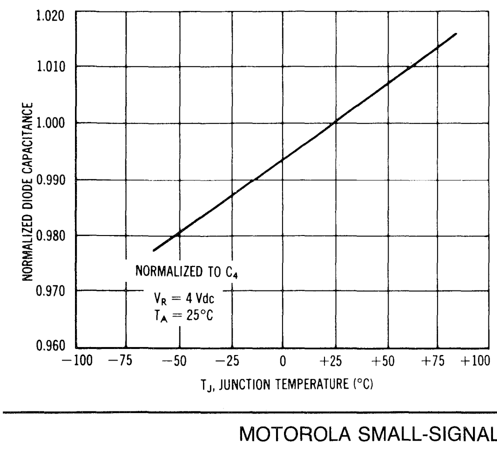


FIGURE 4 — NORMALIZED FIGURE OF MERIT versus JUNCTION TEMPERATURE

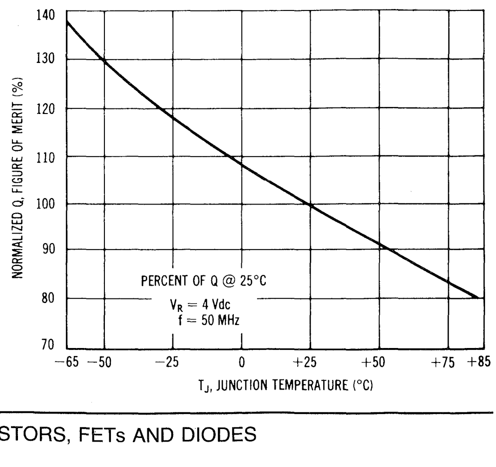


FIGURE 5 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

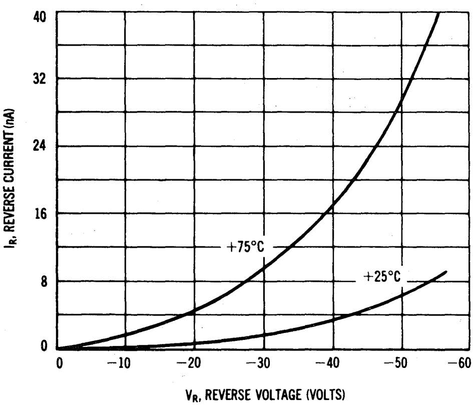
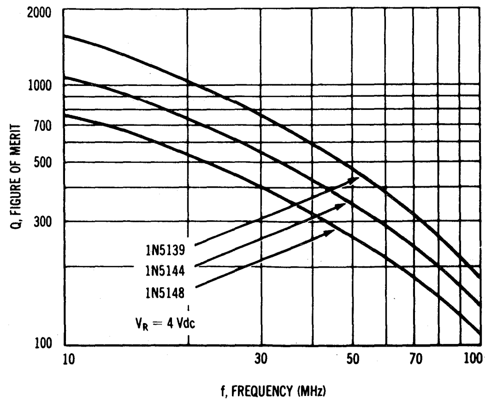


FIGURE 6 — FIGURE OF MERIT versus FREQUENCY



6

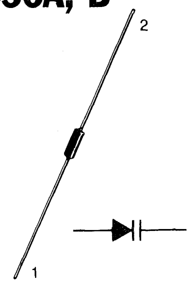
SILICON EPICAP DIODES

. . . epitaxial passivated abrupt junction tuning diodes designed for electronic tuning, FM, AFC and harmonic-generation applications in AM through UHF ranges, providing solid-state reliability to replace mechanical tuning methods.

- Excellent Q Factor at High Frequencies
- Guaranteed Capacitance Change — 2.0 to 30 V
- Capacitance Tolerance — 10% and 5.0%
- Complete Typical Design Curves

1N5441A, B thru 1N5456A, B

CASE 51-02
(DO-204AA)



6.8–100 pF
30 VOLTS
VOLTAGE-VARIABLE CAPACITANCE DIODES

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Operating Junction Temperature Range	T_J	+175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

*Indicates JEDEC Registered Data.

6

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C) (V_R = 25 Vdc, T_A = 150°C)	I_R	— —	— —	0.02 20	μAdc
Series Inductance (f = 250 MHz, lead length ≈ 1/16″)	L_S	—	4.0	—	nH
Case Capacitance (f = 1.0 MHz, lead length ≈ 1/16″)	C_C	—	0.17	—	pF
Diode Capacitance Temperature Coefficient (Note 6) (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	300	—	ppm/°C

Device	C_T, Diode Capacitance (1) V_R = 4.0 Vdc, f = 1.0 MHz pF			TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz
	Min (Nom −10%)	Nom	Max (Nom +10%)	Min	Max	Min
1N5441A	6.1	6.8	7.5	2.5	3.2	450
1N5443A	9.0	10	11	2.6	3.2	400
1N5444A	10.8	12	13.2	2.6	3.2	400
1N5445A	13.5	15	16.5	2.6	3.2	400
1N5446A	16.2	18	19.8	2.6	3.2	350
1N5448A	19.8	22	24.2	2.6	3.2	350
1N5449A	24.3	27	29.7	2.6	3.2	350
1N5450A	29.7	33	36.3	2.6	3.2	350
1N5451A	35.1	39	42.9	2.6	3.2	300
1N5452A	42.3	47	51.7	2.6	3.2	250
1N5453A	50.4	56	61.6	2.6	3.3	200
1N5455A	73.8	82	90.2	2.7	3.3	175
1N5456A	90	100	110	2.7	3.3	175

(1) To order devices with C_T Nom ±5.0% add Suffix B.
*Indicates JEDEC Registered Data.

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE
L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter or equivalent).

2. C_C, CASE CAPACITANCE
C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. C_T, DIODE CAPACITANCE
($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. TR, TUNING RATIO
TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

5. Q, FIGURE OF MERIT
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

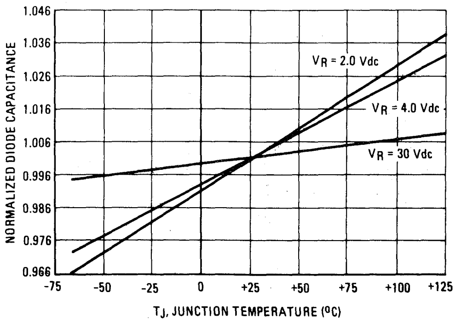
(Boonton Electronics Model 33AS8 or equivalent).

6. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT
TC_C is guaranteed by comparing C_T at $V_R = 4.0$ Vdc, f = 1.0 MHz, $T_A = -65°C$ with C_T at $V_R = 4.0$ Vdc, f = 1.0 MHz, $T_A = +85°C$ in the following equation, which defines TC_C:

$$TC_C = \left| \frac{C_T(+85°C) - C_T(-65°C)}{85 + 65} \right| \cdot \frac{10^6}{C_T(25°C)}$$

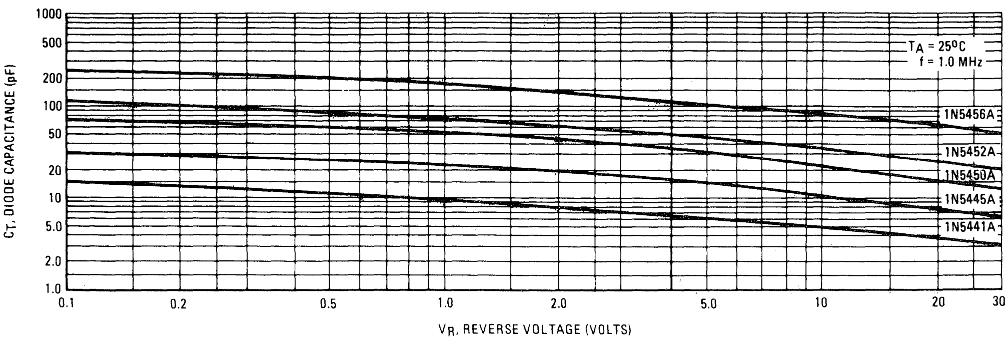
Accuracy limited by C_T measurement to ±0.1 pF.

FIGURE 1 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



TYPICAL DEVICE PERFORMANCE

FIGURE 2 — DIODE CAPACITANCE versus REVERSE VOLTAGE



6

FIGURE 3 — FIGURE OF MERIT versus REVERSE VOLTAGE

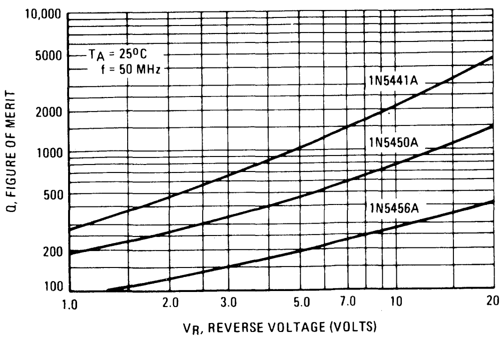


FIGURE 4 — FIGURE OF MERIT versus FREQUENCY

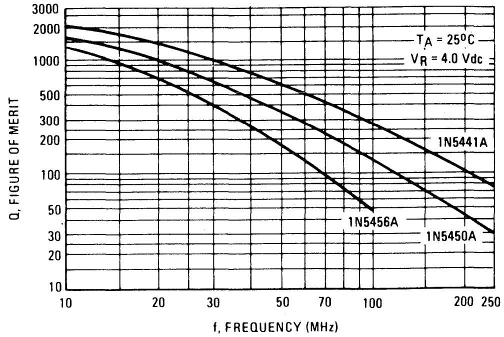


FIGURE 5 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

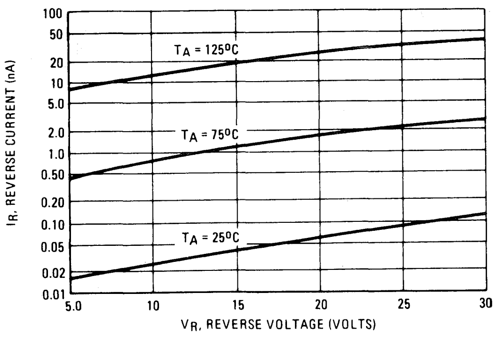
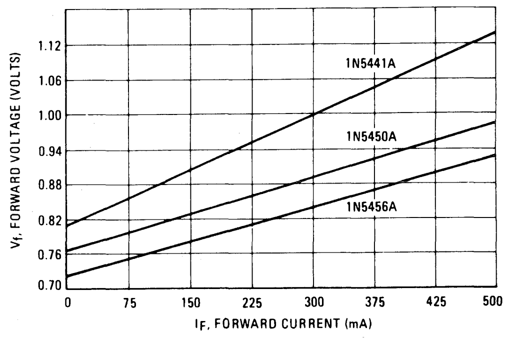


FIGURE 6 — FORWARD VOLTAGE versus FORWARD CURRENT



6

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 FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

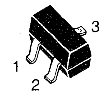
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BAL99LT1 = JF

BAL99LT1★

CASE 318-07, STYLE 18
SOT-23 (TO-236AB)



SWITCHING DIODE

★This is a Motorola designated preferred device.

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 70 V) (V_R = 25 V, T_J = 150°C) (V_R = 70 V, T_J = 150°C)	I_R	 — — —	 2.5 30 50	μA
Reverse Breakdown Voltage (I_R = 100 μA)	$V_{(BR)}$	70	—	V
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA) (I_F = 50 mA) (I_F = 150 mA)	V_F	 — — — —	 715 855 1000 1250	mV
Recovery Current (I_F = 10 mA, V_R = 5.0 V, R_L = 500 Ω)	Q_S	—	45	pC
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mA, R_L = 100 Ω, measured at I_R = 1.0 mA)	t_{rr}	—	6.0	ns
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V

6

FIGURE 1 — FORWARD VOLTAGE

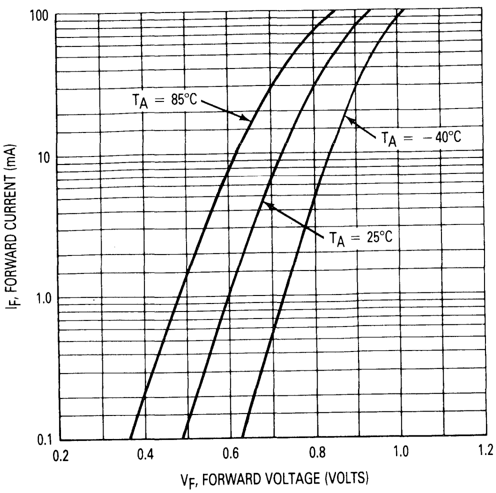
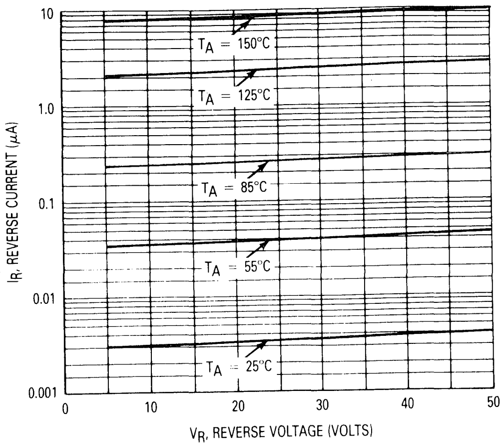
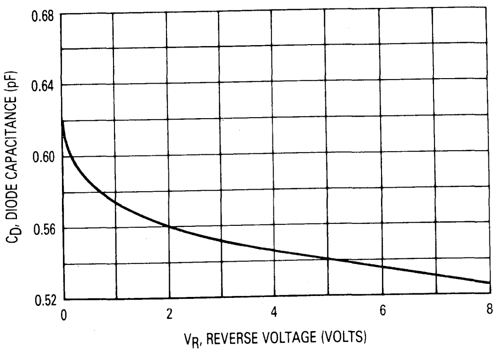


FIGURE 2 — LEAKAGE CURRENT



6

FIGURE 3 — CAPACITANCE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	75	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

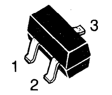
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

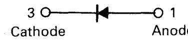
DEVICE MARKING

BAS16LT1 = A6

BAS16LT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





SWITCHING DIODE

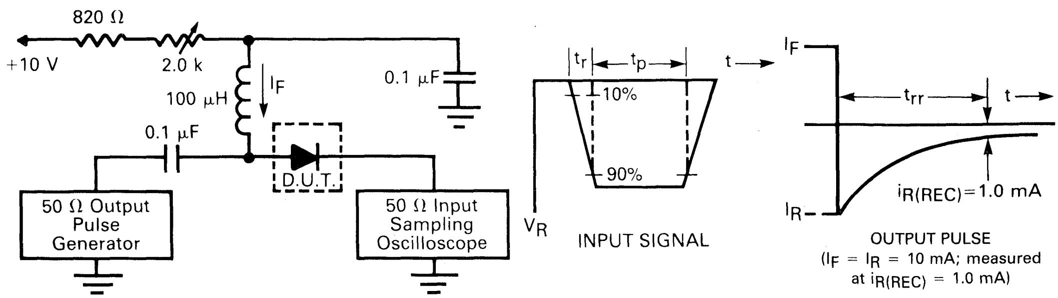
★This is a Motorola designated preferred device.

6

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current	I_R			μA
(V_R = 75 V)		—	1.0	
(V_R = 75 V, T_J = 150°C)		—	50	
(V_R = 25 V, T_J = 150°C)		—	30	
Reverse Breakdown Voltage (I_{BR} = 100 μA)	$V_{(BR)}$	75	—	V
Forward Voltage	V_F			mV
(I_F = 1.0 mA)		—	715	
(I_F = 10 mA)		—	855	
(I_F = 50 mA)		—	1000	
(I_F = 150 mA)		—	1250	
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	2.0	pF
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V
Reverse Recovery Time (I_F = I_R = 10 mA, R_L = 50 Ω)	t_{rr}	—	6.0	ns
Stored Charge (I_F = 10 mA to V_R = 5.0 V, R_L = 500 Ω)	Q_S	—	45	pC

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 $I_{R(peak)}$ is equal to 10 mA.
3. t_p » t_{rr}

FIGURE 2 — FORWARD VOLTAGE

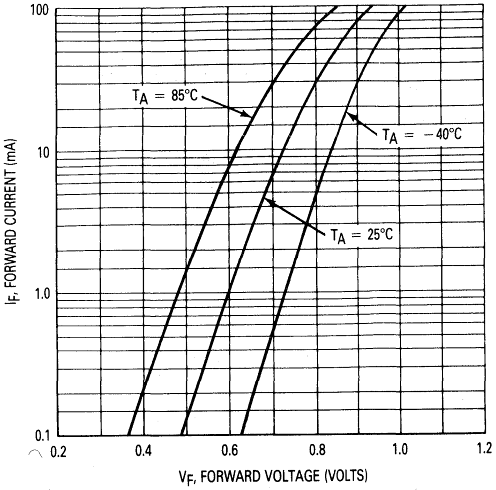
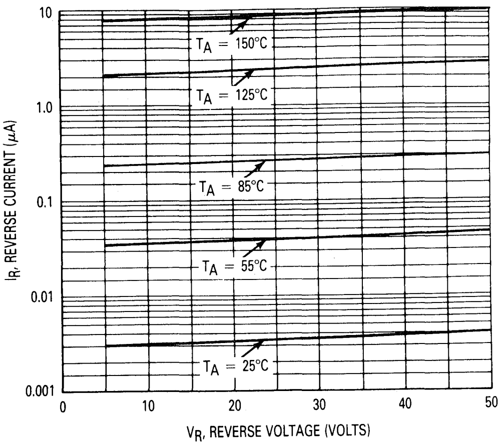
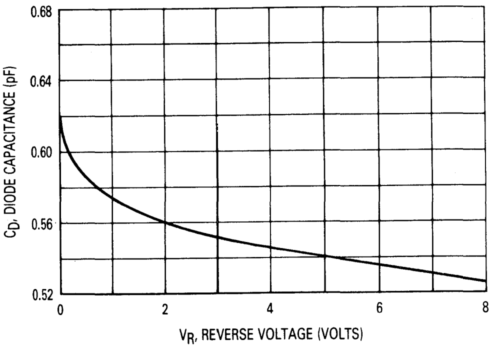


FIGURE 3 — LEAKAGE CURRENT



6

FIGURE 4 — CAPACITANCE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	250	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	625	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

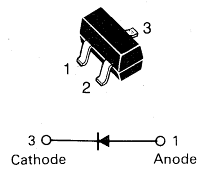
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BAS21LT1 = JS

BAS21LT1★

CASE 318-07, STYLE 8
SOT-23 (TO)-236AB)



SWITCHING DIODE

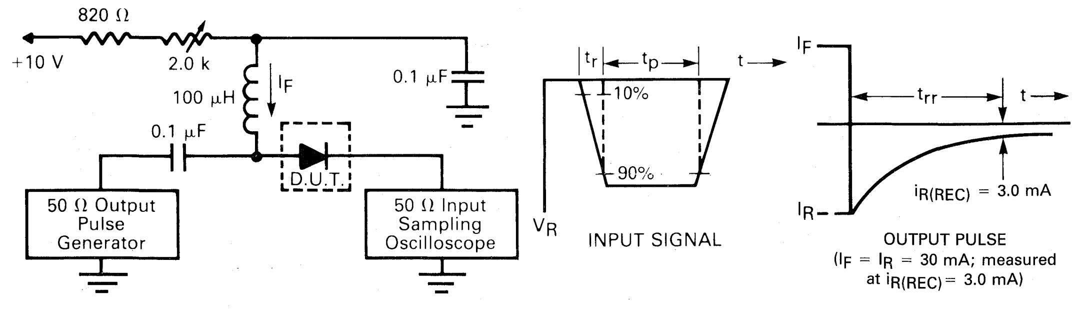
★This is a Motorola designated preferred device.

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 200 V) (V_R = 200 V, T_J = 150°C)	I_R	 — —	 0.1 100	μA
Reverse Breakdown Voltage (I_{BR} = 100 μA)	$V_{(BR)}$	250	—	V
Forward Voltage (I_F = 100 mA) (I_F = 200 mA)	V_F	 — —	 1000 1250	mV
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	5.0	pF
Reverse Recovery Time (I_F = I_R = 30 mA, R_L = 100 Ω)	t_{rr}	—	50	ns

6

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 30 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 30 mA.
3. $t_p \gg t_{rr}$

6

MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

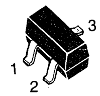
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

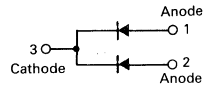
DEVICE MARKING

BAV70LT1 = A4

BAV70LT1★

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)





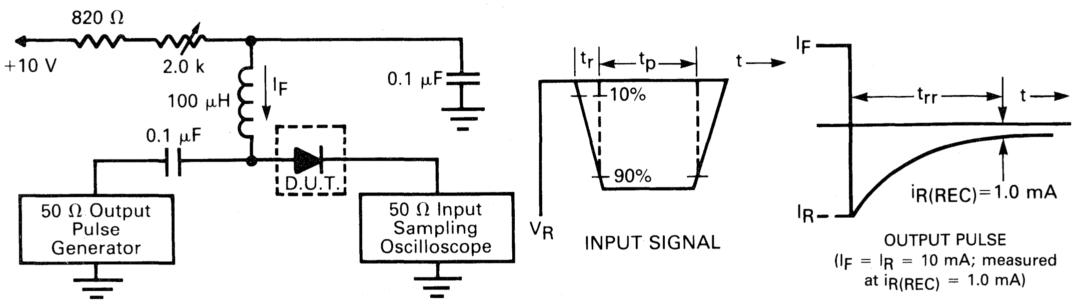
MONOLITHIC DUAL SWITCHING DIODE

★This is a Motorola designated preferred device.

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	>70	—	Vdc
Reverse Voltage Leakage Current	I_R			μAdc
(V_R = 25 Vdc, T_J = 150°C)		—	60	
(V_R = 70 Vdc)		—	2.5	
(V_R = 70 Vdc, T_J = 150°C)		—	100	
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Forward Voltage	V_F			mVdc
(I_F = 1.0 mAdc)		—	715	
(I_F = 10 mAdc)		—	855	
(I_F = 50 mAdc)		—	1000	
(I_F = 150 mA)		—	1250	
Reverse Recovery Time R_L = 100Ω (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, $I_{R(REC)}$ = 1.0 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 $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

Curves Applicable to each Anode

FIGURE 2 — FORWARD VOLTAGE

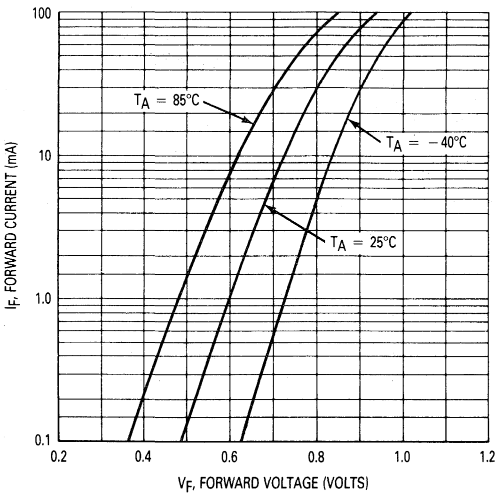


FIGURE 3 — LEAKAGE CURRENT

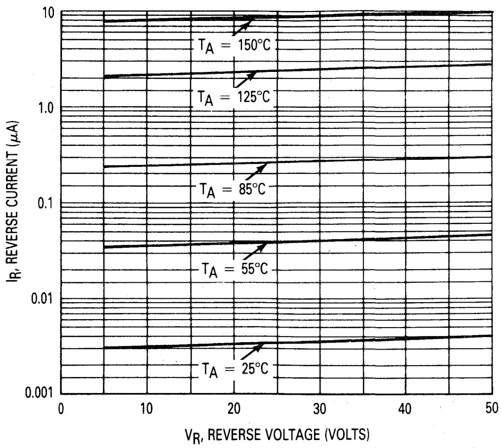
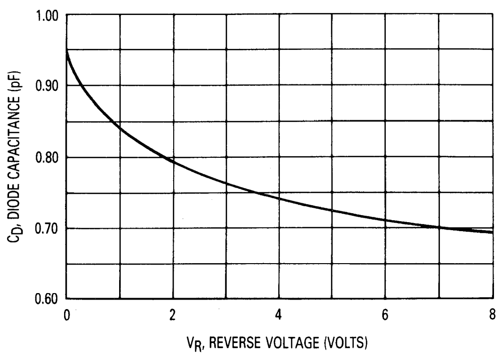


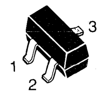
FIGURE 4 — CAPACITANCE

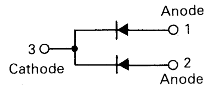


6

BAV74LT1

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)





MONOLITHIC DUAL SWITCHING DIODE

MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BAV74LT1 = JA

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 5.0 μAdc)	$V_{(BR)}$	50	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc, T_J = 125°C) (V_R = 50 Vdc)	I_R	 — —	 100 0.1	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	2.0	pF
Forward Voltage (I_F = 100 mAdc)	V_F	—	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc, measured at I_R = 1.0 mA, R_L = 100 Ω)	t_{rr}	—	4.0	ns

Curves Applicable to each Anode

FIGURE 2 — FORWARD VOLTAGE

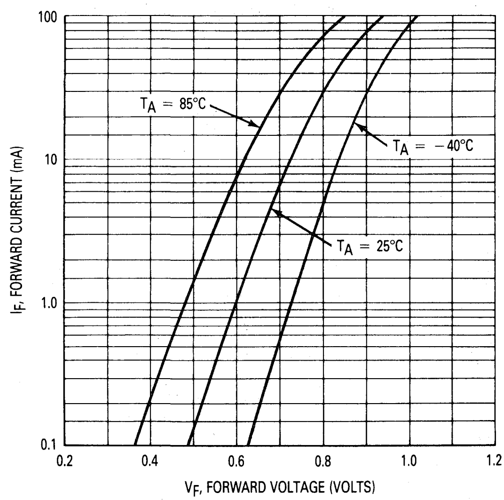


FIGURE 3 — LEAKAGE CURRENT

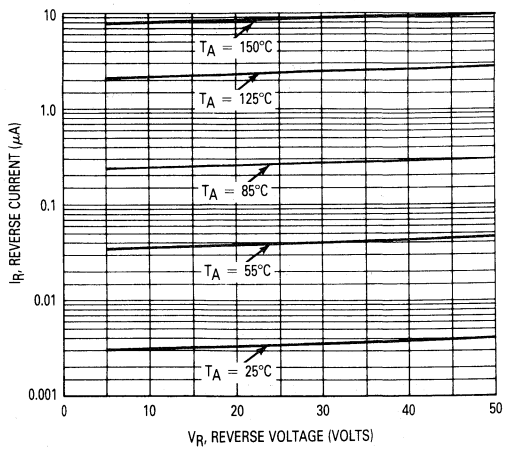
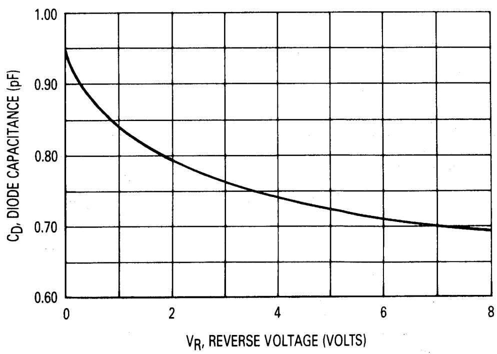


FIGURE 4 — CAPACITANCE



MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	215	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc
Repetitive Peak Reverse Voltage	V_{RRM}	70	V
Average Rectified Forward Current* (averaged over any 20 ms period)	$I_{F(AV)}$	715	mA
Repetitive Peak Forward Current	I_{FRM}	450	mA
Non-Repetitive Peak Forward Current	I_{FSM}		A
t = 1.0 μs		2.0	
t = 1.0 ms		1.0	
t = 1.0 A		0.5	

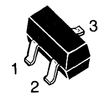
THERMAL CHARACTERISTICS

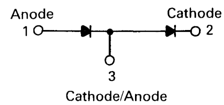
Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−65 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

BAV99LT1★

CASE 318-07, STYLE 11
SOT-23 (TO-236AB)





DUAL SERIES SWITCHING DIODE

★This is a Motorola designated preferred device.

DEVICE MARKING

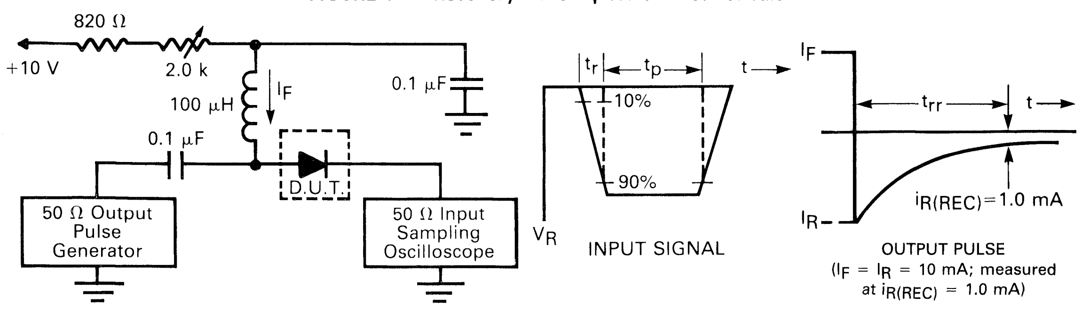
BAV99LT1 = A7

6

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μA)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 70 Vdc)	I_R	—	2.5	μAdc
(V_R = 25 Vdc, T_J = 150°C)		—	30	
(V_R = 70 Vdc, T_J = 150°C)		—	50	
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	715	mVdc
(I_F = 10 mAdc)		—	855	
(I_F = 50 mAdc)		—	1000	
(I_F = 150 mAdc)		—	1250	
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1) R_L = 100Ω	t_{rr}	—	6.0	ns
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V

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 $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

Curves Applicable to each Diode

FIGURE 2 — FORWARD VOLTAGE

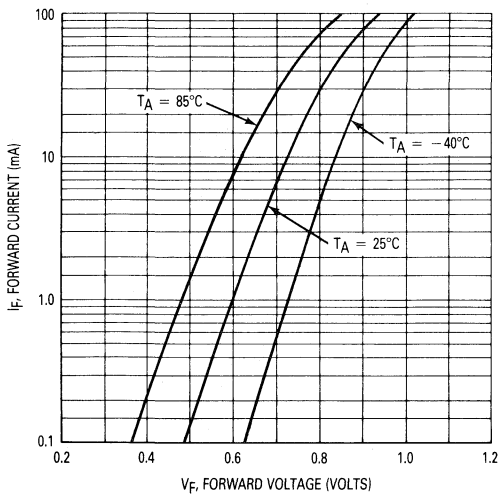


FIGURE 3 — LEAKAGE CURRENT

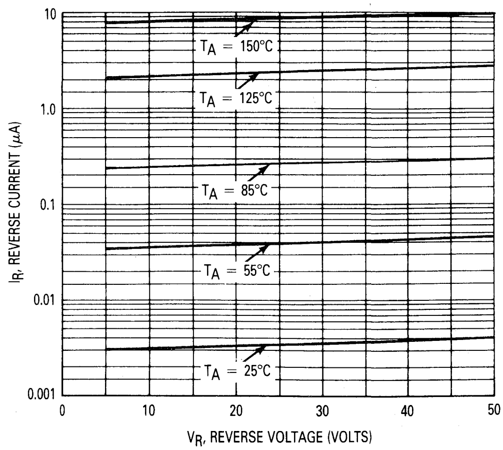
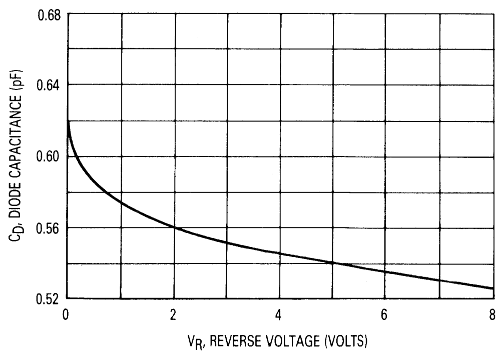


FIGURE 4 — CAPACITANCE



MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

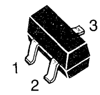
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

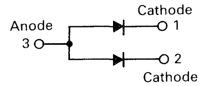
DEVICE MARKING

BAW56LT1 = A1

BAW56LT1★

CASE 318-07, STYLE 12
SOT-23 (TO-236AB)





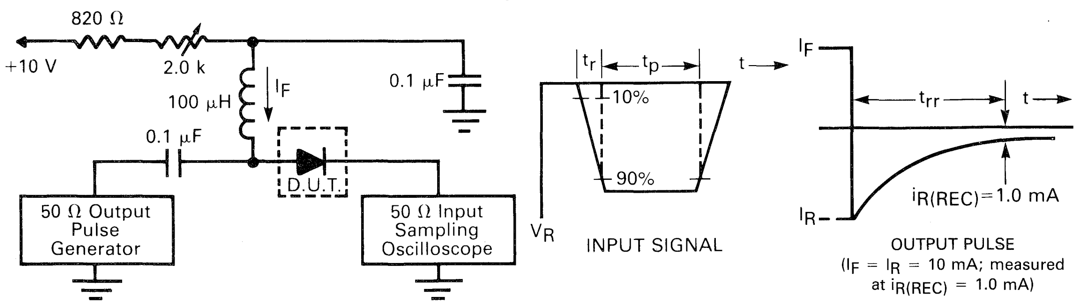
MONOLITHIC DUAL SWITCHING DIODE

★This is a Motorola designated preferred device.

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	 — — —	 30 2.5 50	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	2.0	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mA)	V_F	 — — — —	 715 855 1000 1250	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) (Figure 1) R_L = 100Ω	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 $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

Curves Applicable to each Cathode

FIGURE 2 — FORWARD VOLTAGE

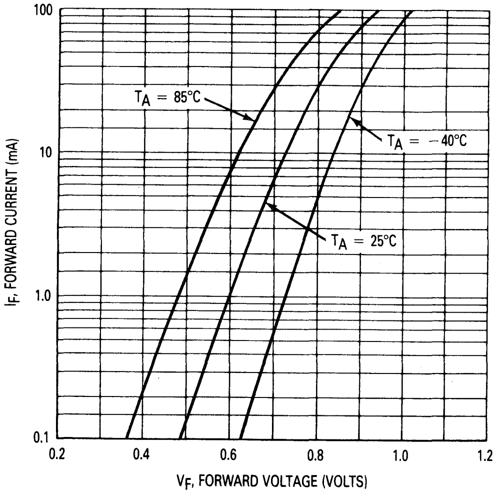


FIGURE 3 — LEAKAGE CURRENT

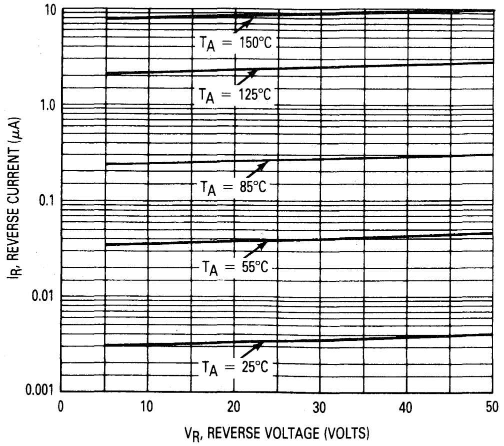
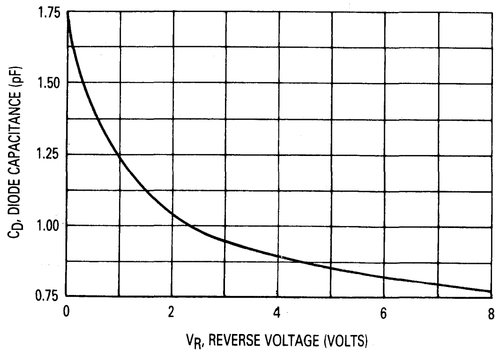


FIGURE 4 — CAPACITANCE



6

Single Silicon Switching Diode

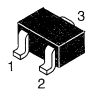
M1MA141KT1
M1MA142KT1

Motorola Preferred Devices

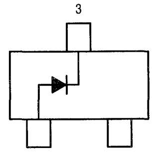
This Silicon Epitaxial Planar Diode is designed for use in ultra high speed switching applications. This device is housed in the SC-70 package which is designed for low power surface mount applications.

- Fast t_{rr}, < 3.0 ns
- Low C_D, < 2.0 pF
- Available in 8 mm Tape and Reel
  Use M1MA141/2KT1 to order the 7 inch/3000 unit reel.
  Use M1MA141/2KT3 to order the 13 inch/10,000 unit reel.

**SC-70/SOT-323 PACKAGE
SINGLE SILICON
SWITCHING DIODE
40/80 V-100 mA
SURFACE MOUNT**



**CASE 419-02, STYLE 2
SC-70/SOT-323**



6

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage	M1MA141KT1	V_R	40	Vdc
	M1MA142KT1		80	
Peak Reverse Voltage	M1MA141KT1	V_{RM}	40	Vdc
	M1MA142KT1		80	
Forward Current		I_F	100	mAdc
Peak Forward Current		I_{FM}	225	mAdc
Peak Forward Surge Current		I_{FSM}(1)	500	mAdc

(1) t = 1 SEC

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	150	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	−55 ~ +150	°C

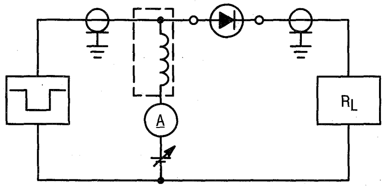
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA141KT1	I_R	V_R = 35 V	—	0.1	μA
	M1MA142KT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA141KT1	V_R	I_R = 100 μA	40	—	Vdc
	M1MA142KT1			80	—	
Diode Capacitance		C_D	V_R = 0, f = 1.0 MHz	—	2.0	pF
Reverse Recovery Time		t_{rr}(2)	I_F = 10 mA, V_R = 6.0 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	3.0	ns

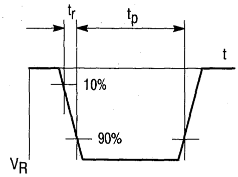
(2) t_{rr} Test Circuit

Preferred devices are Motorola recommended choices for future use and best overall value.

