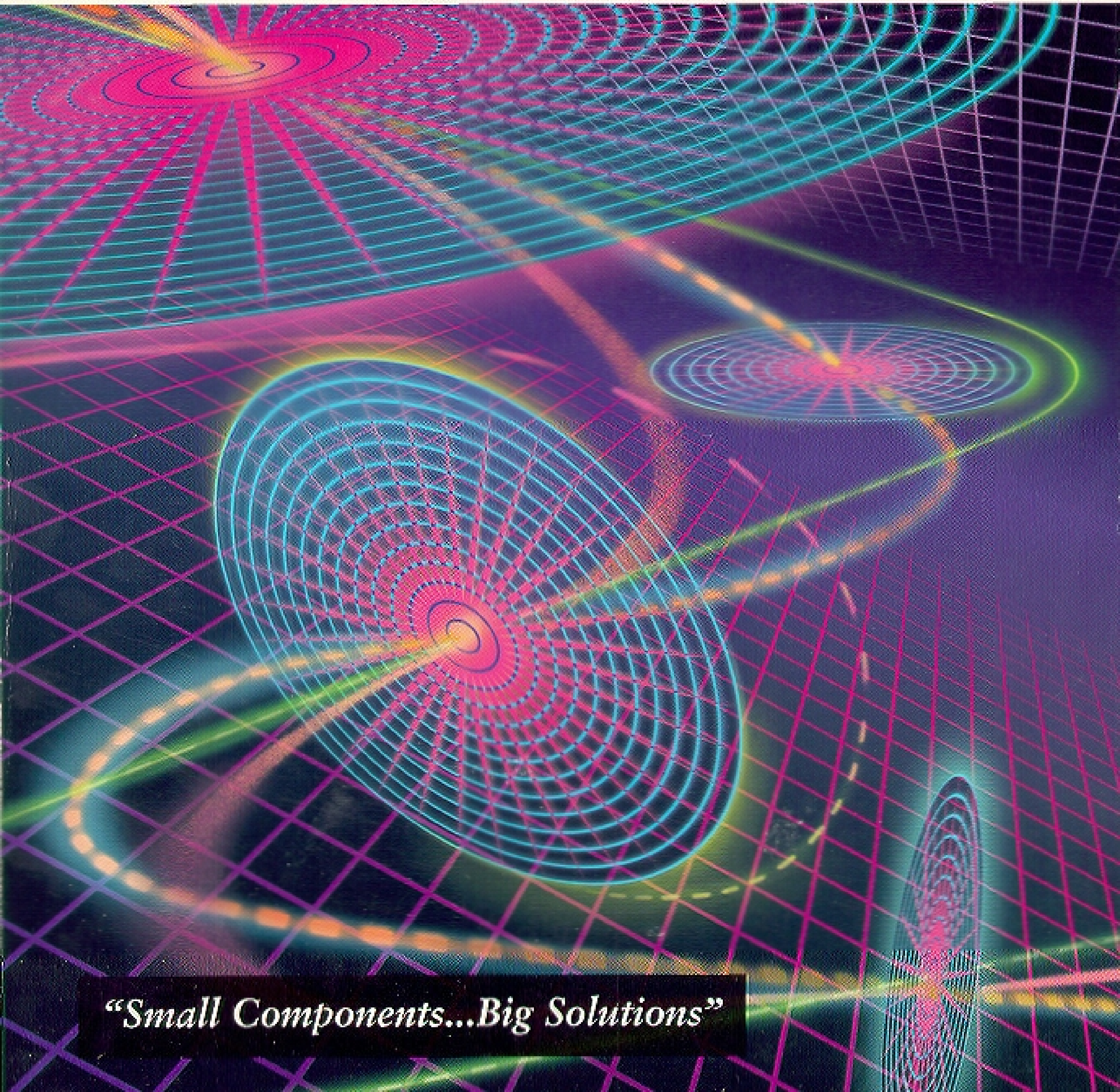
MOTOROLA

DL126/D
REV 6

Small-Signal

Transistors, FETs and Diodes Device Data



"Small Components...Big Solutions"

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 transistors, field–effect transistors, and diodes. These are available in a variety of through hole and surface mount packages. 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.

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

Printed in U.S.A.

About This Revision

To accomodate the increasing requirements for surface mount components, this publication adds a variety of device types in several choices of surface mount packages.

- An expanded MOSFET portfolio to include new lower $R_{DS(on)}$ HDTMOS devices in the TSOP–6 package.
- Dual transistors and diodes in the SC–70 multi–lead package.
- A Family of transistors and diodes in the smaller SC–90 package.

It should be noted that Metal Can Transistors previously listed in this data book have been removed for this revision. Replacement devices for these parts can be found in Chapter 10.

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).

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.

Table of Contents

Section 1

Selector Guide

In Brief . . .

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

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–90/SOT–416, SC-59, SOD-123, SOT–223, SOT–363, and TSOP–6. 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.

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.

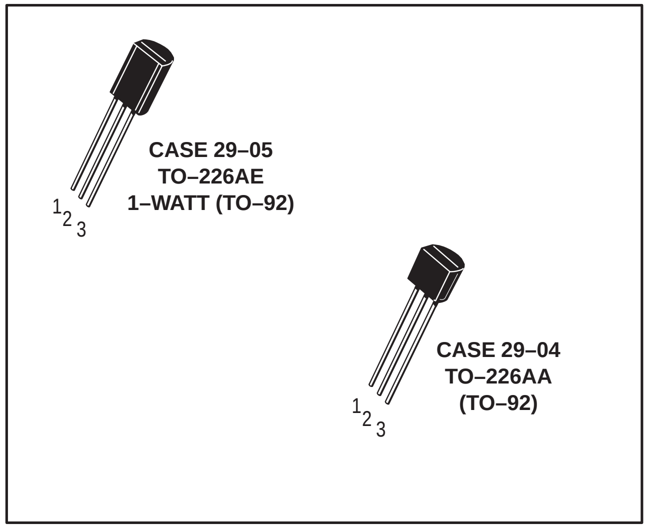


Table 1. Plastic–Encapsulated General–Purpose Transistors

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).

NPN	PNP	$V_{(BR)CEO}$ 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	NF 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
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	—	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)												
BDC01D	—	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
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	—	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.

Plastic–Encapsulated Transistors (continued)

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.

NPN	PNP	$V_{(BR)CEO}$ Volts	I_C Max	h_{FE} @ I_C Min	Max	mA	$V_{CE(sat)}$ @ I_C & I_B Volts Max	mA	mA	f_T @ I_C 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.

NPN	PNP	$V_{(BR)CEO}$ Volts Min	f_T @ I_C MHz Min	mA	I_C mA 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)												
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.

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										
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
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
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
Case 29–04 — TO–266AA (TO–92) — PNP										
MPSH81	20	50	60	5.0	10	600(2)	0.85	—	—	2

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

Device Type	t_{on} & t_{off} @ I_C			$V_{(BR)CEO}$ Volts Min	h_{FE} @ I_C		$V_{CE(sat)}$ @ I_C & I_B			f_T @ I_C		Style
	ns Max	ns Max	mA		Min	mA	Volts Max	mA	mA	MHz Min	mA	
Case 29–04 — TO–226AA (TO–92) — NPN												
2N4264	25	35	10	15	40	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

(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 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										
MPSA17	15	100	200	5.0	0.25	10	1.0	80	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} Min	Max	mA	Volts	f_T MHz Min	Style
Case 29–04 — TO–226AA (TO–92) — NPN									
P2N2222A	40	625	600	75	—	10	10	300	17
Case 29–04 — TO–226AA (TO–92) — PNP									
P2N2907A	60	625	600	100	—	10	10	200	17

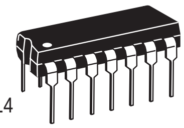
(1) Typical

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.



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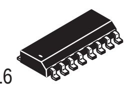
CASE 646–06
(TO–116)
STYLE 1



16
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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 10 and 11 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} 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, 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 $|V_{BE1} - V_{BE2}|$. Differential Amplifiers
t_{on} — turn–on time
t_{off} — turn–off time

Power Dissipation specified at 25°C. Single die rating.
Ref. Point: A — Ambient Temperature
C — Case Temperature

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

Plastic–Encapsulated Multiple Transistors (continued)

Table 10. 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
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 11. 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		f_T @ I_C	
			Min	mA	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
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.

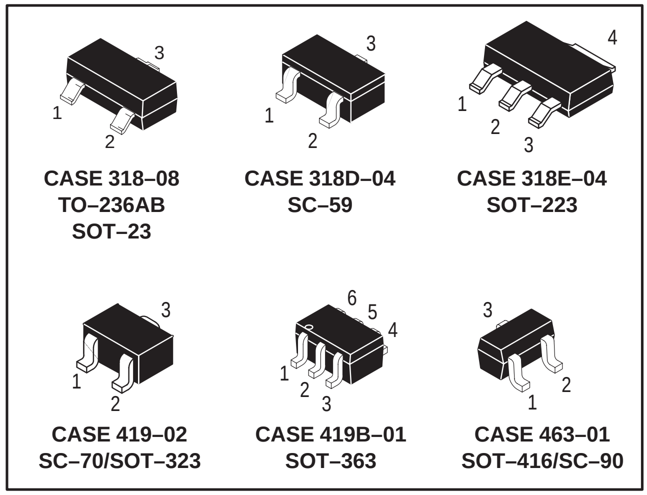


Table 12. Plastic–Encapsulated Surface Mount General–Purpose Transistors

The following tables are a listing of small–signal general–purpose transistors in the SOT–23, SC–59, SOT–223, SC–70, SC–90, and SOT–363 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			f_T
			Min	Max	mA	MHz Min
Case 318–08 — TO–236AB (SOT–23) — NPN						
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	300
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 318–08 — TO–236AB (SOT–23) — PNP						
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
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

Devices listed in bold, italic are Motorola preferred devices.

Table 12. 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 318D–04 — 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–04 — SC–59 — PNP						
MSB709–RT1	AR	25	210	340	2.0	100(1)
MSB710–RT1	CR	25	120	240	150	200(1)
Case 419–02 — SC–70/SOT–323 —NPN						
BC818WT1	6I	45	100	600	100	—
BC818–25WT1	6F	45	160	400	100	—
BC818–40WT1	6G	45	250	600	100	—
BC846AWT1	1A	65	110	220	2.0	100
BC846BWT1	1B	65	200	450	2.0	100
BC847AWT1	1E	45	110	220	2.0	100
BC847BWT1	1F	45	200	450	2.0	100
BC847CWT1	1G	45	420	800	2.0	100
BC848AWT1	1J	30	110	220	2.0	100
BC848BWT1	1K	30	200	450	2.0	100
BC848CWT1	1L	30	420	800	2.0	100
MMBT2222AWT1	1P	40	100	300	150	300
MMBT3904WT1	AM	40	100	300	10	300
MSC3930–BT1	VB	20	70	140	1.0	150
MSD1819A–RT1	ZR	50	210	340	2.0	—
Case 419–02 — SC–70/SOT–323 —PNP						
BC808–25WT1	5F	45	160	400	100	—
BC808–40WT1	6F	45	250	600	100	—
BC856AWT1	3A	65	125	250	2.0	100
BC856BWT1	3B	65	220	475	2.0	100
BC857AWT1	3E	45	125	250	2.0	100
BC857BWT1	3F	45	220	475	2.0	100
BC858AWT1	3J	30	110	220	2.0	100
BC858BWT1	3K	30	200	450	2.0	100
BC858CWT1	3L	30	420	800	2.0	100
MMBT2907AWT1	20	60	100	300	150	200
MMBT3906WT1	2A	40	100	300	10	250
MSB1218A–RT1	BR	45	210	340	2.0	—
Case 419B–01 — SOT–363 — Dual NPN						
MBT3904DW1T1	MA	40	100	300	10	300
MBT3904DW9T1	MB	40	100	300	10	300
Case 419B–01 — SOT–363 — Dual PNP						
MBT3906DW1T1	A2	–40	100	300	10	250
MBT3906DW9T1	A3	–40	100	300	10	250

(1) Typical

Devices listed in bold, italic are Motorola preferred devices.

Plastic–Encapsulated Surface Mount Transistors (continued)

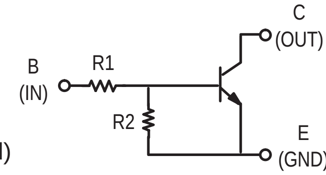


Table 12. Plastic–Encapsulated Surface Mount General–Purpose Transistors (continued)
Pinout: 1–Base, 2–Emitter, 3–Collector
Devices are listed in order of descending breakdown voltage.

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 419B–01 — SOT–363 — Dual Combination NPN and PNP						
MBT3946DW1T1	46	40	100	300	10	250
Case 463–01 — SOT–416/SC–90 — NPN						
2SC4617	B9	50	120	560	1.0	180
Case 463–01 — SOT–416/SC–90 — PNP						
2SA1774	F9	50	120	560	1.0	140

Table 13. Plastic–Encapsulated Surface Mount Bias Resistor Transistors for General Purpose Applications

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

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

Device		Marking		$V_{(BR)CEO}$ Volts (Min)	h_{FE}@ I_C		I_C mA Max	R_1 Ohm	R_2 Ohm
NPN	PNP	NPN	PNP		Min	mA			
Case 318D–04 — 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
MUN2215T1	***MUN2115T1***	8E	6E	50	160	5.0	100	10K	∞
MUN2216T1	***MUN2116T1***	8F	6F	50	160	5.0	100	4.7K	∞
MUN2230T1	***MUN2130T1***	8G	6G	50	3.0	5.0	100	1.0K	1.0K
MUN2231T1	***MUN2131T1***	8H	6H	50	8.0	5.0	100	2.2K	2.2K
MUN2232T1	***MUN2132T1***	8J	6J	50	15	5.0	100	4.7K	4.7K
MUN2233T1	***MUN2133T1***	8K	6K	50	80	5.0	100	4.7K	47K
MUN2234T1	***MUN2134T1***	8L	6L	50	80	5.0	100	22K	47K
Case 318–08 — TO–236AB (SOT–23)									
MMUN2211LT1	***MMUN2111LT1***	A8A	A6A	50	35	5.0	100	10K	10K
MMUN2212LT1	***MMUN2112LT1***	A8B	A6B	50	60	5.0	100	22K	22K
MMUN2213LT1	***MMUN2113LT1***	A8C	A6C	50	80	5.0	100	47K	47K
MMUN2214LT1	***MMUN2114LT1***	A8D	A6D	50	80	5.0	100	10K	47K
MMUN2215LT1	***MMUN2115LT1***	A8E	A6E	50	160	5.0	100	10K	∞
MMUN2216LT1	***MMUN2116LT1***	A8F	A6F	50	160	5.0	100	4.7K	∞
MMUN2230LT1	***MMUN2130LT1***	A8G	A6G	50	3.0	5.0	100	1.0K	1.0K
MMUN2231LT1	***MMUN2131LT1***	A8H	A6H	50	8.0	5.0	100	2.2K	2.2K
MMUN2232LT1	***MMUN2132LT1***	A8J	A6J	50	15	5.0	100	4.7K	4.7K
MMUN2233LT1	***MMUN2133LT1***	A8K	A6K	50	80	5.0	100	4.7K	47K
MMUN2234LT1	***MMUN2134LT1***	A8L	A6L	50	80	5.0	100	22K	47K

Devices listed in bold, italic are Motorola preferred devices.

Table 13. 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 (Min)	h_{FE} @ I_C		I_C mA Max	R_1 Ohm	R_2 Ohm
NPN	PNP	NPN	PNP		Min	mA			
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
MUN5215T1	***MUN5115T1***	8E	6E	50	160	5.0	50	10K	∞
MUN5216T1	***MUN5116T1***	8F	6F	50	160	5.0	50	4.7K	∞
MUN5230T1	***MUN5130T1***	8G	6G	50	3.0	5.0	50	1.0K	1.0K
MUN5231T1	***MUN5131T1***	8H	6H	50	8.0	5.0	50	2.2K	2.2K
MUN5232T1	***MUN5132T1***	8J	6J	50	15	5.0	50	4.7K	4.7K
MUN5233T1	***MUN5133T1***	8K	6K	50	80	5.0	50	4.7K	47K
MUN5234T1	***MUN5134T1***	8L	6L	50	80	5.0	50	22K	47K
Case 419B–01 — SOT–363 Duals									
MUN5211DW1T1	***MUN5111DW1T1***	7A	8A	50	35	5.0	100	10K	10K
MUN5212DW1T1	***MUN5112DW1T1***	7B	8B	50	60	5.0	100	22K	22K
MUN5213DW1T1	***MUN5113DW1T1***	7C	8C	50	80	5.0	100	47K	47K
MUN5214DW1T1	***MUN5114DW1T1***	7D	8D	50	80	5.0	100	10K	47K
MUN5215DW1T1	***MUN5115DW1T1***	7E	8E	50	160	5.0	100	10K	∞
MUN5216DW1T1	***MUN5116DW1T1***	7F	8F	50	160	5.0	100	4.7K	∞
MUN5230DW1T1	***MUN5130DW1T1***	7G	8G	50	3.0	5.0	100	1.0K	1.0K
MUN5231DW1T1	***MUN5131DW1T1***	7H	8H	50	8.0	5.0	100	2.2K	2.2K
MUN5232DW1T1	***MUN5132DW1T1***	7J	8J	50	15	5.0	100	4.7K	4.7K
MUN5233DW1T1	***MUN5133DW1T1***	7K	8K	50	80	5.0	100	4.7K	47K
MUN5234DW1T1	***MUN5134DW1T1***	7L	8L	50	80	5.0	100	22K	47K
MUN5235DW1T1	***MUN5135DW1T1***	7M	8M	50	80	5.0	100	2.2K	47K

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C		I_C mA Max	R_1 Ohm	R_2 Ohm
			Min	mA			
Case 419B–01 — SOT–363 — Dual Combination NPN and PNP							
MUN5311DW1T1	11	50	35	5.0	100	10K	10K
MUN5312DW1T1	12	50	60	5.0	100	22K	22K
MUN5313DW1T1	13	50	80	5.0	100	47K	47K
MUN5314DW1T1	14	50	80	5.0	100	10K	47K
MUN5315DW1T1	15	50	160	5.0	100	10K	∞
MUN5316DW1T1	16	50	160	5.0	100	4.7K	∞
MUN5330DW1T1	3X	50	3.0	5.0	100	1.0K	1.0K
MUN5331DW1T1	31	50	8.0	5.0	100	2.2K	2.2K
MUN5332DW1T1	32	50	15	5.0	100	4.7K	4.7K
MUN5333DW1T1	33	50	80	5.0	100	4.7K	47K
MUN5334DW1T1	34	50	80	5.0	100	22K	47K
MUN5335DW1T1	35	50	80	5.0	100	2.2K	47K

Device		Marking		$V_{(BR)CEO}$ Volts (Min)	h_{FE} @ I_C		I_C mA Max	R_1 Ohm	R_2 Ohm
NPN	PNP	NPN	PNP		Min	mA			
Case 463–01 — SOT–416/SC–90									
DTC114TE	—	94	—	50	100	1.0	100	10K	∞
DTC114YE	***DTA114YE***	69	59	50	80	5.0	100	10K	47K
—	***DTA143EE***	—	43	50	15	5.0	100	4.7K	4.7K

Devices listed in bold, italic are Motorola preferred devices.