RECOVERY TIME EQUIVALENT TEST CIRCUIT

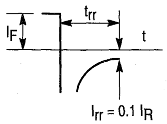


INPUT PULSE



$t_p = 2\ \mu s$
$t_r = 0.35\ ns$

OUTPUT PULSE

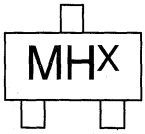


$I_F = 10\ mA$
$V_R = 6\ V$
$R_L = 100\ \Omega$

DEVICE MARKING — EXAMPLE

Marking Symbol

Type No.	141K	142K
Symbol	MH	MI



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

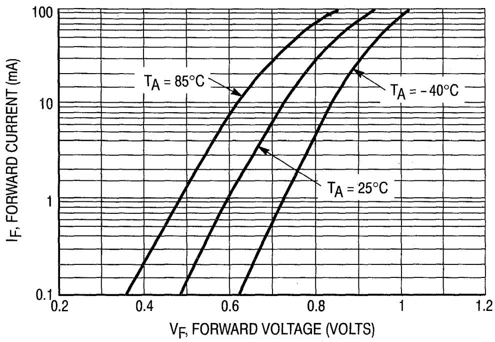


Figure 1. Forward Voltage

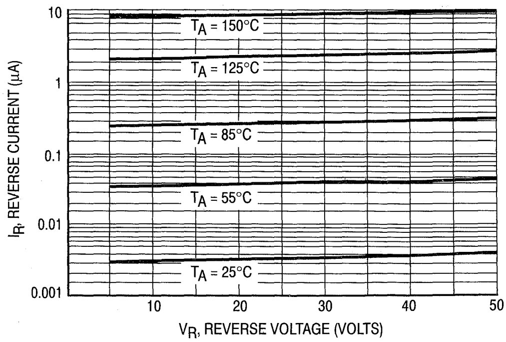


Figure 2. Reverse Current

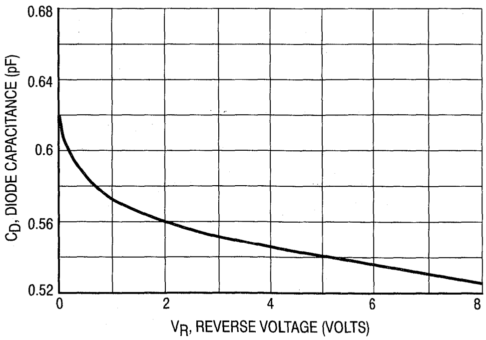


Figure 3. Diode Capacitance

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Common Anode Silicon Dual Switching Diode

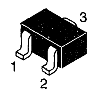
M1MA141WAT1
M1MA142WAT1

Motorola Preferred Devices

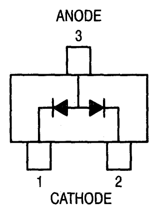
This Common Anode Silicon Epitaxial Planar Dual Diode is designed for use in ultra high speed switching applications. This device is housed in the SC-59 package which is designed for low power surface mount applications.

- Fast t_{rr}, < 10 ns
- Low C_D, < 15 pF
- Available in 8 mm Tape and Reel
  Use M1MA141/2WAT1 to order the 7 inch/3000 unit reel.
  Use M1MA141/2WAT3 to order the 13 inch/10,000 unit reel.

SC-70/SOT-323 PACKAGE
COMMON ANODE
DUAL SWITCHING DIODE
40/80 V-100 mA
SURFACE MOUNT



CASE 419-02, STYLE 4
SC-70/SOT-323



6

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage	M1MA141WAT1	V_R	40	Vdc
	M1MA142WAT1		80	
Peak Reverse Voltage	M1MA141WAT1	V_{RM}	40	Vdc
	M1MA142WAT1		80	
Forward Current	Single	I_F	100	mAdc
	Dual		150	
Peak Forward Current	Single	I_{FM}	225	mAdc
	Dual		340	
Peak Forward Surge Current	Single	I_{FSM}(1)	500	mAdc
	Dual		750	

(1) t = 1 SEC

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	150	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	−55 ~ +150	°C

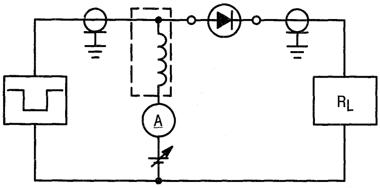
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA141WAT1	I_R	V_R = 35 V	—	0.1	µA
	M1MA142WAT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA141WAT1	V_R	I_R = 100 µA	40	—	Vdc
	M1MA142WAT1			80	—	
Diode Capacitance		C_D	V_R = 0, f = 1.0 MHz	—	15	pF
Reverse Recovery Time		t_{rr}(2)	I_F = 10 mA, V_R = 6.0 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	10	ns

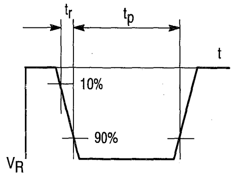
(2) t_{rr} Test Circuit

Preferred devices are Motorola recommended choices for future use and best overall value.

RECOVERY TIME EQUIVALENT TEST CIRCUIT

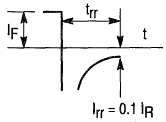


INPUT PULSE



$t_p = 2\ \mu s$
$t_r = 0.35\ ns$

OUTPUT PULSE

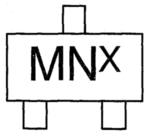


$I_F = 10\ mA$
$V_R = 6\ V$
$R_L = 100\ \Omega$

DEVICE MARKING — EXAMPLE

Marking Symbol

Type No.	141WA	142WA
Symbol	MN	MO



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

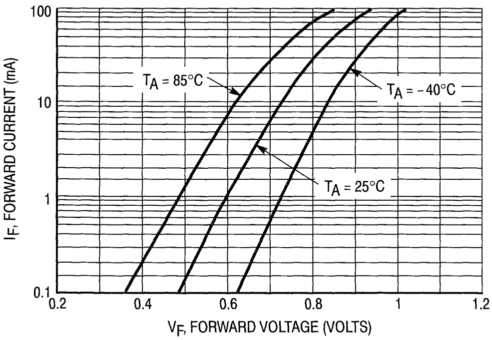


Figure 1. Forward Voltage

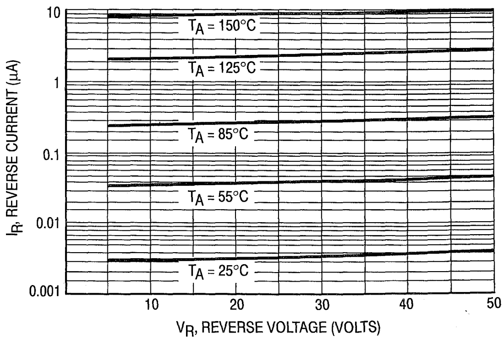


Figure 2. Reverse Current

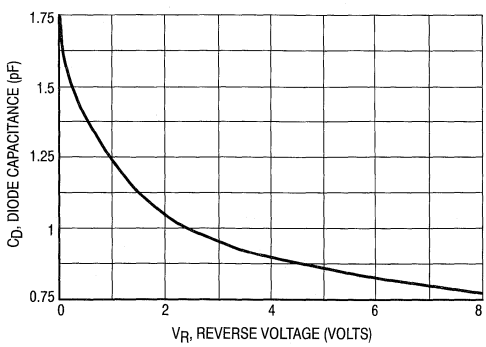


Figure 3. Diode Capacitance

6

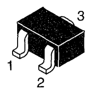
6

Common Cathode Silicon Dual Switching Diode

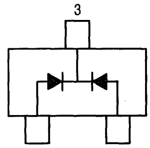
M1MA141WKT1
M1MA142WKT1

Motorola Preferred Devices

SC-70/SOT-323 PACKAGE
COMMON CATHODE
DUAL SWITCHING DIODE
40/80 V-100 mA
SURFACE MOUNT



CASE 419-02, STYLE 5
SC-70/SOT-323



This Common Cathode Silicon Epitaxial Planar Dual Diode is designed for use in ultra high speed switching applications. This device is housed in the SC-59 package which is designed for low power surface mount applications.

- Fast t_{rr}, < 3.0 ns
- Low C_D, < 2.0 pF
- Available in 8 mm Tape and Reel
  Use M1MA141/2WKT1 to order the 7 inch/3000 unit reel.
  Use M1MA141/2WKT3 to order the 13 inch/10,000 unit reel.

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage	M1MA141WKT1	V_R	40	Vdc
	M1MA142WKT1		80	
Peak Reverse Voltage	M1MA141WKT1	V_{RM}	40	Vdc
	M1MA142WKT1		80	
Forward Current	Single	I_F	100	mAdc
	Dual		150	
Peak Forward Current	Single	I_{FM}	225	mAdc
	Dual		340	
Peak Forward Surge Current	Single	I_{FSM}(1)	500	mAdc
	Dual		750	

(1) t = 1 SEC

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	150	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	−55 ~ +150	°C

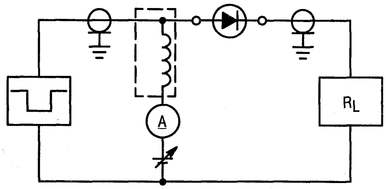
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA141WKT1	I_R	V_R = 35 V	—	0.1	μA
	M1MA142WKT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA141WKT1	V_R	I_R = 100 μA	40	—	Vdc
	M1MA142WKT1			80	—	
Diode Capacitance		C_D	V_R = 0, f = 1.0 MHz	—	2.0	pF
Reverse Recovery Time		t_{rr}(2)	I_F = 10 mA, V_R = 6.0 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	3.0	ns

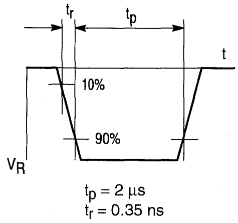
(2) t_{rr} Test Circuit

Preferred devices are Motorola recommended choices for future use and best overall value.

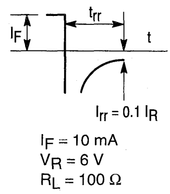
RECOVERY TIME EQUIVALENT TEST CIRCUIT



INPUT PULSE



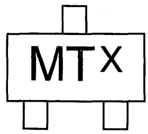
OUTPUT PULSE



DEVICE MARKING — EXAMPLE

Marking Symbol

Type No.	141WK	142WK
Symbol	MT	MU



The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

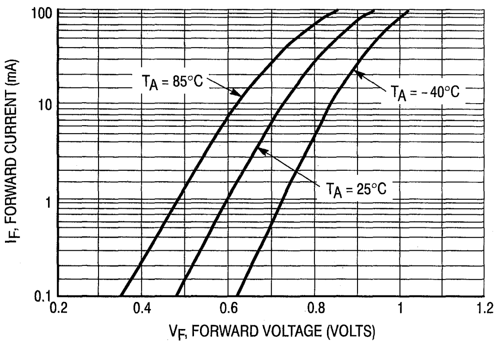


Figure 1. Forward Voltage

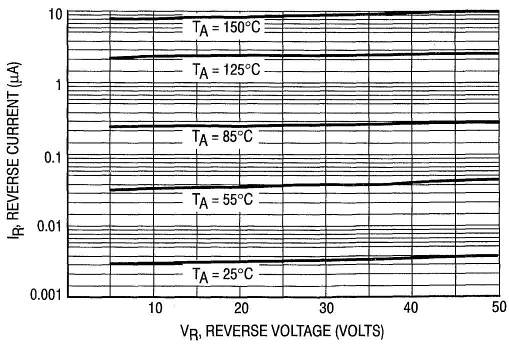


Figure 2. Reverse Current

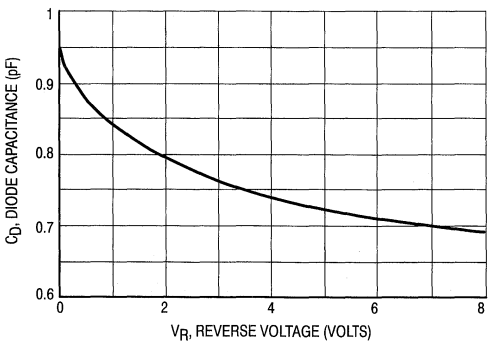
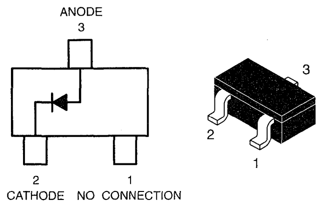


Figure 3. Diode Capacitance

M1MA151AT1★

CASE 318D-03, STYLE 4



SC-59 PACKAGE
SINGLE SILICON
SWITCHING DIODE
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	40	Vdc
Peak Reverse Voltage	V_{RM}	40	Vdc
Forward Current	I_F	100	mAdc
Peak Forward Current	I_{FM}	225	mAdc
Peak Forward Surge Current	I_{FSM}*	500	mAdc

*t = 1 SEC

THERMAL CHARACTERISTICS

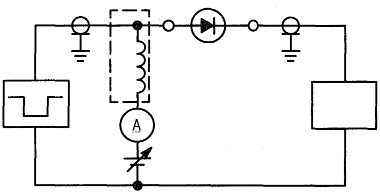
Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

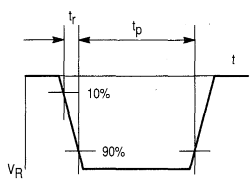
Characteristic	Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	I_R	V_R = 35 V	—	0.1	µA
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 µA	40	—	Vdc
Diode Capacitance	C_D	V_R = 0, f = 1 MHz	—	2	pF
Reverse Recovery Time	t_{rr}*	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	3	ns

*t_{rr} Test Circuit

RECOVERY TIME EQUIVALENT TEST CIRCUIT

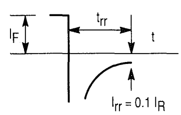


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

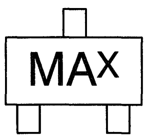
OUTPUT PULSE



I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING

Marking Symbol



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

FIGURE 1 — FORWARD VOLTAGE

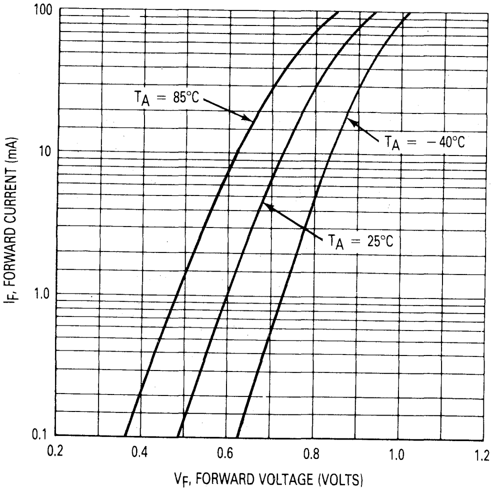


FIGURE 2 — LEAKAGE CURRENT

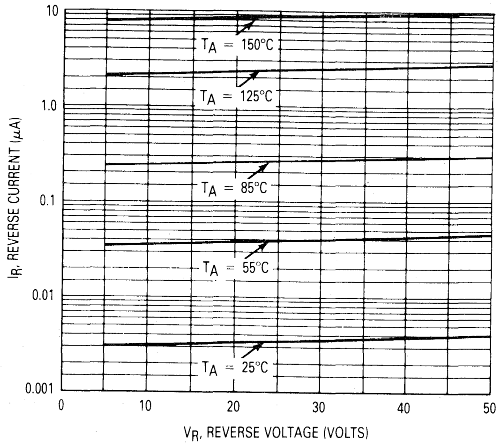
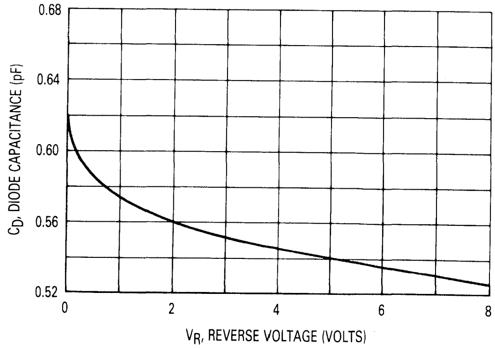


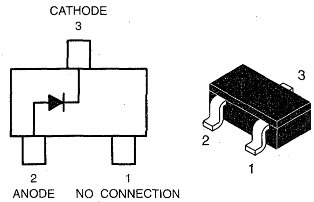
FIGURE 3 — CAPACITANCE



6

M1MA151KT1★

CASE 318D-03, STYLE 2



SC-59 PACKAGE
SINGLE SILICON
SWITCHING DIODE
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	40	Vdc
Peak Reverse Voltage	V_{RM}	40	Vdc
Forward Current	I_F	100	mAdc
Peak Forward Current	I_{FM}	225	mAdc
Peak Forward Surge Current	I_{FSM}*	500	mAdc

*t = 1 SEC

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

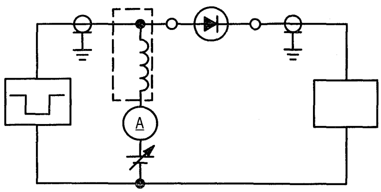
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	I_R	V_R = 35 V	—	0.1	µA
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 µA	40	—	Vdc
Diode Capacitance	C_D	V_R = 0, f = 1 MHz	—	2	pF
Reverse Recovery Time	t_{rr}*	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	3	ns

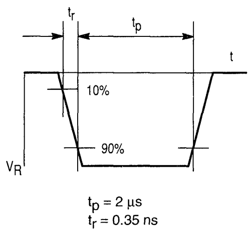
*t_{rr} Test Circuit

6

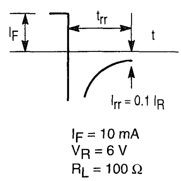
RECOVERY TIME EQUIVALENT TEST CIRCUIT



INPUT PULSE

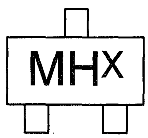


OUTPUT PULSE



DEVICE MARKING

Marking Symbol



The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

FIGURE 1 — FORWARD VOLTAGE

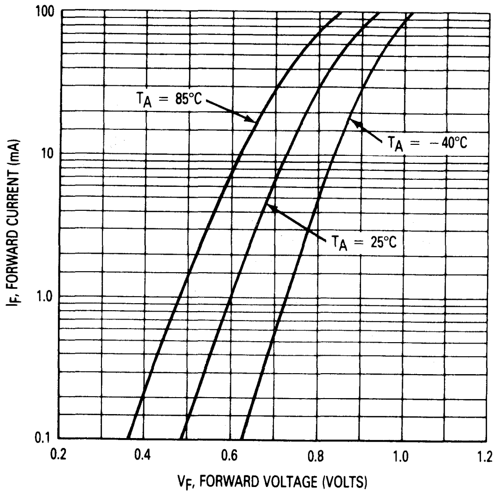


FIGURE 2 — LEAKAGE CURRENT

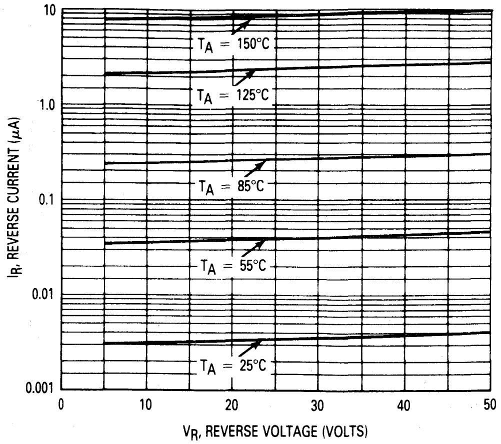
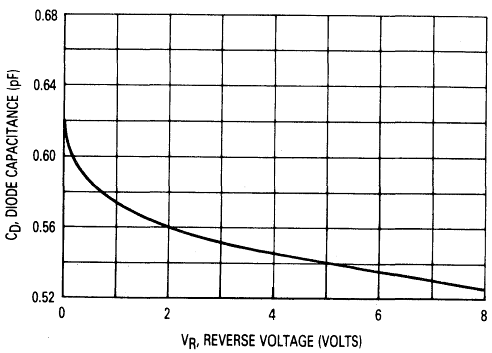


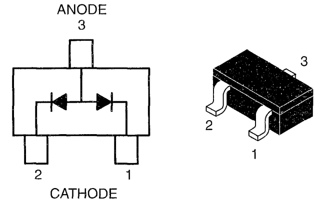
FIGURE 3 — CAPACITANCE



6

M1MA151WAT1★

CASE 318D-03, STYLE 5



**SC-59 PACKAGE
COMMON ANODE
DUAL SWITCHING DIODE
SURFACE MOUNT
MONOLITHIC DIE**

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage		V_R	40	Vdc
Peak Reverse Voltage		V_{RM}	40	Vdc
Forward Current	Single	I_F	100	mAdc
	Dual		150	
Peak Forward Current	Single	I_{FM}	225	mAdc
	Dual		340	
Peak Forward Surge Current	Single	I_{FSM}*	500	mAdc
	Dual		750	

*t = 1 SEC

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

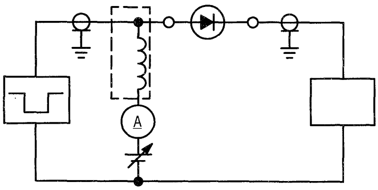
ELECTRICAL CHARACTERISTICS (T_A = 25°C) **(EACH DIODE)**

Characteristic	Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	I_R	V_R = 35 V	—	0.1	µA
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 µA	40	—	Vdc
Diode Capacitance	C_D	V_R = 0, f = 1 MHz	—	15	pF
Reverse Recovery Time	t_{rr}*	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	10	ns

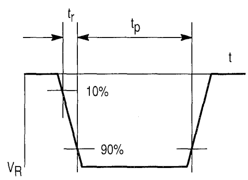
*t_{rr} Test Circuit

6

RECOVERY TIME EQUIVALENT TEST CIRCUIT

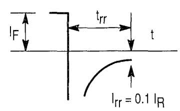


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

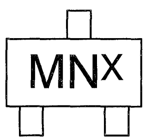
OUTPUT PULSE



I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING

Marking Symbol



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

Curves Applicable to each Cathode

FIGURE 1 — FORWARD VOLTAGE

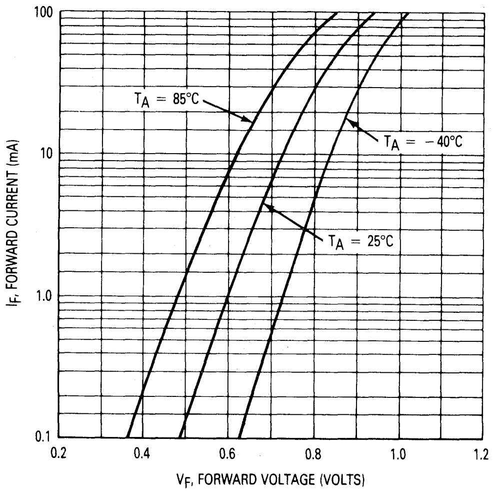


FIGURE 2 — LEAKAGE CURRENT

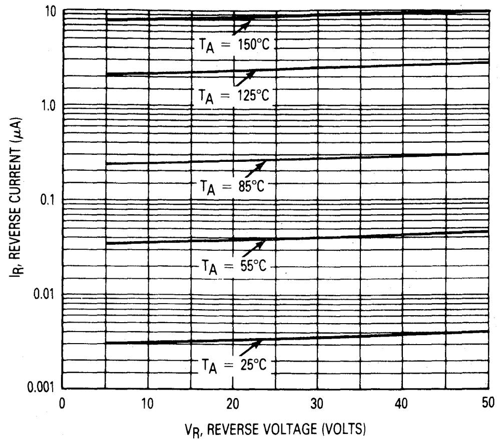
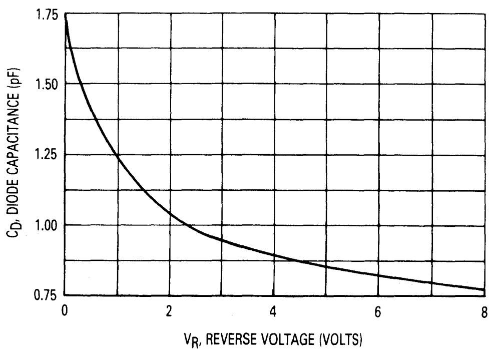


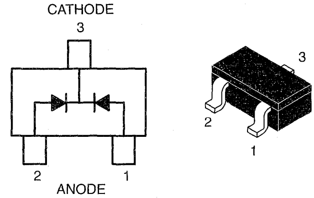
FIGURE 3 — CAPACITANCE



6

M1MA151WKT1★

CASE 318D-03, STYLE 3



SC-59 PACKAGE COMMON CATHODE DUAL SWITCHING DIODE SURFACE MOUNT MONOLITHIC DIE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage		V_R	40	Vdc
Peak Reverse Voltage		V_{RM}	40	Vdc
Forward Current	Single	I_F	100	mAdc
	Dual		150	
Peak Forward Current	Single	I_{FM}	225	mAdc
	Dual		340	
Peak Forward Surge Current	Single	I_{FSM}*	500	mAdc
	Dual		750	

*t = 1 SEC

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

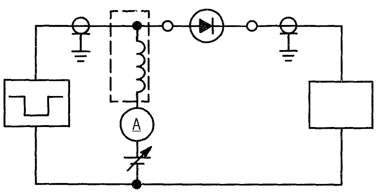
ELECTRICAL CHARACTERISTICS (T_A = 25°C) **(EACH DIODE)**

Characteristic	Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	I_R	V_R = 35 V	—	0.1	µA
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 µA	40	—	Vdc
Diode Capacitance	C_D	V_R = 0, f = 1 MHz	—	2	pF
Reverse Recovery Time	t_{rr}*	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	3	ns

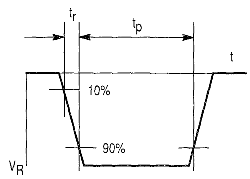
*t_{rr} Test Circuit

6

RECOVERY TIME EQUIVALENT TEST CIRCUIT

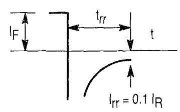


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

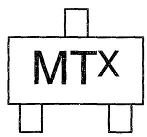
OUTPUT PULSE



I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING

Marking Symbol



The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

Curves Applicable to each Anode

FIGURE 1 — FORWARD VOLTAGE

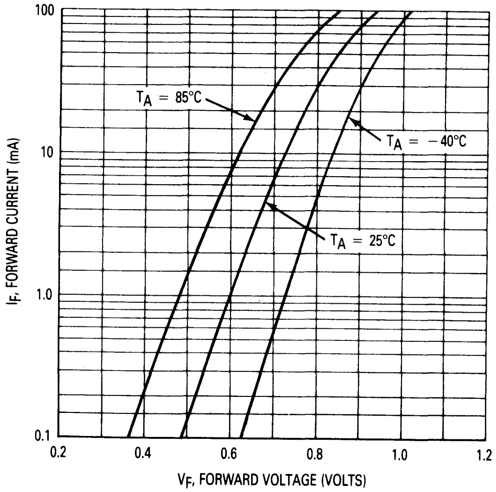


FIGURE 2 — LEAKAGE CURRENT

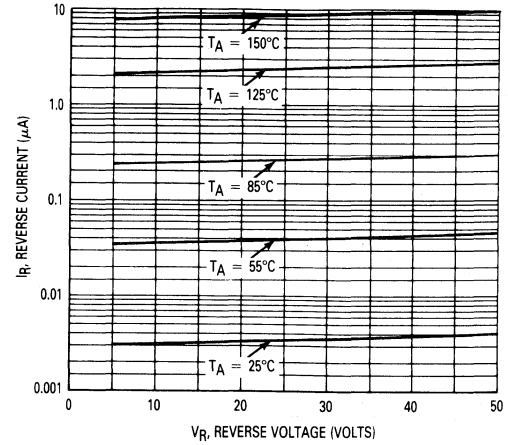
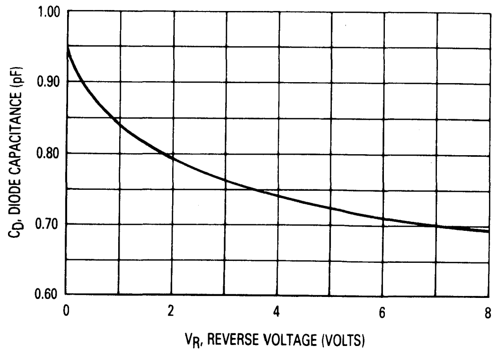
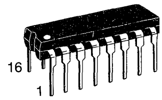


FIGURE 3 — CAPACITANCE



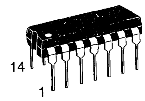
6

MAD130P★
MAD1103P★
MAD1107P★
MAD1108P★



MAD1108P
CASE 648-08

MAD130P
MAD1103P, MAD1107P
CASE 646-06



MONOLITHIC DIODE ARRAYS

★These are Motorola designated preferred devices.

MAXIMUM RATINGS (@ 25°C Free-Air Temperature unless otherwise noted.)

Rating	Symbol	Value	Unit
Peak Reverse Voltage(1)	V_{RM}	50	Vdc
Steady-State Reverse Voltage	V_R	50	Vdc
Peak Forward Current at (or below) 25°C Free-Air Temperature(1)	I_{FM}	500	mA
Continuous Forward Current at (or below) 25°C Free-Air Temperature(2)	I_F	400	mA
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature(3)	P_D	600	mW
Operating Free-Air Temperature Range	T_A	−65 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Lead Temperature 1/16″ from Case for 10 Seconds		260	°C

NOTES:
1. These values apply for PW ≤ 100 μs, duty cycle ≤ 20%.
2. Derate linearity to +125°C temperature at rate of 3.2 mA/°C.
3. Derate linearity to +125°C temperature at rate of 6.0 mW/°C.

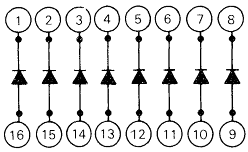
PACKAGE OPTIONS

Device	PLASTIC P Suffix Pin Connection Ref. No.	PLASTIC P Suffix Case	Device	PLASTIC P Suffix Pin Connection Ref. No.	PLASTIC P Suffix Case
MAD130P Dual 10-Diode Array	3	646-06	MAD1107P Dual 8-Diode Array	2	646-06
MAD1103P Dual 8-Diode Array	4	646-06	MAD1108P 8-Diode Array	1	648-08

PIN CONNECTION DIAGRAMS

1

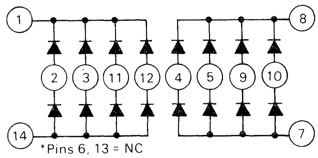
8-Diode Array
16-Pin Package



Case 648

2

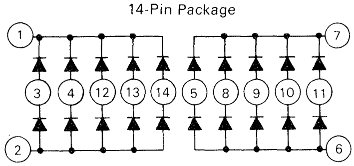
Dual 8-Diode Array
14-Pin Package



*Pins 6, 13 = NC
Case 646

3

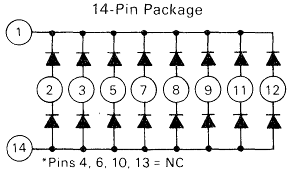
Dual 10-Diode Array
14-Pin Package



Case 646

4

Dual 8-Diode Array
14-Pin Package



*Pins 4, 6, 10, 13 = NC
Case 646

ELECTRICAL CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Limit Min	Limit Max	Unit
Reverse Breakdown Voltage(1) (I_R = 10 μA)	$V_{(BR)}$	50	—	Vdc
Static Reverse Current (V_R = 40 V)	I_R	—	0.1	μA
Static Forward Voltage (I_F = 100 mA) (I_F = 500 mA)(2)	V_F	— —	1.2 1.6	Vdc
Peak Forward Voltage(3) (I_F = 500 mA)	V_{FM}	—	5.0	Vdc

SWITCHING CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Typical Value		Unit
Forward Recovery Time, Figure 3 (I_F = 500 mA)	t_{fr}	20		ns
Reverse Recovery Time, Figure 2 (I_F = 200 mA, I_{RM} = 200 mA, R_L = 100 Ω, i_{rr} = 20 mA)	t_{rr}	MAD1108	8.0	ns
		Others	10.0	

NOTES:
1. This parameter must be measured using pulse techniques. PW = 100 μs, duty cycle ≤ 20%.
2. This parameter is measured using pulse techniques. PW = 300 μs, duty cycle ≤ 2.0%. Read time is 90 μs from the leading edge of the pulse.
3. The initial instantaneous value is measured using pulse techniques. PW = 150 ns, duty cycle ≤ 2.0%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.

6

FIGURE 1 — TYPICAL CHARACTERISTICS STATIC FORWARD VOLTAGE

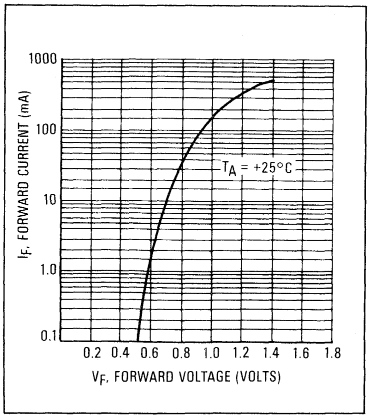


FIGURE 2 — FORWARD RECOVERY TIME AND PEAK FORWARD VOLTAGE TEST CIRCUIT AND WAVEFORMS

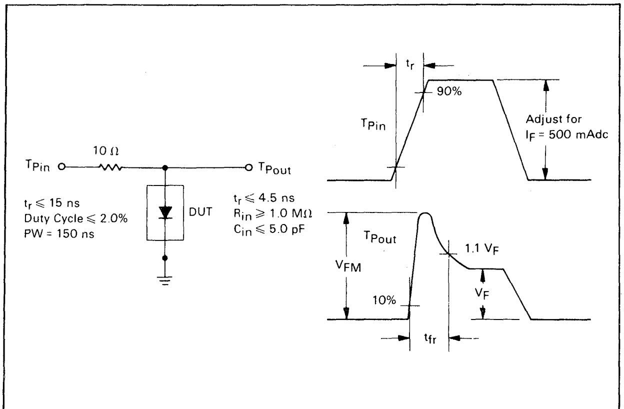
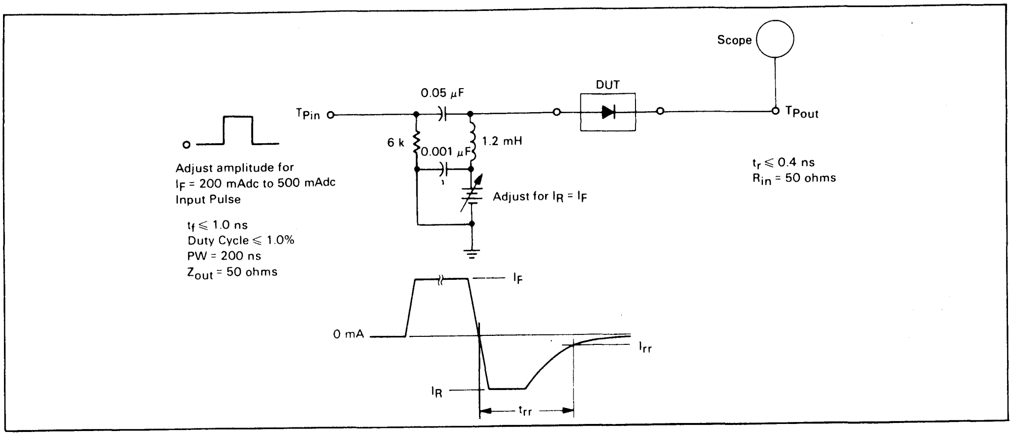


FIGURE 3 — REVERSE RECOVERY TIME TEST CIRCUIT AND WAVEFORMS



6

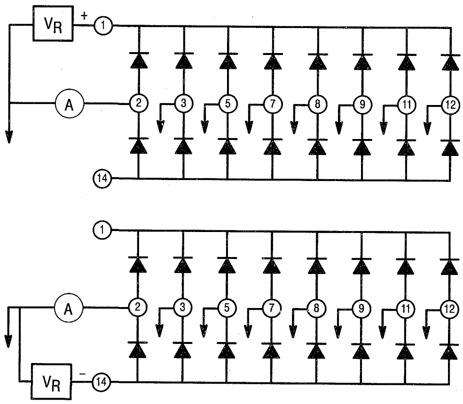
TEST PROCEDURE FOR MULTIPLE DIODES

1.0. REVERSE BIAS TESTING

1.1. LEAKAGE

Regardless of device configuration type, when testing any reverse bias condition, the forcing power supply must be applied only to the uncommon terminal of the pair. As in Figure 1, this would be pins 1 and 14. This can be referred as the high side of the test circuit. The low side of the test circuit must be connected to the common terminal of the pair which in most testers is where the current measurement is taken. This method is used to eliminate the possibility of degrading the diode in that pair which is not under test. Diode arrays with multiple pairs such as the MAD1103, also have leakage paths in the die between common terminals of the pairs. To isolate the device under test so that the leakage from the other pairs in the package do not affect the test result, the leakage current from the common terminals of the pairs not under test must be shunted to measurement common. Figure 1 shows the test configuration for both of these cases.

FIGURE 1



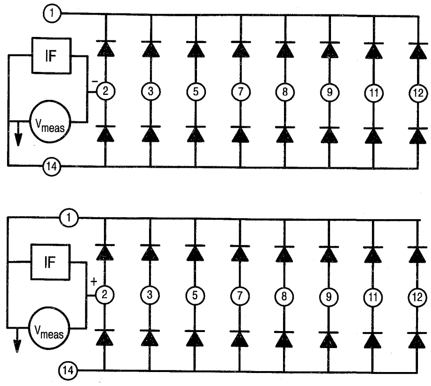
1.2. BREAKDOWN

It is not recommended to test breakdown on these devices due to the possibility of degrading the device. Breakdown may be checked on a curve tracer but extreme caution should be used.

2.0. FORWARD BIAS TESTING

Diode arrays are designed with the pairs in parallel therefore care must be taken to prevent the other diodes in the array from affecting the measured value of the diode under test. Figure 2 illustrates the proper technique to measure only the correct value of the diode under test.

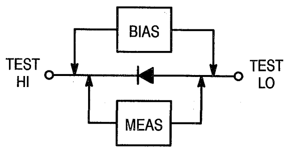
FIGURE 2



2.1. KELVIN CONNECTION

To achieve the best possible accuracy when testing bias currents over 10 mA, Kelvin connection to the leads of the device under test is mandatory. True Kelvin connection dictates that two test connections are made directly to the leads of the device. One is for power which is the bias supply, and the other is for sense which is for the measurement circuit. Kelvin connections are used to eliminate the effects of the connection resistance between the lead of the device and the contacts of the test handler and/or hand fixture. Figure 3 is an example of Kelvin connection.

FIGURE 3



2.2. PULSE TESTING

When testing bias currents over 10 mA, pulse testing should be used to minimize thermal drift of the measured value. The pulse width of a pulse test is approximately 300 μs to 380 μs.

3.0. TESTING PROTOCOL

3.1. TEST TYPES

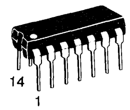
When testing in sequence all of the electrical characteristics, all reverse bias conditions should be tested before the forward bias conditions are tested.

3.2. BIASING MAGNITUDES

Tests of the same test type should be grouped together with the bias conditions in ascending order. For example:

V_F @ 10 mA < 0.6 V
V_F @ 50 mA < 0.8 V
V_F @ 100 mA < 1 V
V_F @ 500 mA < 1.5 V

MAD1109P★



PLASTIC
CASE 646-06
TO-116

MONOLITHIC DIODE ARRAY

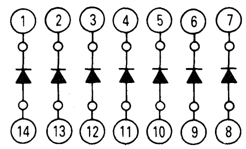
★This is a Motorola designated preferred device.

MAXIMUM RATINGS (@ 25°C Free-Air Temperature unless otherwise noted.)

Rating	Symbol	Value	Unit
Peak Reverse Voltage(1)	V_{RM}	50	Vdc
Steady-State Reverse Voltage	V_R	50	Vdc
Peak Forward Current at (or below) 25°C Free-Air Temperature(1)	I_{FM}	500	mA
Continuous Forward Current at (or below) 25°C Free-Air Temperature(2)	I_F	400	mA
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature(3)	P_D	600	mW
Operating Free-Air Temperature Range	T_A	−55 to +125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C
Lead Temperature 1/16″ from Case for 10 Seconds		260	°C

NOTES:
1. These values apply for PW ≤ 100 μs, duty cycle ≤ 20%.
2. Derate linearity to +125°C temperature at rate of 3.2 mA/°C.
3. Derate linearity to +125°C temperature at rate of 6.0 mW/°C.

PIN CONNECTION DIAGRAM



ELECTRICAL CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Limit		Unit
		Min	Max	
Reverse Breakdown Voltage(4) (I_R = 10 μA)	$V_{(BR)}$	50	—	Vdc
Static Reverse Current (V_R = 40 V)	I_R	—	0.1	μA
Static Forward Voltage (I_F = 100 mA) (I_F = 500 mA)(5)	V_F	— —	1.10 1.55	Vdc
Peak Forward Voltage(6) (I_F = 500 mA)	V_{FM}	—	5.0	Vdc

SWITCHING CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Typical Value	Unit
Forward Recovery Time, Figure 3 (I_F = 500 mA)	t_{fr}	20	ns
Reverse Recovery Time, Figure 2 (I_F = 200 mA, I_{RM} = 200 mA, R_L = 100 Ω, i_{rr} = 20 mA)	t_{rr}	8.0	ns

NOTES:
4. This parameter must be measured using pulse techniques. PW = 100 μs, duty cycle ≤ 20%.
5. This parameter is measured using pulse techniques. PW = 300 μs, duty cycle ≤ 2.0%. Read time is 90 μs from the leading edge of the pulse.
6. The initial instantaneous value is measured using pulse techniques. PW = 150 ns, duty cycle ≤ 2.0%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.

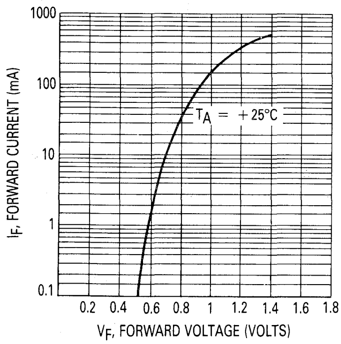


Figure 1. Typical Characteristics Static Forward Voltage

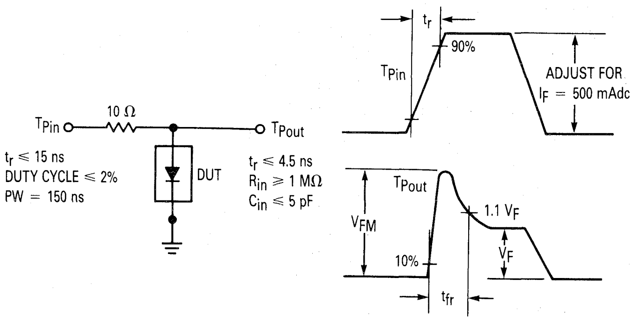


Figure 2. Forward Recovery Time and Peak Forward Voltage Test Circuit and Waveforms

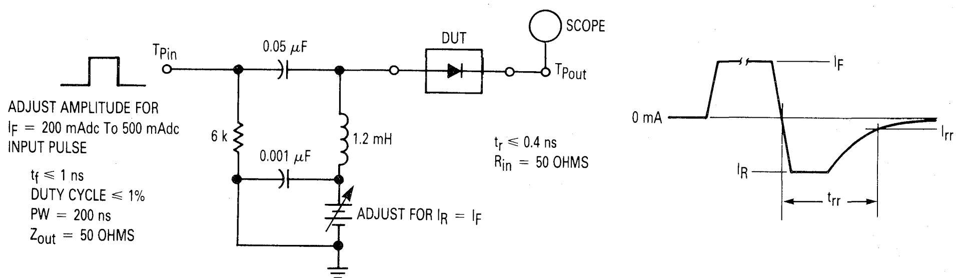


Figure 3. Reverse Recovery Time Test Circuit and Waveforms

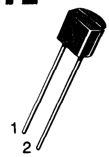
SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits. Supplied in an inexpensive plastic package for low-cost, high-volume consumer requirements. Also available in Surface Mount package.

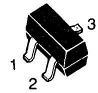
- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure — 6.0 dB Typ @ 1.0 GHz
- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- High Forward Conductance — 0.5 Volts (Typ) @ I_F = 10 mA

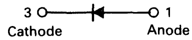
MBD101★
MMBD101LT1★

CASE 182-02, STYLE 1 (TO-226AC)



CASE 318-07, STYLE 8 SOT-23 (TO-236AB)





SILICON HOT-CARRIER UHF MIXER DIODES

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	MBD101 Value	MMBD101LT1 Value	Unit
Reverse Voltage	V_R	7.0		Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 280 2.8	 200 2.0	 mW mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBD101LT1 = 4M

6

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	7.0	10	—	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	—	0.88	1.0	pF
Forward Voltage (1) (I_F = 10 mA)	V_F	—	0.5	0.6	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	—	6.0	—	dB
Reverse Leakage (V_R = 3.0 V)	I_R	—	0.02	0.25	μA

MMBD101LT1 is also available in bulk packaging. Use MMBD101L as the device title to order this device in bulk.

TYPICAL CHARACTERISTICS
(T_A = 25°C unless noted)

FIGURE 1 — REVERSE LEAKAGE

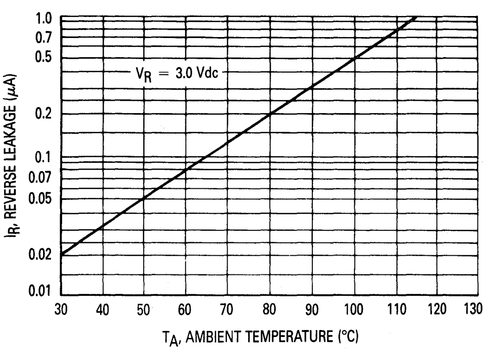


FIGURE 2 — FORWARD VOLTAGE

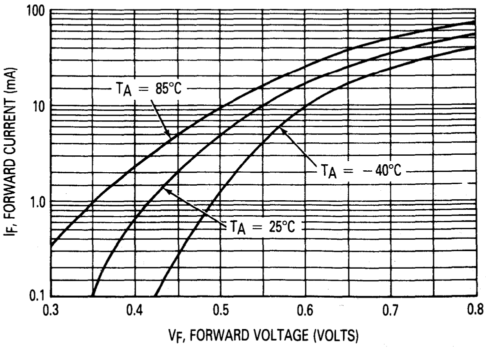


FIGURE 3 — CAPACITANCE

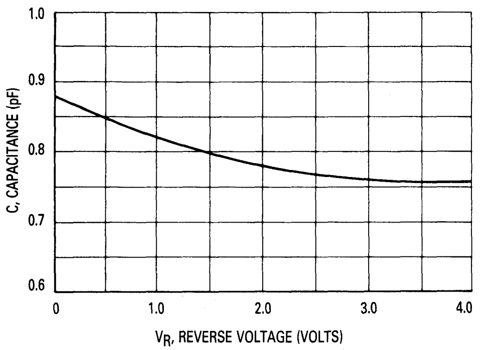


FIGURE 4 — NOISE FIGURE

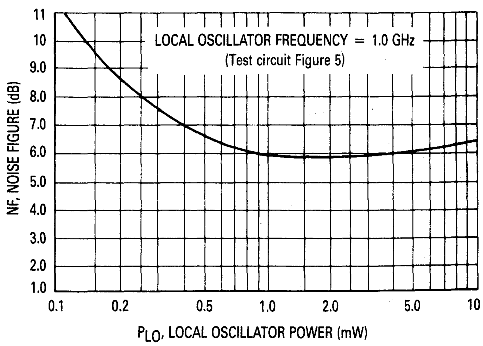
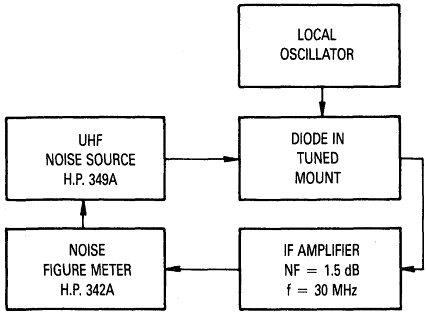


FIGURE 5 — NOISE FIGURE TEST CIRCUIT



NOTES ON TESTING AND SPECIFICATIONS

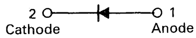
Note 1 — C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

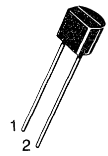
Note 2 — Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 — L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

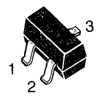
MBD301★
MMBD301LT1★

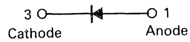
CASE 182-02, STYLE 1 (TO-226AC)





CASE 318-07, STYLE 8 SOT-23 (TO-236AB)





30 VOLTS SILICON HOT-CARRIER DETECTOR AND SWITCHING DIODES

★These are Motorola designated preferred devices.

6

SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for high-efficiency UHF and VHF detector applications. Readily adaptable to many other fast switching RF and digital applications. Supplied in an inexpensive plastic package for low-cost, high-volume consumer and industrial/commercial requirements. Also available in Surface Mount package.

- The Schottky Barrier Construction Provides Ultra-Stable Characteristics By Eliminating the "Cat-Whisker" or "S-Bend" Contact
- Extremely Low Minority Carrier Lifetime — 15 ps (Typ)
- Very Low Capacitance — 1.5 pF (Max) @ V_R = 15 V
- Low Reverse Leakage — I_R = 13 nAdc (Typ) MBD301, MMBD301

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	MBD301 Value	MMBD301LT1 Value	Unit
Reverse Voltage	V_R	30		Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	280 2.8	200 2.0	mW mW/°C
Operating Junction Temperature Range	T_J	−55 to +125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBD301LT1 = 4T

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	30	—	—	Volts
Total Capacitance, Figure 1 (V_R = 15 Volts, f = 1.0 MHz)	C_T	—	0.9	1.5	pF
Minority Carrier Lifetime, Figure 2 (I_F = 5.0 mA, Krakauer Method)	τ	—	15	—	ps
Reverse Leakage, Figure 3 (V_R = 25 V)	I_R	—	13	200	nAdc
Forward Voltage, Figure 4 (I_F = 1.0 mAdc)	V_F	—	0.38	0.45	Vdc
Forward Voltage, Figure 4 (I_F = 10 mAdc)	V_F	—	0.52	0.6	Vdc

MMBD301LT1 is also available in bulk packaging. Use MMBD301L as the device title to order this device in bulk.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — TOTAL CAPACITANCE

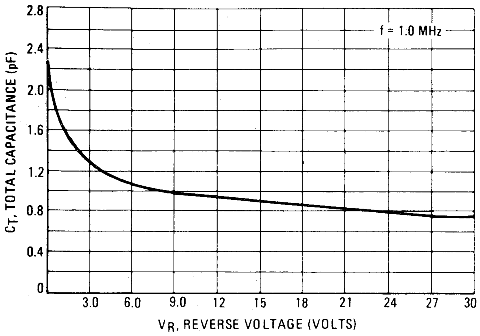


FIGURE 2 — MINORITY CARRIER LIFETIME

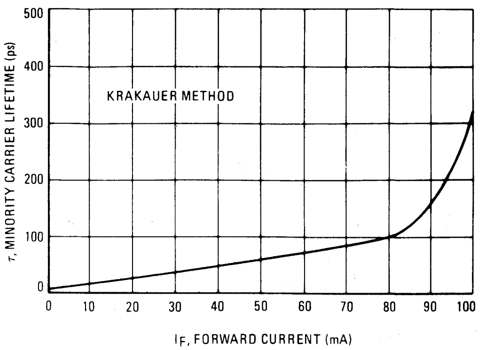


FIGURE 3 — REVERSE LEAKAGE

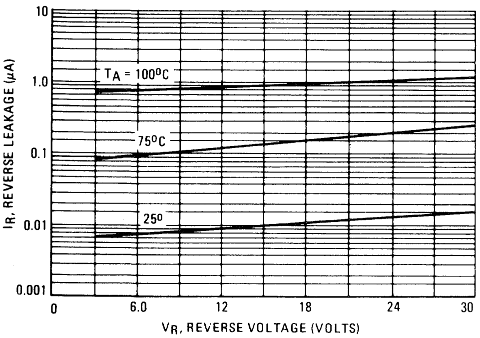
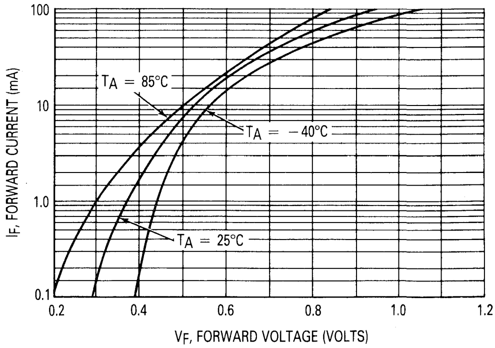
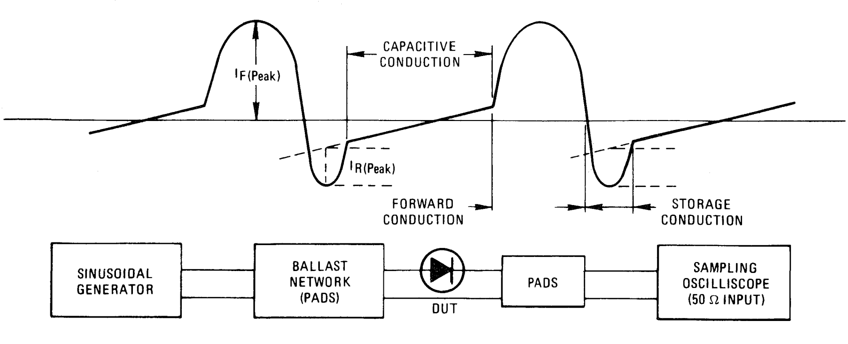


FIGURE 4 — FORWARD VOLTAGE



6

KRAKAUER METHOD OF MEASURING LIFETIME



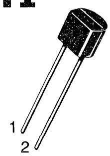
SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

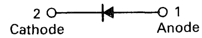
. . . designed primarily for high-efficiency UHF and VHF detector applications. Readily adaptable to many other fast switching RF and digital applications. Supplied in an inexpensive plastic package for low-cost, high-volume consumer and industrial/commercial requirements. Also available in Surface Mount package.

- The Schottky Barrier Construction Provides Ultra-Stable Characteristics by Eliminating the "Cat-Whisker" or "S-Bend" Contact
- Extremely Low Minority Carrier Lifetime — 15 ps (Typ)
- Very Low Capacitance — 1.0 pF @ V_R = 20 V
- High Reverse Voltage — to 70 Volts
- Low Reverse Leakage — 200 nA (Max)

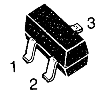
MBD701★
MMBD701LT1★

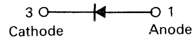
CASE 182-02, STYLE 1
(TO-226AC)





CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





70 VOLTS
HIGH-VOLTAGE
SILICON HOT-CARRIER
DETECTOR AND SWITCHING
DIODES

★**These are Motorola designated preferred devices.**

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	MBD701	MMBD701LT1	Unit
		Value		
Reverse Voltage	V_R	70		Volts
Forward Power Dissipation @ T_A = 25°C	P_F	280	200	mW
Derate above 25°C		2.8	2.0	mW/°C
Operating Junction Temperature Range	T_J	−55 to +125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

6

DEVICE MARKING

MMBD701LT1 = 5H

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	70	–	–	Volts
Total Capacitance, Figure 1 (V_R = 20 Volts, f = 1.0 MHz)	C_T	–	0.5	1.0	pF
Minority Carrier Lifetime, Figure 2 (I_F = 5.0 mA, Krakauer Method)	τ	–	15	–	ps
Reverse Leakage, Figure 3 (V_R = 35 V)	I_R	–	9.0	200	nAdc
Forward Voltage, Figure 4 (I_F = 1.0 mAdc)	V_F	–	0.42	0.5	Vdc
Forward Voltage, Figure 4 (I_F = 10 mAdc)	V_F	–	0.7	1.0	Vdc

MMBD701LT1 is also available in bulk packaging. Use MMBD701L as the device title to order this device in bulk.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — TOTAL CAPACITANCE

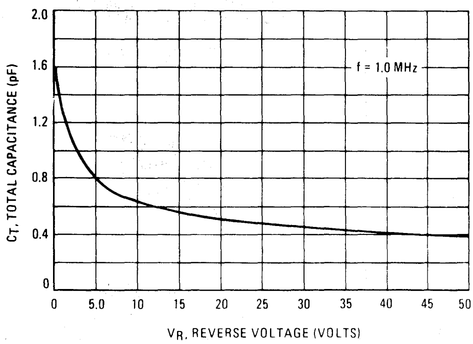


FIGURE 2 — MINORITY CARRIER LIFETIME

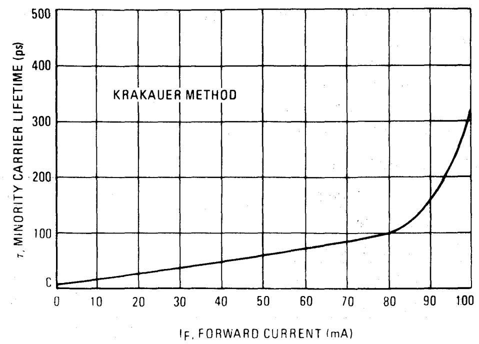


FIGURE 3 — REVERSE LEAKAGE

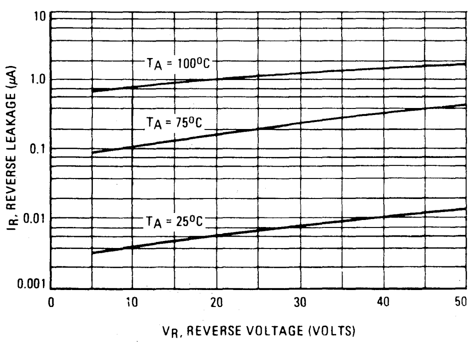
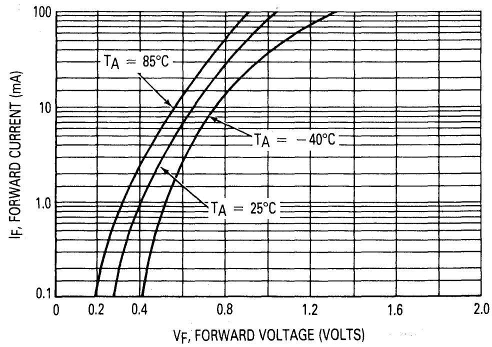
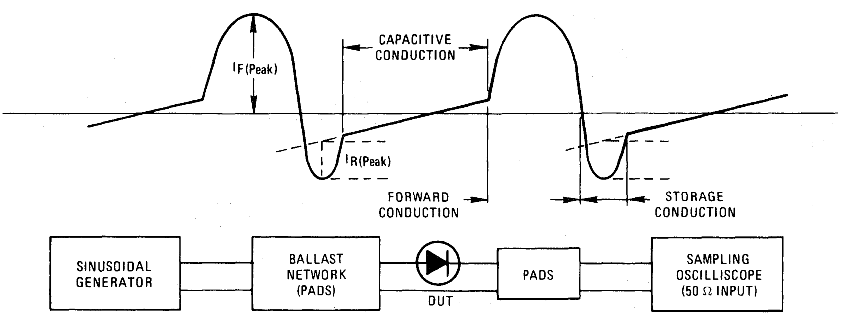


FIGURE 4 — FORWARD VOLTAGE



6

KRAKAUER METHOD OF MEASURING LIFETIME



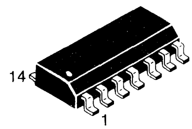
SURFACE MOUNT DIODE ARRAYS

These diode arrays are multiple diode junctions fabricated by a planar process and mounted in integrated circuit packages for use in high-current, fast-switching core-driver applications. These arrays offer many of the advantages of integrated circuits such as high-density packaging and improved reliability. These advantages result from such factors as fewer glass-to-metal seals.

- Designed for Use in Computers and Peripheral Equipment
- Applications Include:
  Magnetic Cores
  Thin-Film Memories
  Plated-Wire Memories
  Decoding or Encoding Applications

MMAD130
MMAD1103
thru
MMAD1107
MMAD1109★

CASE 751A-03
SO-14



MONOLITHIC DIODE ARRAYS

★MMAD130, MMAD1103, MMAD1107 and MMAD1109 are Motorola designated preferred devices.

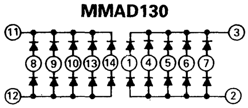
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Voltage	V_{RM}	50	Vdc
Steady-State Reverse Voltage	V_R	50	Vdc
Peak Forward Current 25°C	I_{FM}	500	mA
Continuous Forward Current	I_F	400	mA
Power Dissipation Derating Factor	P_D	500 4.0	mW mW/°C
Operating Temperature	T_A	−65 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

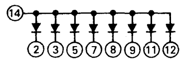
6

SO-14 Pin Diagram

1. Dual 10 Diode Array — **MMAD130**

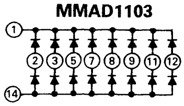


4. 8 Diode Array (Common Anode) — **MMAD1106**



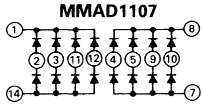
NC Pin 1, 4, 6, 10, 13

2. 16 Diode Array — **MMAD1103**



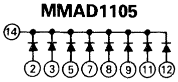
NC Pin 4, 6, 10, 13

5. Dual 8 Diode Array — **MMAD1107**



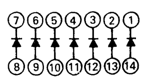
NC Pin 6, 13

3. 8 Diode Array (Common Cathode) — **MMAD1105**



NC Pin 1, 4, 6, 10, 13

6. 7 Diode Array (Independent) — **MMAD1109**



Device	Description	Diagram
MMAD130	Dual 10 Diode Array	1
MMAD1103	16 Diode Array	2
MMAD1105	8 Diode Array Common Cathode	3
MMAD1106	8 Diode Array Common Anode	4
MMAD1107	Dual 8 Diode Array	5
MMAD1109	7 Diode Array	6

ELECTRICAL CHARACTERISTICS (@ 25°C Free-Air Temperature)

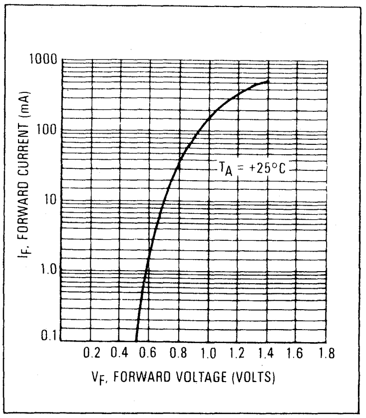
Characteristic	Symbol	Limit Min	Limit Max	Unit
Reverse Breakdown Voltage (1) (I_R = 10 μA)	$V_{(BR)}$	50	—	Vdc
Static Reverse Current (V_R = 40 V)	I_R	—	0.1	μA
Static Forward Voltage (I_F = 100 mA) (I_F = 500 mA) (2)	V_F	— —	1.2 1.6	Vdc
Peak Forward Voltage (3) (I_F = 500 mA)	V_{FM}	—	5.0	Vdc

SWITCHING CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Typical Value	Unit
Forward Recovery Time (I_F = 500 mA)	t_{fr}	20	ns
Reverse Recovery Time (I_F = 200 mA, I_{RM} = 200 mA, R_L = 100 Ω, i_{rr} = 20 mA)	t_{rr}	8.0	ns

1. This parameter must be measured using pulse techniques. PW = 100 μs, duty cycle ≤ 20%.
2. This parameter is measured using pulse techniques. PW = 300 μs, duty cycle ≤ 2.0%. Read time is 90 μs from the leading edge of the pulse.
3. The initial instantaneous value is measured using pulse techniques. PW = 150 ns, duty cycle ≤ 2.0%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.

FIGURE 1 — TYPICAL CHARACTERISTICS
STATIC FORWARD VOLTAGE



6

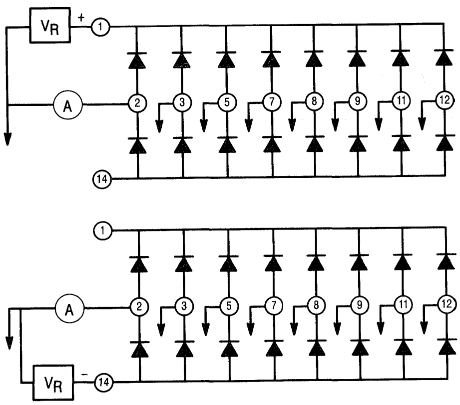
TEST PROCEDURE FOR MULTIPLE DIODES

1.0. REVERSE BIAS TESTING

1.1. LEAKAGE

Regardless of device configuration type, when testing any reverse bias condition, the forcing power supply must be applied only to the uncommon terminal of the pair. As in Figure 1, this would be pins 1 and 14. This can be referred as the high side of the test circuit. The low side of the test circuit must be connected to the common terminal of the pair which in most testers is where the current measurement is taken. This method is used to eliminate the possibility of degrading the diode in that pair which is not under test. Diode arrays with multiple pairs such as the MAD1103, also have leakage paths in the die between common terminals of the pairs. To isolate the device under test so that the leakage from the other pairs in the package do not affect the test result, the leakage current from the common terminals of the pairs not under test must be shunted to measurement common. Figure 1 shows the test configuration for both of these cases.

FIGURE 1



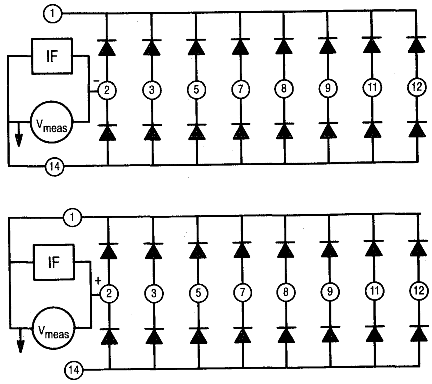
1.2. BREAKDOWN

It is not recommended to test breakdown on these devices due to the possibility of degrading the device. Breakdown may be checked on a curve tracer but extreme caution should be used.

2.0. FORWARD BIAS TESTING

Diode arrays are designed with the pairs in parallel therefore care must be taken to prevent the other diodes in the array from affecting the measured value of the diode under test. Figure 2 illustrates the proper technique to measure only the correct value of the diode under test.

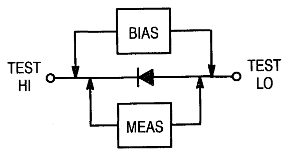
FIGURE 2



2.1. KELVIN CONNECTION

To achieve the best possible accuracy when testing bias currents over 10 mA, Kelvin connection to the leads of the device under test is mandatory. True Kelvin connection dictates that two test connections are made directly to the leads of the device. One is for power which is the bias supply, and the other is for sense which is for the measurement circuit. Kelvin connections are used to eliminate the effects of the connection resistance between the lead of the device and the contacts of the test handler and/or hand fixture. Figure 3 is an example of Kelvin connection.

FIGURE 3



2.2. PULSE TESTING

When testing bias currents over 10 mA, pulse testing should be used to minimize thermal drift of the measured value. The pulse width of a pulse test is approximately 300 µs to 380 µs.

3.0. TESTING PROTOCOL

3.1. TEST TYPES

When testing in sequence all of the electrical characteristics, all reverse bias conditions should be tested before the forward bias conditions are tested.

3.2. BIASING MAGNITUDES

Tests of the same test type should be grouped together with the bias conditions in ascending order. For example:

V_F @ 10 mA < 0.6 V
V_F @ 50 mA < 0.8 V
V_F @ 100 mA < 1 V
V_F @ 500 mA < 1.5 V

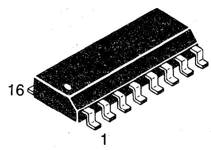
SURFACE MOUNT
ISOLATED 8-DIODE ARRAY

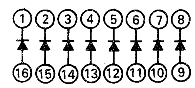
This diode array is a multiple diode junction fabricated by a planar process and mounted in integrated circuit packages for use in high-current, fast-switching core-driver applications. This array offers the advantages of an integrated circuit with high-density packaging and improved reliability. This advantage results from such factors as fewer connections, more uniform device parameters, smaller size, less weight and fewer glass-to-metal seals.

- Designed for use in Computers and Peripheral Equipment
- Applications Include: Magnetic Cores; Plated-Wire Memories; Thin-Film Memories; Decoding or Encoding

MMAD1108★

CASE 751B-05
SO-16





Pin Connections Diagram

MONOLITHIC DIODE ARRAY

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Voltage	V_{RM}	50	Vdc
Steady-State Reverse Voltage	V_R	50	Vdc
Peak Forward Current 25°C	I_{FM}	500	mA
Continuous Forward Current	I_F	400	mA
Power Dissipation Derating Factor	P_D	500 4.0	mW mW/°C
Operating Temperature	T_A	−65 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Limit Min	Limit Max	Unit
Reverse Breakdown Voltage (1) (I_R = 10 μA)	$V_{(BR)}$	50	—	Vdc
Static Reverse Current (V_R = 40 V)	I_R	—	0.1	μA
Static Forward Voltage (I_F = 100 mA) (I_F = 500 mA) (2)	V_F	 — —	 1.10 1.55	Vdc
Peak Forward Voltage (3) (I_F = 500 mA)	V_{FM}	—	5.0	Vdc

SWITCHING CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Typical Value	Unit
Forward Recovery Time (I_F = 500 mA)	t_{fr}	20	ns
Reverse Recovery Time (I_F = 200 mA, I_{RM} = 200 mA, R_L = 100 Ω, i_{rr} = 20 mA)	t_{rr}	8.0	ns

1. This parameter must be measured using pulse techniques. PW = 100 μs, duty cycle ≤ 20%.
2. This parameter is measured using pulse techniques. PW = 300 μs, duty cycle ≤ 2.0%. Read time is 90 μs from the leading edge of the pulse.
3. The initial instantaneous value is measured using pulse techniques. PW = 150 ns, duty cycle ≤ 2.0%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.

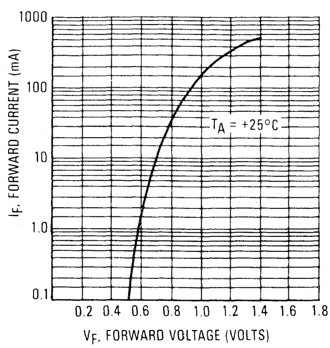


FIGURE 1 — TYPICAL CHARACTERISTICS STATIC FORWARD VOLTAGE

6

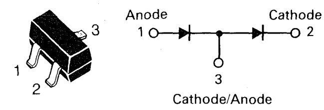
DUAL SILICON HOT-CARRIER DIODES (SCHOTTKY BARRIER DIODES)

. . . designed primarily for UHF mixer applications. but suitable also for use in detector and ultra-fast switching circuits.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- Low Forward Voltage — 0.5 Volts (Typ) @ I_F = 10 mA

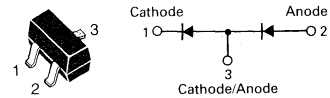
MMBD352LT1★

CASE 318-07, STYLE 11
SOT-23 (TO-236AB)



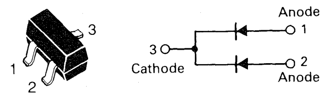
MMBD353LT1★

CASE 318-07, STYLE 19
SOT-23 (TO-236AB)



MMBD354LT1★

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)



DUAL HOT CARRIER MIXER DIODES

★These are Motorola designated preferred devices.

MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	7.0	V_{CC}

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +125	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

6

DEVICE MARKING

MMBD352LT1 = M5G; MMBD353LT1 = M4F; MMBD354LT1 = M6H

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Forward Voltage (I_F = 10 mA)	V_F	—	0.60	V
Reverse Voltage Leakage Current (V_R = 3.0 V) (V_R = 7.0V)	I_R	 — —	 0.25 10	µA
Capacitance (V_R = 0 V, f = 1.0 MHz)	C	—	1.0	pF

MMBD352LT1, MMBD353LT1 and MMBD354LT1 are also available in bulk packaging. Use MMBD352L, MMBD353L or MMBD354L as the device title when ordering these devices in bulk.

FIGURE 1 — FORWARD VOLTAGE

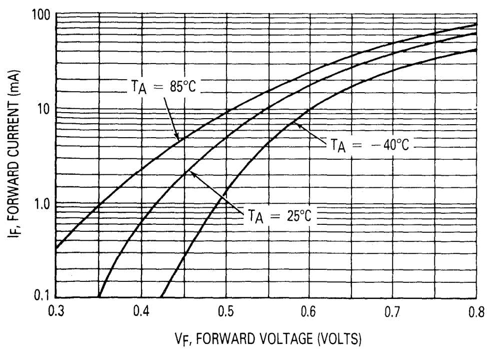
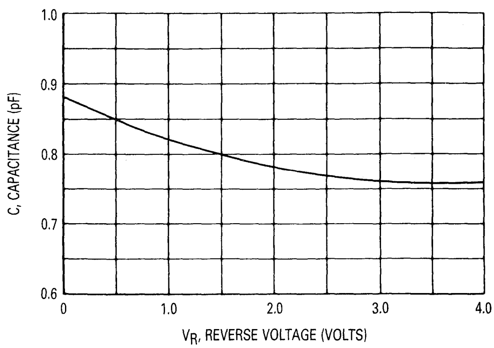
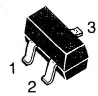


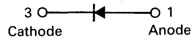
FIGURE 2 — CAPACITANCE



MMBD914LT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





HIGH-SPEED SWITCHING DIODE

★This is a Motorola designated preferred device.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

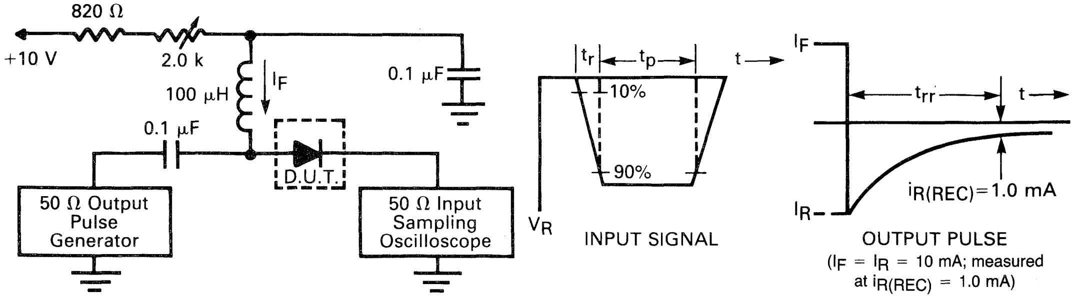
DEVICE MARKING

MMBD914LT1 = 5D

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_R = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current	I_R			
(V_R = 20 Vdc)		—	25	nAdc
(V_R = 75 Vdc)		—	5.0	μAdc
Diode Capacitance (V_R = 0, 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 $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

FIGURE 2 — FORWARD VOLTAGE

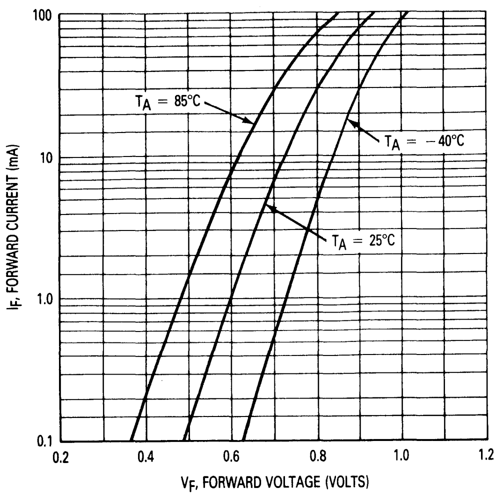
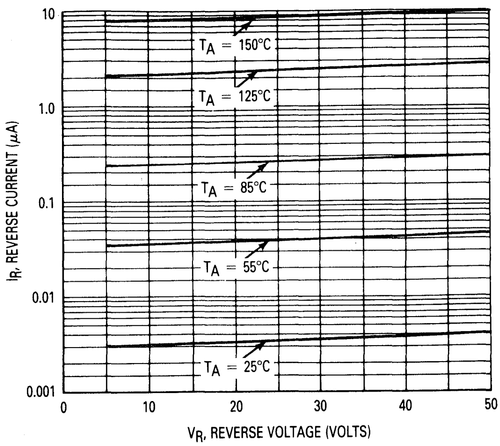
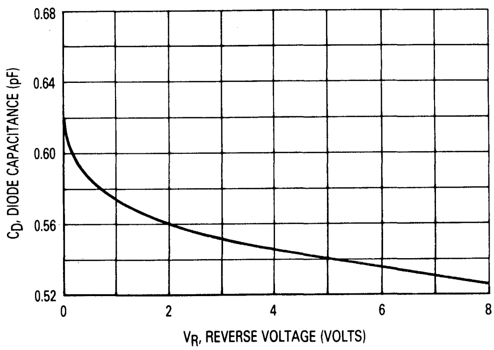


FIGURE 3 — LEAKAGE CURRENT



6

FIGURE 4 — CAPACITANCE



MAXIMUM RATINGS (EACH DIODE)

Rating		Symbol	Value	Unit
Reverse Voltage	MMBD2836LT1 MMBD2835LT1	V_R	75 35	Vdc
Forward Current		I_F	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

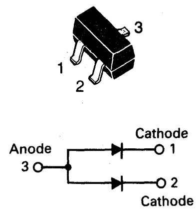
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBD2835LT1 = A3; MMBD2836LT1 = A2

MMBD2835LT1
MMBD2836LT1

CASE 318-07, STYLE 12
SOT-23 (TO-236AB)



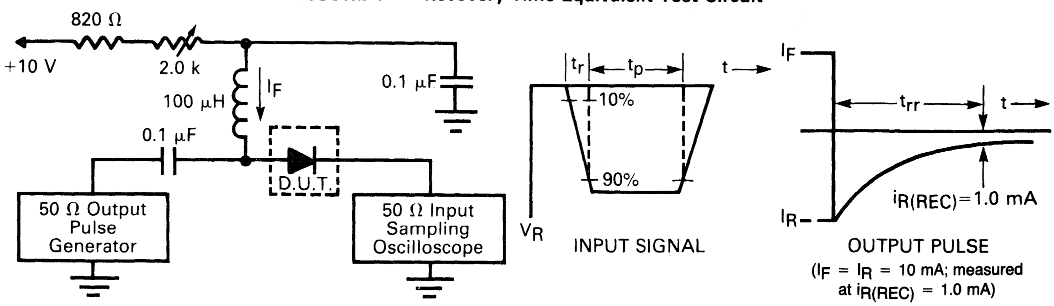
MONOLITHIC DUAL SWITCHING DIODES

6

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 100 μAdc)	MMBD2835LT1 MMBD2836LT1	$V_{(BR)}$	35 75	— —	Vdc
Reverse Voltage Leakage Current (V_R = 30 Vdc) (V_R = 50 Vdc)	MMBD2835LT1 MMBD2836LT1	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}	—	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 $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

Curves Applicable to each Cathode

FIGURE 2 — FORWARD VOLTAGE

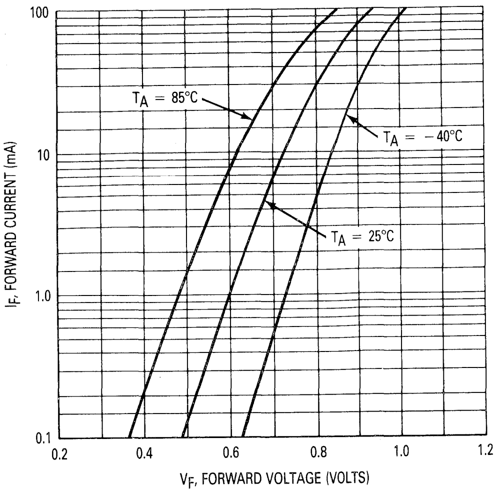


FIGURE 3 — LEAKAGE CURRENT

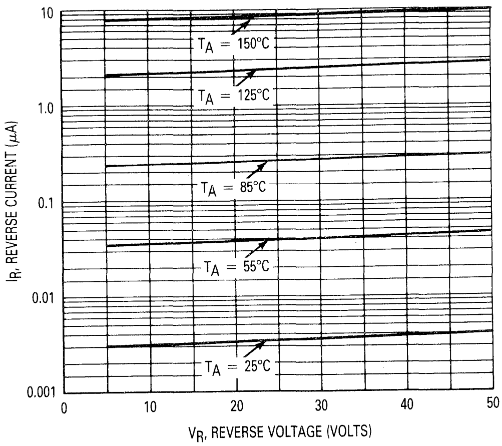
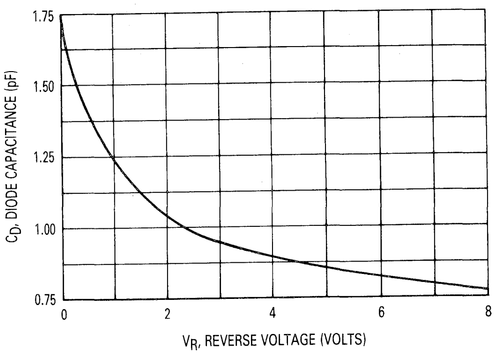