Table 14. 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 MHz Min
		t_{on}	t_{off}		Min	Max	mA	
Case 318–08 — TO–236AB (SOT–23) — NPN								
MMBT2369LT1	M1J	12	18	15	20	—	100	—
MMBT2369ALT1	1JA	12	18	15	20	—	100	—
BSV52LT1	B2	12	18	12	40	120	10	400
Case 318–08 — TO–236AB (SOT–23) — PNP								
MMBT3640LT1	2J	25	35	12	20	—	50	500

Table 15. 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 318–08 — 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 318–08 — 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–04 — 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
MSC3130T1	1S	10	—	1.4	5.0
Case 318D–04 — SC–59 — PNP					
MSA1022–CT1	EC	20	2.0(13)	0.15	1.0

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

Devices listed in bold, italic are Motorola preferred devices.

Plastic–Encapsulated Surface Mount Transistors (continued)

Table 16. 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 318–08 — TO–236AB (SOT–23) — PNP						
MMBT404ALT1	2N	35	25	30	400	12

Table 17. 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 318–08 — TO–236AB (SOT–23) — NPN						
MMBTA14LT1	1N	30	1.5	20K	—	100
MMBTA13LT1	1M	30	1.5	10K	—	100
Case 318–08 — TO–236AB (SOT–23) — PNP						
MMBTA64LT1	2V	30	1.5	20K	—	100

Table 18. 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			f_T MHz Min
				Min	Max	mA	
Case 318–08 — 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 318–08 — TO–236AB (SOT–23) — PNP							
MMBT5087LT1	2Q	2.0(15)	50	250	—	10	40

(15) Max

Devices listed in bold, italic are Motorola preferred devices.

Table 19. 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 318–08 — TO–236AB (SOT–23) — NPN						
MMBT6517LT1	1Z	350	15	—	100	40
MMBTA42LT1	1D	300	40	—	30	50
MMBT5551LT1	G1	160	30	—	50	100
Case 318–08 — TO–236AB (SOT–23) — PNP						
MMBT6520LT1	2Z	350	15	—	100	40
MMBTA92LT1	2D	300	25	—	30	50
MMBT5401LT1	2L	150	50	—	50	100

Table 20. 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	$V_{(BR)CEO}$	$V_{CE(sat)}$	$V_{BE(sat)}$	h_{FE}@ I_C Min	Max	mA
Case 318–08 — TO–236AB (SOT–23) — NPN							
MMBTA06LT1	1GM	80	0.25	—	100	—	100
BSS64LT1	AM	80	0.15	—	20	—	10
Case 318–08 — TO–236AB (SOT–23) — PNP							
BSS63LT1	T1	100	–0.25	–0.90	30	—	25
MMBTA56LT1	2GM	80	–0.25	—	100	—	100
The following devices are designed to conserve energy. They offer ultra–low collector saturation voltage.							
Case 318–08 — TO–236AB (SOT–23) — PNP							
MMBT1010LT1	GLP	15	0.1	1.1	300	600	100
Case 318–03 — SC–59 — PNP							
MSD1010T1	GLP	15	0.1	1.1	300	600	100

Table 21. 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

Devices listed in bold, italic are Motorola preferred devices.

Table 22. 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}		f_T	
					Min	Max	@ 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

Table 23. 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}		@ I_C (mA)
				Min	Max	
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 24. Plastic–Encapsulated Surface Mount High–Voltage Transistors
Pinout: 1–Base, 2–Collector, 3–Emitter, 4–Collector

Device	Marking	$V_{(BR)CEO}$	h_{FE}		f_T	
			Min	Max	@ I_C (mA)	Min (MHz)
Case 318E–04 — SOT–223 — NPN						
BSP19AT1	SP19A	350	40	—	20	70
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 25. Plastic–Encapsulated Surface Mount High Current Transistors
Pinout: 1–Base, 2–Collector, 3–Emitter, 4–Collector

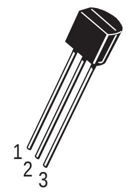
Device	Marking	$V_{(BR)CEO}$	$V_{CE(sat)}$ Volts	h_{FE}@ I_C		
				Min	Max	mA
Case 318E–04 — SOT–223 — NPN						
PZT651T1	651	60	0.5	75	—	1000
BCP68T1	CA	20	0.5	60	—	1000
Case 318E–04 — SOT–223 — PNP						
PZT751T1	ZT751	60	0.5	75	—	1000
BCP69T1	CE	20	0.5	60	—	1000

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 26. 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	$R_e \|Y_{fs}\|$ @ f		$R_e \|Y_{os}\|$ @ f		C_{iss} pF Max	C_{rss} pF Max	$V_{(BR)GSS}$ $V_{(BR)GDO}$ Volts Min	$V_{GS(off)}$ Volts		I_{DSS} mA		Style
	mmho Min	kHz	µmho Max	kHz				Min	Max	Min	Max	
Case 29–04 — TO–226AA (TO–92) — N–Channel												
J202	—	—	—	—	—	—	40	0.8	4.0	0.9	4.5	5
2N5457	1.0	1.0	50	1.0	7.0	3.0	25	0.5	6.0	1.0	5.0	5
2N5458	1.5	1.0	50	1.0	7.0	3.0	25	1.0	7.0	2.0	9.0	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 27. 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	$R_e \|Y_{fs}\|$ @ f		$R_e \|Y_{os}\|$ @ f		C_{iss} pF Max	C_{rss} pF Max	NF @ R_G = 1K		$V_{(BR)GSS}$ $V_{(BR)GDO}$ Volts Min	$V_{GS(off)}$ Volts		I_{DSS} mA		Style
	mmho Min	MHz	µmho Max	MHz			dB Max	f MHz		Min	Max	Min	Max	
Case 29–04 — TO–226AA (TO–92) — N–Channel														
MPF102	1.6	100	200	100	7.0	3.0	—	—	25	—	8.0	2.0	20	5
2N5484	2.5	100	75	100	5.0	1.0	3.0	100	25	0.3	3.0	1.0	5.0	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
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 28. 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												
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
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
2N5555	150	—	—	1.0(16)	15	—	25	5.0	1.2	10	25	5
J110	18	—	0.5	4.0	10	—	25	—	—	—	—	5

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

Devices listed in bold, italic are Motorola preferred devices.

TMOS FETs

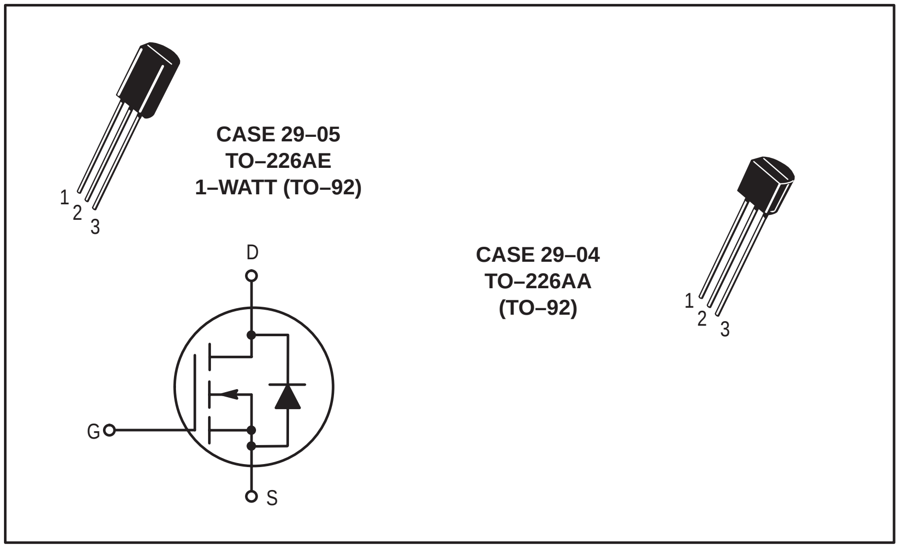


Table 29. TMOS Switches and Choppers

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	$R_{DS(on)}$ @ I_D A	$V_{GS(th)}$ Volts Min	$V_{GS(th)}$ Volts 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
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
VN2406L	6.0	0.5	0.8	2.0	240	125	20	8.0	23	22
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.

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.

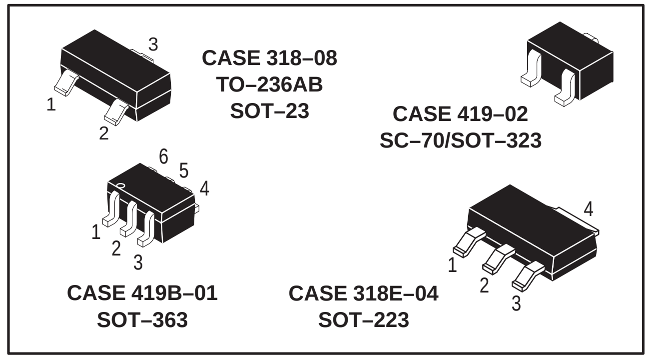


Table 30. Surface Mount RF JFETs

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

Device	Marking	NF		Y_{fs} @ V_{DS}			$V_{(BR)GSS}$	Style
		dB Typ	f MHz	mmhos Min	mmhos Max	Volts		
Case 318–08 — 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
Case 419B–01 — SOT–363— Dual N–Channel								
MBF4416DW1T1	M6	2.0	100	4.5	7.5	15	30	7

(3) Max

Table 31. 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

Device	Marking	$V_{(BR)GSS}$	Y_{fs} @ V_{DS}			I_{DSS}		Style
			mmhos Min	mmhos Max	Volts	mA Min	mA Max	
Case 318–08 — TO–236AB (SOT–23) — N–Channel								
MMBF5457LT1	6D	25	1.0	5.0	15	1.0	5.0	10
Case 318–08 — TO–236AB (SOT–23) — P–Channel								
MMBF5460LT1	M6E	40	1.0	4.0	15	1.0	5.0	10
Case 419B–01 — SOT–363 — Dual N–Channel								
MBF5457DW1T1	6D	25	1.0	5.0	15	1.0	5.0	7

(3) Max

Devices listed in bold, italic are Motorola preferred devices.

Surface Mount FETs (continued)

Table 32. 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 318–08 — TO–236AB (SOT–23) — N–Channel									
MMBF4391LT1	6J	30	20	30	–4.0	–10	50	150	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 318–08 — 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 33. 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 318–08 — 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
BSS138LT1	J1	3.5	200	50	0.5	1.5	20	20	21
2N7002LT1	702	7.5	500	60	1.0	2.5	20	20	21
MMBF0201NLT1	N1	1.0	300	20	1.0	2.4	2.5	15	21
MGSF1N02LT1	N2	0.085	1200	20	1.0	2.4	2.5	16	21
MGSF1N03LT1	N3	0.09	1200	30	1.0	2.4	2.5	16	21
Case 318–08 — TO–236 (SOT–23) — P–Channel									
BSS84LT1	PD	6.0	100	50	1.0	2.4	2.5	16	21
MMBF0202PLT1	P3	1.4	200	20	1.0	2.0	2.5	16	21
MGSF1P02LT1	PC	0.35	1500	20	1.0	2.4	2.5	16	21
MGSF1P02ELT1	PE	0.16	1500	20	0.7	1.2	2.5	15	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									
MMFT960T1	FT960	1.7	1000	60	1.0	3.5	15	15	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 419–02 — SC–70/SOT–323 — N–Channel									
MMBF2201NT1	N1	1.0	300	20	1.0	2.4	2.5	15	8
Case 419–02 — SC–70/SOT–323 — P–Channel									
MMBF2202PT1	P3	2.2	200	20	1.0	2.4	2.5	16	8

Devices listed in bold, italic are Motorola preferred devices.

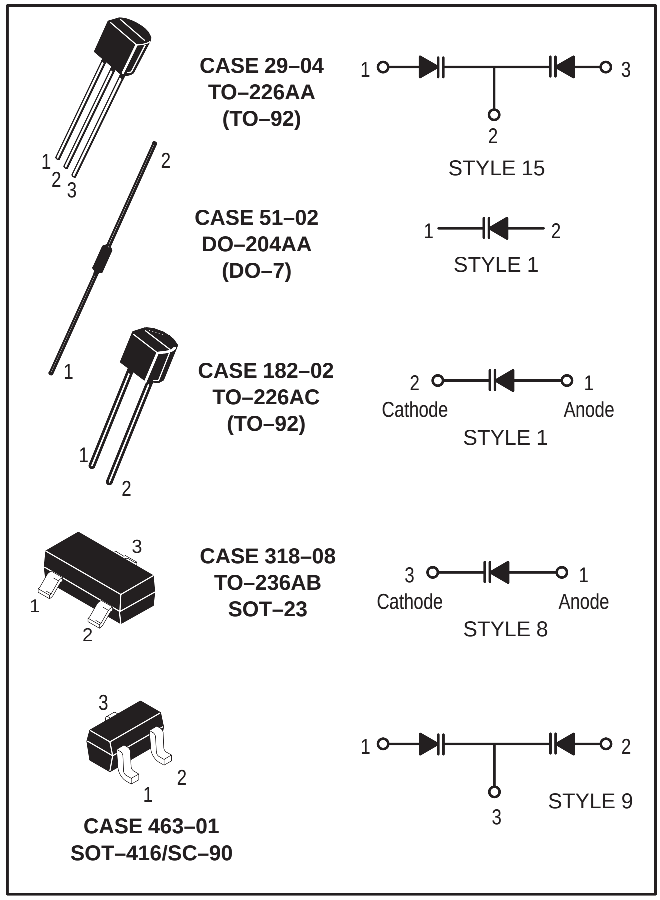
Tuning and Switching Diodes

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:

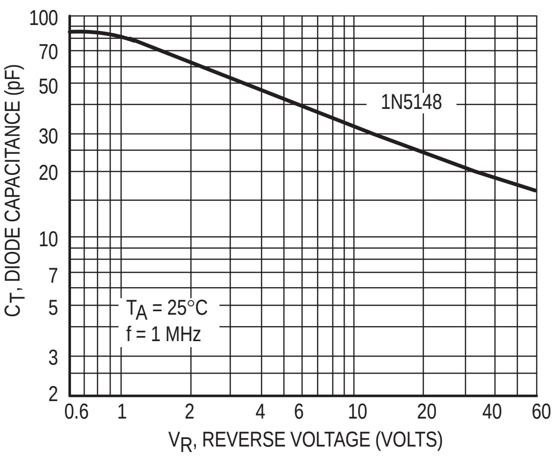
- Phase–locked loop tuning systems
- Local oscillator tuning
- Tuned RF preselectors
- RF filters
- RF phase shifters
- RF amplifiers
- Automatic frequency control
- Video filters and delay lines
- Harmonic generators
- FM modulators

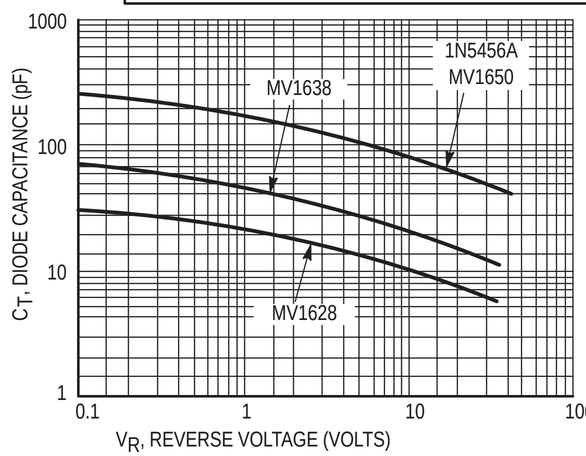
Two families of devices are available: Abrupt Junction and Hyper Abrupt Junction. The Abrupt Junction family includes devices suitable for virtually all tuned–circuit and narrow–range tuning applications throughout the spectrum.



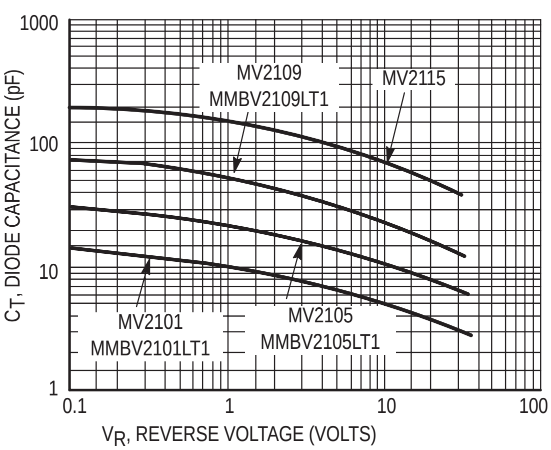
Typical Characteristics

Diode Capacitance versus Reverse Voltage

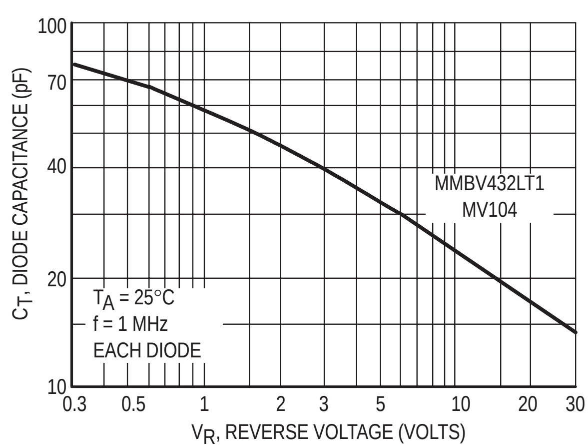




(See Tables 34 Thru 36)



(See Tables 37 and 38)



(See Table 39)

Tuning Diodes — Abrupt Junction (continued)

Table 34. 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			$V_{(BR)R}$ Volts	Cap Ratio C4/C60 Min	Q 4.0 V, 50 MHz Min
	pF Min	pF Nominal	pF Max			
Case 51–02 — DO–204AA (DO–7)						
1N5148	42.3	47	51.7	60	3.2	200

Table 35. 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			$V_{R(BR)R}$ Volts	Cap Ratio C2/C30 Min	Q 4.0 V, 50 MHz Min
	pF Min	pF Nominal	pF Max			
Case 51–02 — DO–204AA (DO–7)						
1N5446ARL	16.2	18	19.8	30	2.6	350
1N5448ARL	19.8	22	24.2	30	2.6	350
1N5456A	90	100	110	30	2.7	175

(19)Suffix A = 10.0%
(20)Suffix B = 5.0%

Table 36. 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			$V_{(BR)R}$ Volts	Cap Ratio C2/C20 Min	Q 4.0 V, 50 MHz Typ
	pF Min	pF Nominal	pF Max			
Case 51–02 — DO–204AA (DO–7)						
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
MV1634	19.8	22	24.2	20	2.0	250
MV1638	29.7	33	36.3	20	2.0	200
MV1648	73.8	82	90.2	20	2.0	150
MV1650	90	100	110	20	2.0	150

Table 37. 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			$V_{R(BR)R}$ Volts	Cap Ratio C4/C30 Min	Q 4.0 V, 50 MHz Typ
	pF Min	pF Nominal	pF Max			
Case 182–02 — TO–226AC (TO–92) — 2–Lead						
MV2101	6.1	6.8	7.5	30	2.5	400
MV2104	10.8	12	13.2	30	2.5	350
MV2105	13.5	15	16.5	30	2.5	350
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
MV2115	90	100	110	30	2.6	100

Table 38. 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			$V_{R(BR)R}$	Cap Ratio C2/C30	Q 4.0 V, 50 MHz
	pF Min	pF Nominal	pF Max	Volts	Min	Typ
Case 318–08 — DO–236AB (SOT–23)						
MMBV2101LT1	6.1	6.8	7.5	30	2.5	400
MMBV2103LT1	9.0	10	11	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 39. 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.