FIGURE 4 — CAPACITANCE



6

MAXIMUM RATINGS (EACH DIODE)

Rating		Symbol	Value	Unit
Peak Reverse Voltage		V_{RM}	75	Vdc
D.C. Reverse Voltage	MMBD2837LT1 MMBD2838LT1	V_R	30 50	Vdc
Peak Forward Current		I_{FM}	450 300	mAdc
Average Rectified Current		I_O	150 100	mAdc

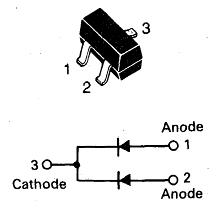
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

MMBD2837LT1
MMBD2838LT1

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)



MONOLITHIC DUAL SWITCHING DIODES

DEVICE MARKING

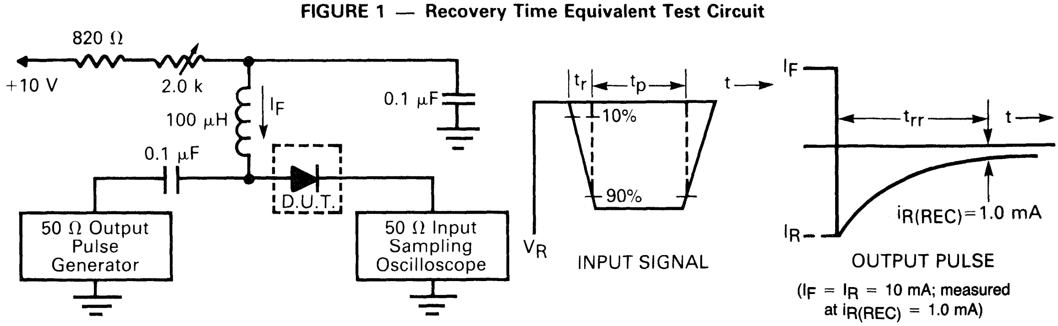
MMBD2837LT1 = A5; MMBD2838LT1 = A6

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	 MMBD2837LT1 MMBD2838LT1	$V_{(BR)}$	 35 75	 — —	Vdc
Reverse Voltage Leakage Current (V_R = 30 Vdc) (V_R = 50 Vdc)	 MMBD2837LT1 MMBD2838LT1	I_R	 — —	 0.1 0.1	μAdc
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}	—	4.0	ns

6

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 $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

Curves Applicable to each Anode

FIGURE 2 — FORWARD VOLTAGE

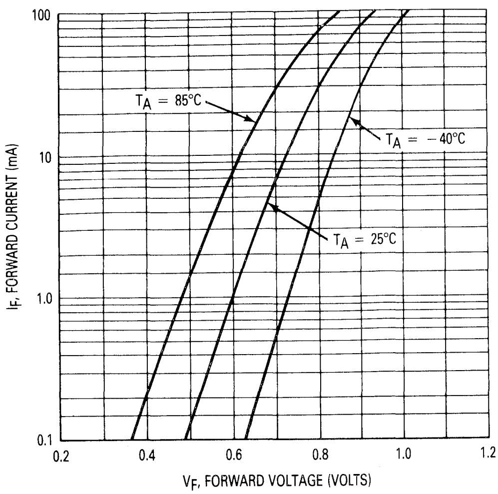
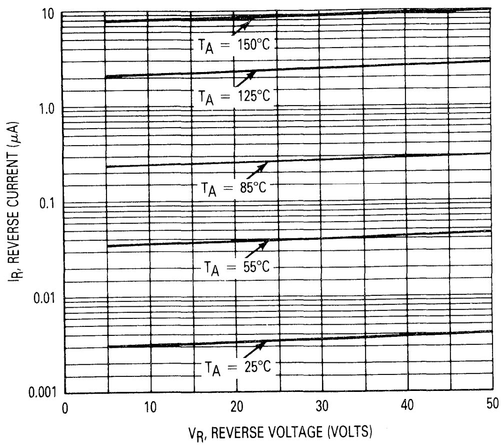
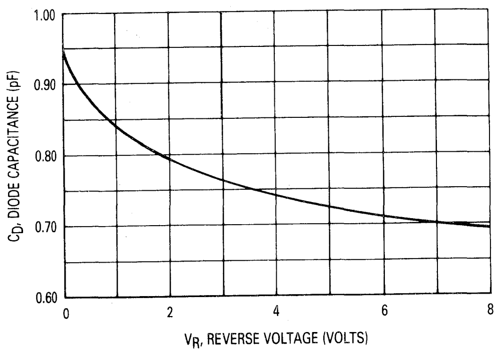


FIGURE 3 — LEAKAGE CURRENT



6

FIGURE 4 — CAPACITANCE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

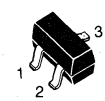
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

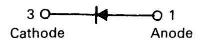
DEVICE MARKING

MMBD6050LT1 = 5AM

MMBD6050LT1

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



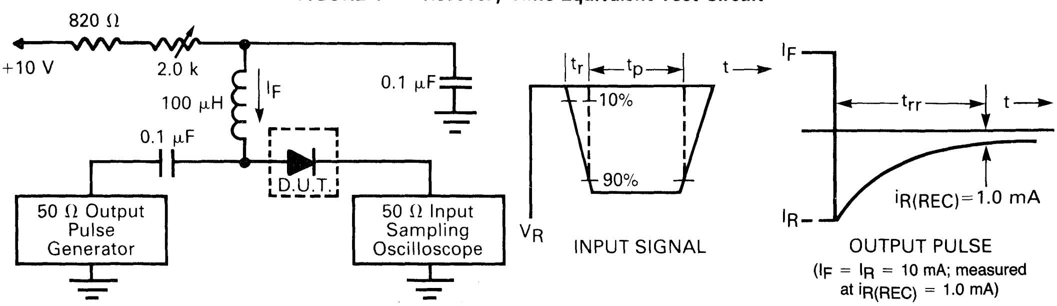


SWITCHING DIODE

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	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}	—	4.0	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 $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

FIGURE 2 — FORWARD VOLTAGE

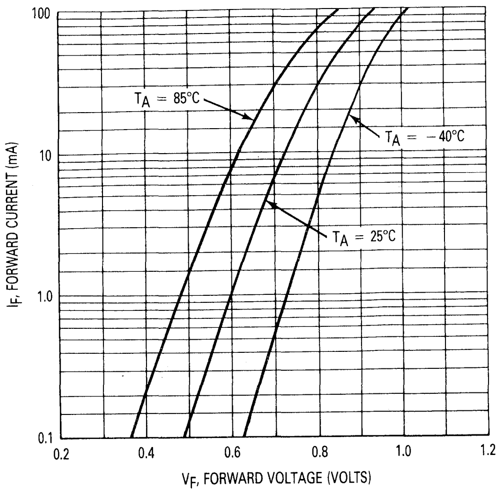


FIGURE 3 — LEAKAGE CURRENT

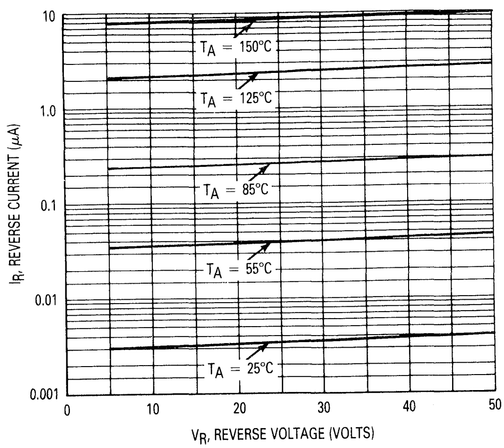
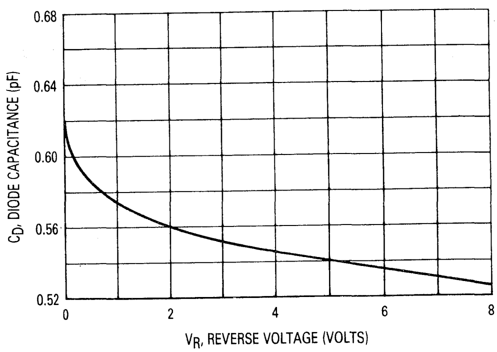


FIGURE 4 — CAPACITANCE



6

MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

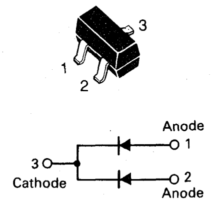
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBD6100LT1 = 5BM

MMBD6100LT1

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)



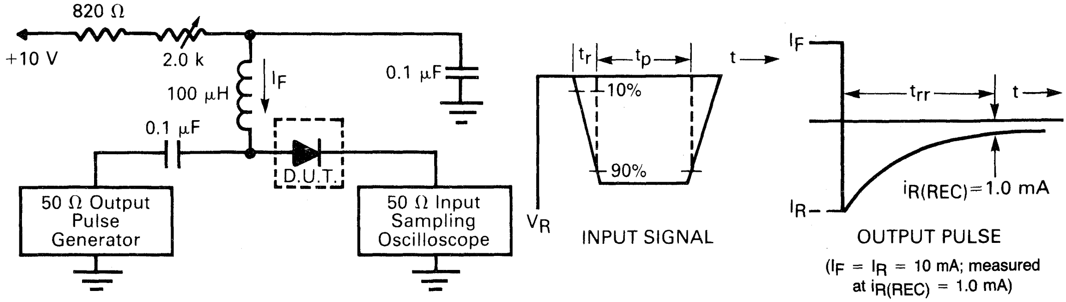
MONOLITHIC DUAL SWITCHING DIODE

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	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}	—	4.0	ns
Capacitance (V_R = 0)	C	—	2.5	pF

6

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 $I_{R(peak)}$ is equal to 10 mA.
3. t_p » t_{rr}

Curves Applicable to each Anode

FIGURE 2 — FORWARD VOLTAGE

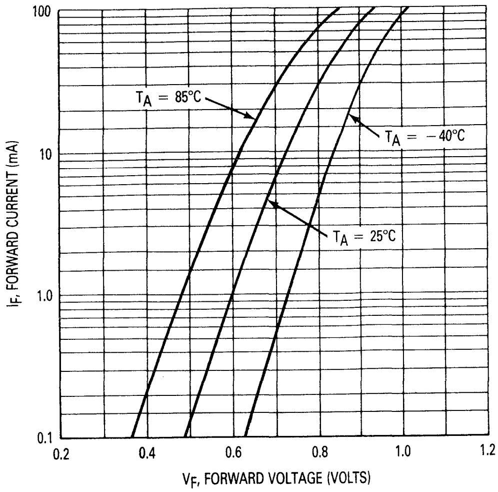


FIGURE 3 — LEAKAGE CURRENT

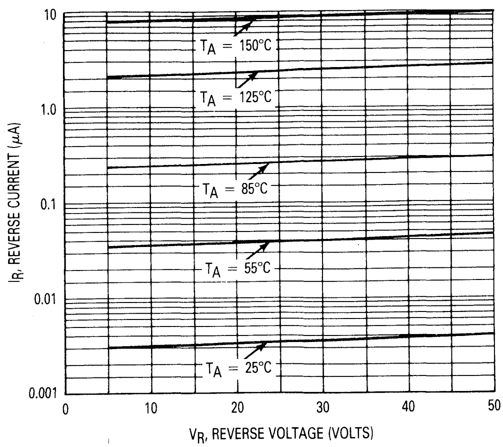
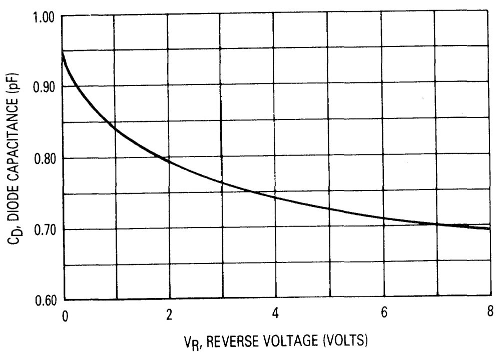


FIGURE 4 — CAPACITANCE



MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$ Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

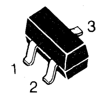
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

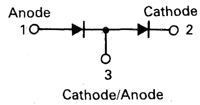
DEVICE MARKING

MMBD7000LT1 = M5C

MMBD7000LT1★

CASE 318-07, STYLE 11
SOT-23 (TO-236AB)





DUAL SWITCHING DIODE

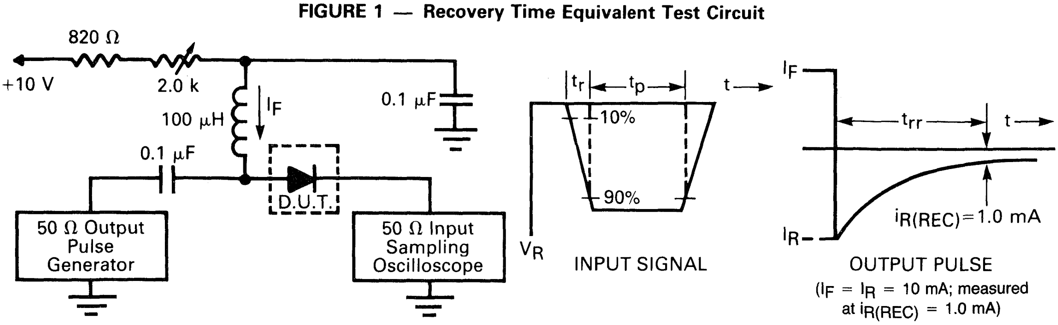
★This is a Motorola designated preferred device.

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc) (V_R = 100 Vdc) (V_R = 50 Vdc, 125°C)	 I_R I_{R2} I_{R3}	 — — —	 1.0 3.0 100	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.67 0.75	 0.7 0.82 1.1	Vdc
Reverse Recovery Time ($I_F = I_R$ = 10 mAdc) (Figure 1)	t_{rr}	—	4.0	ns
Capacitance (V_R = 0)	C	—	1.5	pF

6

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 $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

Curves Applicable to each Diode

FIGURE 2 — FORWARD VOLTAGE

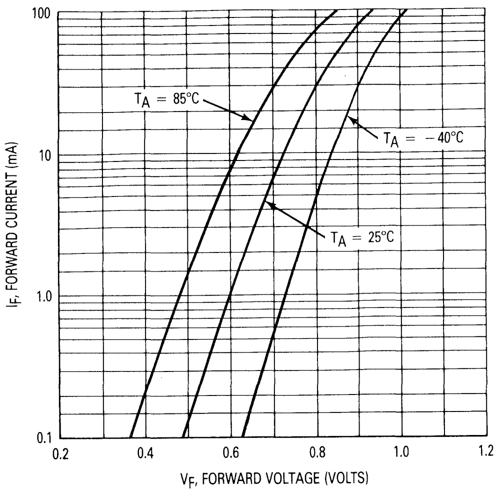
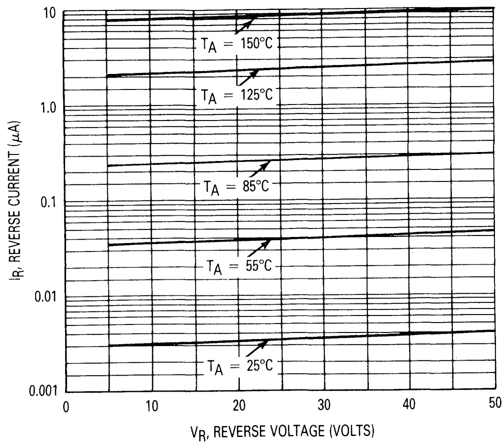
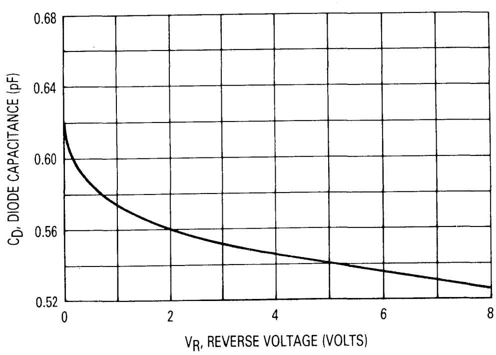


FIGURE 3 — LEAKAGE CURRENT



6

FIGURE 4 — CAPACITANCE



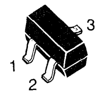
SILICON EPICAP DIODE

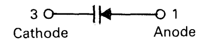
. . . designed in the Surface Mount package for general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- Controlled and Uniform Tuning Ratio

MMBV105GLT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





30 VOLT
VOLTAGE VARIABLE
CAPACITANCE DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

DEVICE MARKING

MMBV105GLT1 = M4E

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

Characteristic	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	Vdc
Reverse Voltage Leakage Current (VR = 28 V)	I_R	—	50	nAdc

Device Type	C_T V_R = 25 Vdc, f = 1.0 MHz pF		Q f = 100 MHz V_R = 3.0 V	C_R f = 1.0 MHz C_3/C_{25}	
	Min	Max	Typ	Min	Max
MMBV105GLT1	1.8	2.8	250	4.0	6.0

MMBV105GLT1 is also available in bulk packaging. Use MMBV105GL as the device title to order this device in bulk.

FIGURE 1 — DIODE CAPACITANCE

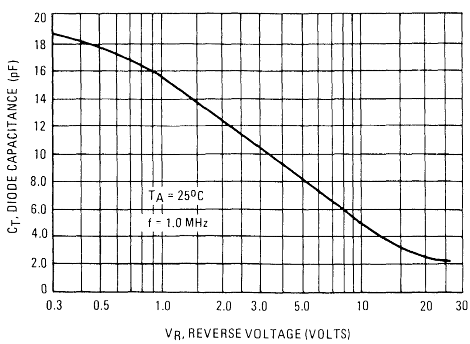


FIGURE 2 — FIGURE OF MERIT

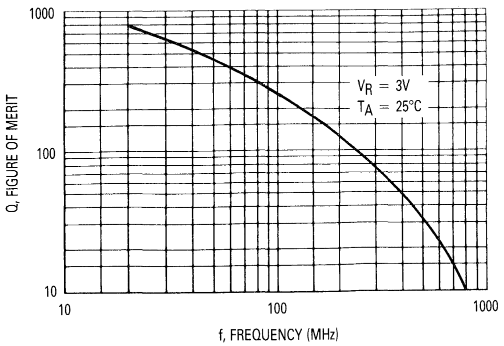
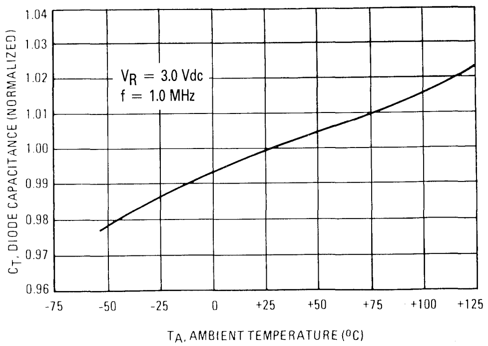


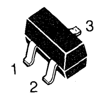
FIGURE 3 — DIODE CAPACITANCE



6

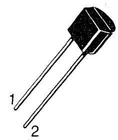
MMBV109LT1★
MV209★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



3 Cathode — 1 Anode

CASE 182-02, STYLE 1
(TO-226AC)



2 Cathode — 1 Anode

26–32 pF
VOLTAGE VARIABLE
CAPACITANCE DIODES

★These are Motorola designated preferred devices.

SILICON EPICAP DIODES

. . . designed for general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q with Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Available in Surface Mount Package

MAXIMUM RATINGS

Rating	Symbol	MV209	MMBV109LT1	Unit
		Value		
Reverse Voltage	V_R	30		Volts
Forward Current	I_F	200		mA
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	 280 2.8	 200 2.0	 mW mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBV109LT1 = M4A

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

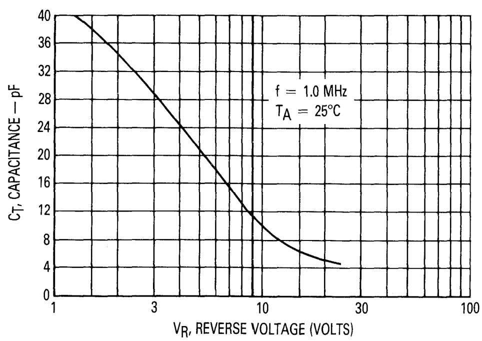
Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	—	—	0.1	μAdc
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	—	300	—	ppm/°C

	C_t, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 50 MHz	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz (Note 1)	
Device	**Min**	**Nom**	**Max**	**Min**	**Min**	**Max**
MMBV109LT1, MV209	26	29	32	200	5.0	6.5

(1) C_R is the ratio of C_t measured at 3 Vdc divided by C_t measured at 8 Vdc.

MMBV109LT1 is also available in bulk packaging. Use MMBV109L as the device title to order this device in bulk.

FIGURE 1 — DIODE CAPACITANCE



6

FIGURE 2 — FIGURE OF MERIT

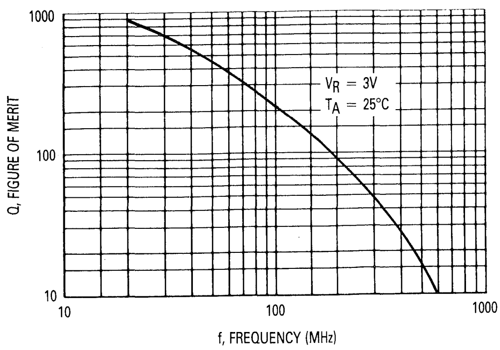


FIGURE 3 — LEAKAGE CURRENT

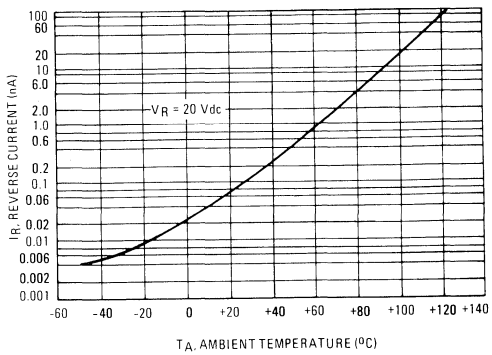
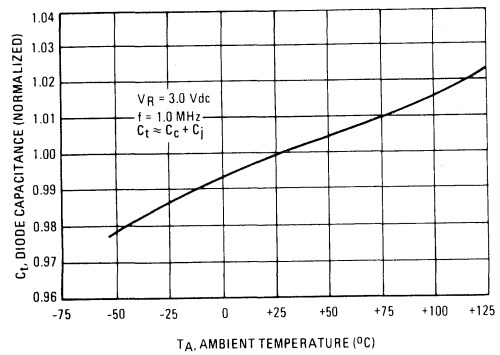


FIGURE 4 — DIODE CAPACITANCE



6

NOTES ON TESTING AND SPECIFICATIONS

1. C_R is the ratio of C_t measured at 3.0 Vdc divided by C_t measured at 25 Vdc.

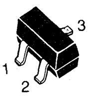
SILICON EPICAP DIODES

. . . designed for general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

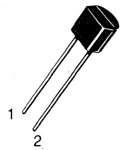
- High Q with Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Available in Surface Mount Package

MMBV409LT1★
MV409★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



CASE 182-02, STYLE 1
TO-92 (TO-226AC)



VOLTAGE VARIABLE CAPACITANCE DIODES

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value MV409	Value MMBV409LT1	Unit
Reverse Voltage	V_R	20		Volts
Forward Current	I_F	200		mA
Forward Power Dissipation @ T_A = 25°C	P_D	280	200	mW
Derate above 25°C		2.8	2.0	mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBV409LT1 = X5

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

Characteristic — All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	20	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 15 Vdc)	I_R	—	—	0.1	μAdc
Diode Capacitance Temperature Coefficient (V_R = 3 Vdc, f = 1 MHz)	TC_C	—	300	—	ppm/°C

	C_t, Diode Capacitance V_R = 3 Vdc, f = 1 MHz pF			Q, Figure of Merit V_R = 3 Vdc f = 50 MHz	C_R, Capacitance Ratio C_3/C_8 f = 1 MHz (Note 1)	
Device	Min	Nom	Max	Min	Min	Max
MMBV409LT1, MV409	26	29	32	200	1.5	1.9

NOTES ON TESTING AND SPECIFICATIONS

(1) C_R is the ratio of C_t measured at 3 Vdc divided by C_t measured at 8 Vdc.

MMBV409LT1 is also available in bulk packaging. Use MMBV409L as the device title to order this device in bulk.

6

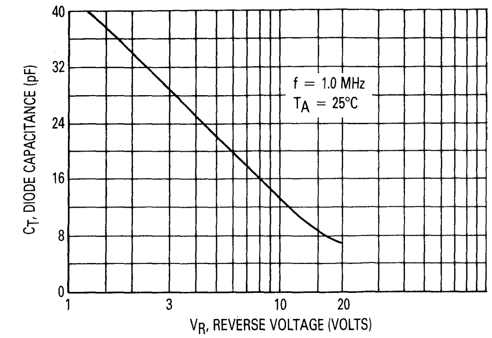


Figure 1. Diode Capacitance

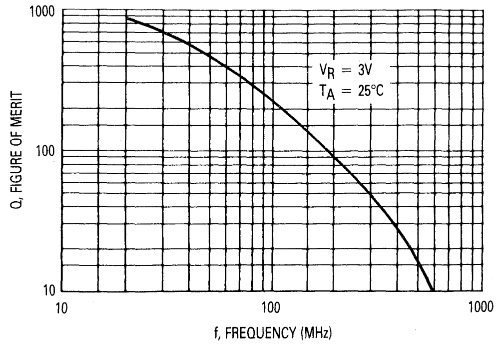


Figure 2. Figure of Merit

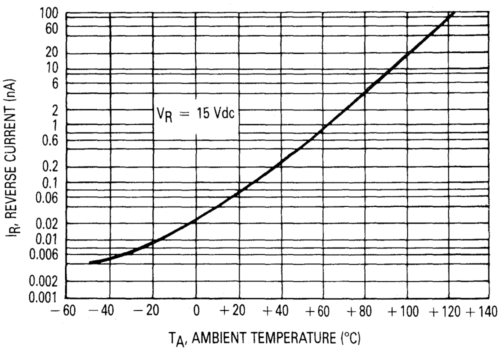


Figure 3. Leakage Current

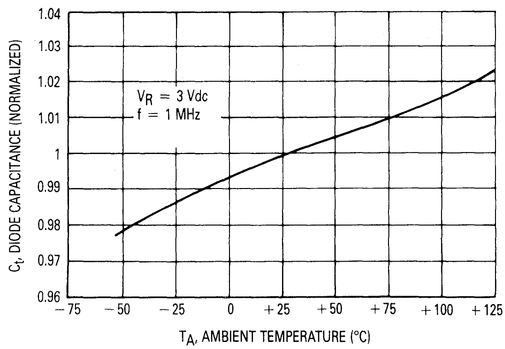


Figure 4. Diode Capacitance

6

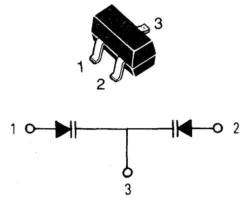
SILICON EPICAP DIODE

. . . designed for FM tuning, general frequency control and tuning, or any top-of-the-line application requiring back-to-back diode configuration for minimum signal distortion and detuning. This device is supplied in the SOT-23 plastic package for high volume, pick and place assembly requirements.

- High Figure of Merit — Q = 150 (Typ) @ V_R = 2.0 Vdc, f = 100 MHz
- Guaranteed Capacitance Range
- Dual Diodes — Save Space and Reduce Cost
- Surface Mount Package
- Available in 8 mm Tape and Reel
- Monolithic Chip Provides Improved Matching — Guaranteed ±1.0% (Max) Over Specified Tuning Range

MMBV432LT1★

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)



DUAL VOLTAGE-VARIABLE CAPACITANCE DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (Each Diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	14	Volts
Forward Current	I_F	200	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +125	°C

DEVICE MARKING

MMBV432LT1 = M4B

6

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	14	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 9.0 Vdc)	I_R	—	—	100	nAdc
Diode Capacitance (V_R = 2.0 Vdc, f = 1.0 MHz)	C_T	43	—	48.1	pF
Capacitance Ratio C2/C8 (f = 1.0 MHz)	C_R	1.5	—	2.0	—
Figure of Merit (V_R= 2.0 Vdc, f = 100 MHz)	Q	100	150	—	—

MMBV432LT1 is also available in bulk packaging. Use MMBV432L as the device title to order this device in bulk.

TYPICAL CHARACTERISTICS (Each Diode)

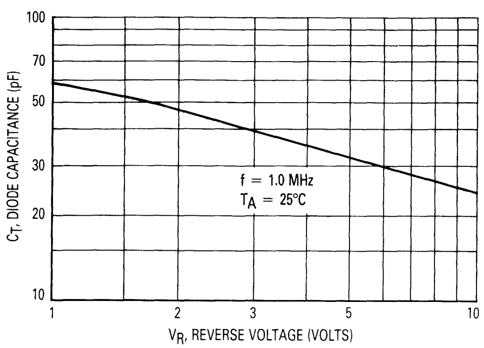


Figure 1. Diode Capacitance

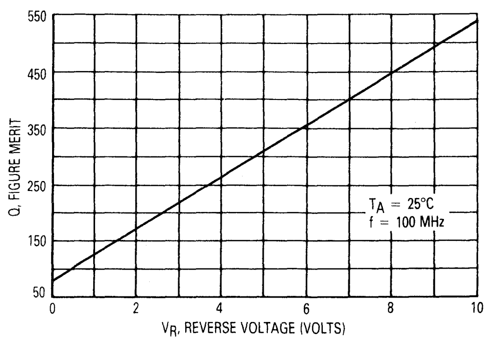


Figure 2. Figure of Merit versus Voltage

TYPICAL CHARACTERISTICS (Each Diode)

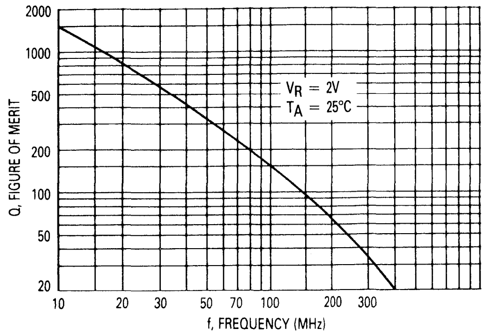


Figure 3. Figure of Merit versus Frequency

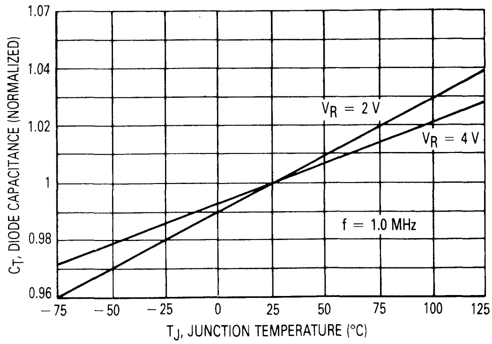


Figure 4. Diode Capacitance versus Temperature

6

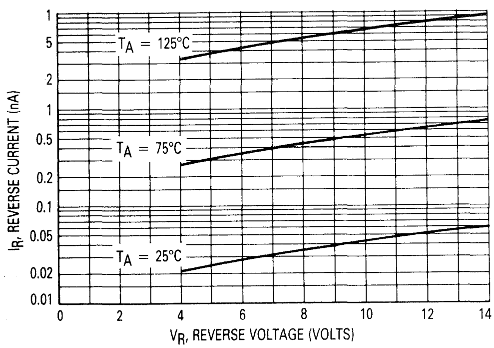


Figure 5. Reverse Current versus Reverse Voltage

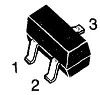
SILICON EPICAP DIODE

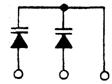
. . . designed for FM tuning, general frequency control and tuning, or any top-of-the-line application requiring back-to-back diode configuration for minimum signal distortion and detuning. This device is supplied in the SOT-23 plastic package for high volume, pick and place assembly requirements.

- High Figure of Merit — Q = 450 (Typ) @ V_R = 3.0 Vdc, f = 50 MHz
- Guaranteed Capacitance Range
- Dual Diodes — Save Space and Reduce Cost
- Surface Mount Package
- Available in 8 mm Tape and Reel
- Monolithic Chip Provides Improved Matching
- Hyper Abrupt Junction Process Provides High Tuning Ratio

MMBV609LT1★

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)





DUAL VOLTAGE-VARIABLE CAPACITANCE DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (Each Diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Current	I_F	100	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +125	°C

DEVICE MARKING

MMBV609LT1 = 5L

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	20	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 15 Vdc)	I_R	—	—	10	nAdc
Diode Capacitance (V_R = 3.0 Vdc, f = 1.0 MHz)	C_T	26	—	32	pF
Capacitance Ratio C3/C8 (f = 1.0 MHz)	C_R	1.8	—	2.4	—
Figure of Merit (V_R = 3.0 Vdc, f = 50 MHz)	Q	250	450	—	—

MMBV609LT1 is also available in bulk packaging. Use MMBV609L as the device title to order this device in bulk.

6

TYPICAL CHARACTERISTICS — EACH DIODE

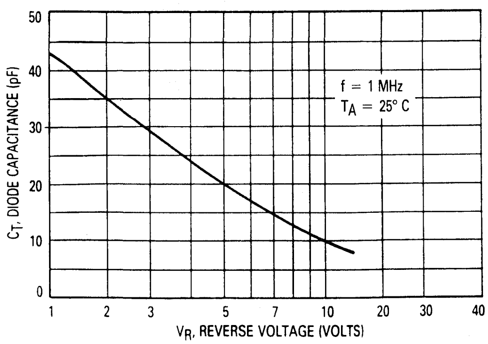


Figure 1. Diode Capacitance

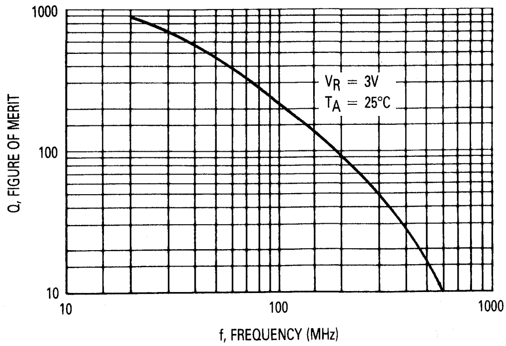


Figure 2. Figure of Merit

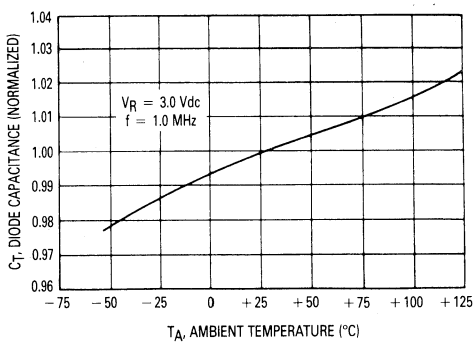


Figure 3. Diode Capacitance

6

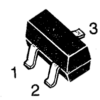
SILICON EPICAP DIODE

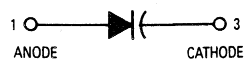
. . . designed for 900 MHz frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- Controlled and Uniform Tuning Ratio
- Available in Surface Mount Package
- Available in 8 mm Tape and Reel

MMBV809LT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





VOLTAGE VARIABLE CAPACITANCE DIODE
4.5–6.1 pF

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Current	I_F	20	mA
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225* 1.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +125	°C

*FR5 Board 1.0 × 0.75 × 0.62 in.

DEVICE MARKING

MMBV809LT1 = 5K

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

Characteristic — All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	20	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 15 Vdc)	I_R	—	—	50	nAdc

	C_t, Diode Capacitance V_R = 2.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 500 MHz	CR, Capacitance Ratio C_2/C_8 f = 1.0 MHz (Note 1)	
Device	Min	Typ	Max	Typ	Min	Max
MMBV809LT1	4.5	5.3	6.1	75	1.8	2.6

(1) C_R is the ratio of C_t measured at 2.0 Vdc divided by C_t measured at 8.0 Vdc.

MMBV809LT1 is also available in bulk packaging. Use MMBV809L as the device title to order this device in bulk.

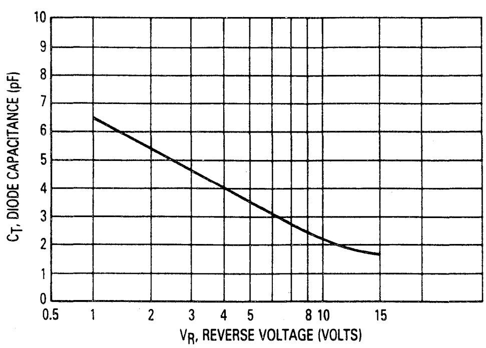


Figure 1. Diode Capacitance

6

FIGURE 2. FIGURE OF MERIT

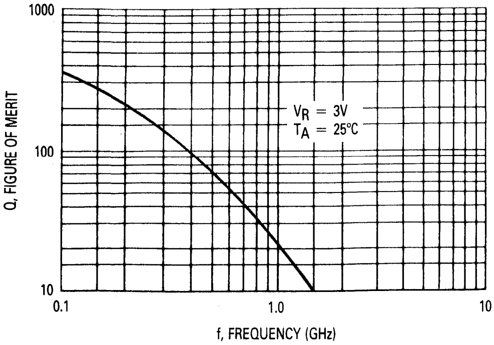


FIGURE 3. SERIES RESISTANCE

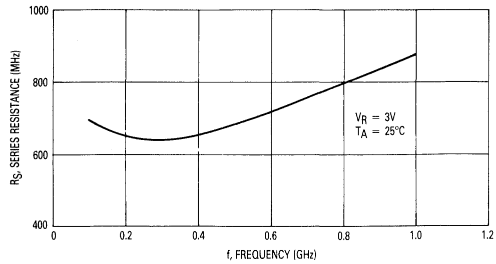
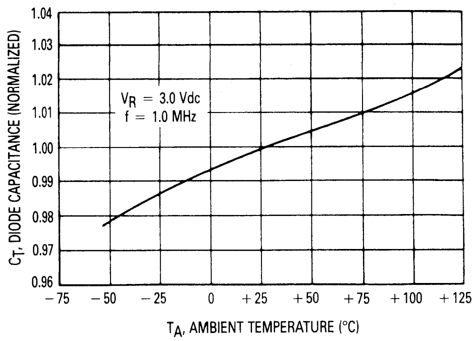


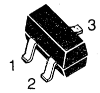
FIGURE 4. DIODE CAPACITANCE

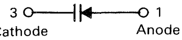


6

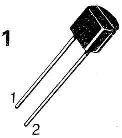
MMBV2101LT1
MMBV2103LT1 thru
MMBV2105LT1
MMBV2107LT1 thru
MMBV2109LT1★
MV2101
MV2103 thru MV2105
MV2107 thru MV2109
MV2111
MV2113 thru MV2115★

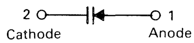
CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





CASE 182-02, STYLE 1
(TO-226AC)





6.8–100 pF
30 VOLTS
VOLTAGE-VARIABLE
CAPACITANCE DIODES

★MMBV2101LT1, MMBV2105LT1, MMBV2109LT1, MV2101, MV2104, MV2108, MV2109, MV2111, MV2113 and MV2115 are Motorola designated preferred devices.