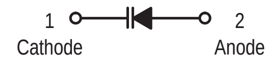
Device	C_T @ V_R (22)			Cap Ratio C3/C30	Q 3.0 V, 50 MHz	$V_{(BR)R}$	Device	Style
	pF Min	pF Max	Volts	Min	Min	Volts	Marking	
Case 29–04 — TO–226AA (TO–92)								
MV104	37	42	3.0	2.5	100	32	—	15
Case 318–08 — TO–236AB (SOT–23)								
MMBV432LT1	43	48.1	2.0	1.5(21)	100	14	M4B	9

(21) C2/C8
(22) Each Diode

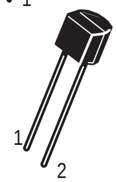
Tuning Diodes — Hyper–Abrupt Junction

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.

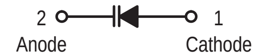
CASE 51–02
DO–204AA
(DO–7)



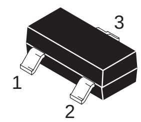
STYLE 1



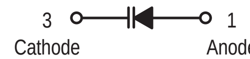
CASE 182–02
TO–226AC
(TO–92)



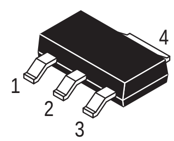
STYLE 1



CASE 318–08
TO–236AB
SOT–23



STYLE 8



CASE 318E–04
SOT–223

STYLE 2

Typical Characteristics

Diode Capacitance versus Reverse Voltage

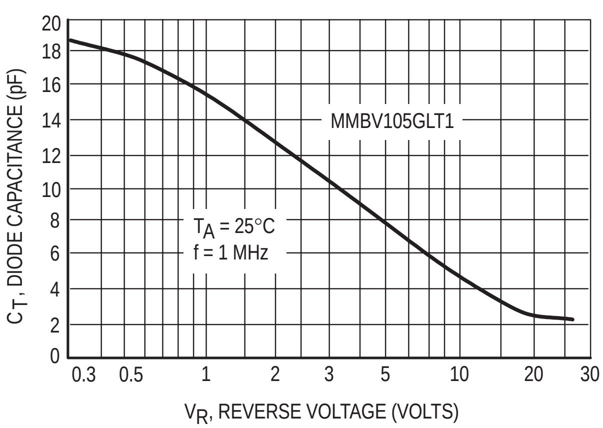


Figure 1. Diode Capacitance

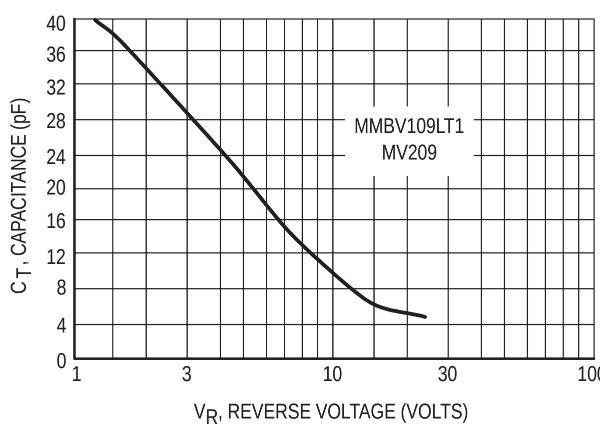


Figure 2. Diode Capacitance

Tuning Diodes — Hyper–Abrupt Junction (continued)

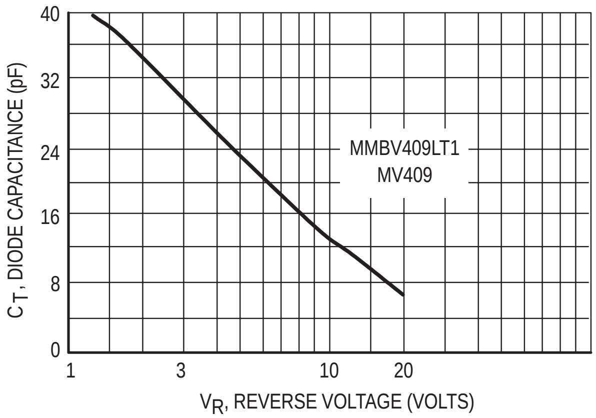


Figure 3. Diode Capacitance

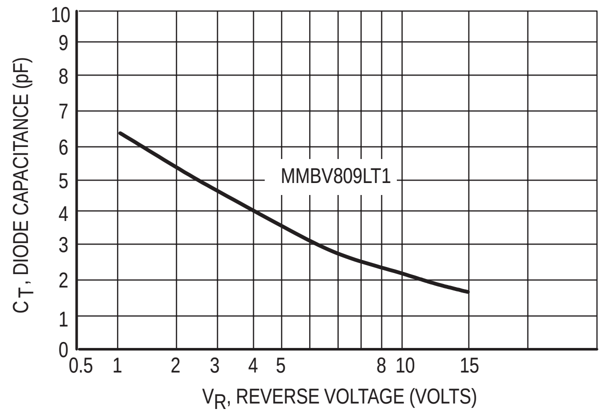


Figure 4. Diode Capacitance

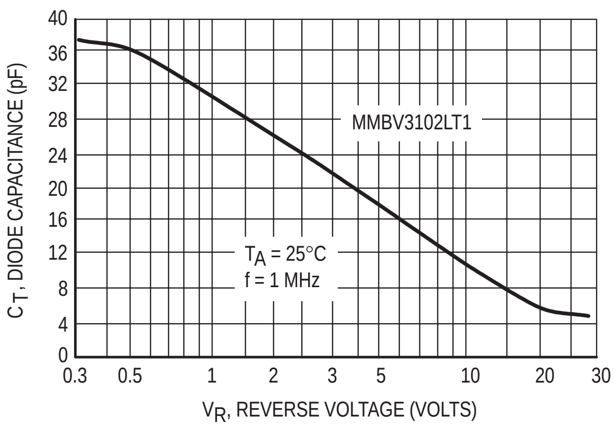


Figure 5. Diode Capacitance

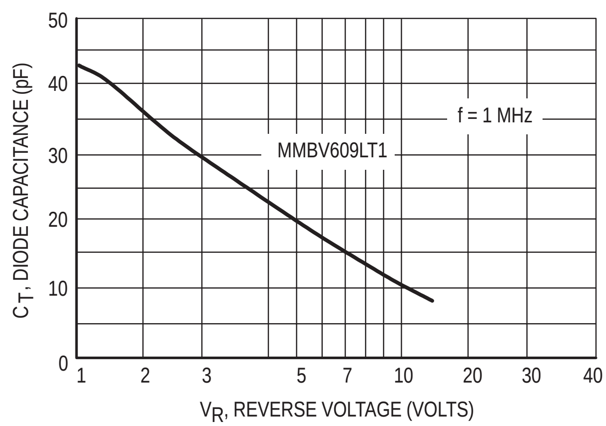


Figure 6. Diode Capacitance
Each Die

MV7005T1

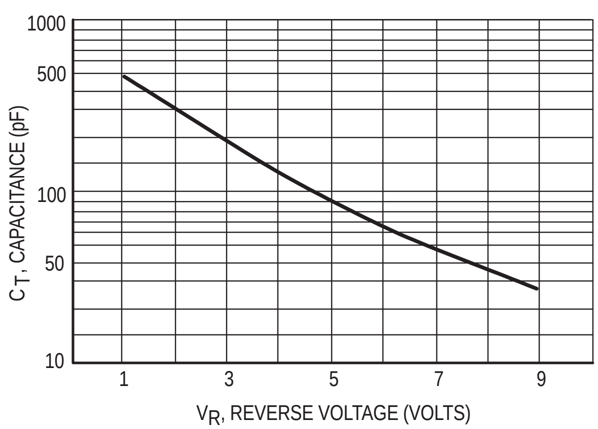


Figure 7. Capacitance versus Reverse Voltage

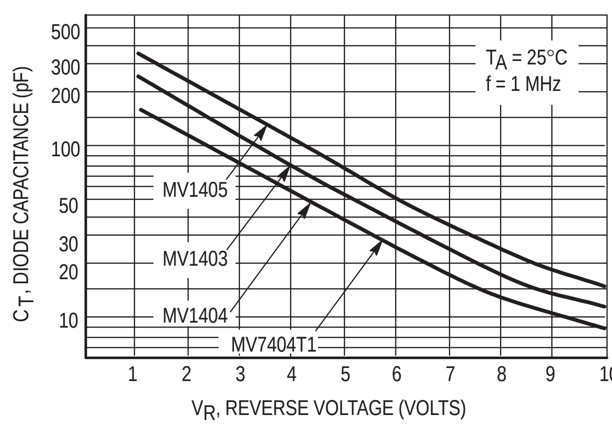


Figure 8. Diode Capacitance versus Reverse Voltage

Tuning Diodes — Hyper–Abrupt Junction (continued)

Table 40. 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 318–08 — TO–236AB (SOT–23)												
MMBV105GLT1	1.5	2.8	25	4.0	6.5	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	1.9	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
Case 419–02 — SC–70/SOT–323												
MBV109T1	26	32	3.0	5.0	6.5	3/25	200	—	30	M4A	8	—

Table 41. 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 318–08 — TO–236AB (SOT–23)												
MMBV609LT1	26	32	3.0	1.8	2.4	3/8	250	—	20	5L	9	6

Table 42. 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 43. Hyper–Abrupt High Capacitance Tuning Diodes — Axial Lead Glass Package

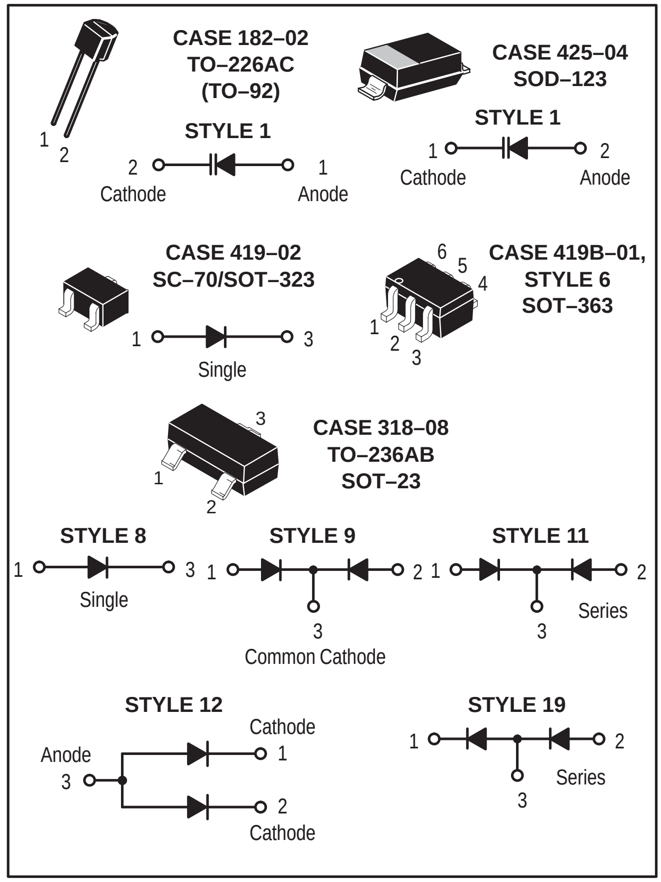
Device	C_T @ V_R pF Min	pF Max	Volts	Cap Ratio C2/C10 Min	Q 2.0 V, 1.0 MHz Min	$V_{(BR)R}$ Volts	Style	CV Curve Figure
Case 51–02 — DO–204AA (DO–7)								
MV1404	96	144	2.0	10	200	12	1	11
MV1403	140	210	2.0	10	200	12	1	11
MV1405	200	300	2.0	10	200	12	1	11

(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.

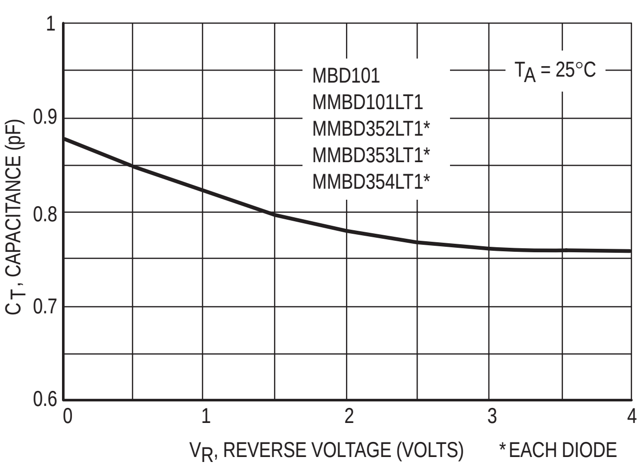
Schottky Diodes

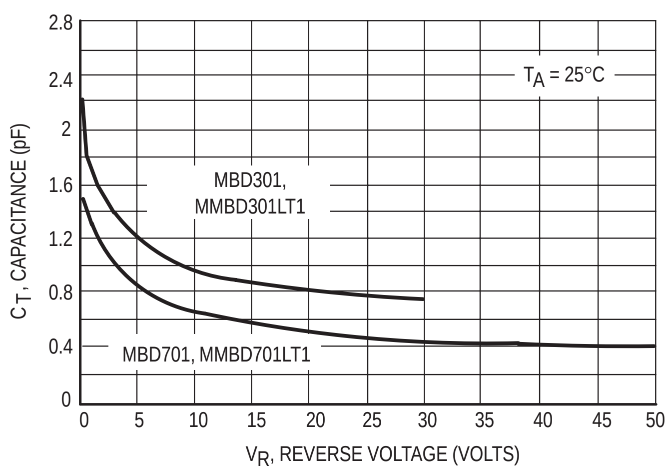
Schottky diodes are ideal for VHF and UHF mixer and detector applications as well as many higher frequency applications. They provide stable electrical characteristics by eliminating the point–contact diode presently used in many applications.



Typical Characteristics

Capacitance versus Reverse Voltage





(See Table 44)

Devices listed in bold, italic are Motorola preferred devices.

Schottky Diodes (continued)

Table 44. Schottky Diodes

The following is a listing of 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 318–08 — TO–236AB (SOT–23) – Single							
BAS40LT1	40	5.0 @ 1.0 V	0.5 @ 30 mA	1000 @ 25 V	—	B1	8
BAS40–04LT1	40	5.0 @ 1.0 V	0.5 @ 30 mA	1000 @ 25 V	—	—	12
BAS70LT1	70	2.0 @ 0 V	0.75	100 @ 50 V	—	BE	8
BAT54ALT1	30	10 @ 1.0 V	0.4	2000 @ 25 V	—	—	12
BAT54LT1	30	10 @ 1.0 V	0.4	2000 @ 25 V	—	LV3	8
BAT54SLT1	30	10 @ 1.0 V	0.4	2000 @ 25 V	—	LD3	11
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	15	4M	8
Case 318–08 — TO–236AB (SOT–23) – Dual							
BAS40–06LT1	40	5.0 @ 1.0 V	0.5 @ 30 mA	1000 @ 25 V	—	—	11
BAS70–04LT1(23)	70	2.0 @ 0 V	0.75	100 @ 50 V	—	—	12
MMBD352LT1	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	15	M5G	11
MMBD353LT1	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	15	M4F	19
MMBD354LT1	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	15	M6H	9
MMBD355LT1	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	15	MJ1	12
MMBD452LT1	30	1.5 @ 1.5 V	0.6	200 @ 25 V	15	5N	11
Case 425–04 — (SOD–123)							
BAT54T1	30	10 @ 1.0 V	0.4	2000 @ 25 V	—	—	1
MMSD701T1	70	1.0 @ 20 V	1.2	0.2 @ 35 V	15	5H	1
MMSD301T1	30	1.5 @ 15 V	0.6	0.2 @ 25 V	15	4T	1
MMSD101T1	4	1.0 @ 0 V	0.6	0.25 @ 3 V	15	4M	1
Case 419–02 — (SC–70/SOT–323) – Single							
BAT54WT1	30	10 @ 1.0 V	0.4	2000 @ 25 V	—	—	2
MMBD330T1	30	1.5 @ 15 V	0.6	0.2 @ 25 V	—	4T	2
MMBD770T1	70	1.0 @ 20 V	1.0	0.2 @ 35 V	—	5H	2
Case 419–02 — (SC–70/SOT–323) – Dual							
BAT54SWT1	30	10 @ 1.0 V	0.4	2000 @ 25 V	—	—	9
MMBD352WT1	7.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	M5	9
MMBD717LT1(23)	20	2.5 @ 1.0 V	0.37 @ 1 mA	0.2 @ 10 V	—	B3	2

(23) Common Anode

Case 419B–01 — SOT–363 – Duals

Device	Marking	$V_{(BR)R}$		I_R		V_F			C_T(30) Max (pF)	t_{rr} Max (ns)	Case Style
		Min Volts	@ I_{BR} (µA)	Max (µA)	@ V_R Volts	Min Volts	Max Volts	@ I_F (mA)			
MBD54DWT1	BL	30	10	2.0	25	—	0.32	1.0	1.0	5.0	6
MBD110DWT1	M4	7.0	10	200	25	—	0.6	1.0	1.0	—	6
MBD330DWT1	T4	30	10	200	25	—	0.4	1.0	1.5	—	6
MBD770DWT1	H5	70	10	200	25	—	0.5	1.0	1.0	—	6

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

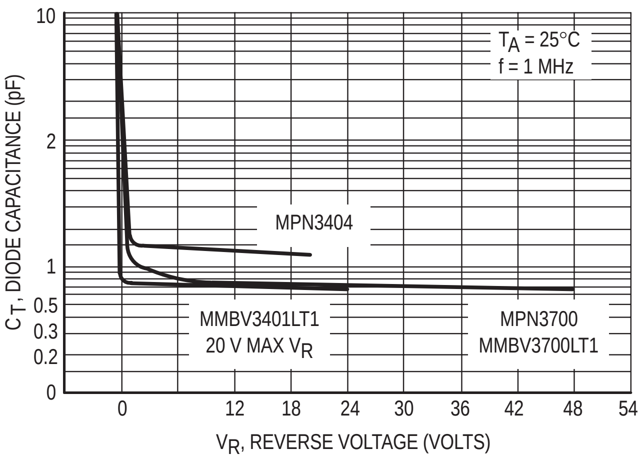
Devices listed in bold, italic are Motorola preferred devices.

Switching Diodes

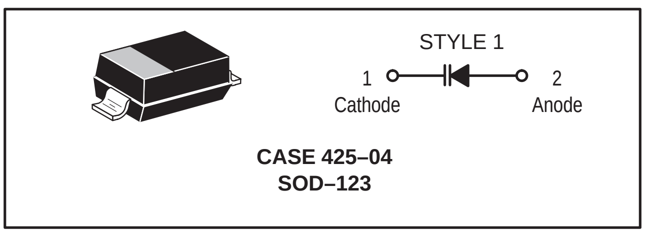
Small–signal switching diodes are intended for low current switching and steering applications. Hot–Carrier, PIN and general–purpose diodes allow a wide selection for specific application requirements.

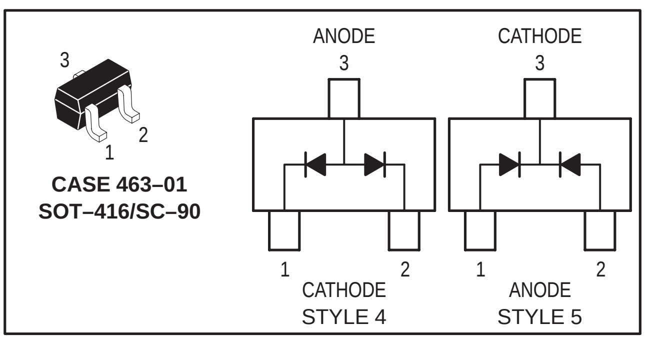
Typical Characteristics

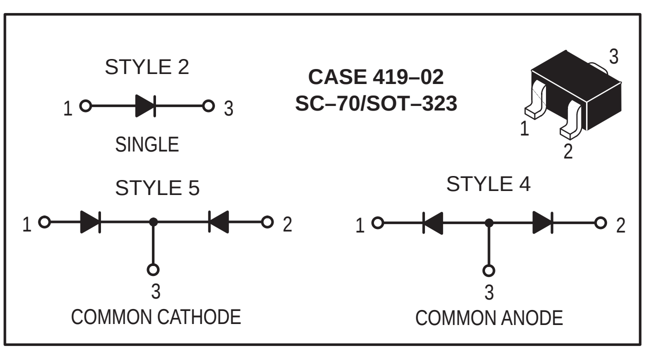
Capacitance versus Reverse Voltage

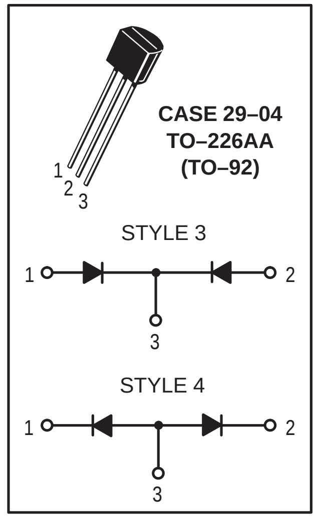


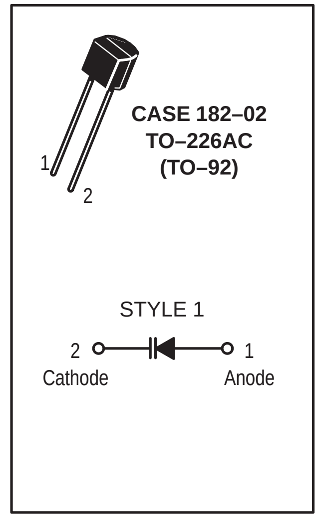
(See Table 45)

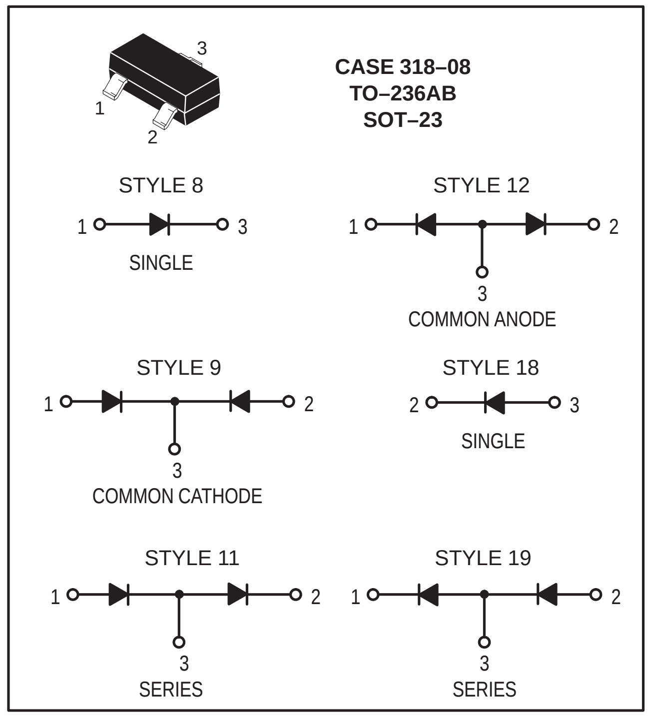


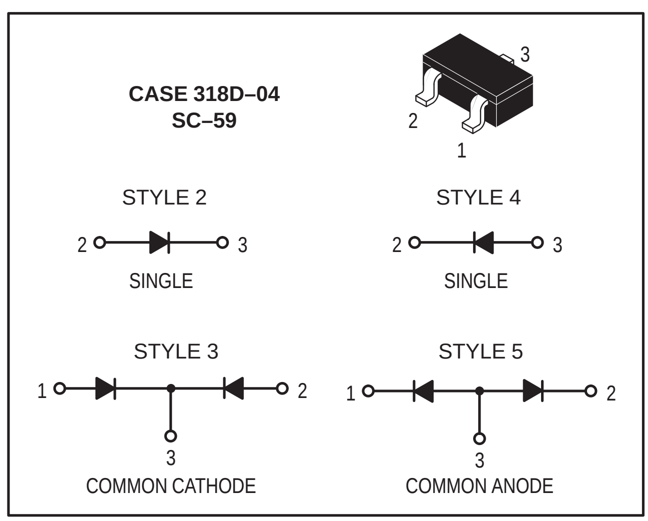












Switching Diodes (continued)

Table 45. 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 µA 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 318–08 — 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 46. 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)	Case Style
Case 318–08 — 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
Case 318D–04 — 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											
BAS16WT1	A6	75	1.0	0.02	20	—	1.25	150	2.0	6.0	2
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
M1MA174T1	J6	100	100	5.0	75	—	1.0	10	4.0	4.0	2
Case 425–04— SOD–123											
MMSD914T1	5D	100	100	5.0	75	—	1.0	10	4.0	4.0	1
MMSD71RKT1	6S	—	—	0.5	80	—	1.2	100	2.0	4.0	1

[30] V_R = 0 V, f = 1.0 MHz

Devices listed in bold, italic are Motorola preferred devices.

Switching Diodes (continued)

Table 47. 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.

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)	Case Style
Case 318–08 — TO–236AB (SOT–23)											
MMBD7000LT1	M5C	100	100	1.0	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–04 — 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											
M1MA142WKT1	MU	80	100	0.1	75	—	1.2	100	2.0	3.0	5
M1MA142WAT1	MO	80	100	0.1	75	—	1.2	100	15	10	4
BAW56WT1	A1	70	100	2.5	70	—	1.0	50	2.0	6.0	4
BAV70WT1	A4	70	100	5.0	70	—	1.0	50	1.5	6.0	5
BAV99WT1	A7	70	100	2.5	70	—	1.0	50	1.5	6.0	9
BAV99RWT1	F7	70	100	2.5	70	—	1.0	50	1.5	6.0	10
M1MA141WKT1	MT	40	100	0.1	35	—	1.2	100	2.0	3.0	5
M1MA141WAT1	MN	40	100	0.1	35	—	1.2	100	15	10	4
Case 463–01 — SOT–416/SC–90 (Common Anode)											
DAP222	P9	80	100	100	70	—	1.2	100	3.5	4.0	4
Case 463–01 — SOT–416/SC–90 (Common Cathode)											
DAN222	N9	80	100	100	70	—	1.2	100	3.5	4.0	5

Table 48. Low–Leakage Medium Speed Switching Diodes — Single

Device	Marking	$V_{(BR)R}$ Min Volts	$V_{(BR)R}$ @ I_{BR} (μA)	I_R Max (nA)	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)	Case Style
Case 318–08 — TO–236AB (SOT–23)											
BAS116LT1	JV	75	100	5.0	75	—	1.0	10	2.0	3000	8
MMBD1000LT1	AY	30	100	0.5	30	—	0.95	10	2.0	3000	6
Case 419–02 — (SOT–323)/(SC–70)											
MMBD2000T1	DH	30	100	0.5	30	—	0.95	10	2.0	3000	2
Case 318D–04 — (SC–59)											
MMBD3000T1	XP	30	100	0.5	30	—	0.95	10	2.0	3000	2
Case 425–04 — (SOD–123)											
MMSD1000T1	4K	30	100	0.5	30	—	0.95	10	2.0	3000	1

Devices listed in bold, italic are Motorola preferred devices.

Switching Diodes (continued)

Table 49. Low–Leakage Medium Speed Switching Diodes — Dual

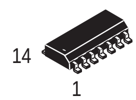
Device	Marking	$V_{(BR)R}$ Min Volts	@ I_{BR} (μA)	I_R Max (nA)	@ V_R Volts	V_F Min Volts	V_F Max Volts	@ I_F (mA)	C_T[30] Max (pF)	t_{rr} Max (ns)	Case Style
Case 318–08 — TO–236AB (SOT–23)											
BAV170LT1	JX	70	100	5.0	70	—	1.0	10	2.0	3000	9
BAV199LT1	JY	70	100	5.0	70	—	1.0	10	2.0	3000	11
BAW156LT1	JZ	70	100	5.0	70	—	1.0	10	2.0	3000	12
MMBD1005LT1	A3	30	100	0.5	30	—	0.95	10	2.0	3000	12
MMBD1010LT1	A5	30	100	0.5	30	—	0.95	10	2.0	3000	9
Case 419–02 — (SOT–323)/(SC–70) — DUAL											
MMBD2005T1	DI	30	100	0.5	30	—	0.95	10	2.0	3000	4
MMBD2010T1	DP	30	100	0.5	30	—	0.95	10	2.0	3000	5
Case 318D–04 — (SC–59) — DUAL											
MMBD3005T1	XQ	30	100	0.5	30	—	0.95	10	2.0	3000	5
MMBD3010T1	XS	30	100	0.5	30	—	0.95	10	2.0	3000	3

[30] V_R = 0 V, f = 1.0 MHz

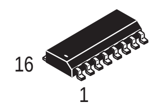
Devices listed in bold, italic are Motorola preferred devices.

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 751A–03
SO–14
PLASTIC



CASE 751B–05
SO–16
PLASTIC

Diode Array Diagrams

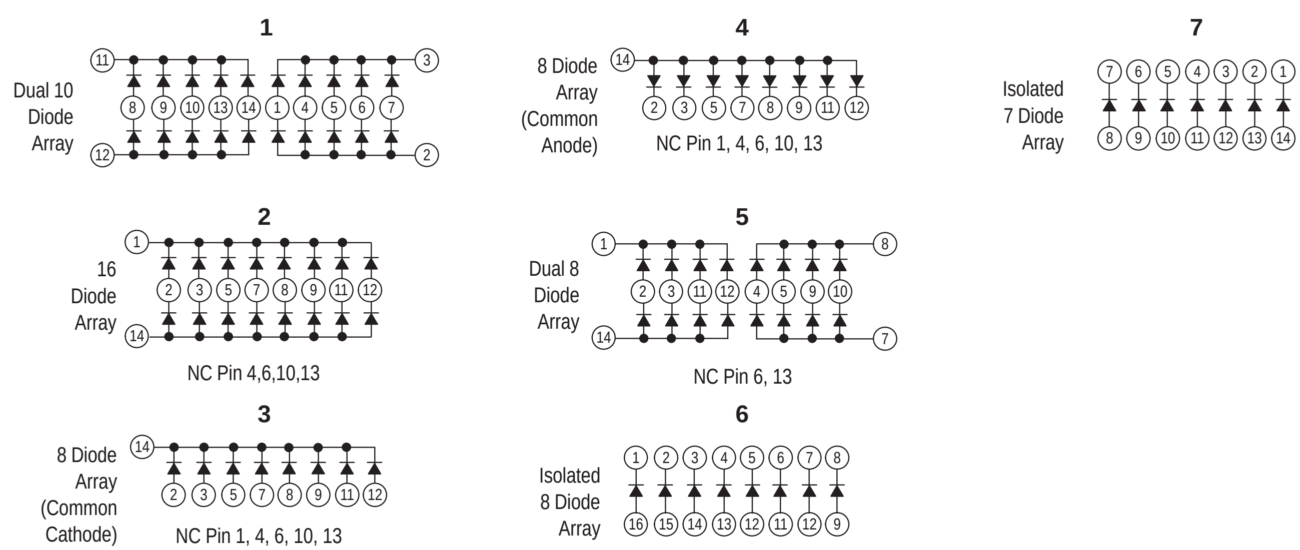


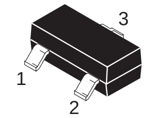
Table 50. Diode Arrays

Case 751A–03— SO–14

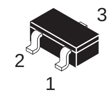
MMAD130	Dual 10 Diode Array	1
MMAD1103	16 Diode Array	2
MMAD1105	8 Diode Common Cathode Array	3
MMAD1106	8 Diode Common Anode Array	4
MMAD1107	Dual 8 Diode Array	5
MMAD1109	7 Isolated Diode Array	7

Case 751B–05 — SO–16

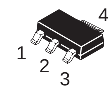
MMAD1108	8 Isolated Diode Array	6



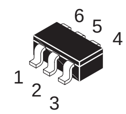
CASE 318–08
TO–236AB
SOT–23



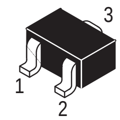
CASE 318D–04
SC–59



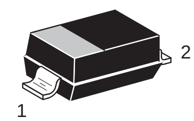
CASE 318E–04
SOT–223



CASE 318G–02
TSOP–6



CASE 419–02
SC–70/SOT–323



CASE 425–04
SOD–123

Plastic–Encapsulated Surface Mount Devices

Energy. It's something Motorola is putting a lot of energy into helping save. That's why we're introducing our GreenLine™ portfolio of devices, featuring energy–conserving traits superior to those of our existing line of standard parts for the same usage. GreenLine devices can actually help reduce the power demands of your products.

Wide Range of Applications

Currently, our portfolio consists of three families.

- **Low–Leakage Switching Diodes:** With reverse leakage specifications guaranteed to 500 pA, they help extend battery life, making them ideal for small battery–operated systems in which standby power is essential. Applications include ESD protection, reverse voltage protection, and steering logic.

- **Bipolar Output Driver Transistors:** Offering ultra–low collector saturation voltage, they deliver more energy to the intended load with less power wasted through dissipation loss. They are especially effective in today's lower voltage battery–powered applications, and prolong battery life in portable and hand–held communications and personal digital equipment.

- **Small Signal HDTMOS™:** These devices provide our lowest ever drain–source resistance versus package size. Lower $r_{DS(on)}$ means less wasted energy through dissipation loss, making them especially effective for low–current applications where energy conservation is crucial, such as low current switchmode power supplies, uninterruptable power supplies (UPS), power management systems, and bias switching. This makes them ideal for portable computer–type products or any system where the combination of power management and energy conservation is key.

Save Energy — Save Money

In an increasingly power–hungry world, Motorola's GreenLine portfolio makes powerful sense. So much sense that we plan to continue adding devices to the portfolio. Chances are, there are Motorola GreenLine devices applicable to one or more of your products — ones that can help save energy, dollars — and the environment.

Table 51. Bipolar Driver Transistor — PNP

These offer ultra–low collector saturation voltage.

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

Device Type	Marking	Case	$V_{(BR)CEO}$	$V_{CE(sat)}$	$V_{BE(sat)}$	h_{FE} @ I_C		
						Min	Max	mA
MMBT1010LT1	GLP	SOT–23	15	0.1	1.1	300	600	100
MSD1010T1	GLP	SC–59	15	0.1	1.1	300	600	100

Table 52. Low Leakage Switching Diodes

These offer reverse leakage specifications guaranteed to 500 pA. Versions available in single and dual.

Device Type	Marking	Case	Style	$V_{(BR)R}$		I_R	
				Min Volts	@ I_{BR} (μA)	Max (nA)	@ V_R Volts
MMBD1000LT1	AY	SOT–23	Single	30	100	0.5	30
MMBD1005LT1	A3	SOT–23	Dual Anode	30	100	0.5	30
MMBD1010LT1	A5	SOT–23	Dual Cathode	30	100	0.5	30
MMBD2000T1	DH	SC–70	Single	30	100	0.5	30
MMBD2005T1	DI	SC–70	Dual Anode	30	100	0.5	30
MMBD2010T1	DP	SC–70	Dual Cathode	30	100	0.5	30
MMBD3000T1	XP	SC–59	Single	30	100	0.5	30
MMBD3005T1	XQ	SC–59	Dual Anode	30	100	0.5	30
MMBD3010T1	XS	SC–59	Dual Cathode	30	100	0.5	30
MMSD1000T1	4K	SOD–123	Single	30	100	0.5	30

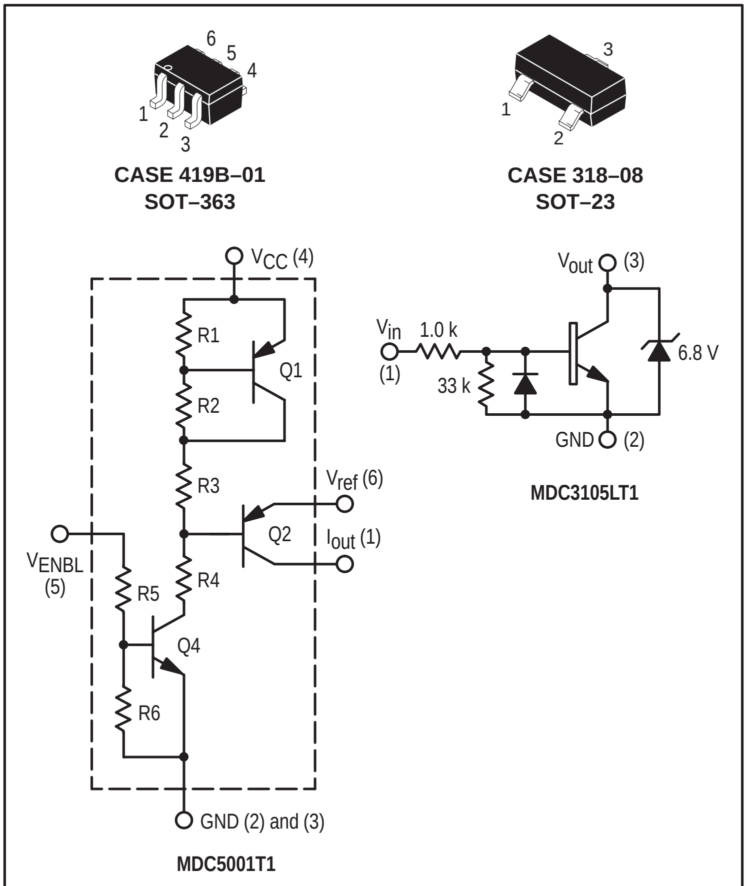
Table 53. Small Signal HDTMOS™ MOSFETs

These provide the lowest drain–source resistance versus package size.