SILICON EPICAP DIODES

. . . designed in the popular PLASTIC PACKAGE for high volume requirements of FM Radio and TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

Also available in Surface Mount Package up to 33 pF.

- High Q
- Controlled and Uniform Tuning Ratio
- Standard Capacitance Tolerance — 10%
- Complete Typical Design Curves

MAXIMUM RATINGS

Rating	Symbol	MV21XX	MMBV21XXLT1	Unit
		Value		
Reverse Voltage	V_R	30		Volts
Forward Current	I_F	200		mA
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	 280 2.8	 200 2.0	 mW mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBV2101LT1 = M4G	MMBV2105LT1 = 4U	MMBV2109LT1 = 4J
MMBV2103LT1 = 4H	MMBV2107LT1 = 4W	
MMBV2104LT1 = 4Z	MMBV2108LT1 = 4X	

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	—	—	0.1	μAdc
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	280	—	ppm/°C

	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		
Device	**Min**	**Nom**	**Max**	**Typ**	**Min**	**Typ**	**Max**
MMBV2101LT1/MV2101	6.1	6.8	7.5	450	2.5	2.7	3.2
MMBV2103LT1/MV2103	9.0	10	11	400	2.5	2.9	3.2
MMBV2104LT1/MV2104	10.8	12	13.2	400	2.5	2.9	3.2
MMBV2105LT1/MV2105	13.5	15	16.5	400	2.5	2.9	3.2
MMBV2107LT1/MV2107	19.8	22	24.2	350	2.5	2.9	3.2
MMBV2108LT1/MV2108	24.3	27	29.7	300	2.5	3.0	3.2
MMBV2109LT1/MV2109	29.7	33	36.3	200	2.5	3.0	3.2
MV2111	42.3	47	51.7	150	2.5	3.0	3.2
MV2113	61.2	68	74.8	150	2.6	3.0	3.3
MV2114	73.8	82	90.2	100	2.6	3.0	3.3
MV2115	90	100	110	100	2.6	3.0	3.3

MMBV2101LT1, MMBV2103LT1 thru MMBV2105LT1 and MMBV2107LT1 thru MMBV2109LT1 are also available in bulk. Use the device title and drop the "T1" suffix when ordering any of these devices in bulk.

6

PARAMETER TEST METHODS

1. C_T, DIODE CAPACITANCE
($C_T = C_C + C_J$), C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

2. TR, TUNING RATIO
TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

3. Q, FIGURE OF MERIT
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈ 1/16".

4. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT
TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = −65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation which defines TC_C:

$$TC_C = \frac{C_T(+85°C) - C_T(-65°C)}{85 + 65} \cdot \frac{10^6}{C_R(25°C)}$$

Accuracy limited by measurement of C_T to ± 0.1 pF.

TYPICAL DEVICE PERFORMANCE

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE

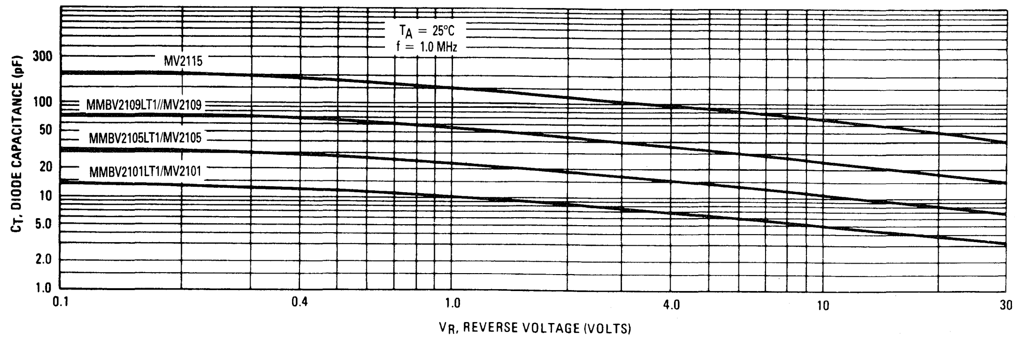


FIGURE 2 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

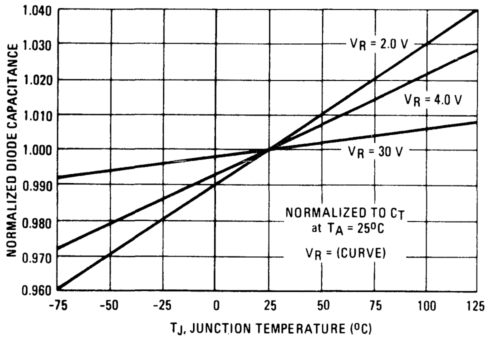


FIGURE 3 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

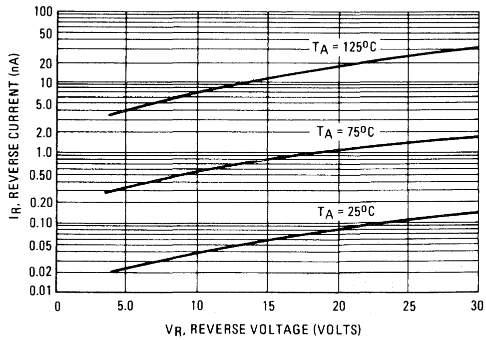


FIGURE 4 — FIGURE OF MERIT versus REVERSE VOLTAGE

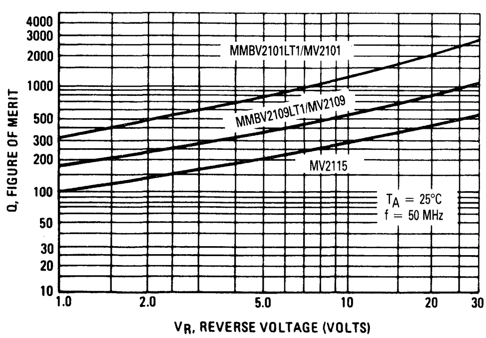
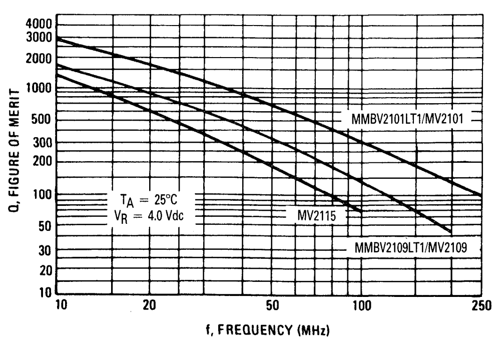


FIGURE 5 — FIGURE OF MERIT versus FREQUENCY



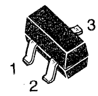
SILICON EPICAP DIODE

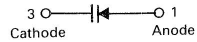
. . . designed in the Surface Mount package for general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q with Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio

MMBV3102LT1

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





22 pF (Nominal)
30 VOLTS
VOLTAGE VARIABLE
CAPACITANCE DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

DEVICE MARKING

MMBV3102LT1 = M4C

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	—	—	0.1	μAdc
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	300	—	ppm/°C

	C_T, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc, f = 50 MHz	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz	
Device	Min	Nom	Max	Min	Min	Typ
MMBV3102LT1	20	22	25	200	4.5	4.8

MMBV3102LT1 is also available in bulk packaging. Use MMBV3102L as the device title to order this device in bulk.

FIGURE 1 — DIODE CAPACITANCE

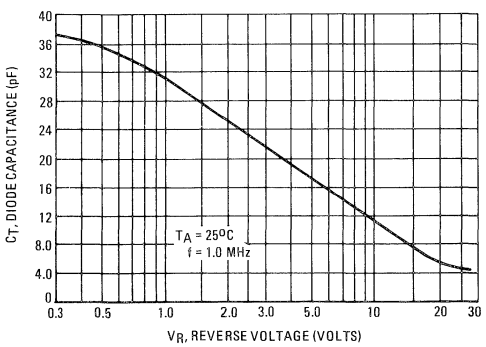


FIGURE 2 — FIGURE OF MERIT

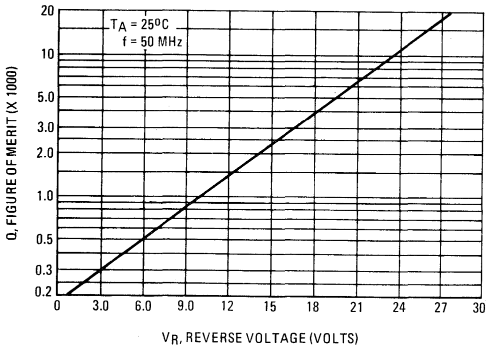


FIGURE 3 — LEAKAGE CURRENT

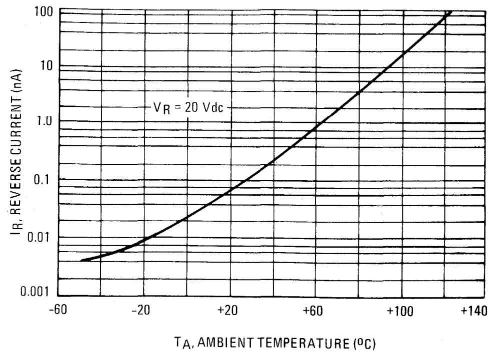
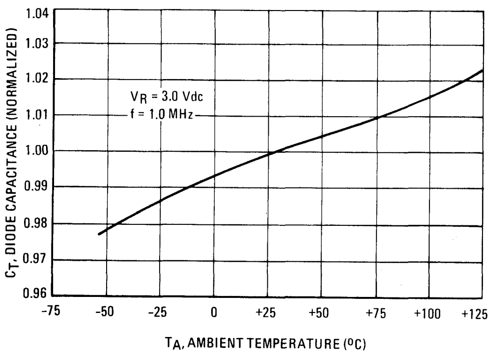


FIGURE 4 — DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. C_R is the ratio of C_T measured at 3.0 Vdc divided by C_T measured at 25 Vdc.

6

6

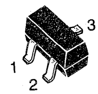
SILICON PIN DIODE

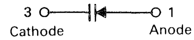
. . . designed primarily for VHF band switching applications but also suitable for use in general-purpose switching circuits. Supplied in a Surface Mount package.

- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Low Capacitance — 0.7 pF Typ at V_R = 20 V
- Very Low Series Resistance at 100 MHz — 0.34 Ohms (Typ) @ I_F = 10 mAdc

MMBV3401LT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





SILICON PIN SWITCHING DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	200 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

DEVICE MARKING

MMBV3401LT1 = 4D

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	35	—	—	Volts
Diode Capacitance (V_R = 20 V)	C_T	—	—	1.0	pF
Series Resistance (Figure 5) (I_F = 10 mA) f = 100 MHz	R_S	—	—	0.7	Ohms
Reverse Leakage Current (V_R = 25 V)	I_R	—	—	0.1	μA

MMBV3401LT1 is also available in bulk packaging. Use MMBV3401L as the device title to order this device in bulk.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — SERIES RESISTANCE

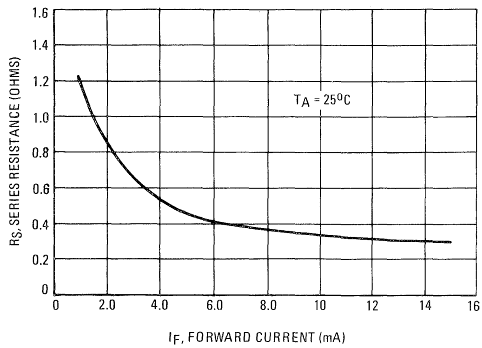


FIGURE 2 — FORWARD VOLTAGE

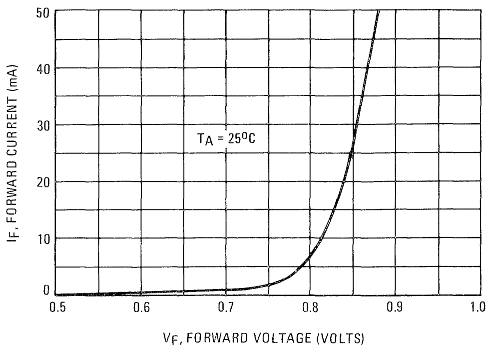


FIGURE 3 — DIODE CAPACITANCE

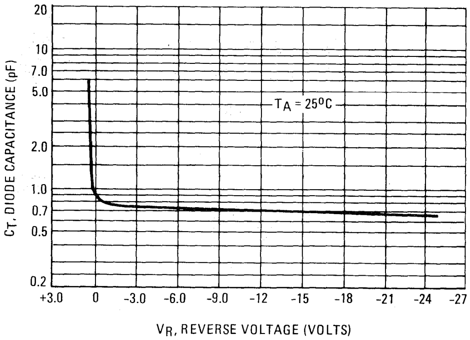


FIGURE 4 — LEAKAGE CURRENT

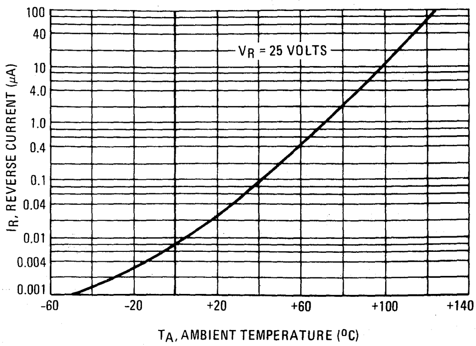
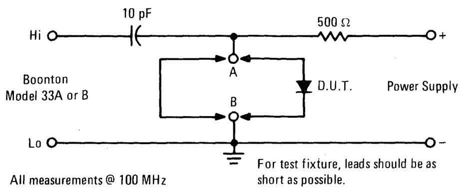


FIGURE 5 — FORWARD SERIES RESISTANCE TEST METHOD



To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\,G}{C^2}$$

Where:
G — in micromhos,
C — in pF,
R_S — in ohms

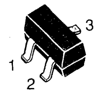
HIGH VOLTAGE SILICON PIN DIODES

. . . designed primarily for VHF band switching applications but also suitable for use in general-purpose switching circuits. Supplied in a cost effective plastic package for economical, high-volume consumer and industrial requirements. Also available in surface mount.

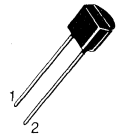
- Long Reverse Recovery Time
  t_{rr} = 300 ns (Typ)
- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Low Series Resistance @ 100 MHz —
  R_S = 0.7 Ohms (Typ) @ I_F = 10 mAdc
- Reverse Breakdown Voltage = 200 V (Min)

MMBV3700LT1
MPN3700

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



CASE 182-02, STYLE 1
(TO-226AC)



SILICON PIN SWITCHING DIODES

MAXIMUM RATINGS

Rating	Symbol	MPN3700	MMBV3700LT1	Unit
		Value		
Reverse Voltage	V_R	200		Volts
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	200 2.0	mW mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBV3700LT1 = 4R

6

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	200	—	—	Volts
Diode Capacitance (V_R = 20 Vdc, f = 1.0 MHz)	C_T	—	—	1.0	pF
Series Resistance (Figure 5) (I_F = 10 mA)	R_S	—	0.7	1.0	Ohms
Reverse Leakage Current (V_R = 150 Vdc)	I_R	—	—	0.1	μA
Reverse Recovery Time (I_F = I_R = 10 mA)	t_{rr}	—	300	—	ns

MMBV3700LT1 is also available in bulk packaging. Use MMBV3700L as the device title to order this device in bulk.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — SERIES RESISTANCE

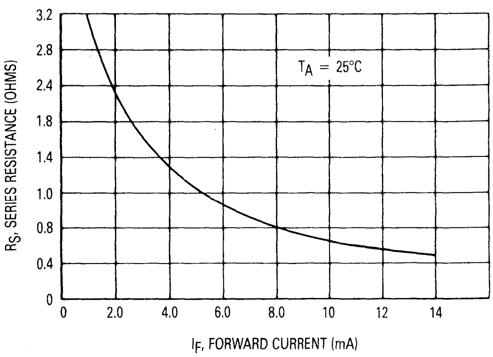


FIGURE 2 — FORWARD VOLTAGE

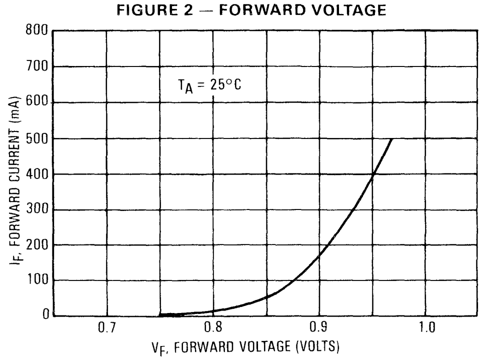


FIGURE 3 — DIODE CAPACITANCE

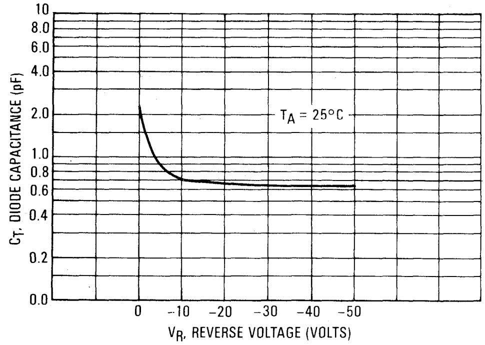


FIGURE 4 — LEAKAGE CURRENT

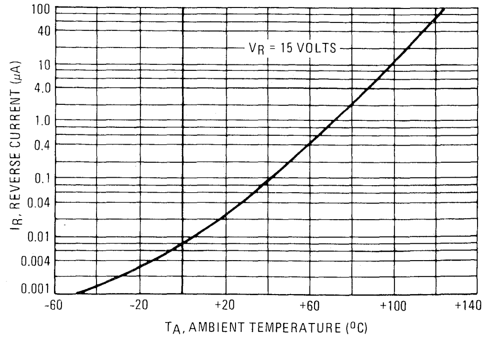
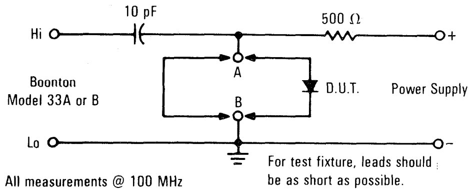


FIGURE 5 — FORWARD SERIES RESISTANCE TEST METHOD



To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\ G}{C^2}$$

Where:
G — in micromhos,
C — in pF,
R_S — in ohms

6

6

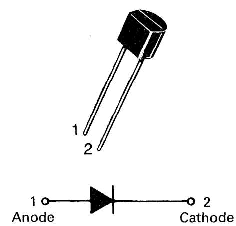
SILICON PIN DIODE

. . . designed primarily for VHF band switching applications but also suitable for use in general-purpose switching circuits. Supplied in a cost effective TO-92 type plastic package for economical, high-volume consumer and industrial requirements.

- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Low Series Resistance @ 100 MHz — R_S = 0.7 Ohms (Typ) @ I_F = 10 mAdc
- Sturdy TO-92 Style Package for Handling Ease

MPN3404★

CASE 182-02, STYLE 1
(TO-226AC)



SILICON PIN SWITCHING DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	20	—	—	Volts
Diode Capacitance (V_R = 15 Vdc, f = 1.0 MHz)	C_T	—	1.3	2.0	pF
Series Resistance (Figure 5) (I_F = 10 mA)	R_S	—	0.7	0.85	Ohms
Reverse Leakage Current (V_R = 15 Vdc)	I_R	—	—	0.1	μA

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SERIES RESISTANCE

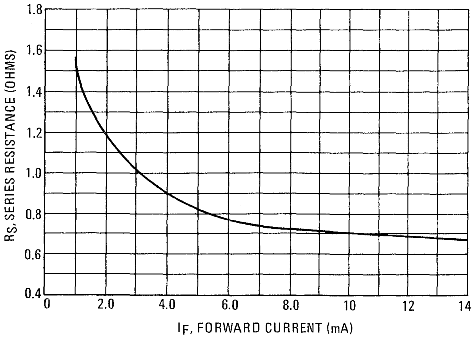


FIGURE 2 – FORWARD VOLTAGE

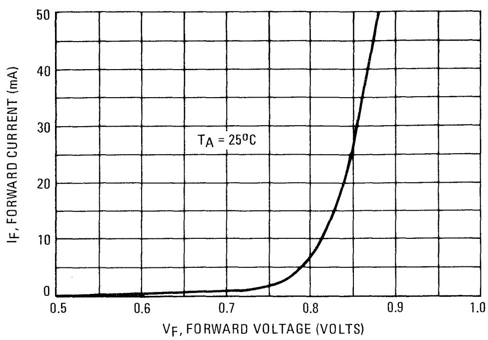


FIGURE 3 – DIODE CAPACITANCE

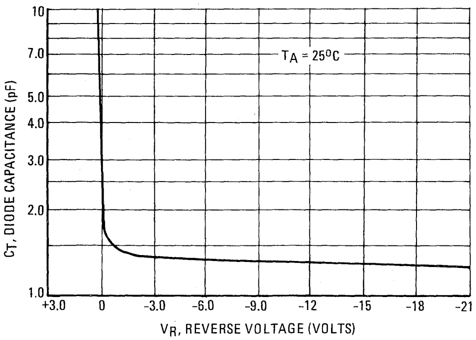


FIGURE 4 – LEAKAGE CURRENT

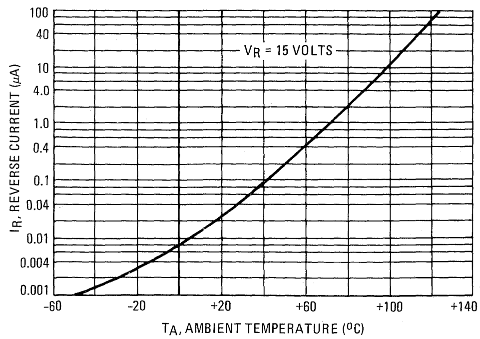
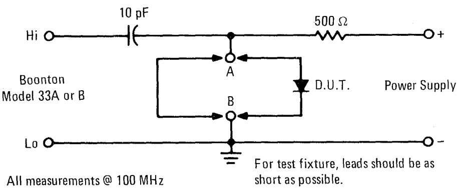


FIGURE 5 – FORWARD SERIES RESISTANCE TEST METHOD



To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

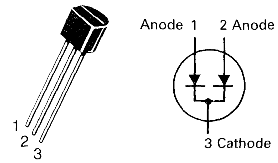
$$R_S = \frac{2.533\,G}{C^2}$$

Where:
G – in micromhos,
C – in pF,
R_S – in ohms

6

MSD6100★

CASE 29-04, STYLE 3
TO-92 (TO-226AA)



DUAL SWITCHING DIODE COMMON CATHODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (EACH DIODE)

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 μsec)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°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

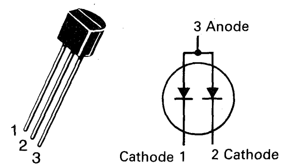
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.) **(EACH DIODE)**

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Current	I_R			μAdc
(V_R = 100 Vdc)		—	5.0	
(V_R = 50 Vdc)		—	0.1	
(V_R = 50 Vdc, T_A = 125°C)		—	50	
Forward Voltage	V_F			Vdc
(I_F = 1.0 mAdc)		0.55	0.7	
(I_F = 10 mAdc)		0.67	0.82	
(I_F = 100 mAdc)		0.75	1.1	
Capacitance (V_R = 0)	C	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	4.0	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = −65 to +150°C, θ_{JC} = 125°C/W.

MSD6150★

CASE 29-04, STYLE 4
TO-92 (TO-226AA)



DUAL DIODE COMMON ANODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (EACH DIODE)

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 μs)	$I_{FM(surge)}$	500	mA
Total Device Dissipation @ T_A = 25°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°C unless otherwise noted.) **(EACH DIODE)**

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	—	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	—	—	0.1	μAdc
Forward Voltage (I_F = 10 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 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	—	100	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 8.0 mW/°C, P_D = 10 W @ T_C = 25°C, Derate above 80 mW/°C, T_J, T_{stg} = −55 to +150°, θ_{JC} = 12.5°C/W, θ_{JA} = 125°C.

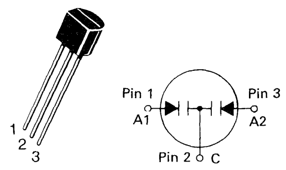
SILICON EPICAP DIODE

. . . designed for FM tuning, general frequency control and tuning, or any top-of-the-line application requiring back-to-back diode configurations for minimum signal distortion and detuning. This device is supplied in the popular TO-92 plastic package for high volume, economical requirements of consumer and industrial applications.

- High Figure of Merit — $Q = 140$ (Typ) @ $V_R = 3.0$ Vdc, f = 100 MHz
- Guaranteed Capacitance Range 37–42 pF @ $V_R = 3.0$ Vdc (MV104)
- Dual Diodes — Save Space and Reduce Cost
- TO-92 Package for Easy Handling and Mounting
- Monolithic Chip Provides Near Perfect Matching — Guaranteed ±1% (Max) Over Specified Tuning Range

MV104★

CASE 29-04, STYLE 15
(TO-226AA)



DUAL VOLTAGE-VARIABLE CAPACITANCE DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (EACH DIODE)

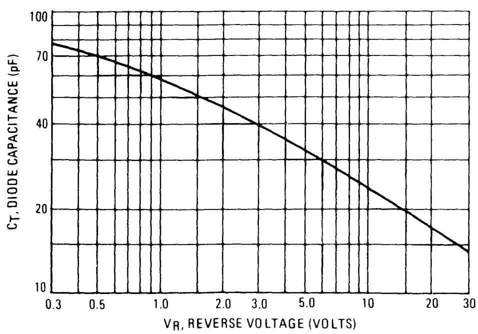
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	32	Volts
Forward Current	I_F	200	mA
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_F	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 10$ μAdc)	$V_{(BR)R}$	32	—	—	Vdc
Reverse Voltage Leakage Current $T_A = 25°C$ ($V_R = 30$ Vdc) $T_A = 60°C$	I_R	— —	— —	50 500	nAdc
Diode Capacitance Temperature Coefficient ($V_R = 4.0$ Vdc, f = 1.0 MHz)	TC_C	—	280	—	ppm/°C

	C_T, Diode Capacitance $V_R = 3.0$ Vdc, f = 1.0 MHz pF		Q, Figure of Merit $V_R = 3.0$ Vdc f = 100 MHz		C_R, Capacitance Ratio C_3/C_{30} f = 1.0 MHz	
Device	Min	Max	Min	Typ	Min	Max
MV104	37	42	100	140	2.5	2.8

FIGURE 1 — DIODE CAPACITANCE (Each Diode)



TYPICAL CHARACTERISTICS (Each Diode)

FIGURE 2 – FIGURE OF MERIT versus VOLTAGE

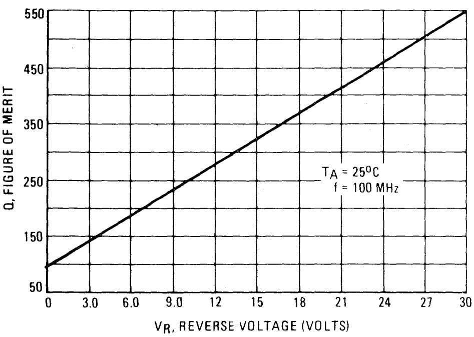


FIGURE 3 – FIGURE OF MERIT versus FREQUENCY

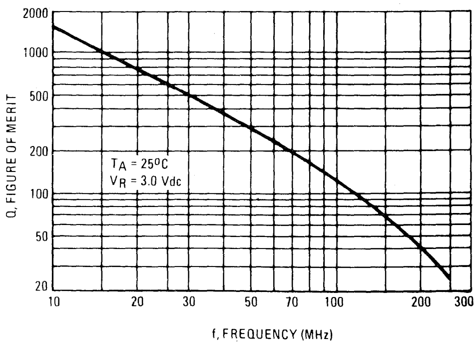


FIGURE 4 – DIODE CAPACITANCE versus TEMPERATURE

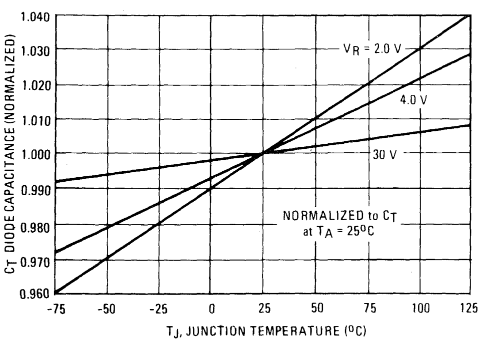
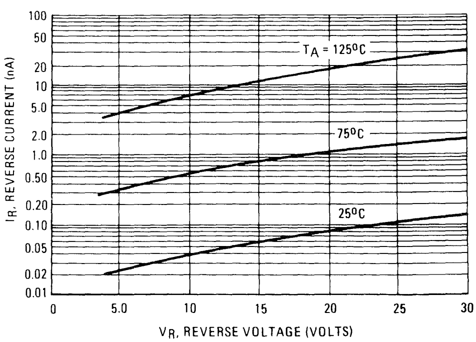


FIGURE 5 – REVERSE CURRENT versus REVERSE VOLTAGE



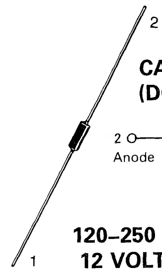
6

SILICON HYPER-ABRUPT TUNING DIODES

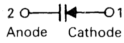
. . . designed with high capacitance and a capacitance change of greater than TEN TIMES for a bias change from 2.0 to 10 volts. Provides tuning over broad frequency ranges; tunes AM radio broadcast band, general AFC and tuning applications in lower RF frequencies.

- High Capacitance: 120–250 pF
- Large Capacitance Change with Small Bias Change
- Guaranteed High Q
- Available in Standard Axial Glass Packages

MV1403
MV1404
MV1405



CASE 51-02
(DO-204AA)



120–250 pF
12 VOLTS

HIGH TUNING RATIO VOLTAGE-VARIABLE CAPACITANCE DIODES

6

MAXIMUM RATINGS

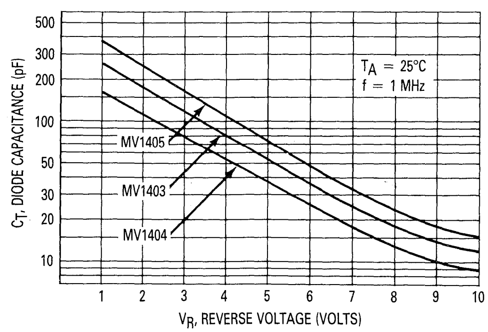
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	12	Volts
Forward Current	I_F	250	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	12	—	—	Vdc
Leakage Current at Reverse Voltage (V_R = 10 Vdc, T_A = 25°C)	I_R	—	—	0.1	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16″)	L_S	—	5.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16″)	C_C	—	0.25	—	pF

	C_T, Diode Capacitance			Q, Figure of Merit	TR, Tuning Ratio	
	V_R = 2.0 Vdc, f = 1.0 MHz pF			V_R = 2.0 Vdc, f = 1.0 MHz	C_1/C_{10} f = 1.0 MHz	C_2/C_{10} f = 1.0 MHz
Device	Min	Nom	Max	Min	Min	Min
MV1403	140	175	210	200	—	10
MV1404	96	120	144	200	—	10
MV1405	200	250	300	200	—	10

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE



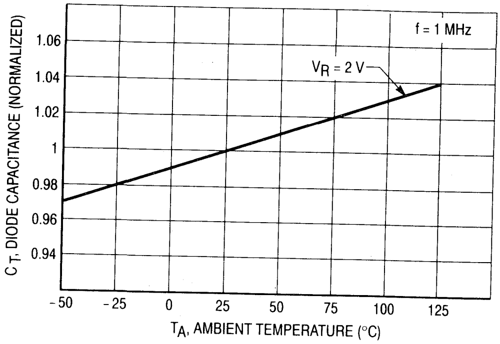


Figure 2. Diode Capacitance versus Ambient Temperature

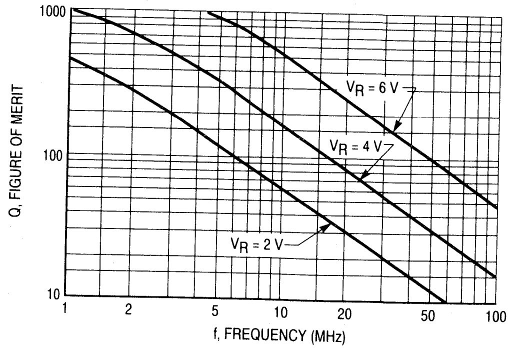
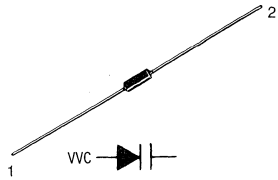


Figure 3. Figure of Merit versus Frequency

6

MV1620
thru
MV1650

CASE 51-02
DO-204AA (DO-7)



VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8–100 pF
20 VOLTS

SILICON EPICAP DIODES

. . . epitaxial passivated tuning diodes designed for AFC applications in radio, TV, and general electronic-tuning.

- Maximum Working Voltage of 20 V
- Excellent Q Factor at High Frequencies
- Solid-State Reliability to Replace Mechanical Tuning Methods

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Current	I_F	250	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

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

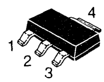
Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	20	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 15 Vdc, T_A = 25°C)	I_R	—	—	0.10	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16″)	L_S	—	4.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16″)	C_C	—	0.17	—	pF

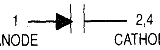
	C_t, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz	T_R, Tuning Ratio C_2/C_{20} f = 1.0 MHz	
Device	Min	Nom	Max	Typ	Min	Max
MV1620	6.1	6.8	7.5	300	2.0	3.2
MV1624	9.0	10.0	11.0	300	2.0	3.2
MV1626	10.8	12.0	13.2	300	2.0	3.2
MV1628	13.5	15.0	16.5	250	2.0	3.2
MV1630	16.2	18.0	19.8	250	2.0	3.2
MV1634	19.8	22.0	24.2	250	2.0	3.2
MV1636	24.3	27.0	29.7	200	2.0	3.2
MV1638	29.7	33.0	36.3	200	2.0	3.2
MV1640	35.1	39.0	42.9	200	2.0	3.2
MV1642	42.3	47.0	51.7	200	2.0	3.2
MV1644	50.4	56.0	61.6	150	2.0	3.2
MV1648	73.8	82.0	90.2	150	2.0	3.2
MV1650	90.0	100.0	110.0	150	2.0	3.2

TR, Tuning Ratio, is the ratio of C_T measured at 2 Vdc divided by C_T measured at 20 Vdc.

MV7005T1★

CASE 318E-04, STYLE 2
TO-261AA





SOT-223 PACKAGE
HIGH CAPACITANCE
VOLTAGE-VARIABLE DIODE
SURFACE MOUNT

★This is a Motorola designated preferred device.

This silicon epicap diode is designed for use in high capacitance, high-tuning ratio applications. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- Guaranteed Capacitance Range
- SOT-223 Package can be Soldered Using Wave or Reflow.
- SOT-223 package ensures level mounting, resulting in improved thermal conduction, and allows visual inspection of soldered joints. The formed leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 12 mm Tape and Reel
  Use MV7005T1 to order the 7 inch/1000 unit reel.
  Use MV7005T3 to order the 13 inch/4000 unit reel.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	15	Volts
Forward Current	I_F	50	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	–55 to +125	°C

DEVICE MARKING

V7005

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

Characteristic	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	15	—	Vdc
Reverse Voltage Leakage Current (V_R = 9.0 Vdc)	I_R	—	100	nAdc
Diode Capacitance (V_R = 1.0 Vdc, f = 1.0 MHz)	C_T	400	520	pF
Capacitance Ratio C1/C9 (f = 1.0 MHz)	C_R	12	—	—
Figure of Merit (V_R = 1.0 Vdc, f = 1.0 MHz)	Q	150	—	—

6

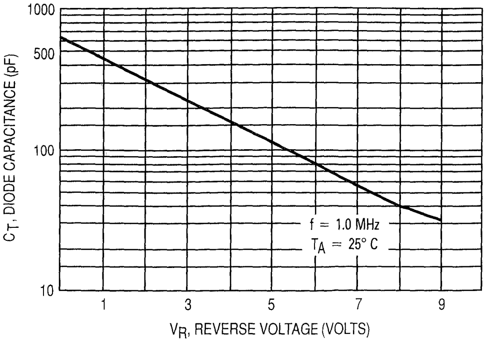


Figure 1. Diode Capacitance versus Reverse Voltage

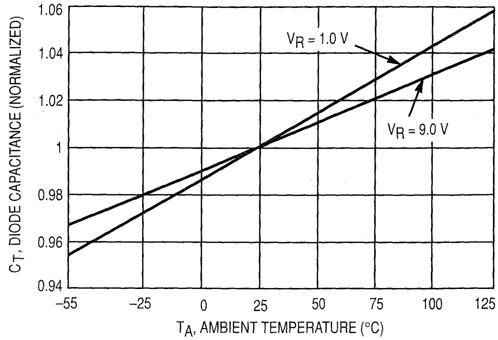


Figure 2. Diode Capacitance versus Ambient Temperature

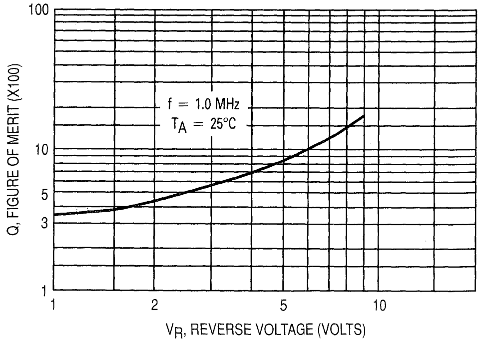


Figure 3. Figure of Merit vs Reverse Voltage

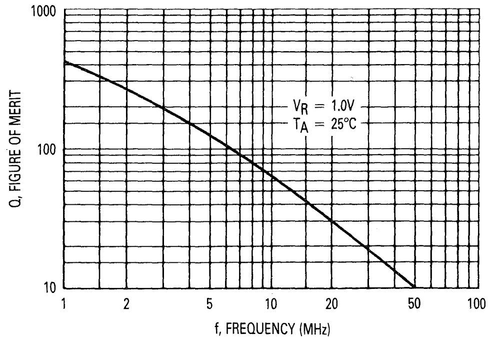


Figure 4. Figure of Merit vs Frequency

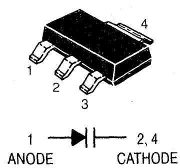
SILICON HYPER-ABRUPT TUNING DIODE

This silicon tuning diode is designed for high capacitance and a tuning ratio of greater than 10 times over a bias range of 2.0 to 10 volts. It provides tuning over a broad frequency range from the AM broadcast band to 100 MHz. The device is housed in the SOT-223 package, which is designed for medium power surface mount applications.

- High Capacitance
- Large Capacitance Change with Small Bias Change
- Guaranteed High Q
- The SOT-223 Package can be soldered using Wave or Reflow
- SOT-223 package ensures level mounting which results in improved thermal conduction and allows visual inspection of soldered joints. The formed leads absorb thermal stress during soldering, eliminating the possibility of damage to the die.
- Available in 12 mm Tape and Reel
  Use MV7404T1 to order the 7 inch/1000 unit reel
  Use MV7404T3 to order the 13 inch/4000 unit reel

MV7404T1★

CASE 318E-04, STYLE 2
TO-261AA



SOT-223 PACKAGE
HIGH TUNING RATIO
VOLTAGE-VARIABLE DIODE
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	12	Volts
Forward Current	I_F	250	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to 125	°C
Lead Temperature for Soldering Purposes, 1/8″ from case Time in Solder Bath	T_L	260 5	°C Sec

DEVICE MARKING

V7404

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	12	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 10 Vdc, f = 1.0 MHz)	I_R	—	—	100	nAdc
Diode Capacitance (V_R = 2.0 Vdc, f = 1.0 MHz)	C_T	96	120	144	pF
Figure of Merit (V_R = 2.0 Vdc, f = 1.0 MHz)	Q	200	—	—	—
Tuning Ratio C2/C10 (f = 1.0 MHz)	TR	10	—	—	—

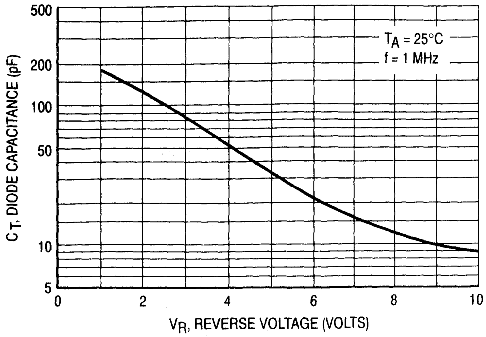


Figure 1. Diode Capacitance versus Reverse Voltage

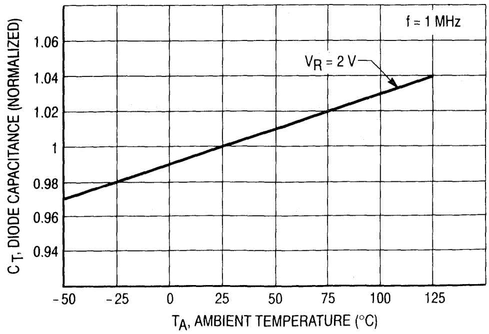


Figure 2. Diode Capacitance versus Ambient Temperature

6

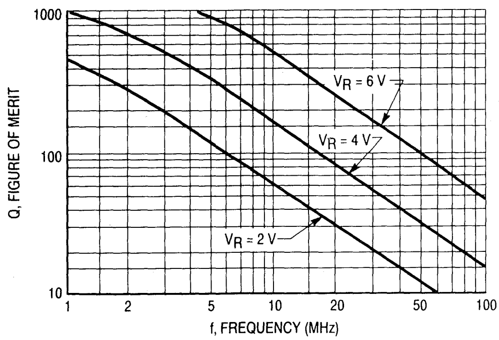
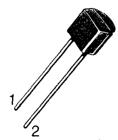


Figure 3. Figure of Merit versus Frequency

MVAM108★
MVAM109★
MVAM115★
MVAM125★

CASE 182-02, STYLE 1
(TO-226AC)



TUNING DIODES WITH VERY HIGH CAPACITANCE RATIO

★These are Motorola designated preferred devices.

SILICON TUNING DIODES

. . . designed for electronic tuning of AM receivers and high capacitance, high tuning ratio applications.

- High Capacitance Ratio — C_R = 15 (Min), MVAM108, 115, 125
- Guaranteed Diode Capacitance — C_t = 440 pF (Min) — 560 pF (Max) @ V_R = 1.0 VDc, f = 1.0 MHz, MVAM108, MVAM115, MVAM125
- Guaranteed Figure of Merit — Q = 150 (Min) @ V_R = 1.0 Vdc, f = 1.0 MHz

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Reverse Voltage	MVAM108 MVAM109 MVAM115 MVAM125	V_R	12 15 18 28	Volts
Forward Current		I_F	50	mA
Power Dissipation @ T_A = 25°C Derate above 25°C		P_D	280 2.8	mW mW/°C
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−55 to +125	°C

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

Characteristic		Symbol	Min	Typ	Max	Unit
Breakdown Voltage (I_R = 10 μAdc)	 MVAM108 MVAM109 MVAM115 MVAM125	$V_{(BR)R}$	 12 15 18 28	 — — — —	 — — — —	Vdc
Reverse Current (V_R = 8.0 V) (V_R = 9.0 V) (V_R = 15 V) (V_R = 25 V)	 MVAM108 MVAM109 MVAM115 MVAM125	I_R	 — — — —	 — — — —	 100 100 100 100	nAdc
Diode Capacitance Temperatujre Coefficient (1) (V_R = 1.0 Vdc, f = 1.0 MHz, T_A = −40°C to +85°C)		TC_C	—	435	—	ppm/°C
Case Capacitance (f = 1.0 MHz, Lead Length 1/16″)		C_C	—	0.18	—	pF
Diode Capacitance (2) (V_R = 1.0 Vdc, f = 1.0 MHz)	 MVAM108, 115, 125 MVAM109	C_t	 440 400	 500 460	 560 520	pF
Figure of Merit (f = 1.0 MHz, Lead Length 1/16″, V_R = 1.0 Vdc)		Q	150	—	—	—
Capacitance Ratio (f = 1.0 MHz)	 MVAM108 MVAM109 MVAM115 MVAM125	 C1/C8 C1/C9 C1/C15 C1/C25	 15 12 15 15	 — — — —	 — — — —	—

NOTES:
1. The effect of increasing temperature 1.0°C, at any operating point, is equivalent to lowering the effective tuning voltage 1.25 mV. The percent change of capacitance per °C is nearly constant from −40°C to +100°C.
2. Upon request, diodes are available in matched sets. All diodes in a set can be matched for capacitance to 3% or 2.0 pF (whichever is greater) at all points along the specified tuning range.

6

FIGURE 1 — TYPICAL AM RADIO APPLICATION

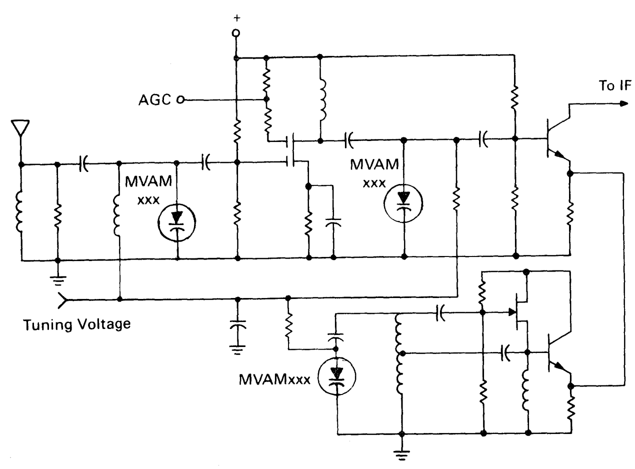


FIGURE 2 — CAPACITANCE versus REVERSE VOLTAGE

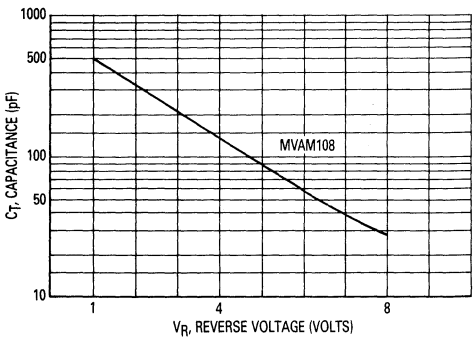


FIGURE 3 — CAPACITANCE versus REVERSE VOLTAGE

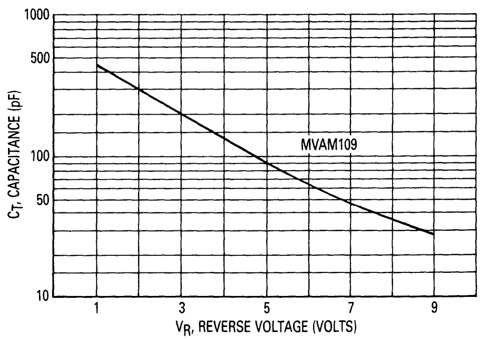


FIGURE 4 — CAPACITANCE versus REVERSE VOLTAGE

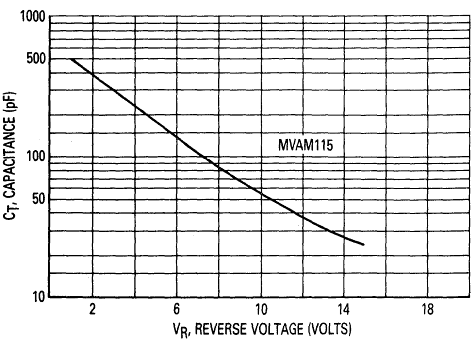
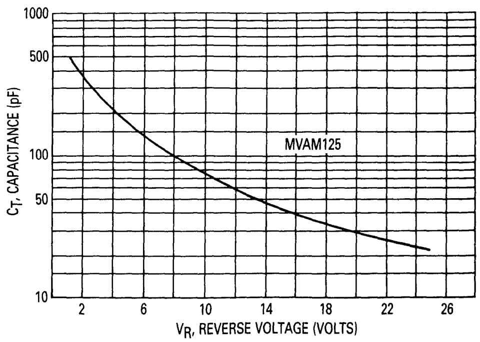
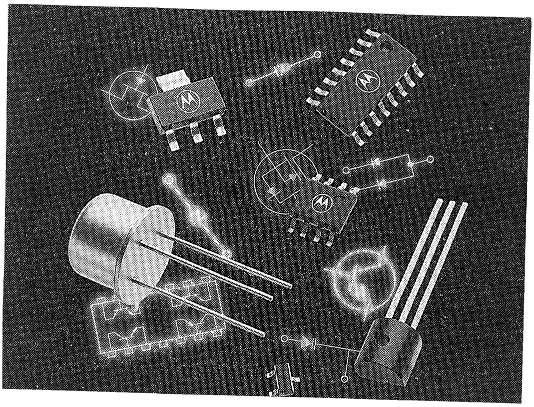


FIGURE 5 — CAPACITANCE versus REVERSE VOLTAGE





Tape and Reel Specifications and Packaging Specifications

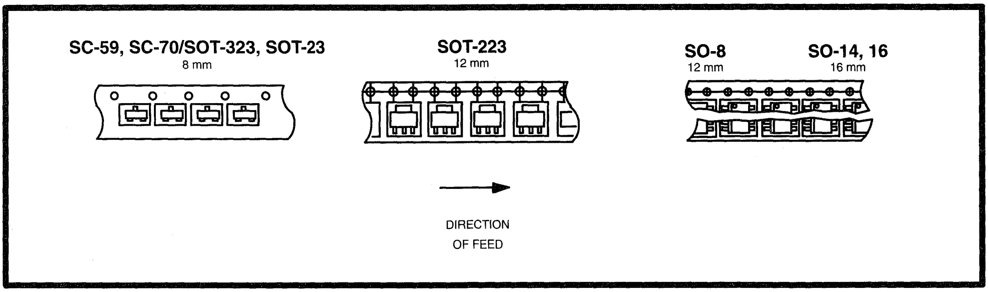
7

Tape and Reel Specifications and Packaging Specifications

Embossed Tape and Reel is used to facilitate automatic pick and place equipment feed requirements. The tape is used as the shipping container for various products and requires a minimum of handling. The antistatic/conductive tape provides a secure cavity for the product when sealed with the "peel-back" cover tape.

- Two Reel Sizes Available (7″ and 13″)
- Used for Automatic Pick and Place Feed Systems
- Minimizes Product Handling
- EIA 481, -1, -2
- SC-59, SC-70/SOT-323, SOT-23 in 8 mm Tape
- SO-8, SOT-223 in 12 mm Tape
- SO-14, SO-16 in 16 mm Tape

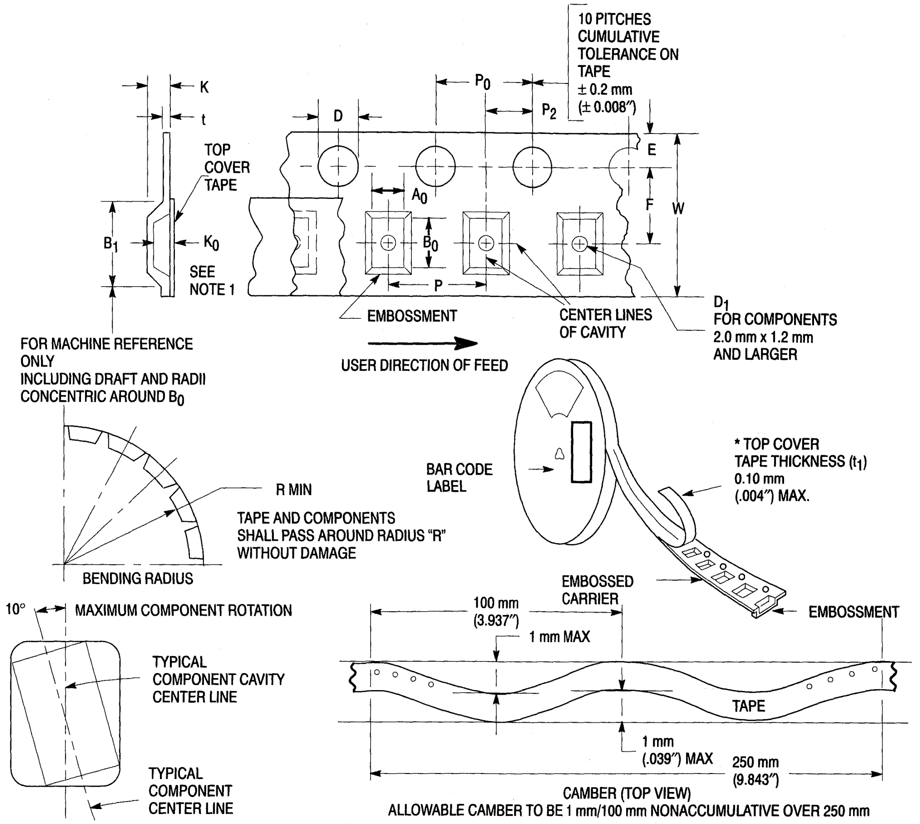
Use the standard device title and add the required suffix as listed in the option table on the following page. Note that the individual reels have a finite number of devices depending on the type of product contained in the tape. Also note the minimum lot size is one full reel for each line item, and orders are required to be in increments of the single reel quantity.



EMBOSSED TAPE AND REEL ORDERING INFORMATION

Package	Tape Width (mm)	Reel Size (inch)	Devices Per Reel and Minimum Order Quantity	Device Suffix
SC-70/SOT-323, SOT-23	8 8	7 13	3,000 10,000	T1 T3
SOT-223	12 12	7 13	1,000 4,000	T1 T3
SO-8	12 12	7 13	500 2,500	R1 R2
SO-14	16 16	7 13	500 2,500	R1 R2
SO-16	16 16	7 13	500 2,500	R1 R2
SC-59	8	7	3,000	T1

EMBOSSED TAPE AND REEL DATA FOR DISCRETES
CARRIER TAPE SPECIFICATIONS



7

DIMENSIONS

Tape Size	B_1 Max	D	D_1	E	F	K	P	P_0	P_2	R Min	T Max	W Max
8 mm	4.55 mm (.179″)	1.5+0.1 mm −0.0 (.059+.004″ −0.0)	1.0 Min (.039″)	1.75±0.1 mm (.069±.004″)	3.5±0.05 mm (.138±.002″)	2.4 mm Max (.094″)	4.0±0.1 mm (.157±.004″)	4.0±0.1 mm (.157±.004″)	2.0±0.1 mm (.079±.002″)	25 mm (.98″)	0.6 mm (.024″)	8.3 mm (.327″)
12 mm	8.2 mm (.323″)		1.5 mm Min (.060″)		5.5±0.05 mm (.217±.002″)	6.4 mm Max (.252″)	4.0±0.1 mm (.157±.004″) 8.0±0.1 mm (.315±.004″)			30 mm (1.18″)		12±.30 mm (.470±.012″)
16 mm	12.1 mm (.476″)				7.5±0.10 mm (.295±.004″)	7.9 mm Max (.311″)	4.0±0.1 mm (.157±.004″) 8.0±0.1 mm (.315±.004″) 12.0±0.1 mm (.472±.004″)					16.3 mm (.642″)
24 mm	20.1 mm (.791″)				11.5±0.1 mm (.453±.004″)	11.9 mm Max (.468″)	16.0±.01 mm (.63±.004″)					24.3 mm (.957″)

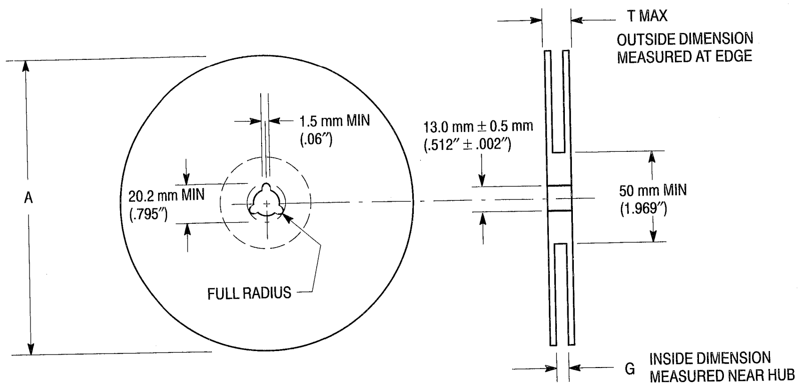
Metric dimensions govern — English are in parentheses for reference only.

NOTE 1: A_0, B_0, and K_0 are determined by component size. The clearance between the components and the cavity must be within .05 mm min. to .50 mm max., the component cannot rotate more than 10° within the determined cavity.

EMBOSSED TAPE AND REEL DATA FOR DISCRETES

Reel Dimensions

Metric Dimensions Govern — English are in parentheses for reference only



7

Size	A Max	G	T Max
8 mm	330 mm (12.992″)	8.4 mm + 1.5 mm, −0.0 (.33″ + .059″, −0.00)	14.4 mm (.56″)
12 mm	330 mm (12.992″)	12.4 mm + 2.0 mm, −0.0 (.49″ + .079″, −0.00)	18.4 mm (.72″)
16 mm	360 mm (14.173″)	16.4 mm + 2.0 mm, −0.0 (.646″ + .078″, −0.00)	22.4 mm (.882″)
24 mm	360 mm (14.173″)	24.4 mm + 2.0 mm, −0.0 (.961″ + .070″, −0.00)	30.4 mm (1.197″)

LEAD TAPE PACKAGING STANDARDS FOR AXIAL-LEAD COMPONENTS

Case Type	Product Category	Device Title Suffix	MPQ Quantity Per Reel (Item 3.3.7)	Component Spacing A Dimension	Tape Spacing B Dimension	Reel Dimension C	Reel Dimension D (Max)	Max Off Alignment E
Case 17-02	Surmetic 40 & 600 Watt TVS	RL	4000	0.2 +/– 0.015	2.062 +/– 0.059	3	14	0.047
Case 41A-02	1500 Watt TVS	RL4	1500	0.4 +/– 0.02	2.062 +/– 0.059	3	14	0.047
Case 51-02	DO-7 Glass (For Reference only)	RL	3000	0.2 +/– 0.02	2.062 +/– 0.059	3	14	0.047
Case 59-03	DO-41 Glass & DO-41 Surmetic 30	RL	6000	0.2 +/– 0.015	2.062 +/– 0.059	3	14	0.047
	Rectifier							
Case 59-04	500 Watt TVS	RL	5000	0.2 +/– 0.02	2.062 +/– 0.059	3	14	0.047
	Rectifier							
Case 194-04	110 Amp TVS (Automotive)	RL	800	0.4 +/– 0.02	1.875 +/– 0.059	3	14	0.047
	Rectifier							
Case 267-02	Rectifier	RL	1500	0.4 +/– 0.02	2.062 +/– 0.059	3	14	0.047
Case 299-02	DO-35 Glass	RL	5000	0.2 +/– 0.02	2.062 +/– 0.059	3	14	0.047

Table 1. Packaging Details (all dimensions in inches)

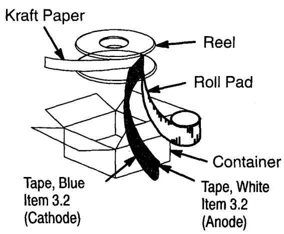


Figure 1. Reel Packing

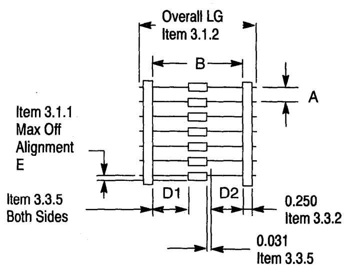


Figure 2. Component Spacing

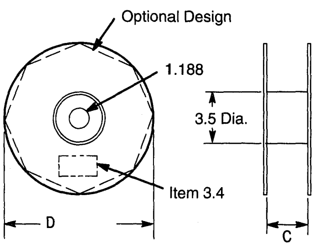
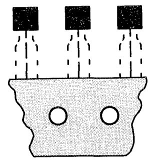


Figure 3. Reel Dimensions

TO-92 EIA, IEC, EIAJ Radial Tape in Fan Fold Box or On Reel

TO-92 RADIAL TAPE IN FAN FOLD BOX OR ON REEL



Radial tape in fan fold box or on reel of the reliable TO-92 package are the best methods of capturing devices for automatic insertion in printed circuit boards. These methods of taping are compatible with various equipment for active and passive component insertion.

- Available in Fan Fold Box
- Available on 365 mm Reels
- Accommodates All Standard Inserters
- Allows Flexible Circuit Board Layout
- 2.5 mm Pin Spacing for Soldering
- EIA-468, IEC 286-2, EIAJ RC1008B

Ordering Notes:

When ordering radial tape in fan fold box or on reel, specify the style per Figures 2, 3, and Figures 9–12. Add the suffix "RLR" and "Style" to the device title, i.e. MPS3904RLRA. This will be a standard MPS3904 radial taped and supplied on a reel per Figure 4.

Fan Fold Box Information — Minimum order quantity 1 Box/$200LL.
Order in increments of 2000.

Reel Information — Minimum order quantity 1 Reel/$200LL.
Order in increments of 2000.

US/European Suffix Conversions

US	EUROPE
RLRA	RL
RLRE	RL1
RLRM	ZL1

TO-92 EIA RADIAL TAPE IN FAN FOLD BOX OR ON REEL

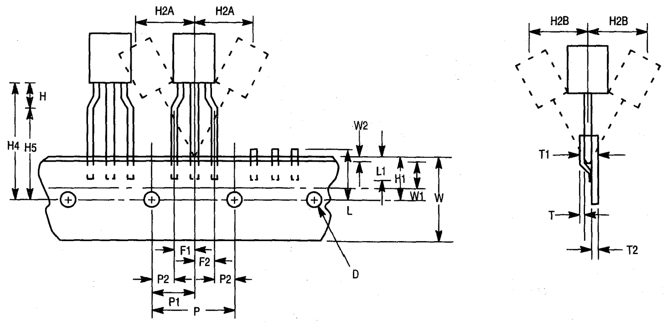


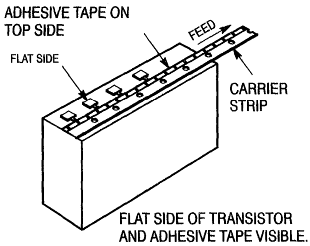
Figure 1. Device Positioning on Tape

Symbol	Item	Specification			
		Inches		Millimeter	
		Min	Max	Min	Max
D	Tape Feedhole Diameter	0.1496	0.1653	3.8	4.2
D2	Component Lead Thickness Dimension	0.015	0.020	0.38	0.51
F1, F2	Component Lead Pitch	0.0945	0.110	2.4	2.8
H	Bottom of Component to Seating Plane	.059	.156	1.5	4.0
H1	Feedhole Location	0.3346	0.3741	8.5	9.5
H2A	Deflection Left or Right	0	0.039	0	1.0
H2B	Deflection Front or Rear	0	0.051	0	1.0
H4	Feedhole to Bottom of Component	0.7086	0.768	18	19.5
H5	Feedhole to Seating Plane	0.610	0.649	15.5	16.5
L	Defective Unit Clipped Dimension	0.3346	0.433	8.5	11
L1	Lead Wire Enclosure	0.09842	—	2.5	—
P	Feedhole Pitch	0.4921	0.5079	12.5	12.9
P1	Feedhole Center to Center Lead	0.2342	0.2658	5.95	6.75
P2	First Lead Spacing Dimension	0.1397	0.1556	3.55	3.95
T	Adhesive Tape Thickness	0.06	0.08	0.15	0.20
T1	Overall Taped Package Thickness	—	0.0567	—	1.44
T2	Carrier Strip Thickness	0.014	0.027	0.35	0.65
W	Carrier Strip Width	0.6889	0.7481	17.5	19
W1	Adhesive Tape Width	0.2165	0.2841	5.5	6.3
W2	Adhesive Tape Position	.0059	0.01968	.15	0.5

NOTES:
1. Maximum alignment deviation between leads not to be greater than 0.2 mm.
2. Defective components shall be clipped from the carrier tape such that the remaining protrusion (L) does not exceed a maximum of 11 mm.
3. Component lead to tape adhesion must meet the pull test requirements established in Figures 5, 6 and 7.
4. Maximum non-cumulative variation between tape feed holes shall not exceed 1 mm in 20 pitches.
5. Holddown tape not to extend beyond the edge(s) of carrier tape and there shall be no exposure of adhesive.
6. No more than 1 consecutive missing component is permitted.
7. A tape trailer and leader, having at least three feed holes is required before the first and after the last component.
8. Splices will not interfere with the sprocket feed holes.

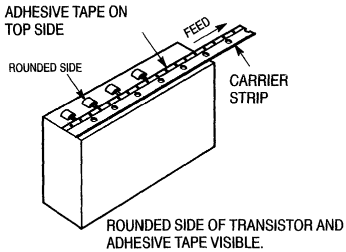
TO-92 EIA RADIAL TAPE IN FAN FOLD BOX OR ON REEL

FAN FOLD BOX STYLES



Style M fan fold box is equivalent to styles E and F of reel pack dependent on feed orientation from box.

Figure 2. Style M



Style P fan fold box is equivalent to styles A and B of reel pack dependent on feed orientation from box.

Figure 3. Style P

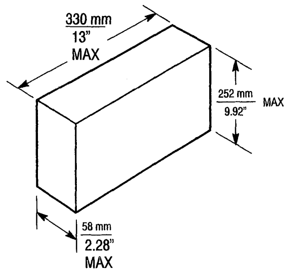
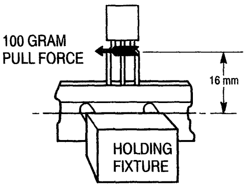


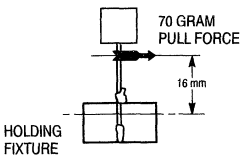
Figure 4. Fan Fold Box Dimensions

ADHESION PULL TESTS



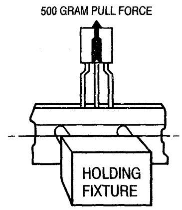
The component shall not pull free with a 300 gram load applied to the leads for 3 ± 1 second.

Figure 5. Test #1



The component shall not pull free with a 70 gram load applied to the leads for 3 ± 1 second.

Figure 6. Test #2

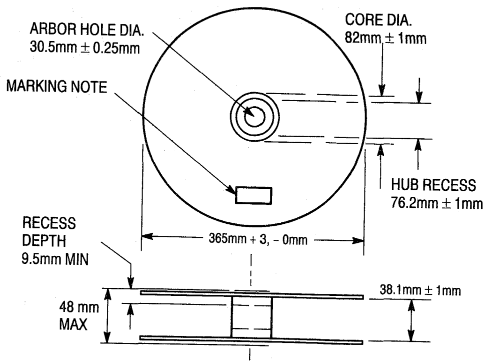


There shall be no deviation in the leads and no component leads shall be pulled free of the tape with a 500 gram load applied to the component body for 3 ± 1 second.

Figure 7. Test #3

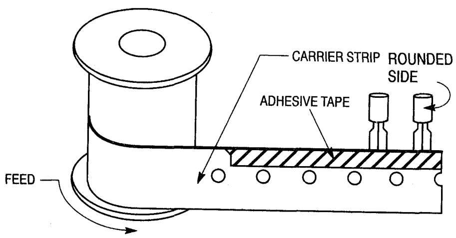
TO-92 EIA RADIAL TAPE IN FAN FOLD BOX OR ON REEL

REEL STYLES



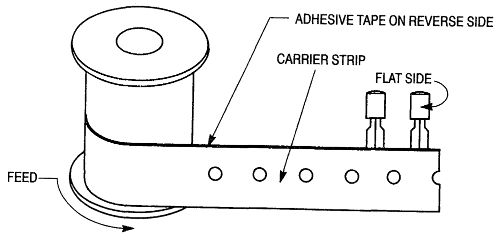
Material used must not cause deterioration of components or degrade lead solderability

Figure 8. Reel Specifications



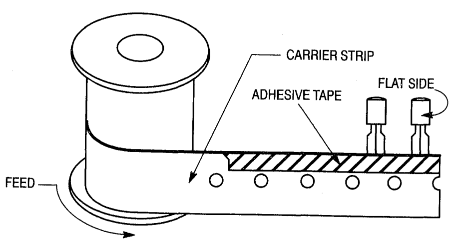
Rounded side of transistor and adhesive tape visible.

Figure 9. Style A



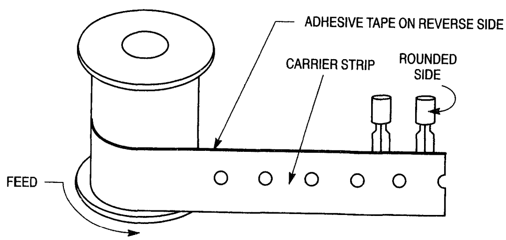
Flat side of transistor and carrier strip visible (adhesive tape on reverse side).

Figure 10. Style B



Flat side of transistor and adhesive tape visible.

Figure 11. Style E



Rounded side of transistor and carrier strip visible (adhesive tape on reverse side).

Figure 12. Style F

7

TO-92 Lead Forming

Figure 13. Ordering Notes

How to choose Lead Form option:

1. Determine option either TO-18 or TO-5, see Dimensional Drawings
   *Identify measurement between centres of the two outside leads:
   i.e. 2.5 mm for TO-18
   5.0 mm for TO-5
2. Determine the pinout of the device (Style Number — see Product Data Sheet)
3. Identify Drawing corresponding to Style Number (see Figures 8a and 8b).

Example:
BC237B configured TO-18. . . .
See Data Sheet for Style Number
Style 17 . . . Drawing indicates Dimensions, and that position of Centre Lead is towards the round side of the product (towards the back)
Order type: **BC237B18**

Other Examples:

P2N2222-18	P2N2222A18
2N5551-5	BC488A18
BC337-25-5	BC547C5

Note: For reverse configurations, please consult the factory.

7

TO-92 Lead Forming

Lead configurations conform to TO-18 or TO-5 pin circles.

Ordering Notes:
When ordering Lead Formed TO-92, verify the style per Figures 1a and 1b.

Figure 1a. TO-18 Styles and Dimensions

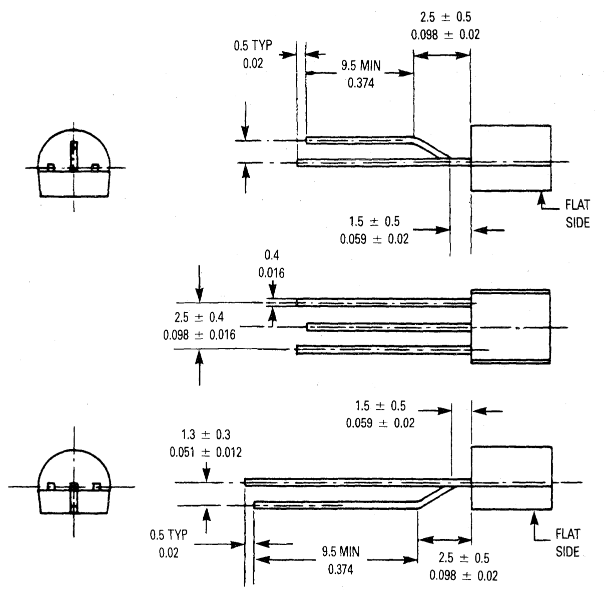
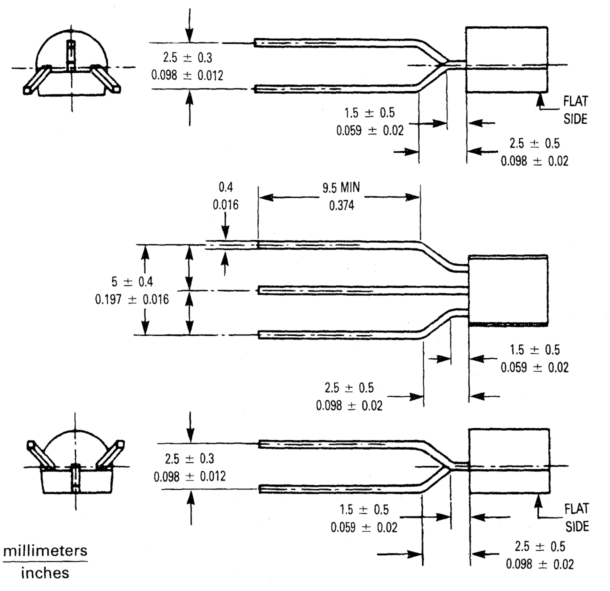


Figure 1b. TO-5 Styles and Dimensions



Dimensions are in $\frac{\text{millimeters}}{\text{inches}}$

7

Bar Code Labelling

The Intermediate Package Label shall contain, as a minimum, the Motorola part number, Motorola lot number, Motorola manufacturing date (date code), and quantity as shown in Exhibit 4a. Customer part number (CPN) label, Exhibit 4b, shall be added when CPN is available.

Data Identifier Codes

Data identifier codes shall be included on both the Intermediate Labels and the Shipping Labels. On these labels a data identifier code in the first position following the start code of the bar code symbol is used to identify the information to follow. This character is not to be included in the human readable line, but is shown in the human readable title for the appropriate data area. See Exhibits 2 and 3.

No additional bar code symbols will be placed on the Shipping Identification Label nor on the Intermediate Package Label unless it contains a data identifier to differentiate it from other bar code symbols.

Motorola had initially attempted to standardize on a set of data identifiers which it believed to be the preferred standard. However, with the establishment of the EIA STANDARD EIA-556A, Electronic Industries Association Shipping Container Bar Code Label Standard and their adoption of the "Standard of the Federation of Automated Coding Technologies" (FACT) identifiers, we have altered our standards to comply with this new Industry Standard. Therefore, the following identifiers will be used to identify data found on our labels:

P — Customer Product Identification — (Customer part number)
1P — Motorola Part Number
Q — Quantity
K — Transaction Number — (Customer P.O. No.)
3S — Package Identification assigned by Motorola to the lowest level of shipping package.* (This is the most common designator used by Motorola.)
4S — Package Identification assigned by Motorola to a master package containing the same items. (Single Product / Single Order)* Lower levels of packaging within this master package will contain separate packaging labels.
5S — Package Identification assigned by Motorola to a master package containing unlike items. (MIXED LOAD / Single Order)* Lower levels of packaging within this master package will contain separate packaging labels.
6S — Package Identification assigned by Motorola to a master package containing the same items over multiple customer orders. (Single Product / Multiple Customer Orders)* Lower levels of packaging within this master package will contain separate packaging labels.
7S — Package Identification assigned by Motorola to a master package containing unlike items over multiple customer orders. (MIXED LOAD / Multiple Customer Orders)* Lower levels of packaging within this master package will contain separate packaging labels.

*NOTE: Supplier Package ID is made up of Vendor ID (Motorola's EIA ID is 185) followed by a "plus" (+) and the ship date (YYWW) and the Packing List Number. This combination will provide a unique identification not repeated by Motorola.
(Example — 185 + 884510000A for Motorola shipment of 45th week 1988 with packing list number 10000A.)

*NOTE: Some identifier codes only apply to shipping labels and others only intermediate containers and vice versa.

9D — Manufacturing Date (Date Code — YYWW)
1T — Motorola Manufacturing Lot Number for traceability
V — Vendor Code assigned by Customer
6V — EIA Manufacturer's identification code for Motorola (185)

Example: Motorola part number in human readable form = MC146805E2CP
Bar code symbol for Motorola part number = 1PMC146805E2CP
Customer part number in human readable form = 1401-23456
Bar code symbol for Customer part number = P1401-23456

7

The human readable part number characters shall be bold and a minimum 0.125 inch (3 mm) high. The bar code symbol of the part number shall be directly below the human readable characters and shall be a minimum 0.250 inch (6.35 mm) high. Depending on the nominal dimension of the narrow bar code elements, part numbers of varying lengths can be printed on one line. The maximum length of any bar code symbol should not exceed 3.5 inches (89 mm). The part number shall be designated by Motorola for Standard Devices or by the customer for Special Devices. The maximum length anticipated for the part number is sixteen (16) characters plus the data identifier ("P" for Customer Part Number or "1P" for Motorola Part Number).

Bar Code Symbology

Bar Codes shall be of the 3-of-9 (Code 39) type and shall conform to the Bar Code Symbology Standard for 3-of-9 Bar Codes published by EIA-556A. In addition to this symbology specification, the following paragraphs cover specific requirements for the Motorola Intermediate and Shipping Labels.

Code Configuration

The Code 39 configuration is in accordance with (AIM) USS 39 Symbol specification.

Code Density and Dimensions

The bar heights shall be a minimum of 0.250 inch (6.35 mm). The width of the narrow elements ('X' dimension) shall be within the range of .007 to 0.16 inch. The ratio of the nominal width of the wide to narrow elements shall be 3:1, with an allowable range of 2.8:1 to 3.2:1.

Check Digits

Check digits shall not be used in the bar codes.

Reflectivity and Contrast

The printed bar code symbols shall meet the contrast and reflectivity requirements specified in EIA-556A, at all electromagnetic wave lengths from B633 to B900 nanometers.

Quiet Zone

The minimum quiet zone for each bar coded data element shall be 0.25 inch.

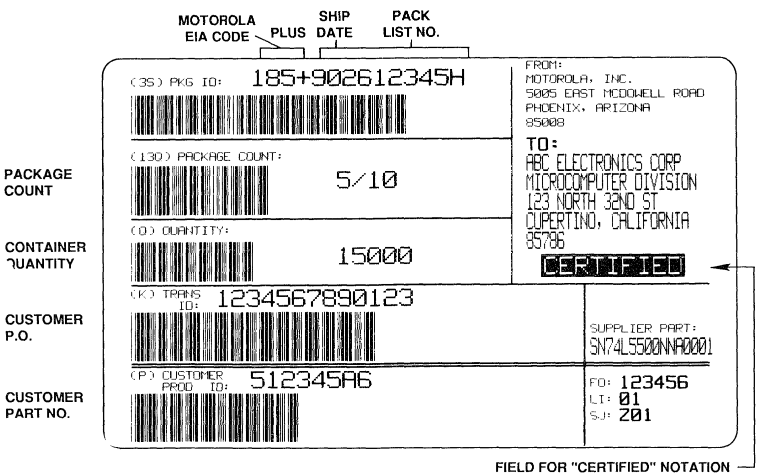
Special Labels

While we hope that these specifications will cover most situations, there will be circumstances where requirements will dictate special arrangements between customers and Motorola. Every effort to minimize these situations should be a goal of all so that complexities and costs are not added.