Device Type	Marking	Channel	$R_{DS(on)}$ Ω Max			V_{DSS}	$V_{GS(th)}$		Switching Time		Style
			@V_{gs1} (10 V)	@V_{gs2} (4.5 V)	@V_{gs3} (2.5 V)		Volts Min	Volts Max	$t_{(on)}$ ns	$t_{(off)}$ ns	
Case 318–08 — TO–236AB (SOT–23) — P–Channel and N–Channel											
2N7002LT1	702	N	7.5	—	—	60	1.0	2.5	—	—	21
BSS84LT1	PD	P	—	10	—	50	0.8	2.0	2.5	16	21
BSS123LT1	SA	N	6.0	—	—	100	0.8	2.8	20	40	21
BSS138LT1	J1	N	—	3.5	—	50	0.5	1.5	20	20	21
MMBF0201NLT1	N1	N	1.0	1.4	—	20	1.0	2.4	2.5	15	21
MMBF0202PLT1	P3	P	1.4	3.5	—	20	1.0	2.4	2.5	16	21
MGSF1N02LT1	—	N	0.085	0.125	—	20	1.0	2.4	2.5	16	21
MGSF1N03LT1	—	N	0.10	0.145	—	30	1.0	2.4	2.5	16	21
MGSF1P02LT1	—	P	3.5	0.5	—	20	1.0	2.4	2.5	16	21
MGSF1P02ELT1	—	P	0.16	0.21	—	20	0.7	1.2	2.5	15	21
Case 318G–02 — TSOP–6 — P–Channel and N–Channel											
MGSF3441VT1	—	P	—	0.10	0.135	20	0.45	—	27	52	1
MGSF3441XT1	—	P	—	0.10	0.135	20	0.45	—	27	52	1
MGSF3442VT1	—	N	—	0.07	0.095	20	0.6	—	8.0	36	1
MGSF3442XT1	—	N	—	0.07	0.095	20	0.6	—	8.0	36	1
MGSF3454VT1	—	N	0.065	0.095	—	30	1.0	—	10	20	1
MGSF3454XT1	—	N	0.065	0.095	—	30	1.0	—	10	20	1
MGSF3455VT1	—	P	0.10	0.19	—	30	1.0	—	10	20	1
MGSF3455XT1	—	P	0.10	0.19	—	30	1.0	—	10	20	1
Case 419–02 — SC–70/SOT–323											
MMBF2202PT1	P3	P	2.2	3.5	—	20	1.0	2.4	2.5	16	7
MMBF2201NT1	N1	N	1.0	1.4	—	20	1.0	2.4	2.5	15	7

Devices listed in bold, italic are Motorola preferred devices.

Small Signal Multi–integrated Devices



INTERNAL CIRCUIT DIAGRAMS

Table 54. Low Voltage Bias Stabilizer

A silicon SMALLBLOCK™ integrated circuit which maintains stable bias current in various discrete bipolar junction and field effect transistors.

Device Type	Marking	V_{CC} (Volts)		I_{CC} µA	V_{ref} Volts	ΔV_{ref} Volts
		Min	Max			
Case 419B–01 — SOT–363						
MDC5001T1	E6	1.8	10	200	2.1	±50

Table 55. Integrated Relay/Solenoid Driver

Monolithic circuit block to switch 3.0 V to 5.0 V relays. It is intended to replace an array of three to six discrete components.

Device Type	V_{CC} (Volts)		V_{in} (Volts)		V_{sat} (Volts)	I_{in} (mA)	$I_{C(on)}$ (mA)
	Min	Max	Min	Max			
Case 318–08 — SOT–23							
MDC3105LT1	2.0	5.5	2.0	5.5	0.4	2.5	250

Devices listed in bold, italic are Motorola preferred devices.

Section 2

Plastic-Encapsulated Transistors

In Brief . . .

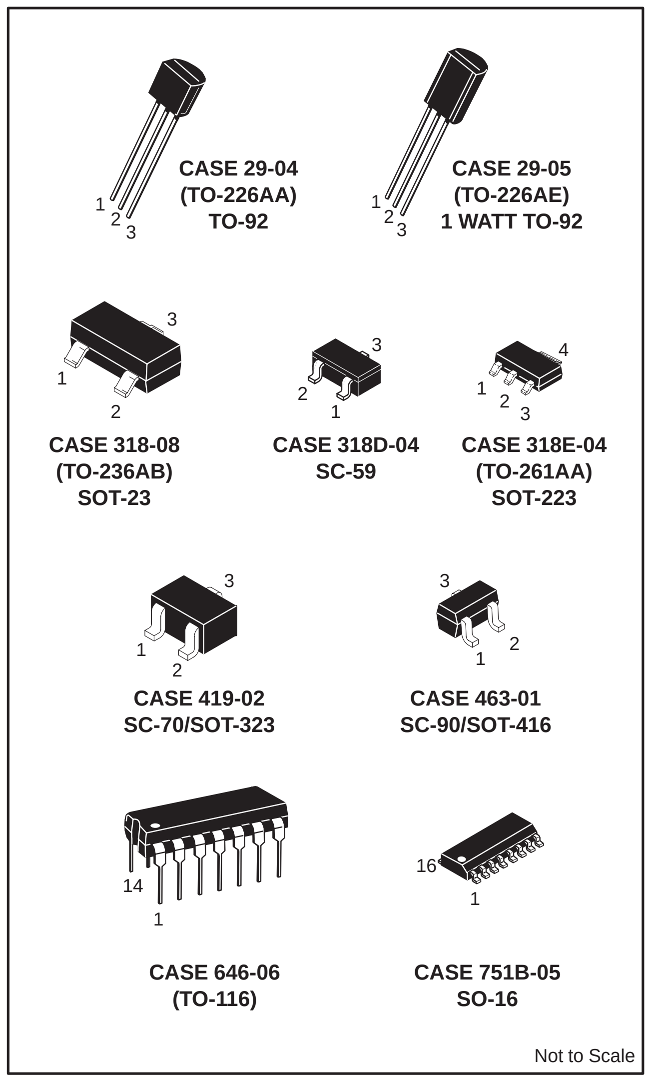
Motorola's plastic transistors and diodes encompass hundreds of devices spanning the gamut from general-purpose amplifiers and switches with a wide variety of characteristics to dedicated special-purpose devices for the most demanding applications. The popular TO-92, 1-Watt TO-92 and TO-116 combine proven reliability performance and economy for through-the-hole manufacturing, while the SOT-23, SC-59, SC-70/SOT-323, SC–90/SOT–416, 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.

This 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, SC–90/SOT–416, 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 6 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 6 on Packaging for Style code characters and additional information on ordering requirements.

DEVICE MARKINGS/DATE CODE CHARACTERS

SOT-23, SC-59, SC-70/SOT-323, and the SC–90/SOT–416 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

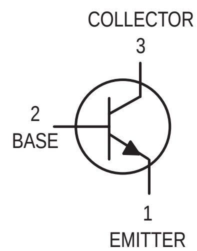
The “D” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

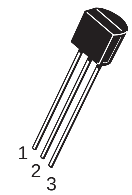
General Purpose Transistors

NPN Silicon

2N3903
2N3904*

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	40	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS(1)

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)	$V_{(BR)CEO}$	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

1. Indicates Data in addition to JEDEC Requirements.
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

REV 2

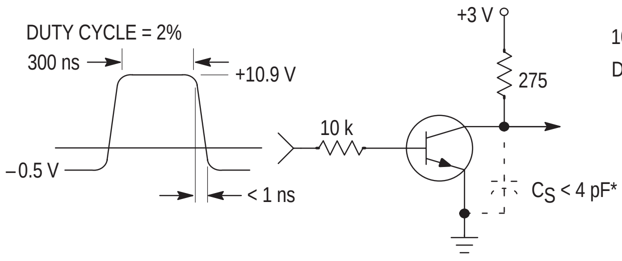
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

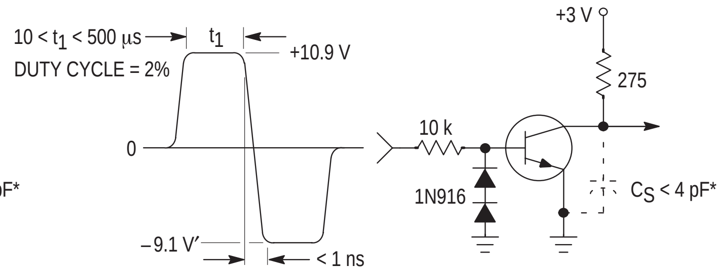
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3903		20	—	
	2N3904		40	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3903		35	—	
	2N3904		70	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3903		50	150	
	2N3904		100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3903		30	—	
	2N3904		60	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3903		15	—	
	2N3904		30	—	
Collector–Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc			—	0.3	
Base–Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.95	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3903		250	—	
	2N3904		300	—	
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		h_{ie}			k Ω
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903		1.0	8.0	
	2N3904		1.0	10	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903		0.1	5.0	
	2N3904		0.5	8.0	
Small–Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903		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		NF			dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k Ω, f = 1.0 kHz)	2N3903		—	6.0	
	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%.





* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

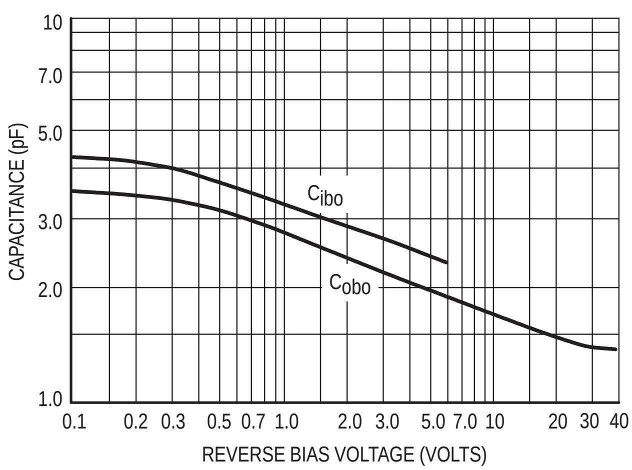


Figure 3. Capacitance

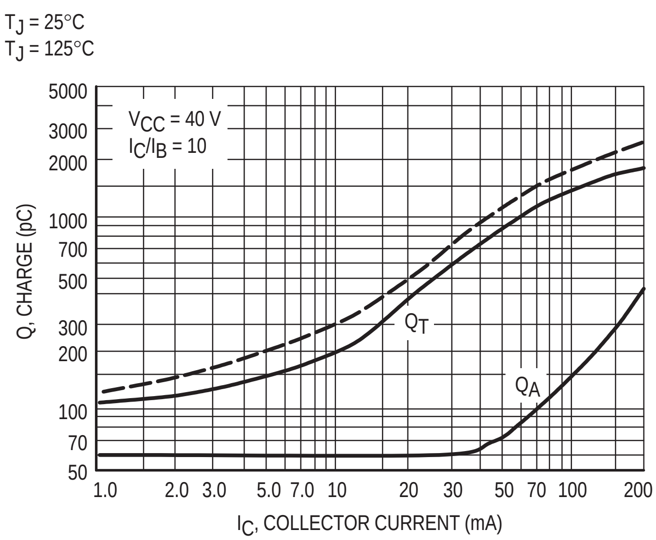


Figure 4. Charge Data

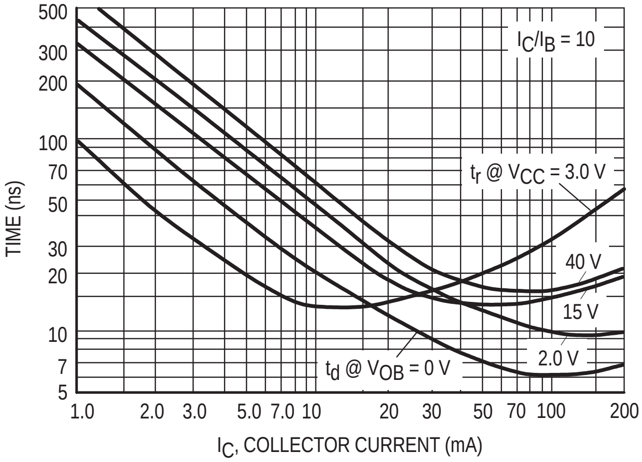


Figure 5. Turn–On Time

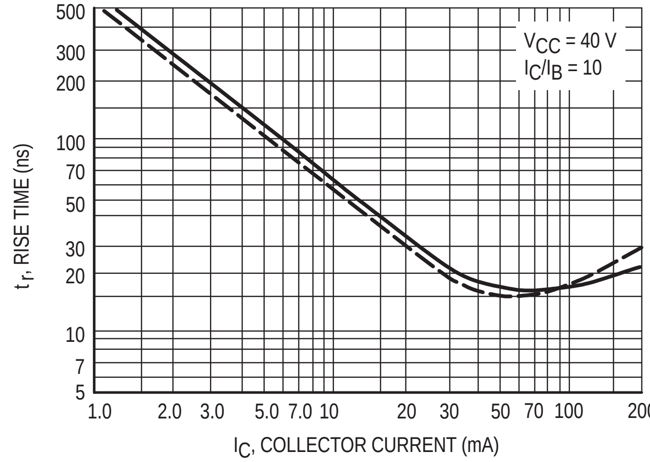


Figure 6. Rise Time

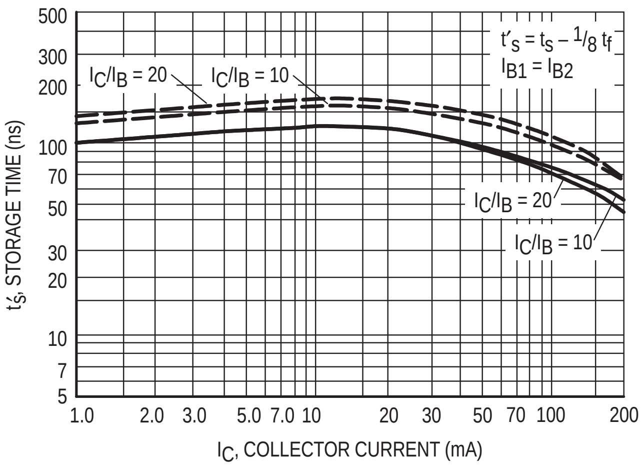


Figure 7. Storage Time

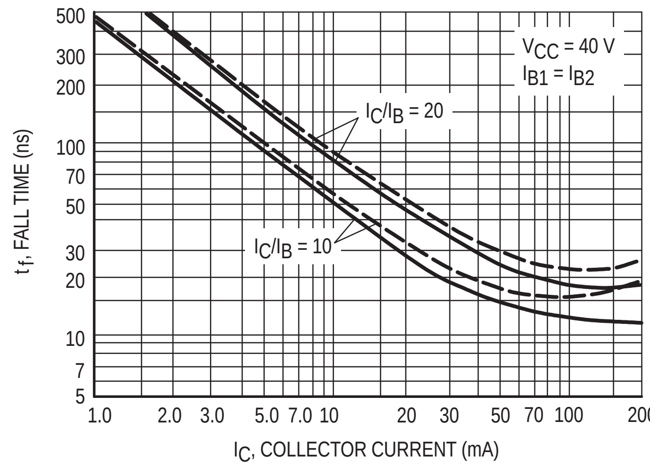


Figure 8. Fall Time

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

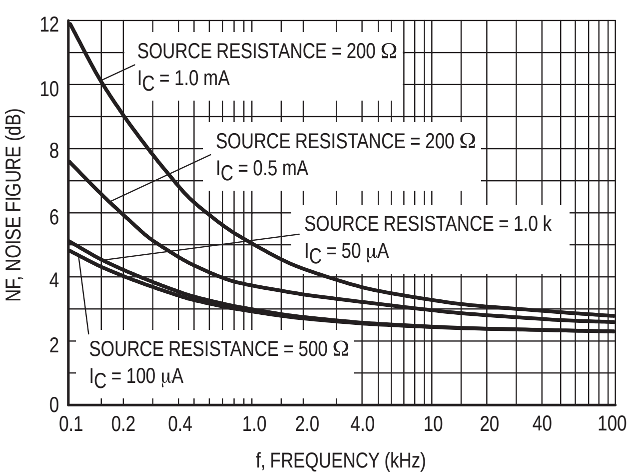


Figure 9.