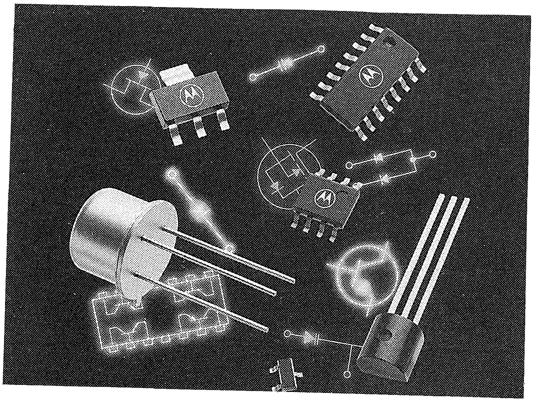
MOTOROLA "INTERNAL USE" INTERMEDIATE CONTAINER LABEL

CUSTOMER PART NUMBER INTERMEDIATE CONTAINER LABEL

7



MOTOROLA STANDARD DEVICE SHIPPING LABEL



Surface Mount Technology is now being utilized to offer answers to many problems that have been created in the use of insertion technology.

Limitations have been reached with insertion packages and PC board technology. Surface Mount Technology offers the opportunity to continue to advance the State-of-the-Art designs that cannot be accomplished with Insertion Technology.

Surface Mount Packages allow more optimum device performance with the smaller Surface Mount configuration. Internal lead lengths, parasitic capacitance and inductance that placed limitations on chip performance have been reduced.

The lower profile of Surface Mount Packages allows more boards to be utilized in a given amount of space. They are stacked closer together and utilize less total volume than insertion populated PC boards.

Printed circuit costs are lowered with the reduction of the number of board layers required. The elimination or reduction of the number of plated through holes in the board contribute significantly to lower PC board prices.

Surface Mount assembly does not require the preparation of components that is common on insertion technology lines. Surface Mount components are sent directly to the assembly line, eliminating an intermediate step.

Automatic placement equipment is available that can place Surface Mount components at the rate of a few thousand per hour to hundreds of thousands of components per hour.

Surface Mount Technology is cost effective, allowing the manufacturer the opportunity to produce smaller units and offer increased functions with the same size product.

Surface Mount Package Information

8

INFORMATION FOR USING SURFACE MOUNT PACKAGES

RECOMMENDED FOOTPRINTS FOR SURFACE MOUNTED APPLICATIONS

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to insure proper solder connection interface between the board and the package. With the correct pad geometry, the packages will self align when subjected to a solder reflow process.

POWER DISSIPATION FOR A SURFACE MOUNT DEVICE

The power dissipation for a surface mount device is a function of the drain/collector pad size. These can vary from the minimum pad size for soldering to a pad size given for maximum power dissipation. Power dissipation for a surface mount device is determined by $T_{J(max)}$, the maximum rated junction temperature of the die, $R_{\theta JA}$, the thermal resistance from the device junction to ambient, and the operating temperature, T_A. Using the values provided on the data sheet, P_D can be calculated as follows:

$$P_D = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

The values for the equation are found in the maximum ratings table on the data sheet. Substituting these values into the equation for an ambient temperature T_A of 25°C, one can calculate the power dissipation of the device. For example, for a SOT-223 device, P_D is calculated as follows.

$$P_D = \frac{150°C - 25°C}{156°C/W} = 800 \text{ milliwatts}$$

The 156°C/W for the SOT-223 package assumes the use of the recommended footprint on a glass epoxy printed circuit board to achieve a power dissipation of 800 milliwatts. There are other alternatives to achieving higher power dissipation from the surface mount packages. One is to increase the area of the drain/collector pad. By increasing the area of the drain/collector pad, the power dissipation can be increased. Although one can almost double the power dissipation with this method, one will be giving up area on the printed circuit board which can defeat the purpose of using surface mount technology. For example, a graph of $R_{\theta JA}$ versus drain pad area is shown in Figure 1.

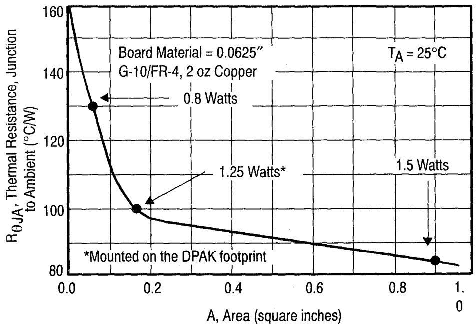


Figure 1. Thermal Resistance versus Drain Pad Area for the SOT-223 Package (Typical)

Another alternative would be to use a ceramic substrate or an aluminum core board such as Thermal Clad™. Using a board material such as Thermal Clad, an aluminum core board, the power dissipation can be doubled using the same footprint.

SOLDER STENCIL GUIDELINES

Prior to placing surface mount components onto a printed circuit board, solder paste must be applied to the pads. Solder stencils are used to screen the optimum amount. These stencils are typically 0.008 inches thick and may be made of brass or stainless steel. For packages such as the SC-59, SC-70/SOT-323, SOT-23, SOT-223, SO-8, SO-14, and SO-16 packages, the stencil opening should be the same as the pad size or a 1:1 registration.

SOLDERING PRECAUTIONS

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
- The delta temperature between the preheat and soldering should be 100°C or less.*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference shall be a maximum of 10°C.
- The soldering temperature and time shall not exceed 260°C for more than 5 seconds.
- When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less.
- After soldering has been completed, the device should be allowed to cool naturally for at least three minutes. Gradual cooling should be used as the use of forced cooling will increase the temperature gradient and result in latent failure due to mechanical stress.
- Mechanical stress or shock should not be applied during cooling

* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

* Due to shadowing and the inability to set the wave height to incorporate other surface mount components, the D2PAK is not recommended for wave soldering.

TYPICAL SOLDER HEATING PROFILE

For any given circuit board, there will be a group of control settings that will give the desired heat pattern. The operator must set temperatures for several heating zones, and a figure for belt speed. Taken together, these control settings make up a heating "profile" for that particular circuit board. On machines controlled by a computer, the computer remembers these profiles from one operating session to the next. Figure 2 shows a typical heating profile for use when soldering a surface mount device to a printed circuit board. This profile will vary among soldering systems but it is a good starting point. Factors that can affect the profile include the type of soldering system in use, density and types of components on the board, type of solder used, and the type of board or substrate material being used. This profile shows temperature versus time. The line on the graph shows the actual temperature that might be experienced on the surface of a test board at or near a central solder joint. The two profiles are based on a high density and a low density board. The Vitronics SMD310 convection/infrared reflow soldering system was used to generate this profile. The type of solder used was 62/36/2 Tin Lead Silver with a melting point between 177–189°C. When this type of furnace is used for solder reflow work, the circuit boards and solder joints tend to heat first. The components on the board are then heated by conduction. The circuit board, because it has a large surface area, absorbs the thermal energy more efficiently, then distributes this energy to the components. Because of this effect, the main body of a component may be up to 30 degrees cooler than the adjacent solder joints.

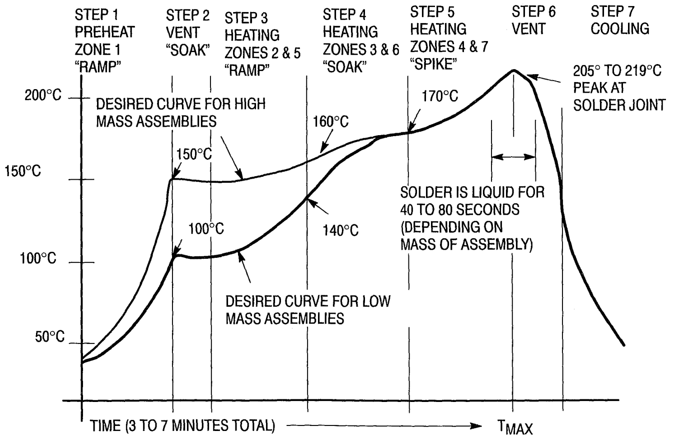
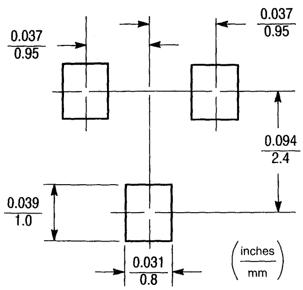


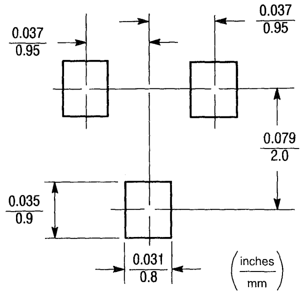
Figure 2. Typical Solder Heating Profile

8

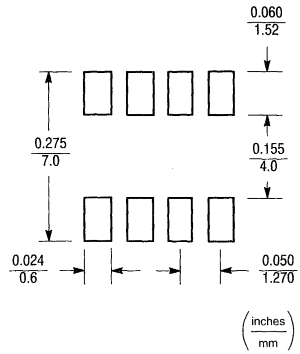
Footprints for Soldering



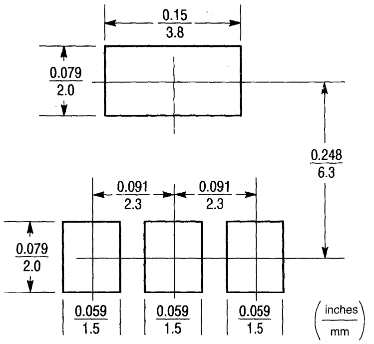
SC-59



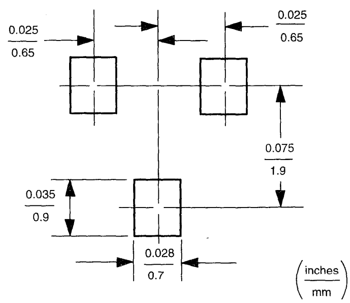
SOT-23



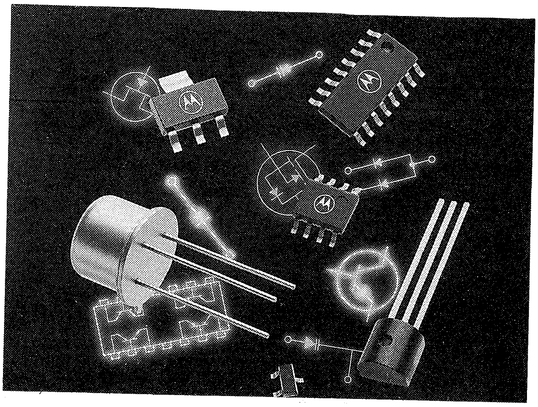
SO-8, SO-14, SO-16



SOT-223



SC-70/SOT-323



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, the new JEDEC "TO" designation, and footprint dimensions for surface mount packages to assist in board layout.

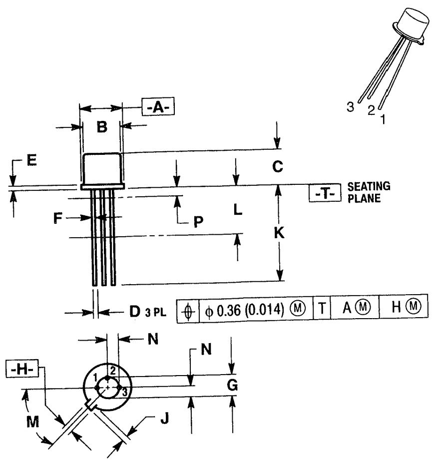
Additionally, abstracts of available application notes are provided. Please contact your local sales representative for those desired.

Package Outline Dimensions and Applications Literature

9

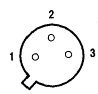
Package Outline Dimensions

Dimensions are in inches unless otherwise noted.



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIM J MEASURED FROM DIM A MAXIMUM.
4. DIM F APPLIES BETWEEN DIM P AND L. DIM D APPLIES BETWEEN DIM L AND K MINIMUM. LEAD DIAMETER IS UNCONTROLLED IN DIM P AND BEYOND DIM K MINIMUM.
5. DIM E INCLUDES THE TAB THICKNESS. (TAB THICKNESS IS 0.51 (0.002) MAXIMUM.
6. 022-01 AND -02 OBSOLETE, NEW STANDARD 022-03.

	MILLIMETERS		INCHES	
DIM	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



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. SOURCE, SUBSTRATE AND CASE
2. GATE
3. DRAIN

STYLE 3:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE & CASE

STYLE 5:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

STYLE 6:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 7:
PIN 1. ANODE
2. BASE
3. CATHODE

STYLE 8:
PIN 1. GATE
2. ANODE 1
3. ANODE 2

STYLE 9:
PIN 1. ANODE 2
2. ANODE 1
3. GATE (CONNECTED TO CASE)

STYLE 10:
PIN 1. BASE
2. EMITTER
3. BASE

STYLE 11:
PIN 1. DRAIN
2. GATE
3. SOURCE, SUBSTRATE

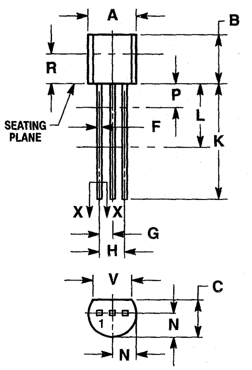
STYLE 12:
PIN 1. SOURCE
2. GATE
3. DRAIN (CASE)

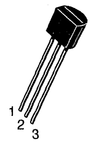
STYLE 13:
PIN 1. ANODE
2. GATE
3. CATHODE

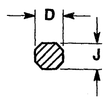
STYLE 14:
PIN 1. ANODE
2. OPEN
3. CATHODE

STYLE 15:
PIN 1. RETURN
2. INPUT
3. OUTPUT

CASE 22-03
TO-18 (TO-206AA)
METAL







SECTION X-X

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIM R IS UNCONTROLLED.
4. DIM F APPLIES BETWEEN P AND L. DIM D AND J APPLIES BETWEEN L AND K MINIMUM. LEAD DIM IS UNCONTROLLED IN P AND BEYOND DIM K MINIMUM.
5. 029-01 AND -02 OBSOLETE, NEW STANDARD 029-04.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.45	5.20	0.175	0.205
B	4.32	5.33	0.170	0.210
C	3.18	4.19	0.125	0.165
D	0.41	0.55	0.016	0.022
F	0.41	0.48	0.016	0.019
G	1.15	1.39	0.045	0.055
H	2.42	2.66	0.095	0.105
J	0.39	0.50	0.015	0.020
K	12.70	—	0.500	—
L	6.35	—	0.250	—
N	2.04	2.66	0.080	0.105
P	—	2.54	—	0.100
R	2.93	—	0.115	—
V	3.43	—	0.135	—

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 3:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 4:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 6:
PIN 1. GATE
2. SOURCE AND SUBSTRATE
3. DRAIN

STYLE 7:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 8:
PIN 1. DRAIN
2. GATE
3. SOURCE AND SUBSTRATE

STYLE 9:
PIN 1. BASE 1
2. EMITTER
3. BASE 2

STYLE 10:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 11:
PIN 1. ANODE
2. CATHODE AND ANODE
3. CATHODE

STYLE 12:
PIN 1. MAIN TERMINAL 1
2. GATE
3. MAIN TERMINAL 2

STYLE 13:
PIN 1. ANODE 1
2. GATE
3. CATHODE 2

STYLE 14:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

STYLE 15:
PIN 1. ANODE 1
2. CATHODE
3. ANODE 2

STYLE 16:
PIN 1. ANODE
2. GATE
3. CATHODE

STYLE 17:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

STYLE 18:
PIN 1. ANODE
2. CATHODE
3. NOT CONNECTED

STYLE 19:
PIN 1. GATE
2. ANODE
3. CATHODE

STYLE 20:
PIN 1. NOT CONNECTED
2. CATHODE
3. ANODE

STYLE 21:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

STYLE 22:
PIN 1. SOURCE
2. GATE
3. DRAIN

STYLE 23:
PIN 1. GATE
2. SOURCE
3. DRAIN

STYLE 24:
PIN 1. EMITTER
2. COLLECTOR/ANODE
3. CATHODE

STYLE 25:
PIN 1. MT 1
2. GATE
3. MT 2

STYLE 26:
PIN 1. V_{CC}
2. GROUND 2
3. OUTPUT

STYLE 27:
PIN 1. MT
2. SUBSTRATE
3. MT

STYLE 28:
PIN 1. CATHODE
2. ANODE
3. GATE

STYLE 29:
PIN 1. NOT CONNECTED
2. ANODE
3. CATHODE

STYLE 30:
PIN 1. DRAIN
2. GATE
3. SOURCE

STYLE 31:
PIN 1. GATE
2. DRAIN
3. SOURCE

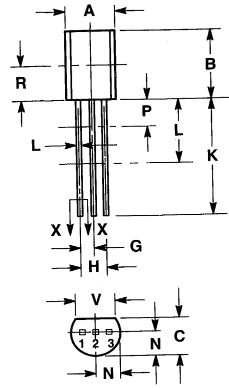
STYLE 32:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

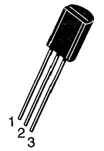
STYLE 33:
PIN 1. RETURN
2. INPUT
3. OUTPUT

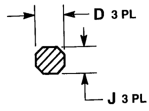
STYLE 34:
PIN 1. INPUT
2. GROUND
3. LOGIC

CASE 29-04
(TO-226AA) TO-92
PLASTIC

9







SECTION X-X

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIM R IS UNCONTROLLED.
4. DIM F APPLIES BETWEEN P AND L. DIM D AND J APPLIES BETWEEN L AND K MIMIMUM. LEAD DIM IS UNCONTROLLED IN P AND BEYOND DIM K MINIMUM.
5. 029-03 OBSOLETE. NEW STANDARD 029-05.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.44	5.21	0.175	0.205
B	7.37	7.87	0.290	0.310
C	3.18	4.19	0.125	0.165
D	0.46	0.56	0.018	0.022
F	0.41	0.48	0.016	0.019
G	1.15	1.39	0.045	0.055
H	2.42	2.66	0.095	0.105
J	0.46	0.61	0.018	0.024
K	12.70	—	0.500	—
L	6.35	—	0.250	—
N	2.04	2.66	0.080	0.105
P	—	2.54	—	0.100
R	3.43	—	0.135	—
V	3.43	—	0.135	—

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 3:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 4:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 6:
PIN 1. GATE
2. SOURCE AND SUBSTRATE
3. DRAIN

STYLE 7:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 8:
PIN 1. DRAIN
2. GATE
3. SOURCE AND SUBSTRATE

STYLE 9:
PIN 1. BASE 1
2. EMITTER
3. BASE 2

STYLE 10:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 11:
PIN 1. ANODE
2. CATHODE AND ANODE
3. CATHODE

STYLE 12:
PIN 1. MAIN TERMINAL 1
2. GATE
3. MAIN TERMINAL 2

STYLE 13:
PIN 1. ANODE 1
2. GATE
3. CATHODE 2

STYLE 14:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

STYLE 15:
PIN 1. ANODE 1
2. CATHODE
3. ANODE 2

STYLE 16:
PIN 1. ANODE
2. GATE
3. CATHODE

STYLE 17:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

STYLE 18:
PIN 1. ANODE
2. CATHODE
3. NOT CONNECTED

STYLE 19:
PIN 1. GATE
2. ANODE
3. CATHODE

STYLE 20:
PIN 1. NOT CONNECTED
2. CATHODE
3. ANODE

STYLE 21:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

STYLE 22:
PIN 1. SOURCE
2. GATE
3. DRAIN

STYLE 23:
PIN 1. GATE
2. SOURCE
3. DRAIN

STYLE 24:
PIN 1. EMITTER
2. COLLECTOR/ANODE
3. CATHODE

STYLE 25:
PIN 1. MT 1
2. GATE
3. MT 2

STYLE 26:
PIN 1. V_{CC}
2. GROUND 2
3. OUTPUT

STYLE 27:
PIN 1. MT
2. SUBSTRATE
3. MT

STYLE 28:
PIN 1. CATHODE
2. ANODE
3. GATE

STYLE 29:
PIN 1. NOT CONNECTED
2. ANODE
3. CATHODE

STYLE 30:
PIN 1. DRAIN
2. GATE
3. SOURCE

STYLE 31:
PIN 1. GATE
2. DRAIN
3. SOURCE

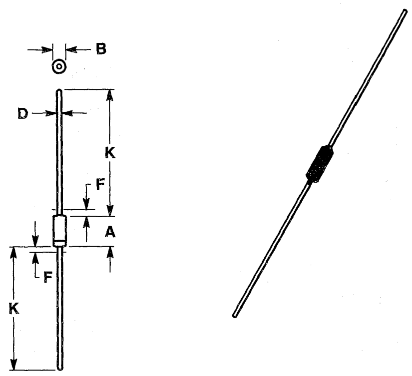
STYLE 32:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

STYLE 33:
PIN 1. RETURN
2. INPUT
3. OUTPUT

STYLE 34:
PIN 1. INPUT
2. GROUND
3. LOGIC

CASE 29-05
(TO-226E) TO-92
1-WATT PLASTIC

9

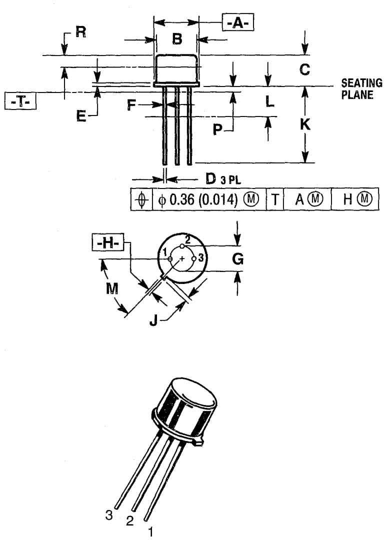


NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	—	1.27	—	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51-02



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 3:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 4:
PIN 1. MAIN TERM. 1
2. GATE
3. MAIN TERM. 2

STYLE 5:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

STYLE 6:
PIN 1. SOURCE
2. GATE
3. DRAIN (CASE)

STYLE 7:
PIN 1. DRAIN
2. GATE
3. SOURCE

STYLE 8:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 9:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 10:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

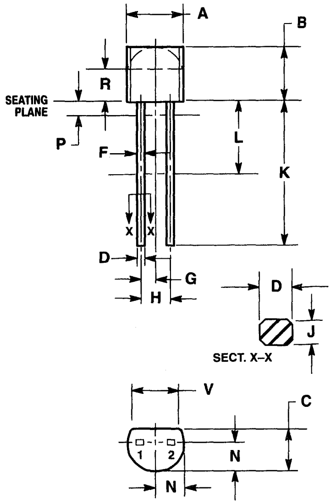
STYLE 11:
PIN 1. ANODE
2. OPEN
3. CATHODE

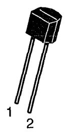
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION J MEASURED FROM DIMENSION A MAXIMUM.
4. DIMENSION B SHALL NOT VARY MORE THAN 0.25 (0.010) IN ZONE R. THIS ZONE CONTROLLED FOR AUTOMATIC HANDLING.
5. DIMENSION F APPLIES BETWEEN DIMENSION P AND L. DIMENSION D APPLIES BETWEEN DIMENSION L AND K MINIMUM. LEAD DIAMETER IS UNCONTROLLED IN DIMENSION P AND BEYOND DIMENSION K MINIMUM.
6. 079-01, -02 OBSOLETE, NEW STANDARD 079-04.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.39	0.335	0.370
B	7.75	8.50	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.41	0.53	0.016	0.021
E	0.23	1.04	0.009	0.041
F	0.41	0.48	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.72	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	19.05	0.500	0.750
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
P	—	1.27	—	0.050
R	2.54	—	0.100	—

CASE 79-04
(TO-205AD) TO-39
METAL

9





STYLE 1:
PIN 1. ANODE
2. CATHODE

STYLE 2:
PIN 1. CATHODE
2. ANODE

STYLE 3:
PIN 1. MAIN TERMINAL 1
2. MAIN TERMINAL 2

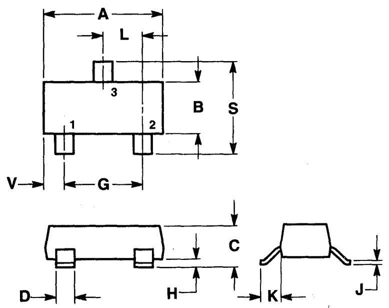
STYLE 4: OBSOLETE

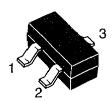
STYLE 5:
PIN 1. INPUT
2. OUTPUT

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND ZONE R IS UNCONTROLLED.
4. DIM F APPLIES BETWEEN P AND L. DIM D AND J APPLIES BETWEEN L AND K MINIMUM. LEAD DIM IS UNCONTROLLED IN P AND BEYOND DIM K MINIMUM.
5. CASE 182-01 AND -03 OBSOLETE, NEW STANDARD 182-02.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.45	5.21	0.175	0.205
B	4.32	5.33	0.170	0.210
C	3.18	4.19	0.125	0.165
D	0.41	0.56	0.016	0.022
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	2.54 BSC		0.100 BSC	
J	0.36	0.41	0.014	0.016
K	12.70	—	0.500	—
L	6.35	—	0.250	—
N	2.03	2.66	0.080	0.105
P	—	1.27	—	0.050
R	2.93	—	0.115	—
V	3.43	—	0.135	—

CASE 182-02
(TO-226AC) TO-92
PLASTIC





NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. 318-03 OBSOLETE, NEW STANDARD 318-07.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	2.80	3.04	0.1102	0.1197
B	1.20	1.40	0.0472	0.0551
C	0.89	1.11	0.0350	0.0440
D	0.37	0.50	0.0150	0.0200
G	1.78	2.04	0.0701	0.0807
H	0.013	0.100	0.0005	0.0040
J	0.085	0.177	0.0034	0.0070
K	0.45	0.60	0.0180	0.0236
L	0.89	1.02	0.0350	0.0401
S	2.10	2.50	0.0830	0.0984
V	0.45	0.60	0.0177	0.0236

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

STYLE 18:
PIN 1. NO CONNECTION
2. CATHODE
3. ANODE

STYLE 19:
PIN 1. CATHODE
2. ANODE
3. CATHODE-ANODE

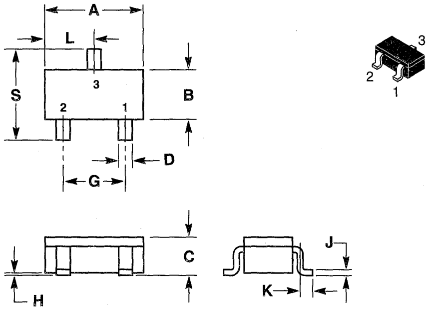
STYLE 20:
PIN 1. CATHODE
2. ANODE
3. GATE

STYLE 22:
PIN 1. RETURN
2. OUTPUT
3. INPUT

STYLE 21:
PIN 1. GATE
2. SOURCE
3. DRAIN

STYLE 23:
PIN 1. ANODE
2. ANODE
3. CATHODE

CASE 318-07
TO-236AB (SOT-23)
PLASTIC



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y15.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. 318D-01 AND -02 OBSOLETE, NEW STANDARD 318D-03.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.70	3.10	0.1063	0.1220
B	1.30	1.70	0.0512	0.0669
C	1.00	1.30	0.0394	0.0511
D	0.35	0.50	0.0138	0.0196
G	1.70	2.10	0.0670	0.0826
H	0.013	0.100	0.0005	0.0040
J	0.10	0.26	0.0040	0.0102
K	0.20	0.60	0.0079	0.0236
L	1.25	1.65	0.0493	0.0649
S	2.50	3.00	0.0985	0.1181

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. N.C.
2. ANODE
3. CATHODE

STYLE 3:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 4:
PIN 1. N.C.
2. CATHODE
3. ANODE

STYLE 5:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 6:
PIN 1. CATHODE
2. ANODE
3. ANODE/CATHODE

CASE 318D-03
(SC-59)

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

STYLE 2:
PIN 1. ANODE
2. CATHODE
3. NC
4. CATHODE

STYLE 3:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE
4. DRAIN

STYLE 5:
PIN 1. DRAIN
2. GATE
3. SOURCE
4. GATE

STYLE 6:
PIN 1. RETURN
2. INPUT
3. OUTPUT
4. INPUT

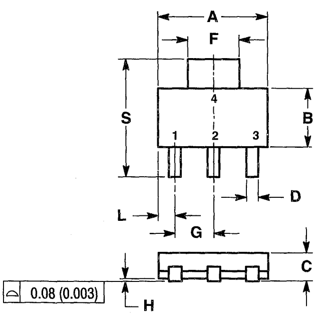
STYLE 7:
PIN 1. ANODE 1
2. CATHODE
3. ANODE 2
4. CATHODE

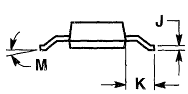
STYLE 8:
PIN 1. INPUT
2. GROUND
3. N.C.
4. GROUND

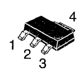
STYLE 9:
PIN 1. INPUT
2. GROUND
3. LOGIC
4. GROUND

STYLE 10:
PIN 1. CATHODE
2. ANODE
3. GATE
4. ANODE

STYLE 11:
PIN 1. MT 1
2. MT 2
3. GATE
4. MT 2







NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 318E-01 THRU -03 OBSOLETE, NEW STANDARD 318E-04.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.30	6.70	0.249	0.263
B	3.30	3.70	0.130	0.145
C	1.50	1.75	0.060	0.068
D	0.60	0.89	0.024	0.035
F	2.90	3.20	0.115	0.126
G	2.20	2.40	0.087	0.094
H	0.020	0.100	0.0008	0.0040
J	0.24	0.35	0.009	0.014
K	1.50	2.00	0.060	0.078
L	0.85	1.05	0.033	0.041
M	0°	10°	0°	10°
S	6.70	7.30	0.264	0.287

CASE 318E-04
(SOT-223)

9

STYLE 1: OBSOLETE

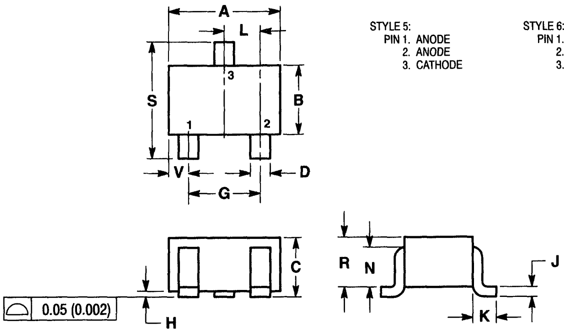
STYLE 2:
PIN 1. ANODE
2. N.C.
3. CATHODE

STYLE 3:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 4:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 5:
PIN 1. ANODE
2. ANODE
3. CATHODE

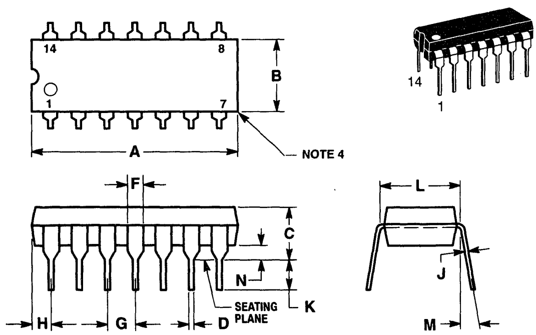
STYLE 6:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.071	0.087	1.80	2.20
B	0.045	0.053	1.15	1.35
C	0.035	0.049	0.90	1.25
D	0.012	0.016	0.30	0.40
G	0.047	0.055	1.20	1.40
H	0.000	0.004	0.00	0.10
J	0.004	0.010	0.10	0.25
K	0.017 REF		0.425 REF	
L	0.026 BSC		0.65 BSC	
N	0.028 REF		0.70 REF	
R	0.031	0.039	0.80	1.00
S	0.079	0.087	2.00	2.20
V	0.012	0.016	0.30	0.40

CASE 419-02
(SC-70/SOT-323)



NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
4. ROUNDED CORNERS OPTIONAL.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	19.56	0.715	0.770
B	6.10	6.60	0.240	0.260
C	3.69	4.69	0.145	0.185
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°	10°	0°	10°
N	0.39	1.01	0.015	0.039

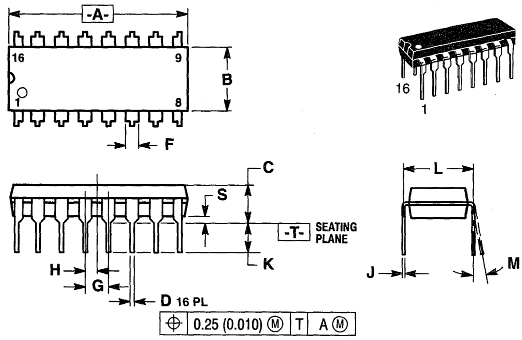
STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NO CONNECTION
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NO CONNECTION
12. EMITTER
13. BASE
14. COLLECTOR

STYLE 5:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. NO CONNECTION
5. SOURCE
6. DRAIN
7. GATE
8. GATE
9. DRAIN
10. SOURCE
11. NO CONNECTION
12. SOURCE
13. DRAIN
14. GATE

CASE 646-06
(14-PIN DIP)
PLASTIC

9

PACKAGE OUTLINE DIMENSIONS (continued)



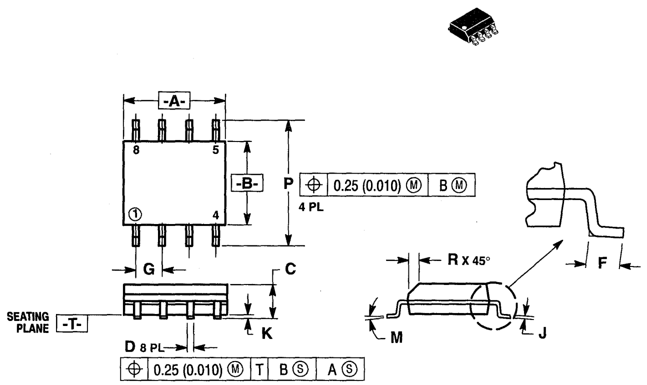
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.740	0.770	18.80	19.55
B	0.250	0.270	6.35	6.85
C	0.145	0.175	3.69	4.44
D	0.015	0.021	0.39	0.53
F	0.040	0.070	1.02	1.77
G	0.100 BSC		2.54 BSC	
H	0.050 BSC		1.27 BSC	
J	0.008	0.015	0.21	0.38
K	0.110	0.130	2.80	3.30
L	0.295	0.305	7.50	7.74
M	0°	10°	0°	10°
S	0.020	0.040	0.51	1.01

STYLE 1:
PIN 1. CATHODE
2. CATHODE
3. CATHODE
4. CATHODE
5. CATHODE
6. CATHODE
7. CATHODE
8. CATHODE
9. ANODE
10. ANODE
11. ANODE
12. ANODE
13. ANODE
14. ANODE
15. ANODE
16. ANODE

STYLE 2:
PIN 1. COMMON DRAIN
2. COMMON DRAIN
3. COMMON DRAIN
4. COMMON DRAIN
5. COMMON DRAIN
6. COMMON DRAIN
7. COMMON DRAIN
8. COMMON DRAIN
9. GATE
10. SOURCE
11. GATE
12. SOURCE
13. GATE
14. SOURCE
15. GATE
16. SOURCE

CASE 648-08
(16-PIN DIP)
PLASTIC



NOTES:
1. DIMENSIONS "A" AND "B" ARE DATUMS AND "T" IS A DATUM SURFACE.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
3. CONTROLLING DIM: MILLIMETER.
4. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
6. DIMENSION "D" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE "D" DIMENSION AT MAXIMUM MATERIAL CONDITION.

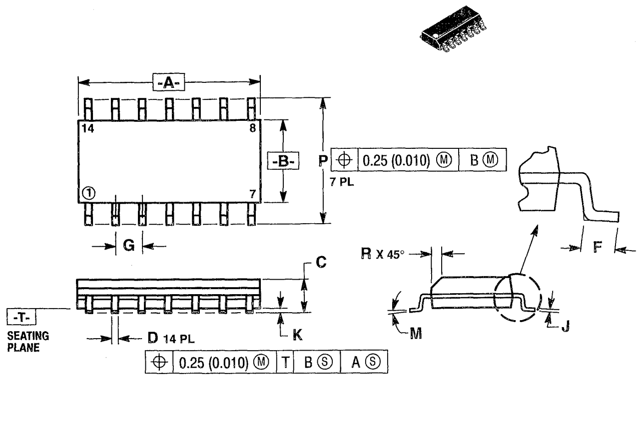
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.80	5.00	0.189	0.196
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.18	0.25	0.007	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

STYLE 11:
PIN 1. SOURCE (DIE 1)
2. GATE (DIE 1)
3. SOURCE (DIE 2)
4. GATE (DIE 2)
5. DRAIN (DIE 2)
6. DRAIN (DIE 2)
7. DRAIN (DIE 1)
8. DRAIN (DIE 1)

CASE 751-04
(SO-8)

9

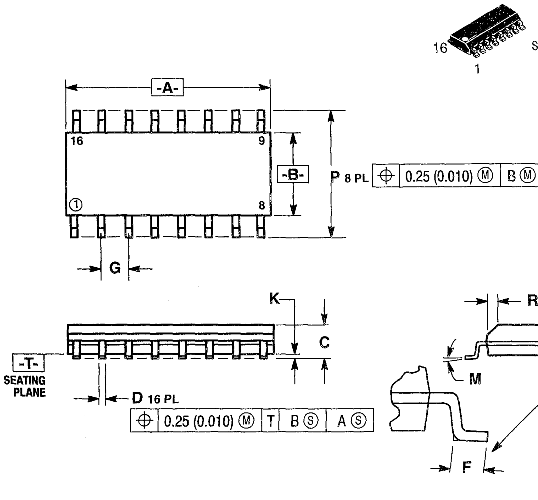
PACKAGE OUTLINE DIMENSIONS (continued)

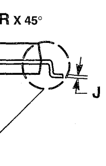


NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
3. CONTROLLING DIMENSION: MILLIMETER.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
6. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

CASE 751A-03
(SO-14)
PLASTIC





STYLE 7:
PIN 1. SOURCE N-CH
2. COMMON DRAIN (OUTPUT)
3. COMMON DRAIN (OUTPUT)
4. GATE P-CH
5. COMMON DRAIN (OUTPUT)
6. COMMON DRAIN (OUTPUT)
7. COMMON DRAIN (OUTPUT)
8. SOURCE P-CH
9. SOURCE P-CH
10. COMMON DRAIN (OUTPUT)
11. COMMON DRAIN (OUTPUT)
12. COMMON DRAIN (OUTPUT)
13. GATE N-CH
14. COMMON DRAIN (OUTPUT)
15. COMMON DRAIN (OUTPUT)
16. SOURCE N-CH

NOTES:
1. DIMENSIONS "A" AND "B" ARE DATUMS AND "T" IS A DATUM SURFACE.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
3. CONTROLLING DIMENSION: MILLIMETER.
4. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
6. DIMENSION "D" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE "D" DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	9.80	10.00	0.386	0.393
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

CASE 751B-05
(SO-16)
PLASTIC

Application Note Abstracts

(Application Notes are available upon request.)

AN-211A Field-Effect Transistors in Theory and Practice

The basic theory, construction, and application information for field-effect transistors (junction and MOS types) are given. Also included are some typical test circuits for checking FET parameters.

AN-220 FETs in Chopper and Analog Switching Circuits

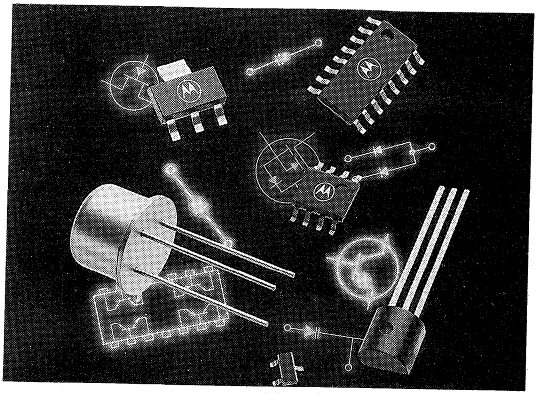
The author's discussion begins with elementary chopper and analog switch characteristics — explores fully the considerations required for conventional FET chopper and analog switch design — and finishes with specific FET circuit examples.

AN-847 Tuning Diode Design Techniques

Tuning diodes are voltage variable capacitors employing the junction capacitance of a reverse biased PN junction. This note presents a simplified theory of tuning diodes and discusses a number of considerations to be employed in designs using tuning diodes.

AR-300 The Hidden Dangers of Electrostatic Discharge — ESD

An in-depth discussion on damage from electrostatic discharge to electronic components. This article covers topics such as ESD Generation, electronic component susceptibility to ESD, typical electrostatic voltages, damage to specific families of electronic devices, static-sensitive components, static protection, combatting ESD and the importance of electronic component packaging.



This Reliability and Quality Assurance section contains information on the measurement of outgoing quality, reliability data analysis, reliability stress test descriptions with the applicable MIL-STD methods, statistical process control techniques, and quality assurance processing.

Reliability and Quality Assurance

10

OUTGOING QUALITY

The Average Outgoing Quality (AOQ) refers to the number of devices per million that are outside the specification limits at the time of shipment. Motorola has established Six Sigma goals to improve its outgoing quality and will continue its "error free performance" focus to achieve the goal of zero parts per million (PPM) outgoing quality. Motorola's present quality level has lead to vendor certification programs with many of its customers. These programs ensure a level of quality which allows the customer either to reduce or eliminate the need for incoming inspections.

AVERAGE OUTGOING QUALITY (AOQ) CALCULATION

AOQ = (Process Average) • (Probability of Acceptance) • (10^6) (PPM)

- $\text{Process Average} = \dfrac{\text{Total Projected Reject Devices}}{\text{Total Number of Devices}}$
- $\text{Projected Reject Devices} = \dfrac{\text{Defects in Sample}}{\text{Sample Size}} \bullet \text{Lot Size}$
- Total Number of Devices = Sum of units in each submitted lot
- $\text{Probability of Acceptance} = 1 - \dfrac{\text{Number of Lots Rejected}}{\text{Number of Lots Tested}}$
- 10^6 = Conversion to parts per million (PPM)

RELIABILITY DATA ANALYSIS

Reliability is the probability that a semiconductor device will perform its specified function in a given environment for a specified period. In other words, reliability is quality over time and environmental conditions. The most frequently used reliability measure for semiconductor devices is the failure rate (λ). The failure rate is obtained by dividing the number of failures observed by the product of the number of devices on test and the interval in hours, usually expressed as percent per thousand hours or failures per billion device hours (FITS). This is called a point estimate because it is obtained from observations on a portion (sample) of the population of devices.

10

To project from the sample to the population in general, one must establish confidence intervals. The application of confidence intervals is a statement of how "confident" one is that the sample failure rate approximates that for the population. To obtain failure rates at different confidence levels, it is necessary to make use of specific probability distributions. The chi-square ($\chi 2$) distribution that relates observed and expected frequencies of an event is frequently used to establish confidence intervals. The relationship between failure rate and the chi-square distribution is as follows:

$$\lambda = \frac{\chi^2 (\alpha, \text{d. f.})}{2t}$$

where:

λ = failure rate
$\chi 2$ = chi-square function
α = (100 – confidence level) /100
d.f. = degrees of freedom = 2r + 2
r = number of failures
t = device hours

Chi-square values for 60% and 90% confidence intervals for up to 12 failures are shown below.

Chi-Square Table

Chi-Square Distribution Function			
60% Confidence Level		90% Confidence Level	
No. Fails	$\chi 2$ Quantity	No. Fails	$\chi 2$ Quantity
0	1.833	0	4.605
1	4.045	1	7.779
2	6.211	2	10.645
3	8.351	3	13.362
4	10.473	4	15.987
5	12.584	5	18.549
6	14.685	6	21.064
7	16.780	7	23.542
8	18.868	8	25.989
9	20.951	9	28.412
10	23.031	10	30.813
11	25.106	11	33.196
12	27.179	12	35.563

The failure rate of semiconductor devices is inherently low. As a result, the industry uses a technique called accelerated testing to assess the reliability of semiconductors. During accelerated tests, elevated stresses are used to produce, in a short period, the same failure mechanisms as would be observed under normal use conditions. The objective of this testing is to identify these failure mechanisms and eliminate them as a cause of failure during the useful life of the product.

Temperature, relative humidity, and voltage are the most frequently used stresses during accelerated testing. Their relationship to failure rates has been shown to follow an Eyring type of equation of the form:

$$\lambda = A\exp(\phi kT) \bullet \exp(B/RH) \bullet \exp(CE)$$

Where A, B, C, ϕ, and k are constants, more specifically B, C, and ϕ are numbers representing the apparent energy at which various failure mechanisms occur. These are called activation energies. "T" is the temperature, "RH" is the relative humidity, and "E" is the electric field. The most familiar form of this equation (shown on following page) deals with the first exponential term that shows an Arrhenius type relationship of the failure rate versus the junction temperature of semiconductors. The junction temperature is related to the ambient temperature through the thermal resistance and power dissipation. Thus, we can test devices near their maximum junction temperatures, analyze the failures to assure that they are the types that are accelerated by temperature and then by applying known acceleration factors, estimate the failure rates for lower junction temperatures.

The Table on the following page shows observed activation energies with references.

Table 1 – Time Dependent Failure Mechanisms in Semiconductor Devices (Applicable to Discrete and Integrated Circuits)

Device Association	Process	Relevant Factors	Accelerating Factors	Typical Activation Energy in eV	Model	Reference
Silicon Oxide Silicon-Silicon Oxide Interface	Surface Charges Inversion, Accumulation	Mobile Ions E/V, T	T, V	1.0	Fitch, et al. Peck	1A 2
	Oxide Pinholes	E/V, T	E, T	0.7 - 1.0 (Bipolar) 1.0 (Bipolar)	1984 WRS Hokari, et al.	18 5
	Dielectric Breakdown (TDDB)	E/V, T	E, T	0.3-0.4 (MOS) 0.3 (MOS)	Domangue, et al. Crook, D.L.	3 4
	Charge Loss	E, T	E, T	0.8 (MOS) EPROM	Gear, G.	11
Metallization	Electromigration	T, J	J, T	1.0 Large grain Al (glassivated)	Nanda, et al.	6
		Grain Size		0.5 Small grain Al	Black, J.R.	7
		Doping		0.7 Cu-Al/Cu-Si-Al (sputtered)	Black, J.R.	12
	Corrosion Chemical Galvanic Electrolytic	Contamination	H, E/V, T	0.6-0.7 (for electrolysis) E/V may have thresholds	Lycoudes, N.E.	8
Bond and Other Mechanical Interfaces	Intermetallic Growth	T, Impurities Bond Strength	T	1.0 (Au/Al)	Fitch, W.T.	9
Various Wafer Fab, Assembly, and Silicon Defects	Metal Scratches Mask Defects, etc. Silicon Defects	T, V	T, V	0.5-0.7 eV 0.5 eV	Howes, et al. MMPD	10 13

V = voltage; E = electric field; T = temperature; J = current density; H = humidity

NO. REFERENCE

1A 1.0 eV activation for leakage type failures.
Fitch, W.T.; Greer, P.; Lycoudes, N.; "Data to Support 0.001%/1000 Hours for Plastic I/C's." Case study on linear product shows 0.914 eV activation energy which is within experimental error of 0.9 To 1.3 eV activation energies for reversible leakage (inversion) failures reported in the literature.

1B 0.7 To 1.0 eV for oxide defect failures for bipolar structures. This is under investigation subsequent to information obtained from 1984 Wafer Reliability Symposium, especially for bipolar capacitors with silicon nitride as dielectric.

2 1.0 eV activation for leakage type failures.
Peck, D.S.; "New Concerns About Integrated Circuit Reliability"' 1978 Reliability Physics Symposium.

3 0.36 eV for dielectric breakdown for MOS gate structures.
Domangue, E.; Rivera, R.; Shedard, C.; "Reliability Prediction Using Large MOS Capacitors", 1984 Reliability Physics Symposium.

4 0.3 eV for dielectric breakdown.
Crook, D.L.; "Method of Determining Reliability Screens for Time Dependent Dielectric Breakdown", 1979 Reliability Physics Symposium.

5 1.0 eV for dielectric breakdown.
Hokari, Y.; et al.; IEDM Technical Digest, 1982.

6 1.0 eV for large grain Al-Si (compared to line width).
Nanda, Vangard, Gj-P; Black, J.R.; "Electromigration of Al-Si Alloy Films", 1978 Reliability Physics Symposium.

7 0.5 eV Al, 0.7 eV Cu-Al small grain (compared to line width).
Black, J.R.; "Current Limitation of Thin Film Conductor" 1982 Reliability Physics Symposium.

8 0.65 eV for corrosion mechanism.
Lycoudes, N.E.; "The Reliability of Plastic Microcircuits in Moist Environments", 1978 Solid State Technology.

9 1.0 eV for open wires or high resistance bonds at the pad bond due to Au-Al intermetallics.
Fitch, W.T.; "Operating Life vs Junction Temperatures for Plastic Encapsulated I/C (1.5 mil Au wire)", unpublished report.

10 0.7 eV for assembly related defects.
Howes, M.G.; Morgan, D.V.; "Reliability and Degradation, Semiconductor Devices and Circuits" John Wiley and Sons, 1981.

11 Gear, G.; "FAMOUS PROM Reliability Studies", 1976 Reliability Physics Symposium

12 Black, J.R.: unpublished report.

13 Motorola Memory Products Division; unpublished report.

THERMAL RESISTANCE

Circuit performance and long-term circuit reliability are affected by die temperature. Normally, both are improved by keeping the junction temperatures low.

Electrical power dissipated in any semiconductor device is a source of heat. This heat source increases the temperature of the die about some reference point, normally the ambient temperature of 25° C in still air. The temperature increase, then, depends on the amount of power dissipated in the circuit and on the net thermal resistance between the heat source and the reference point.

The temperature at the junction depends on the packaging and mounting system's ability to remove heat generated in the circuit from the junction region to the ambient environment. The basic formula for converting power dissipation to estimated junction temperature is:

$$T_J = T_A + P_D(\bar{\theta}_{JC} + \bar{\theta}_{CA}) \quad (1)$$

or:

$$T_J = T_A + P_D(\bar{\theta}_{JA}) \quad (2)$$

where:

T_J = maximum junction temperature

T_A = maximum ambient temperature

P_D = calculated maximum power dissipation, including effects of external loads when applicable

$\bar{\theta}_{JC}$ = average thermal resistance, junction to case

$\bar{\theta}_{CA}$ = average thermal resistance, case to ambient

$\bar{\theta}_{JA}$ = average thermal resistance, junction to ambient

This Motorola recommended formula has been approved by RADC and DESC for calculating a "practical" maximum operating junction temperature for MIL-M-38510 devices.

Only two terms on the right side of equation (1) can be varied by the user, the ambient temperature and the device case-to-ambient thermal resistance, $\bar{\theta}_{CA}$. (To some extent the device power dissipation can also be controlled, but under recommended use the supply voltage and loading dictate a fixed power dissipation.) Both system air flow and the package mounting technique affect the $\bar{\theta}_{CA}$ thermal resistance term. $\bar{\theta}_{JC}$ is essentially independent of air flow and external mounting method, but is sensitive to package material, die bonding method, and die area.

For applications where the case is held at essentially a fixed temperature by mounting on a large or temperature controlled heat sink, the estimated junction temperature is calculated by:

$$T_J = T_C + P_D(\bar{\theta}_{JC}) \quad (3)$$

where T_C = maximum case temperature and the other parameters are as previously defined.

AIR FLOW

Air flow over the packages (due to a decrease in $\bar{\theta}_{CA}$) reduces the thermal resistance of the package, therefore permitting a corresponding increase in power dissipation without exceeding the maximum permissible operating junction temperature.

For thermal resistance values for specific packages, see the Motorola Data Book or Design Manual for the appropriate device family or contact your local Motorola sales office.

ACTIVATION ENERGY

Determination of activation energies is accomplished by testing randomly selected samples from the same population at various stress levels and comparing failure rates due to the same failure mechanism. The activation energy is represented by the slope of the curve relating to the natural logarithm of the failure rate to the various stress levels.

In calculating failure rates, the comprehensive method is to use the specific activation energy for each failure mechanism applicable to the technology and circuit under consideration. A common alternative method is to use a single activation energy value for the "expected" failure mechanism(s) with the lowest activation energy.

RELIABILITY STRESS TESTS

The following are brief descriptions of the reliability tests commonly used in the reliability monitoring program. Not all of the tests listed are performed by each product division. Other tests may be performed when appropriate.

AUTOCLAVE (aka, PRESSURE COOKER)

Autoclave is an environmental test which measures device resistance to moisture penetration and the resultant effects of galvanic corrosion. Autoclave is a highly accelerated and destructive test.

Typical Test Conditions: T_A = 121° C, rh = 100%, p = 1 atmosphere (15 psig), t = 24 to 96 hours
Common Failure Modes: Parametric shifts, high leakage and/or catastrophic
Common Failure Mechanisms: Die corrosion or contaminants such as foreign material on or within the package materials. Poor package sealing

HIGH HUMIDITY HIGH TEMPERATURE BIAS (H3TB, H3TRB, or THB)

This is an environmental test designed to measure the moisture resistance of plastic encapsulated devices. A bias is applied to create an electrolytic cell necessary to accelerate corrosion of the die metallization. With time, this is a catastrophically destructive test.

Typical Test Conditions: T_A = 85° C to 95° C, rh = 85% to 95%, Bias = 80% to 100% of Data Book max. rating, t = 96 to 1750 hours
Common Failure Modes: Parametric shifts, high leakage and/or catastrophic
Common Failure Mechanisms: Die corrosion or contaminants such as foreign material on or within the package materials. Poor package sealing

HIGH TEMPERATURE GATE BIAS (HTGB)

This test is designed to electrically stress the gate oxide under a bias condition at high temperature.

Typical Test Conditions: T_A = 150° C, Bias = 80% of Data Book max. rating, t = 120 to 1000 hours
Common Failure Modes: Parametric shifts in gate leakage and gate threshold voltage
Common Failure Mechanisms: Random oxide defects and ionic contamination
Military Reference: MIL-STD-750, Method 1042

HIGH TEMPERATURE REVERSE BIAS (HTRB)

The purpose of this test is to align mobile ions by means of temperature and voltage stress to form a high-current leakage path between two or more junctions.

Typical Test Conditions: T_A = 85° C to 150° C, Bias = 80% to 100% of Data Book max. rating, t = 120 to 1000 hours
Common Failure Modes: Parametric shifts in leakage and gain
Common Failure Mechanisms: Ionic contamination on the surface or under the metallization of the die
Military Reference: MIL-STD-750, Method 1039

HIGH TEMPERATURE STORAGE LIFE (HTSL)

High temperature storage life testing is performed to accelerate failure mechanisms which are thermally activated through the application of extreme temperatures.

Typical Test Conditions: T_A = 70° C to 200° C, no bias, t = 24 to 2500 hours
Common Failure Modes: Parametric shifts in leakage and gain
Common Failure Mechanisms: Bulk die and diffusion defects
Military Reference: MIL-STD-750, Method 1032

INTERMITTENT OPERATING LIFE (IOL)

The purpose of this test is the same as SSOL in addition to checking the integrity of both wire and die bonds by means of thermal stressing.

Typical Test Conditions: T_A = 25° C, Pd = Data Book maximum rating, $T_{on} = T_{off} = \Delta$ of 50° C to 100° C, t = 42 to 30000 cycles
Common Failure Modes: Parametric shifts and catastrophic
Common Failure Mechanisms: Foreign material, crack and bulk die defects, metallization, wire and die bond defects
Military Reference: MIL-STD-750, Method 1037

MECHANICAL SHOCK

This test is used to determine the ability of the device to withstand a sudden change in mechanical stress due to abrupt changes in motion as seen in handling, transportation, or actual use.

Typical Test Conditions: Acceleration = 1500 g's, Orientation = X_1, Y_1, Y_2 plane, t = 0.5 msec, Blows = 5
Common Failure Modes: Open, short, excessive leakage, mechanical failure
Common Failure Mechanisms: Die and wire bonds, cracked die, package defects
Military Reference: MIL-STD-750, Method 2015

MOISTURE RESISTANCE

The purpose of this test is to evaluate the moisture resistance of components under temperature/humidity conditions typical of tropical environments.

Typical Test Conditions: T_A = –10° C to 65° C, rh = 80% to 98%, t = 24 hours/cycle, cycle = 10
Common Failure Modes: Parametric shifts in leakage and mechanical failure
Common Failure Mechanisms: Corrosion or contaminants on or within the package materials. Poor package sealing
Military Reference: MIL-STD-750, Method 1021

SOLDERABILITY

The purpose of this test is to measure the ability of device leads/terminals to be soldered after an extended period of storage (shelf life).

Typical Test Conditions: Steam aging = 8 hours, Flux = R, Solder = Sn60, Sn63
Common Failure Modes: Pin holes, dewetting, non-wetting
Common Failure Mechanisms: Poor plating, contaminated leads
Military Reference: MIL-STD-750, Method 2026

SOLDER HEAT

This test is used to measure the ability of a device to withstand the temperatures as may be seen in wave soldering operations. Electrical testing is the endpoint criterion for this stress.

Typical Test Conditions: Solder Temperature = 260° C, t = 10 seconds
Common Failure Modes: Parameter shifts, mechanical failure
Common Failure Mechanisms: Poor package design
Military Reference: MIL-STD-750, Method 2031

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.

Typical Test Conditions: T_A = 25° C, P_D = Data Book maximum rating, t = 16 to 1000 hours
Common Failure Modes: Parametric shifts and catastrophic
Common Failure Mechanisms: Foreign material, crack die, bulk die, metallization, wire and die bond defects
Military Reference: MIL-STD-750, Method 1026

TEMPERATURE CYCLING (AIR TO AIR)

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperatures and transitions between temperature extremes. This testing will also expose excessive thermal mismatch between materials.

Typical Test Conditions: T_A = –65° C to 200° C, cycle = 10 to 4000
Common Failure Modes: Parametric shifts and catastrophic
Common Failure Mechanisms: Wire bond, cracked or lifted die and package failure
Military Reference: MIL-STD-750, Method 1051

THERMAL SHOCK (LIQUID TO LIQUID)

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperatures and sudden transitions between temperature extremes. This testing will also expose excessive thermal mismatch between materials.

Typical Test Conditions: T_A = 0° C to 100° C, cycle = 20 to 300
Common Failure Modes: Parametric shifts and catastrophic
Common Failure Mechanisms: Wire bond, cracked or lifted die and package failure
Military Reference: MIL-STD-750, Method 1056

VARIABLE FREQUENCY VIBRATION

This test is used to examine the ability of the device to withstand deterioration due to mechanical resonance.

Typical Test Conditions: Peak acceleration = 20 g's, Frequency range = 20 Hz to 20 KHz, t = 48 minutes.
Common Failure Modes: Open, short, excessive leakage, mechanical failure
Common Failure Mechanisms: Die and wire bonds, cracked die, package defects
Military Reference: MIL-STD-750, Method 2056

STATISTICAL PROCESS CONTROL

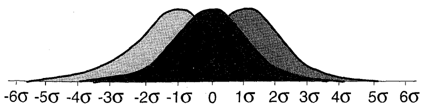
Motorola's Discrete and Materials Technologies Group (DMTG) is continually pursuing new ways to improve product quality. Initial design improvement is one method that can be used to produce a superior product. Equally important to outgoing product quality is the ability to produce product that consistently conforms to specification. Process variability is the basic enemy of semiconductor manufacturing since it leads to product variability. Used in all phases of Motorola's product manufacturing, STATISTICAL PROCESS CONTROL (SPC) replaces variability with predictability. The traditional philosophy in the semiconductor industry has been adherence to the data sheet specification. Using SPC methods assures the product will meet specific process requirements throughout the manufacturing cycle. The emphasis is on defect prevention, not detection. Predictability through SPC methods requires the manufacturing culture to focus on constant and permanent improvements. Usually these improvements cannot be bought with state-of-the-art equipment or automated factories. With quality in design, process and material selection, coupled with manufacturing predictability, Motorola can produce world class products.

The immediate effect of SPC manufacturing is predictability through process controls. Product centered and distributed well within the product specification benefits Motorola with fewer rejects, improved yields and lower cost. The direct benefit to Motorola's customers includes better incoming quality levels, less inspection time and ship-to-stock capability. Circuit performance is often dependent on the cumulative effect of component variability. Tightly controlled component distributions give the customer greater circuit predictability. Many customers are also converting to just-in-time (JIT) delivery programs. These programs require improvements in cycle time and yield predictability achievable only through SPC techniques. The benefit derived from SPC helps the manufacturer meet the customer's expectations of higher quality and lower cost product.

Ultimately, Motorola will have Six Sigma capability on all products. This means parametric distributions will be centered within the specification limits with a product distribution of plus or minus Six Sigma about mean. Six Sigma capability, shown graphically in Figure 1-1 , details the benefit in terms of yield and outgoing quality levels. This compares a centered distribution versus a 1.5 sigma worst case distribution shift.

New product development at Motorola requires more robust design features that make them less sensitive to minor variations in processing. These features make the implementation of SPC much easier.

A complete commitment to SPC is present throughout Motorola. All managers, engineers, production operators, supervisors and maintenance personnel have received multiple training courses on SPC techniques. Manufacturing has identified 22 wafer processing and 8 assembly steps considered critical to the processing of semiconductor products. Processes, controlled by SPC methods, that have shown significant improvement are in the diffusion, photolithography and metallization areas.



Distribution Centered	Distribution Shifted ± 1.5
At ± 3 σ 2700 ppm defective 99.73% yield	66810 ppm defective 93.32% yield
At ± 4 σ 63 ppm defective 99.9937% yield	6210 ppm defective 99.379% yield
At ± 5 σ 0.57 ppm defective 99.999943% yield	233 ppm defective 99.9767% yield
At ± 6 σ 0.002 ppm defective 99.9999998% yield	3.4 ppm defective 99.99966% yield

Figure 1-1 – AOQL and Yield from a Normal Distribution of Product With 6σ Capability

To better understand SPC principles, brief explanations have been provided. These cover process capability, implementation and use.

PROCESS CAPABILITY

One goal of SPC is to ensure a process is **CAPABLE.** Process capability is the measurement of a process to produce products consistently to specification requirements. The purpose of a process capability study is to separate the inherent **RANDOM VARIABILITY** from **ASSIGNABLE CAUSES.** Once completed, steps are taken to identify and eliminate the most significant assignable causes. Random variability is generally present in the system and does not fluctuate. Sometimes, these are considered basic limitations associated with the machinery, materials, personnel skills or manufacturing methods. Assignable cause inconsistencies relate to time variations in yield, performance or reliability.

Traditionally, assignable causes appear to be random due to the lack of close examination or analysis. Figure 1-2 shows the impact on predictability that assignable cause can have. Figure 1-3 shows the difference between process control and process capability.

A process capability study involves taking periodic samples from the process under controlled conditions. The performance characteristics of these samples are charted against time. In time, assignable causes can be identified and engineered out. Careful documentation of the process is key to accurate diagnosis and successful removal of the assignable causes. Sometimes, the assignable causes will remain unclear requiring prolonged experimentation.

Elements which measure process variation control and capability are Cp and Cpk respectively. Cp is the specification width divided by the process width or Cp = (specification width) / 6σ. Cpk is the absolute value of the closest specification value to the mean, minus the mean, divided by half the process width or $Cpk = |\text{closest specification} - \overline{X}/3\sigma$.

10

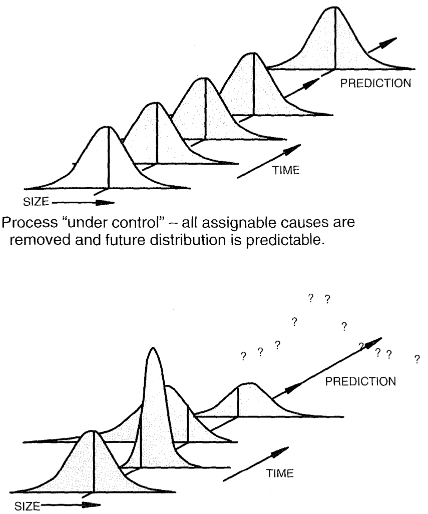


Figure 1-2 – Impact of Assignable Causes on Process Predictable

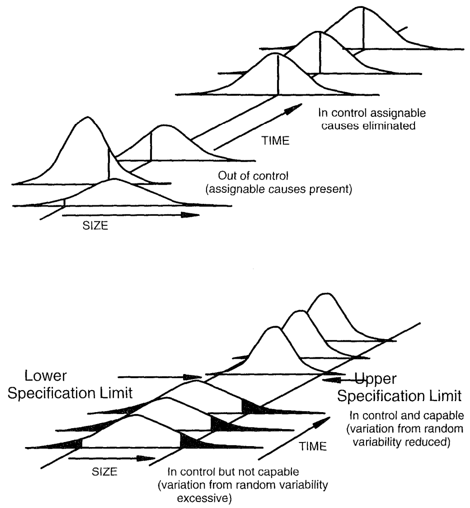


Figure 1-3 – Difference Between Process Control and Process Capability

At Motorola, for critical parameters, the process capability is acceptable with a Cpk = 1.33. The desired process capability is a Cpk = 2 and the ideal is a Cpk = 5. Cpk, by definition, shows where the current production process fits with relationship to the specification limits. Off center distributions or excessive process variability will result in less than optimum conditions

SPC IMPLEMENTATION AND USE

DMTG uses many parameters that show conformance to specification. Some parameters are sensitive to process variations while others remain constant for a given product line. Often, specific parameters are influenced when changes to other parameters occur. It is both impractical and unnecessary to monitor all parameters using SPC methods. Only critical parameters that are sensitive to process variability are chosen for SPC monitoring. The process steps affecting these critical parameters must be identified also. It is equally important to find a measurement in these process steps that correlates with product performance. This is called a critical process parameter.

Once the critical process parameters are selected, a sample plan must be determined. The samples used for measurement are organized into **RATIONAL SUBGROUPS** of approximately 2 to 5 pieces. The subgroup size should be such that variation among the samples within the subgroup remain small. All samples must come from the same source e.g., the same mold press operator, etc.. Subgroup data should be collected at appropriate time intervals to detect variations in the process. As the process begins to show improved stability, the interval may be increased. The data collected must be carefully documented and maintained for later correlation. Examples of common documentation entries would include operator, machine, time, settings, product type, etc.

Once the plan is established, data collection may begin. The data collected will generate $\bar{X}$ and R values that are plotted with respect to time. $\bar{X}$ refers to the mean of the values within a given subgroup, while R is the range or greatest value minus least value. When approximately 20 or more $\bar{X}$ and R values have been generated, the average of these values is computed as follows:

$$\bar{\bar{X}} = (\bar{X} + \bar{X}2 + \bar{X}3 + ...)/K$$
$$\bar{R} = (R1 + R2 + R3 + ...)/K$$

where K = the number of subgroups measured.

The values of $\bar{\bar{X}}$ and $\bar{R}$ are used to create the process control chart. Control charts are the primary SPC tool used to signal a problem. Shown in Figure 1-4 , process control charts show $\bar{X}$ and R values with respect to time and concerning reference to upper and lower control limit values. Control limits are computed as follows:

R upper control limit = $UCL_R = D4\,\bar{R}$

R lower control limit = $LCL_R = D3\,\bar{R}$

$\bar{X}$ upper control limit = $UCL_{\bar{X}} = \bar{\bar{X}} + A2\,\bar{R}$

$\bar{X}$ lower control limit = $LCL\bar{X} = \bar{\bar{X}} - A2\,\bar{R}$

10

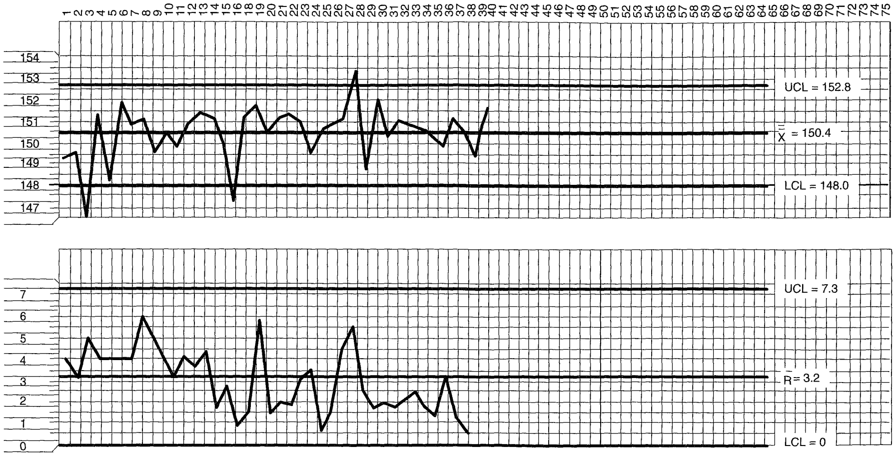


Figure 1-4 – Example of Process Control Chart Showing Oven Temperature Data

Where D4, D3 and A2 are constants varying by sample size, with values for sample sizes from 2 to 10 shown in the following partial table:

n	2	3	4	5	6	7	8	9	10
D_4	3.27	2.57	2.28	2.11	2.00	1.92	1.86	1.82	1.78
D_3	*	*	*	*	*	0.08	0.14	0.18	0.22
A_2	1.88	1.02	0.73	0.58	0.48	0.42	0.37	0.34	0.31

* For sample sizes below 7, the LCL_R would technically be a negative number; in those cases there is no lower control limit; this means that for a subgroup size 6, six "identical" measurements would not be unreasonable.

Control charts are used to monitor the variability of critical process parameters. The R chart shows basic problems with piece to piece variability related to the process. The X chart can often identify changes in people, machines, methods, etc. The source of the variability can be difficult to find and may require experimental design techniques to identify assignable causes.

Some general rules have been established to help determine when a process is **OUT-OF-CONTROL**. Figure 1-9 shows a control chart subdivided into zones A, B, and C corresponding to 3 sigma, 2 sigma, and 1 sigma limits respectively. In Figure 1-8 through Figure 1-6 four of the tests that can be used to identify excessive variability and the presence of assignable causes are shown. As familiarity with a given process increases, more subtle tests may be employed successfully.

Once the variability is identified, the cause of the variability must be determined. Normally, only a few factors have a significant impact on the total variability of the process. The importance of correctly identifying these factors is stressed in the following example. Suppose a process variability depends on the variance of five factors A, B, C, D and E. Each has a variance of 5, 3, 2, 1 and 0.4 respectively.

Since:

$$\sigma\ tot = \sqrt{\sigma A^2 + \sigma B^2 + \sigma C^2 + \sigma D^2 + \sigma E^2}$$

$$\sigma\ tot = \sqrt{5^2 + 3^2 + 2^2 + 1^2 + (0.4)^2} = 6.3$$

Now if only D is identified and eliminated then;

$$\sigma\ tot = \sqrt{5^2 + 3^2 + 2^2 + (0.4)^2} = 6.2$$

This results in less than 2% total variability improvement. If B, C and D were eliminated, then;

$$\sigma\ tot = \sqrt{5^2 + (0.4)^2} = 5.02$$

This gives a considerably better improvement of 23%. If only A is identified and reduced from 5 to 2, then;

$$\sigma\ tot = \sqrt{2^2 + 3^2 + 2^2 + 1^2 + (0.4)^2} = 4.3$$

Identifying and improving the variability from 5 to 2 gives us a total variability improvement of nearly 40%.

Most techniques may be employed to identify the primary assignable cause(s). Out-of-control conditions may be correlated to documented process changes. The product may be analyzed in detail using best versus worst part comparisons or Product Analysis Lab equipment. Multi-variance analysis can be used to determine the family of variation (positional, critical or temporal). Lastly, experiments may be run to test theoretical or factorial analysis. Whatever method is used, assignable causes must be identified and eliminated in the most expeditious manner possible.

After assignable causes have been eliminated, new control limits are calculated to provide a more challenging variability criteria for the process. As yields and variability improve, it may become more difficult to detect improvements because they become much smaller. When all assignable causes have been eliminated and the points remain within control limits for 25 groups, the process is said to be in a state of control.

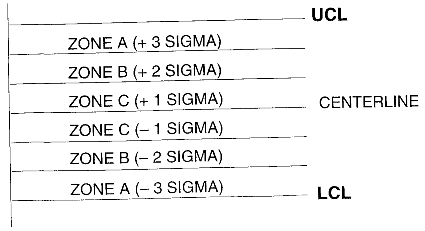


Figure 1-9 – Control Chart Zones

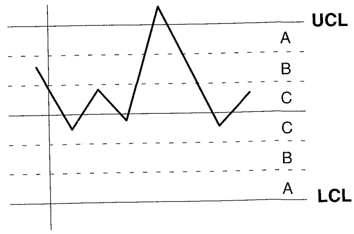


Figure 1-8 – One Point Outside Control Limit Indicating Excessive Variability

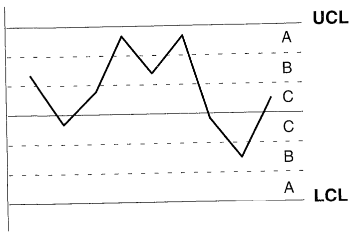


Figure 1-5 – Two Out of Three Points in Zone A or Beyond Indicating Excessive Variability

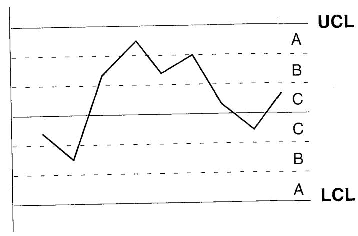


Figure 1-7 – Four Out of Five Points in Zone B or Beyond Indicating Excessive Variability

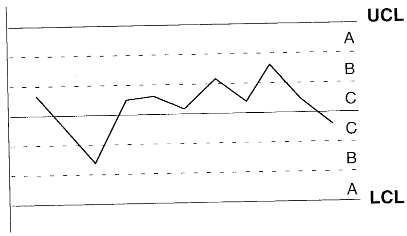
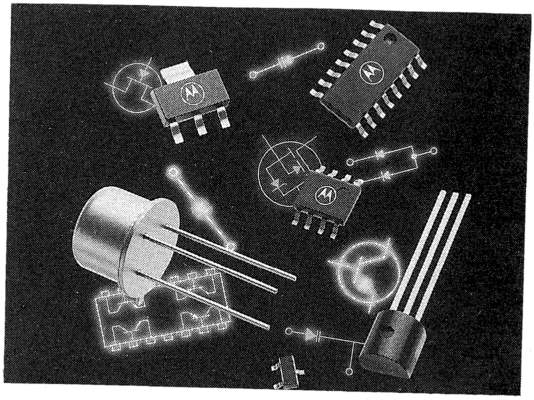


Figure 1-6 – Seven Out of Eight Points in Zone C or Beyond Indicating Excessive Variability

SUMMARY

Motorola is committed to the use of STATISTICAL PROCESS CONTROLS. These principles, used throughout manufacturing, have already resulted in many significant improvements to the processes. Continued dedication to the SPC culture will allow Motorola to reach the Six Sigma and zero defect capability goals. SPC will further enhance the commitment to **TOTAL CUSTOMER SATISFACTION**.



The Replacement Devices index provides you with a list of devices which had been supported with data sheets in the prior edition of the *Small-Signal Transistors, FETs and Diodes* data book (DL126 Rev 3) but are no longer supported in this new edition. A direct or similar replacement part is listed for those devices which have replacement parts.

Replacement Devices

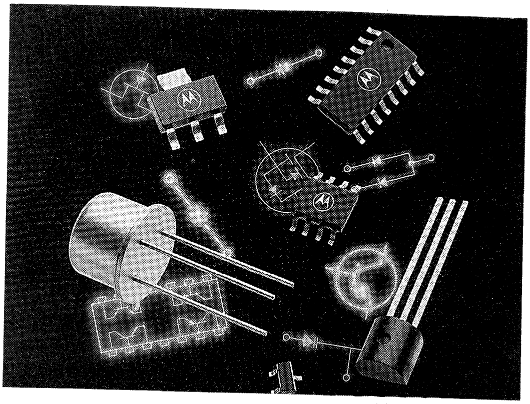
11

REPLACEMENT DEVICES

Device	Replacement Part
2N4404	
2N5058	2N4927
2N5223	MPS6521
2N5440	
2N5458	
2N5459	
2N5484	
2N5485	
2N5638	
2N706A	2N2369A
2N869A	
BC107C	BC107B
BC108A	BC108B
BC108C	BC108B
BC109A	BC109
BC109B	BC109
BC141-16	BC141-10
BC309	BC309B
BCW31LT1	
BCW60CLT1	BCW60BLT1
BCW61ALT1	BCW61BLT1

Device	Replacement Part
BCW71LT1	
BCY58VIII	
BCY58X	
BCY59VII	BCY59VIII
BCY78IX	
BCY78VIII	
BCY79VII	BCY79VIII
BDB01D	BDB01C
BDB02D	BDB02C
BDC02D	
BDC06	
BF244C	BF244B
BF246	BF246A
BF247	BF247B
BF247A	BF247B
BF247C	BF247B
BF256	BF256B
BF259	2N4927
BF491	
BSS78	
CV9507	2N2904A

Device	Replacement Part
J109	
J110	
MM3002	
MM3005	
MM3007	
MM4003	
MM4005	2N4033
MM6427	2N6427
MPF89	
MPS3568	MPS8099
MPS4249	MPS3906
MPS6534	2N4402
P2N3019	
P2N4033	
PBF259RS	
PBF259S	
PBF493	
PBF493R	
PBF493RS	
PBF493S	



Alphanumeric Index

12

Alphanumeric Index

Alphanumeric Index (continued)

12

Alphanumeric Index (continued)

Alphanumeric Index (continued)

Alphanumeric Index (continued)

12

1PHX12549E-10 Printed in USA 3/94 BANTA CO. MOTO 25 8,000 SMALL SIGNAL YBABAA

MOTOROLA

Literature Distribution Centers:

USA: Motorola Literature Distribution; P.O. Box 20912; Phoenix, Arizona 85036.

EUROPE: Motorola Ltd.; European Literature Centre; 88 Tanners Drive, Blakelands, Milton Keynes, MK14 5BP, England.

JAPAN: Nippon Motorola Ltd.; 4-32-1, Nishi-Gotanda, Shinagawa-ku, Tokyo 141 Japan.

ASIA-PACIFIC: Motorola Semiconductors H.K. Ltd.; Silicon Harbour Center, No. 2 Dai King Street, Tai Po Industrial Estate, Tai Po, N.T., Hong Kong.

DL126/D