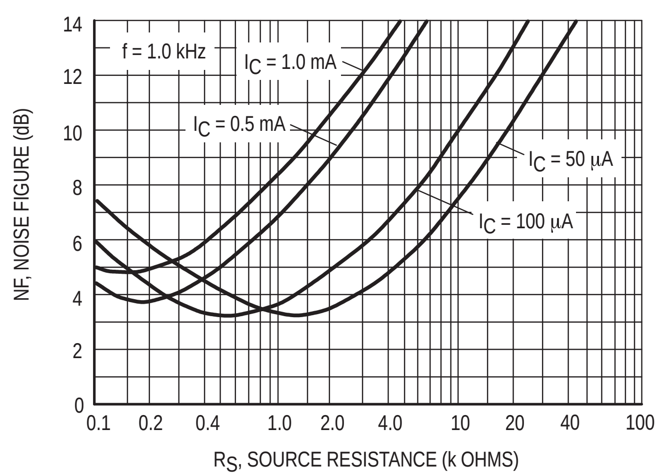


Figure 10.

h PARAMETERS

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

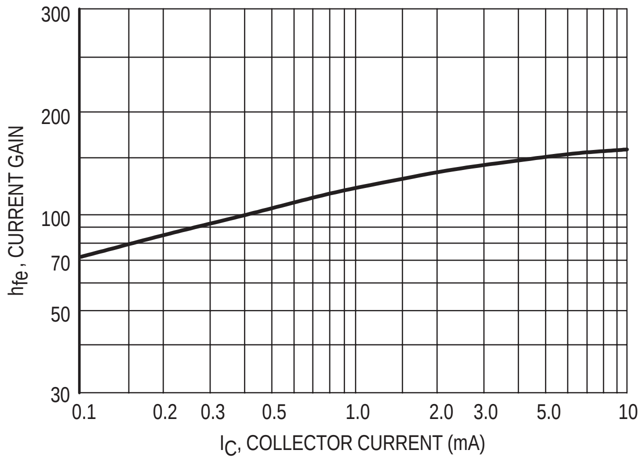


Figure 11. Current Gain

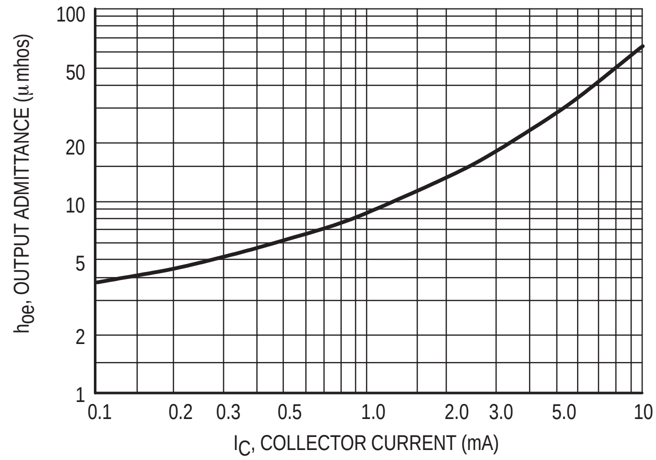


Figure 12. Output Admittance

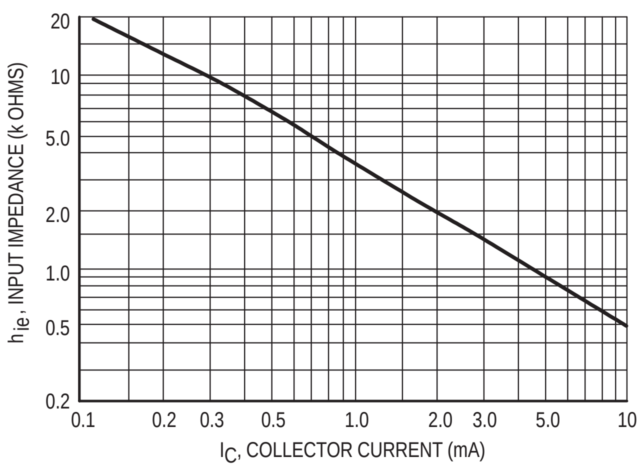


Figure 13. Input Impedance

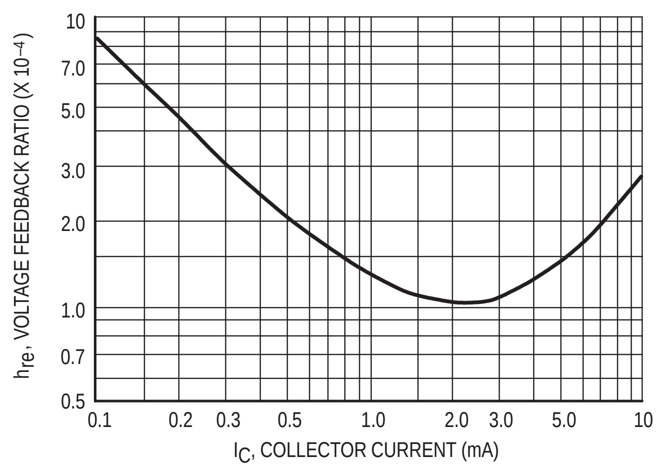


Figure 14. Voltage Feedback Ratio

TYPICAL STATIC CHARACTERISTICS

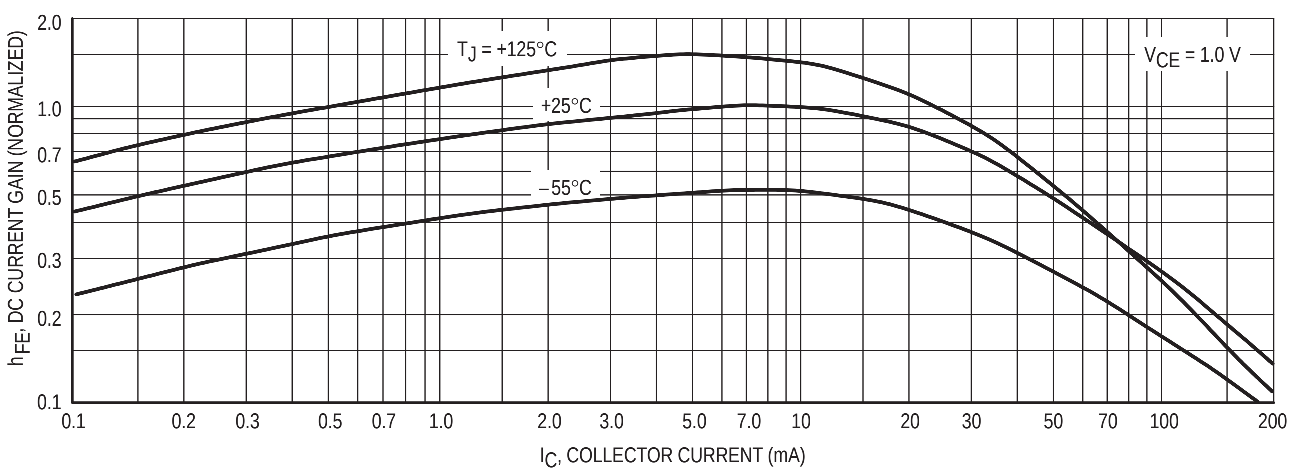


Figure 15. DC Current Gain

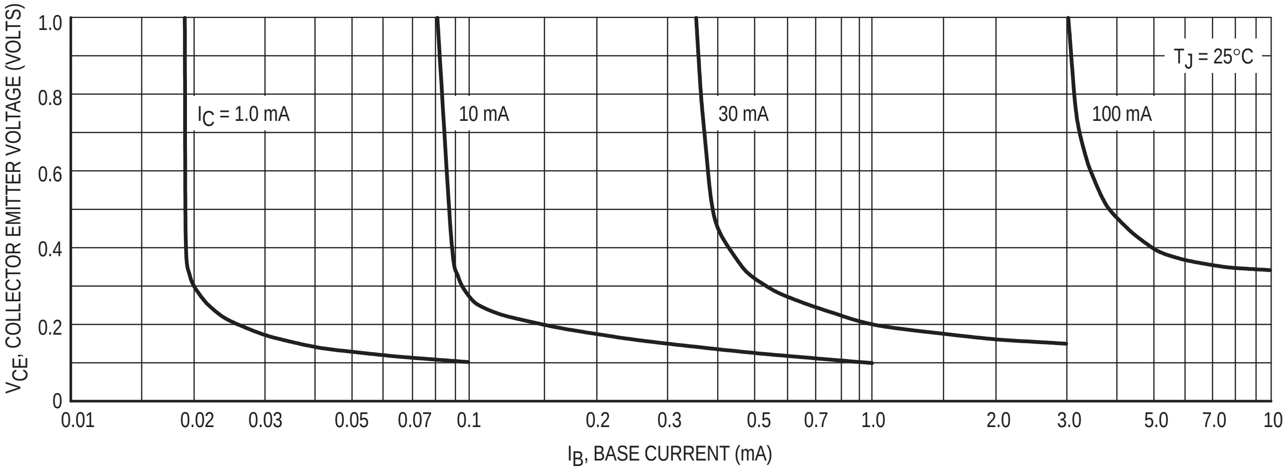


Figure 16. Collector Saturation Region

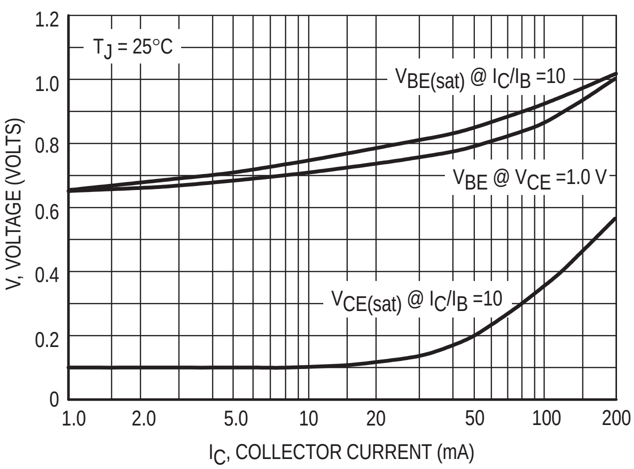


Figure 17. "ON" Voltages

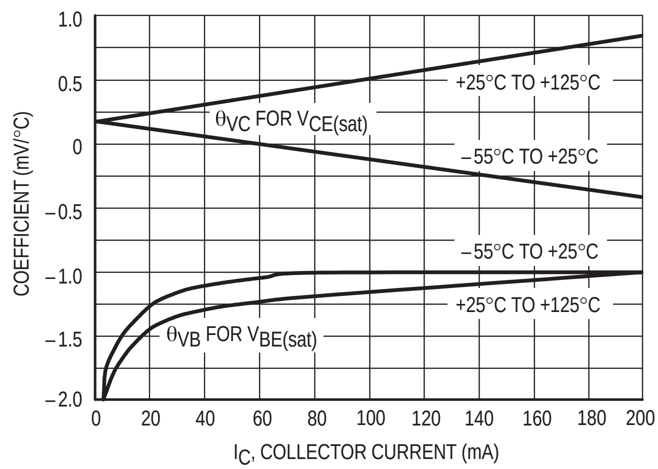


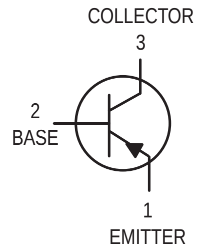
Figure 18. Temperature Coefficients

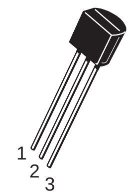
General Purpose Transistors

PNP Silicon

2N3905
2N3906*

*Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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(1)

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)	$V_{(BR)CEO}$	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

1. Indicates Data in addition to JEDEC Requirements.
2. Pulse Test: Pulse Width $\leq$ 300 μs; Duty Cycle $\leq$ 2.0%.

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

REV 2

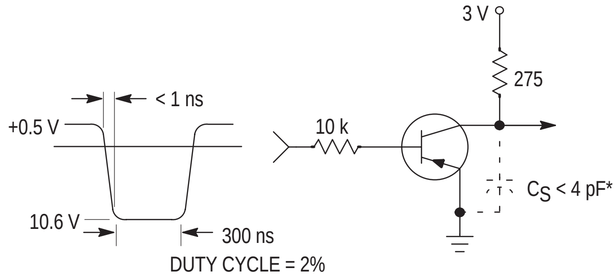
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

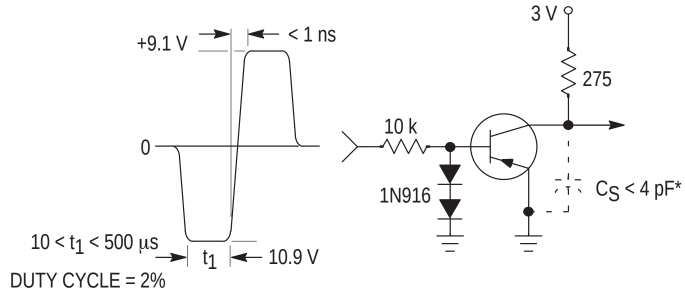
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3905		30	—	
	2N3906		60	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3905		40	—	
	2N3906		80	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3905		50	150	
	2N3906		100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3905		30	—	
	2N3906		60	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3905		15	—	
	2N3906		30	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	0.25	
(I_C = 50 mAdc, I_B = 5.0 mAdc			—	0.4	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.95	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3905		200	—	
	2N3906		250	—	
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		h_{ie}			k Ω
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905		0.5	8.0	
	2N3906		2.0	12	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905		0.1	5.0	
	2N3906		0.1	10	
Small–Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905		50	200	
	2N3906		100	400	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905		1.0	40	
	2N3906		3.0	60	
Noise Figure		NF			dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k Ω, f = 1.0 kHz)	2N3905		—	5.0	
	2N3906		—	4.0	

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 mAd	2N3905	t_s	—	200	ns
		2N3906		—	225	
Fall Time		2N3905	t_f	—	60	ns
		2N3906		—	75	

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.



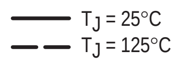


* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS



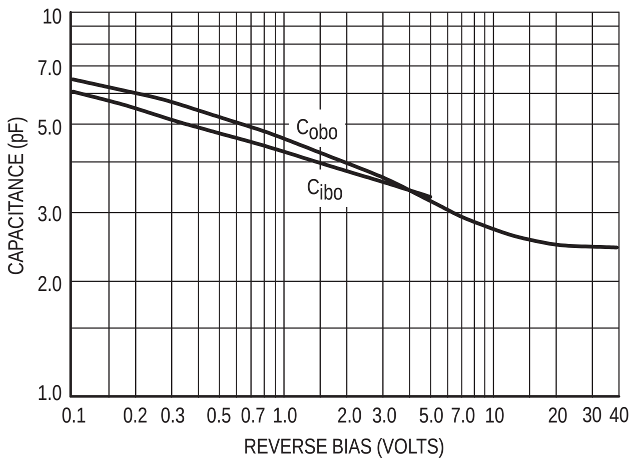


Figure 3. Capacitance

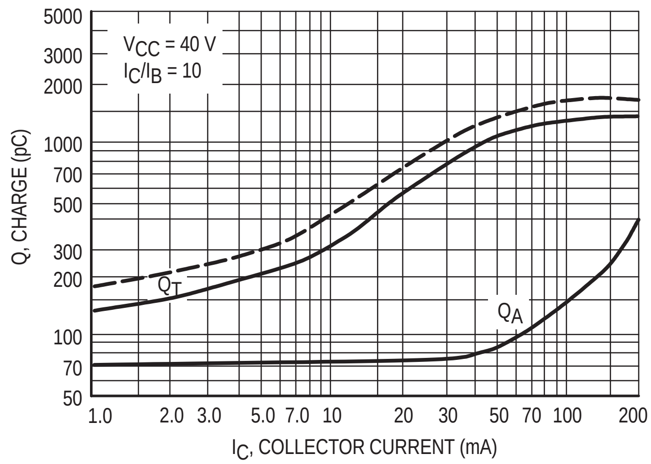


Figure 4. Charge Data

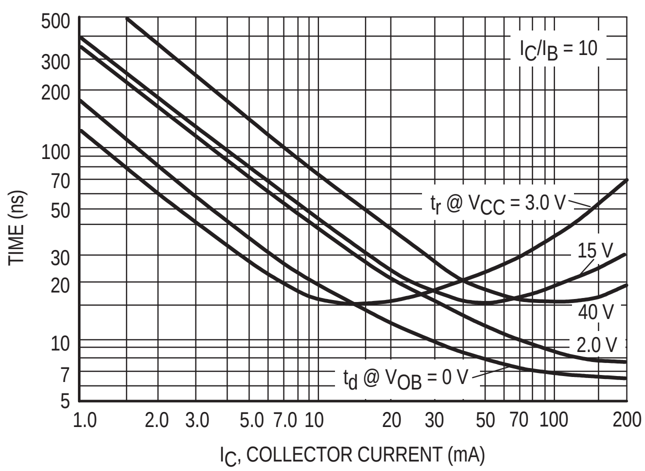


Figure 5. Turn–On Time

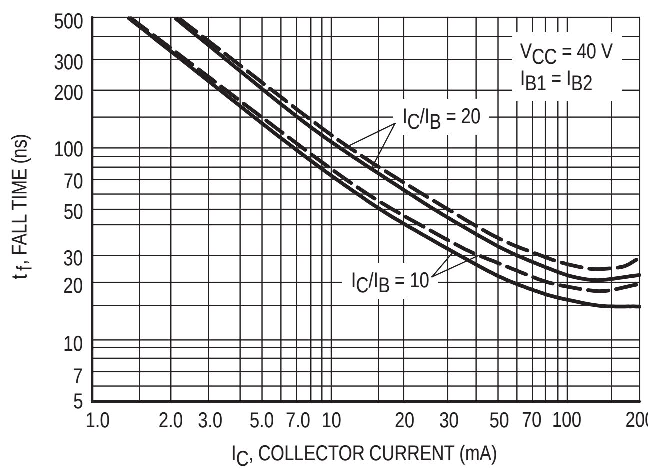


Figure 6. Fall Time

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

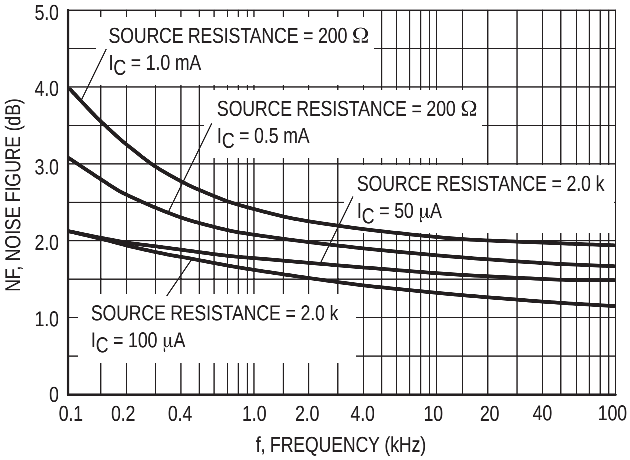


Figure 7.

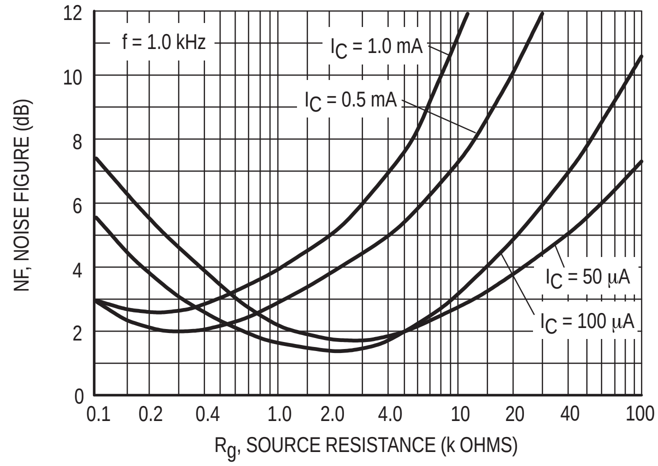


Figure 8.

h PARAMETERS

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

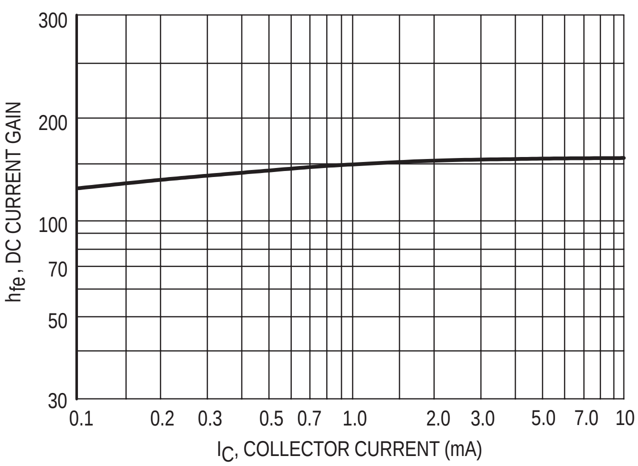


Figure 9. Current Gain

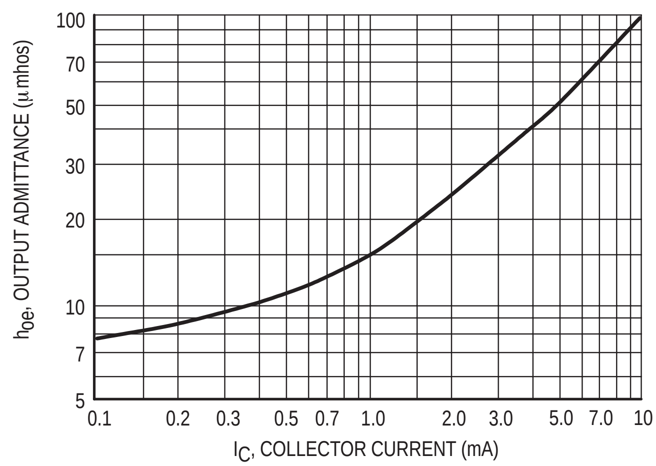


Figure 10. Output Admittance

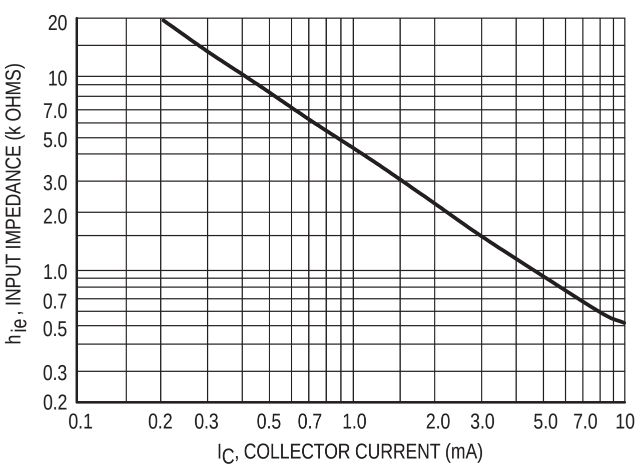


Figure 11. Input Impedance

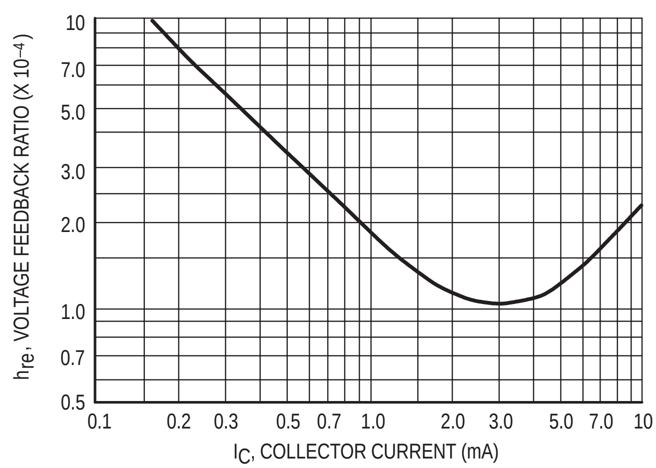


Figure 12. Voltage Feedback Ratio

TYPICAL STATIC CHARACTERISTICS

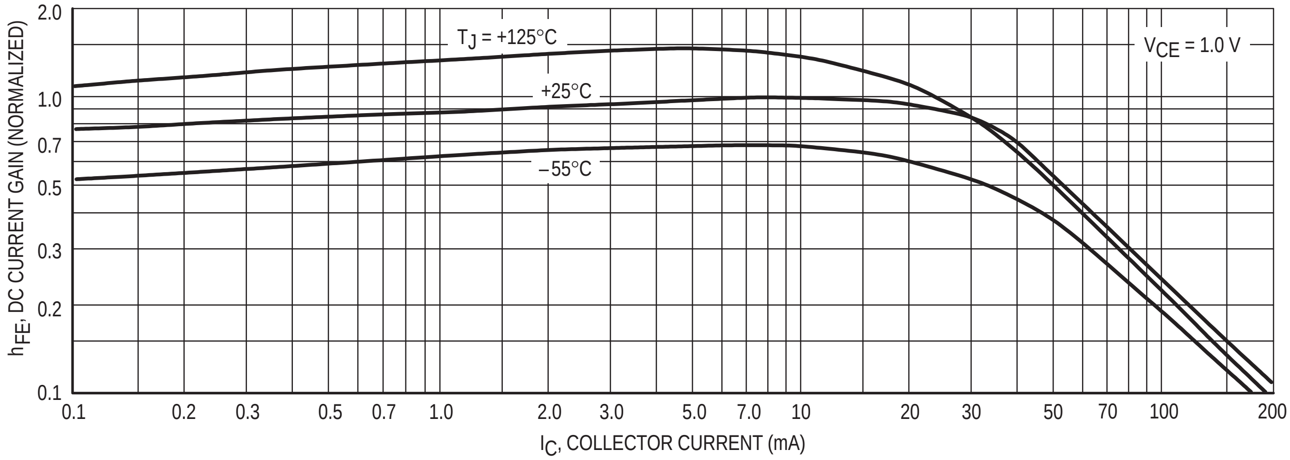


Figure 13. DC Current Gain

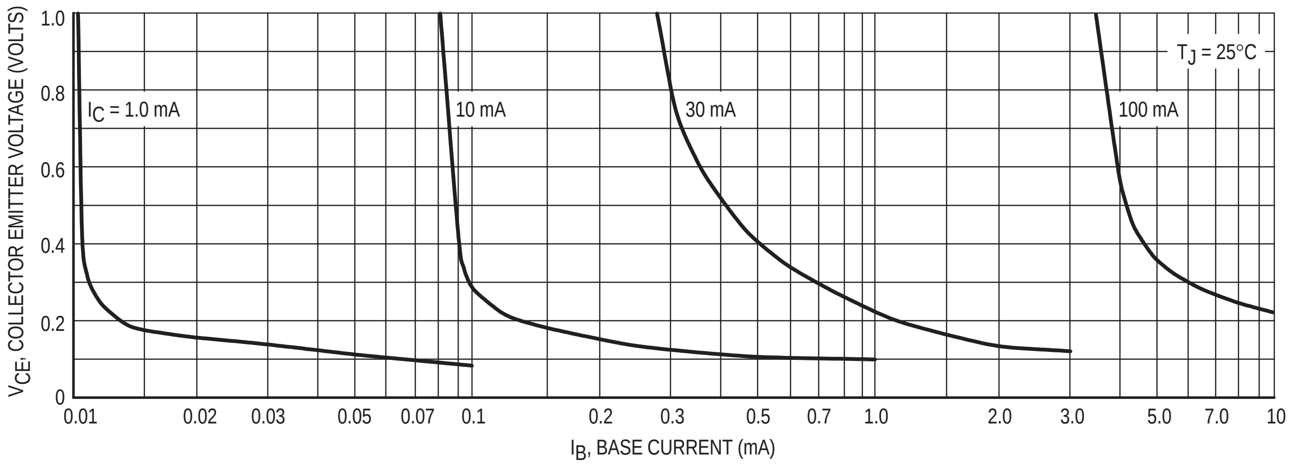


Figure 14. Collector Saturation Region

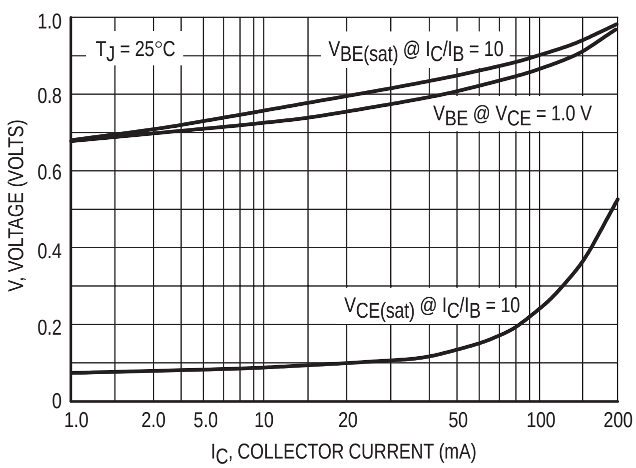


Figure 15. "ON" Voltages

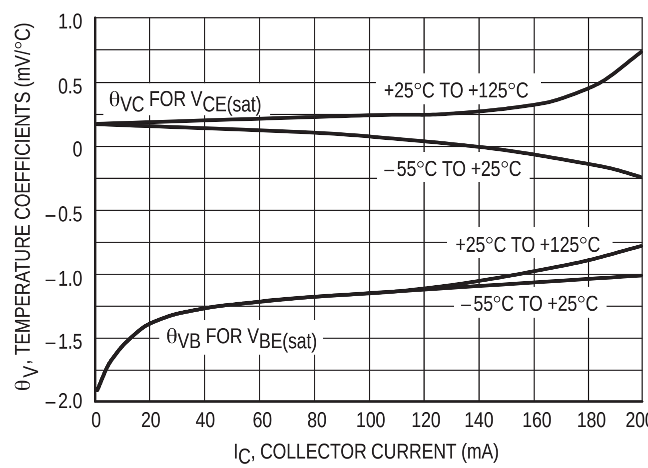
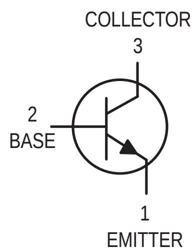


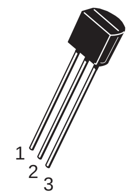
Figure 16. Temperature Coefficients

General Purpose Transistors

NPN Silicon

2N4123
2N4124





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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		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_E = 0)	 2N4123 2N4124	$V_{(BR)CEO}$	 30 25	 — —	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N4123 2N4124	$V_{(BR)CBO}$	 40 30	 — —	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
(I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc)	2N4123		50	150	
	2N4124		120	360	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N4123		25	—	
	2N4124		60	—	
Collector–Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base–Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	—	0.95	Vdc
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123		250	—	
	2N4124		300	—	
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		h_{fe}			—
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 10 k ohm, f = 1.0 kHz)	2N4123		50	200	
	2N4124		120	480	
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%.

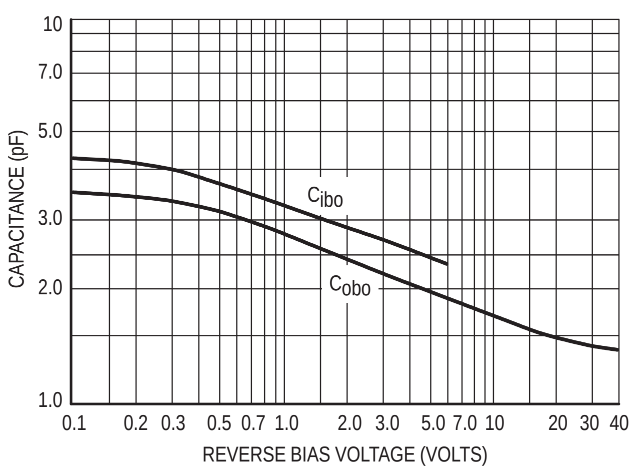


Figure 1. Capacitance

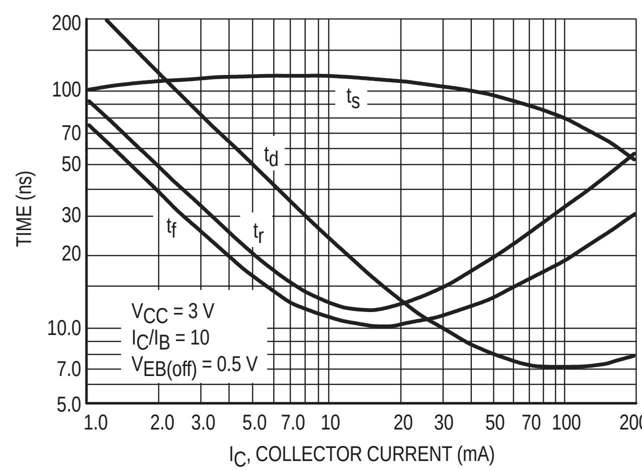


Figure 2. Switching Times

AUDIO SMALL–SIGNAL CHARACTERISTICS

NOISE FIGURE

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

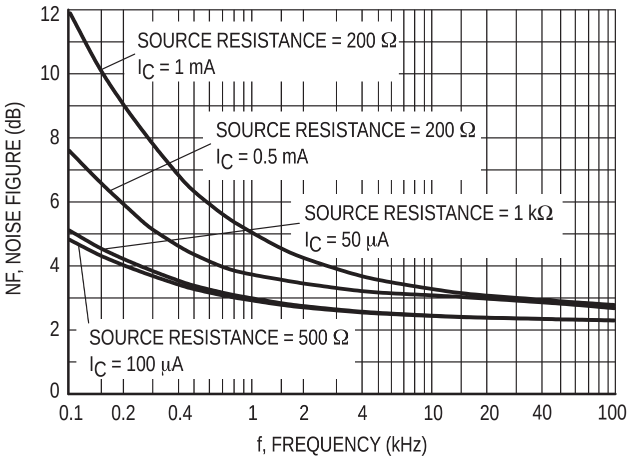


Figure 3. Frequency Variations

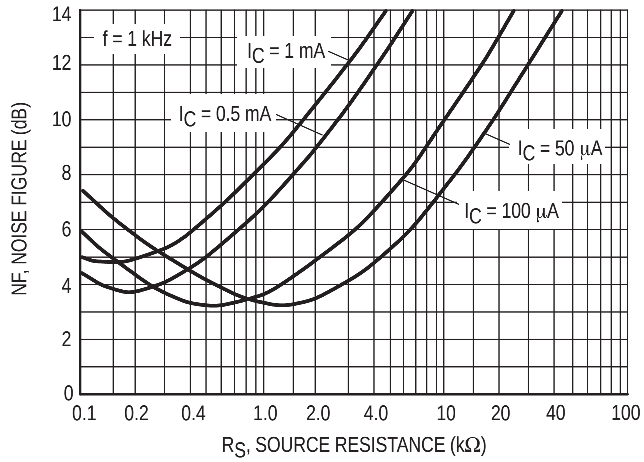


Figure 4. Source Resistance

h PARAMETERS

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

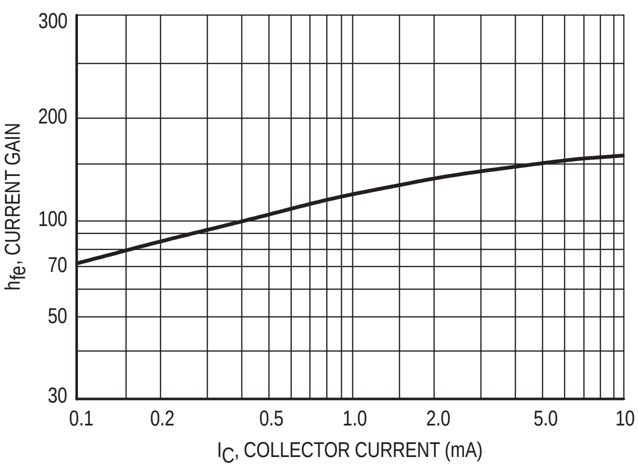


Figure 5. Current Gain

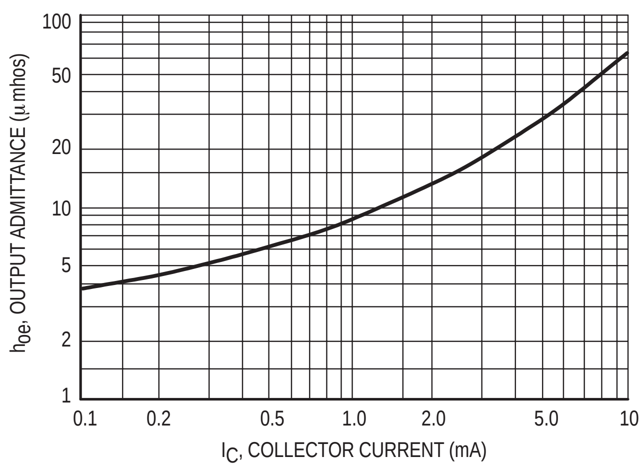


Figure 6. Output Admittance

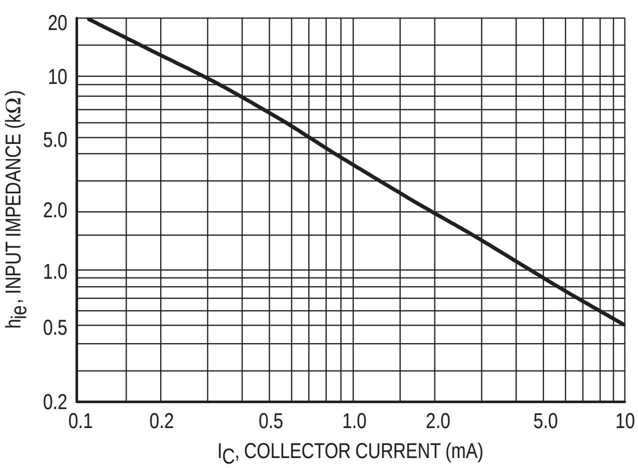


Figure 7. Input Impedance

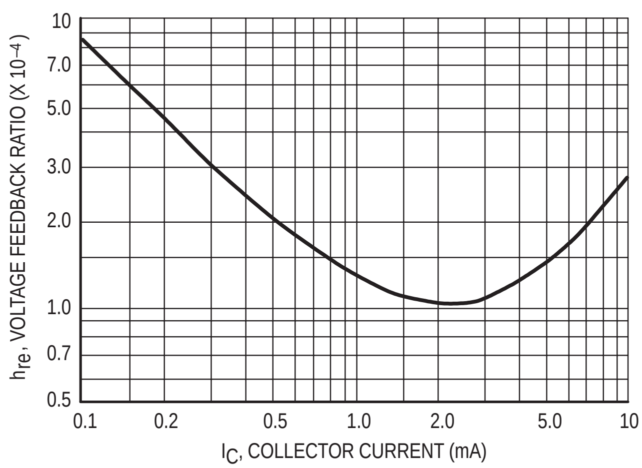


Figure 8. Voltage Feedback Ratio

STATIC CHARACTERISTICS

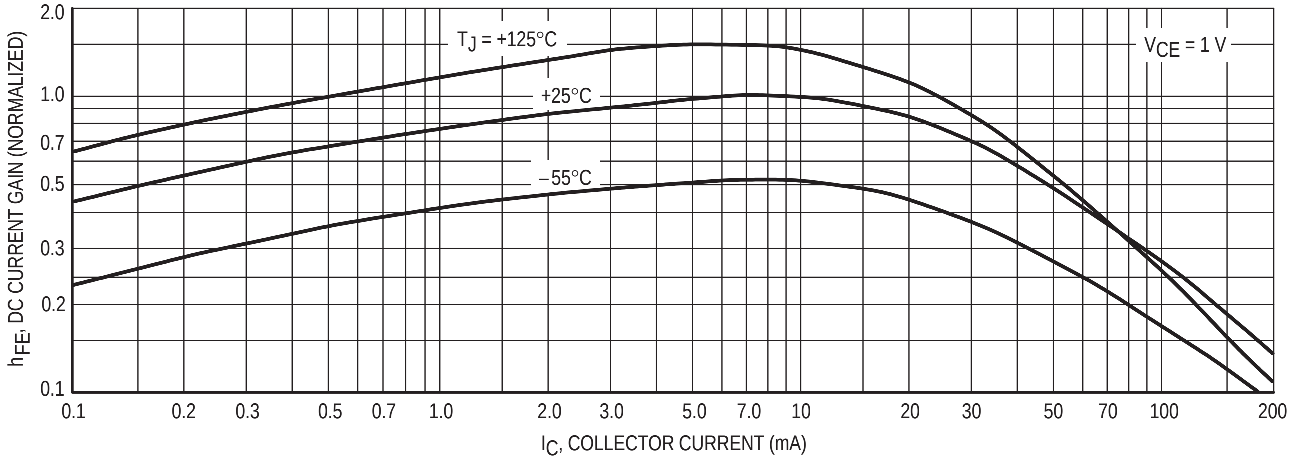


Figure 9. DC Current Gain

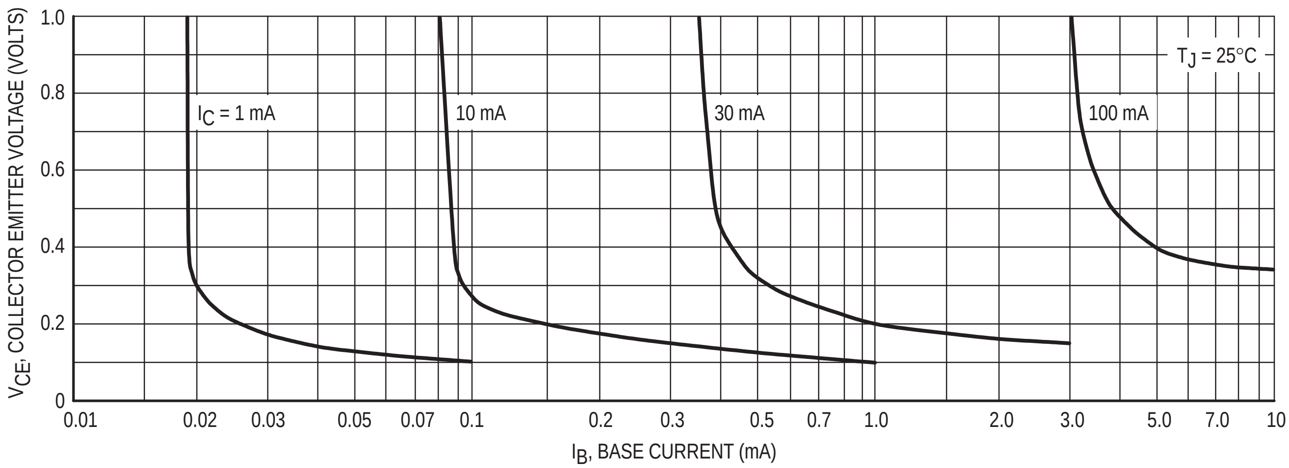


Figure 10. Collector Saturation Region

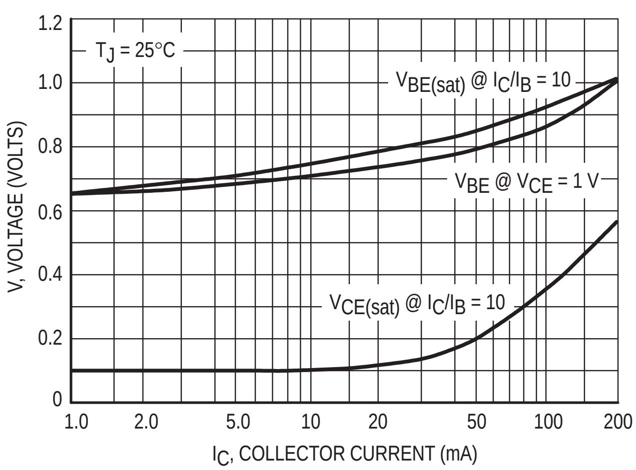


Figure 11. “On” Voltages

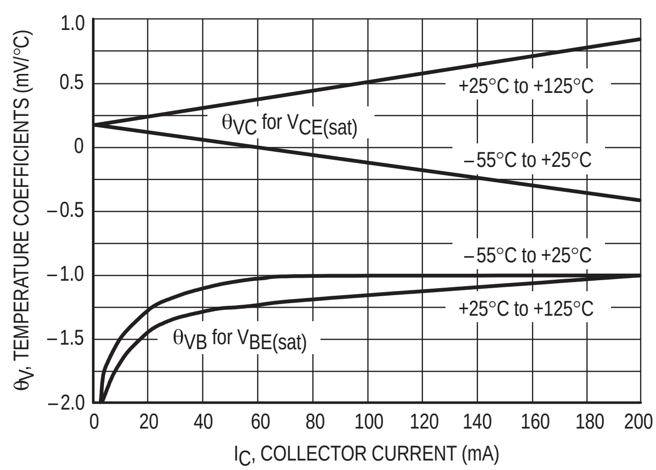
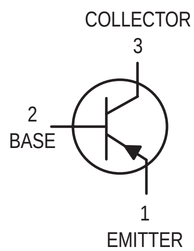
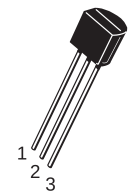


Figure 12. Temperature Coefficients

Amplifier Transistor
PNP Silicon

2N4125





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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
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)	$V_{(BR)CEO}$	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

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

REV 2

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

Characteristic	Symbol	Min	Max	Unit
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)	h_{FE}	50 25	150 —	—
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)	f_T	200	—	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 Vdc, 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)	h_{fe}	50	200	—
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	$\|h_{fe}\|$	2.0	—	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)	NF	—	5.0	dB

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

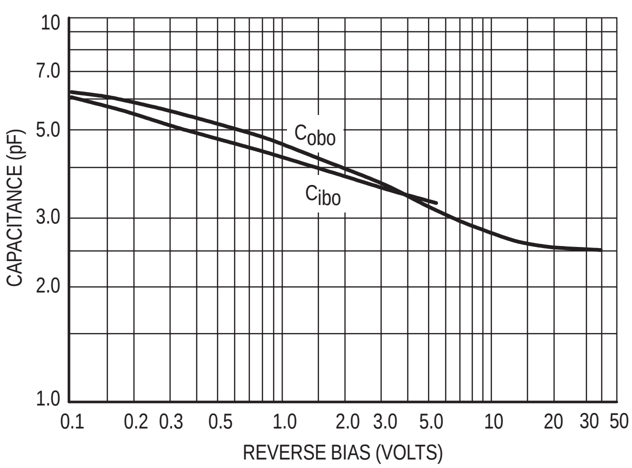


Figure 1. Capacitance

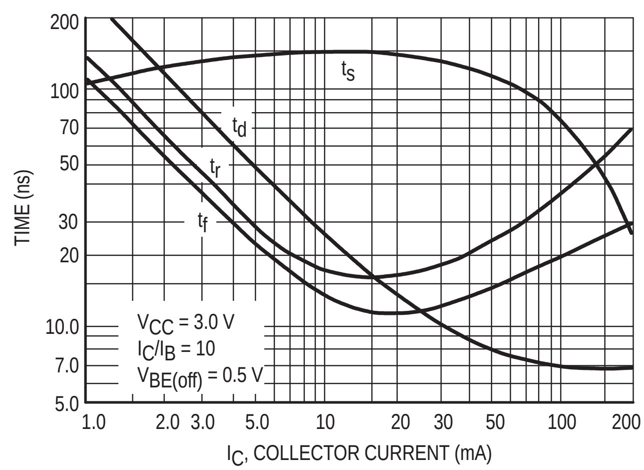


Figure 2. Switching Times

AUDIO SMALL–SIGNAL CHARACTERISTICS

NOISE FIGURE

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

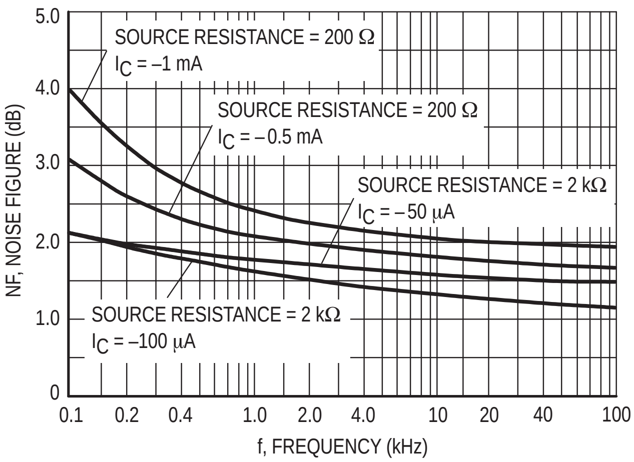


Figure 3. Frequency Variations

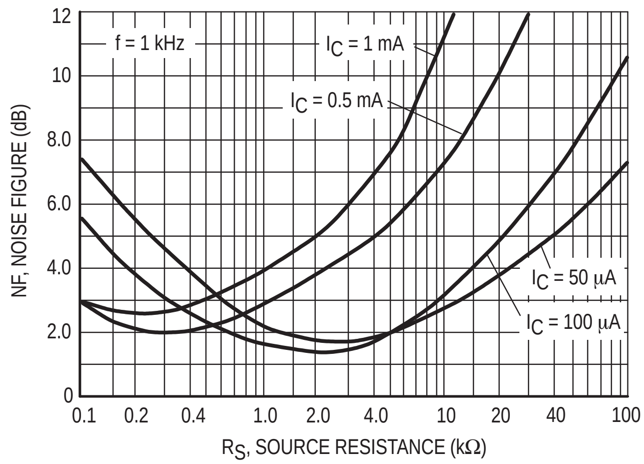


Figure 4. Source Resistance

h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

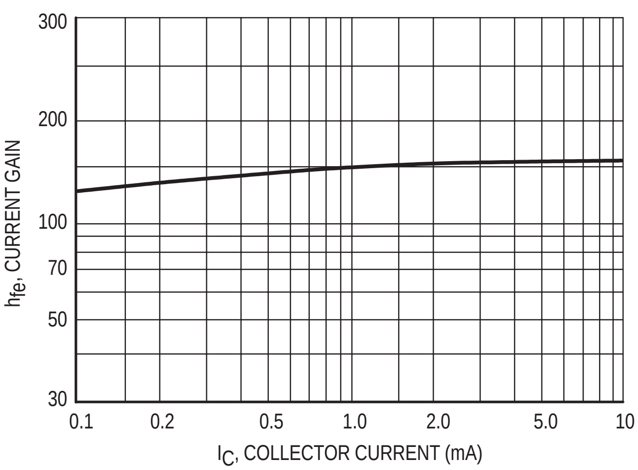


Figure 5. Current Gain

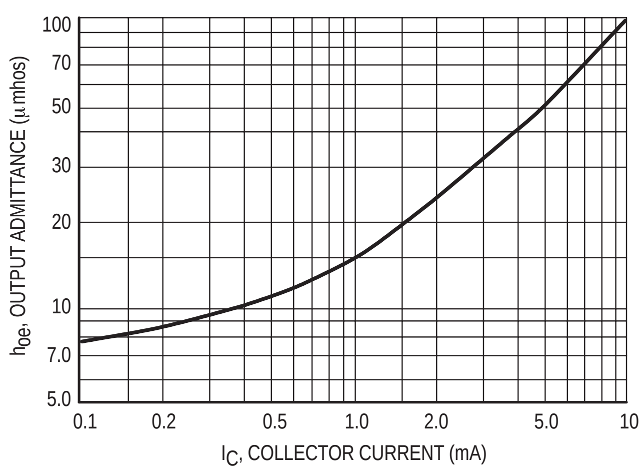


Figure 6. Output Admittance

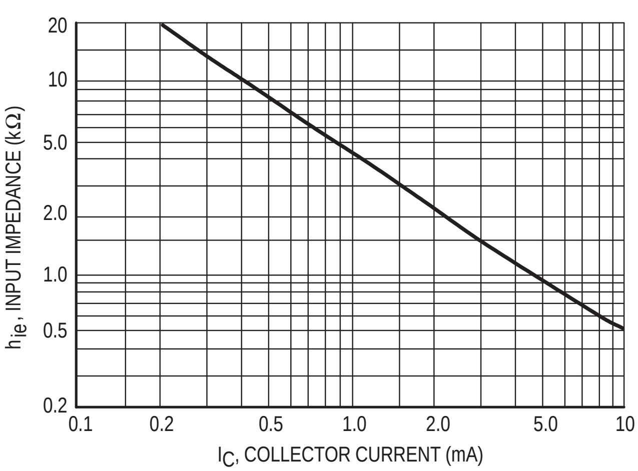


Figure 7. Input Impedance

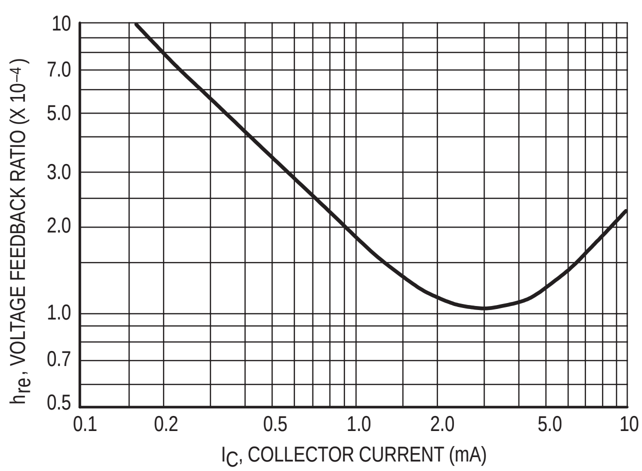


Figure 8. Voltage Feedback Ratio

STATIC CHARACTERISTICS

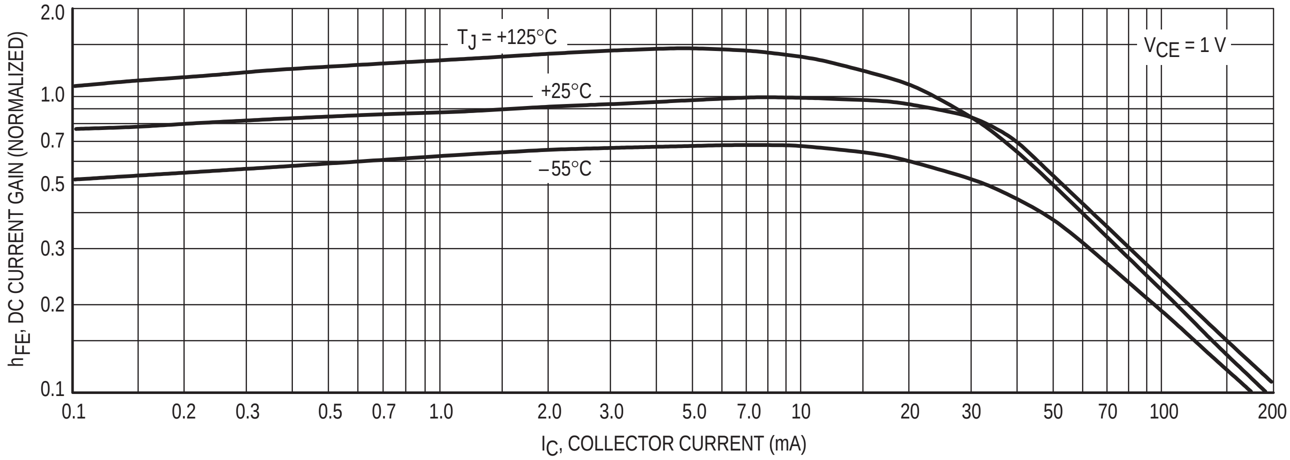


Figure 9. DC Current Gain

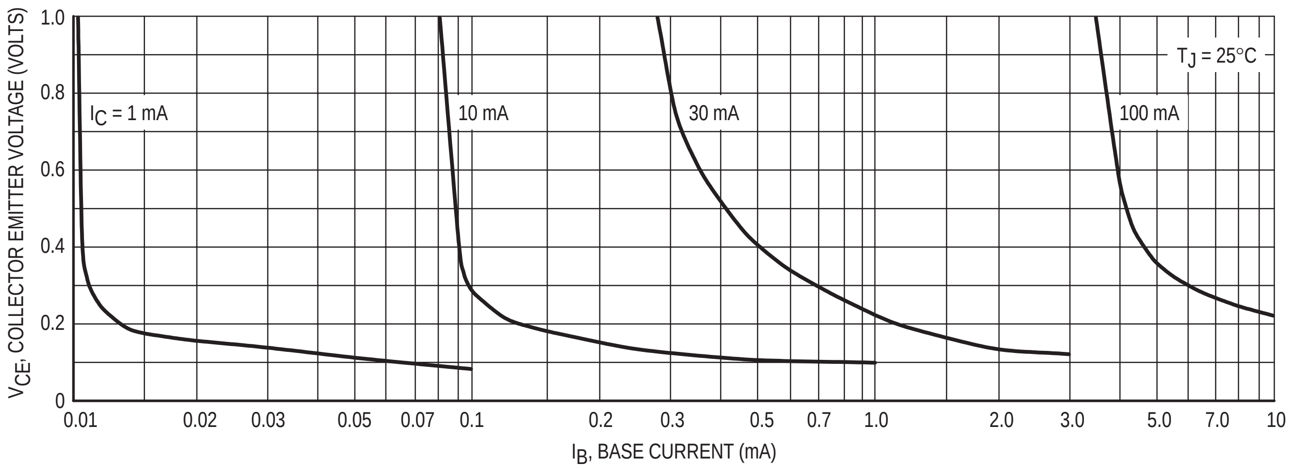


Figure 10. Collector Saturation Region

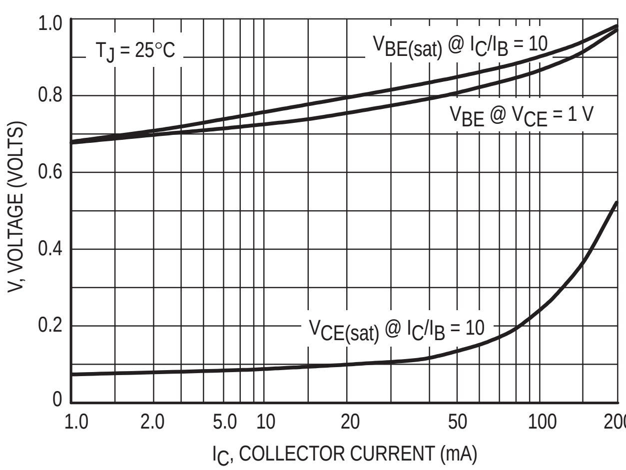


Figure 11. “On” Voltages

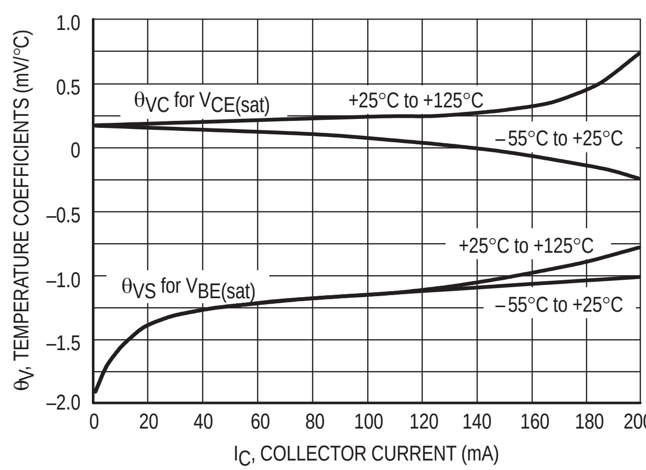
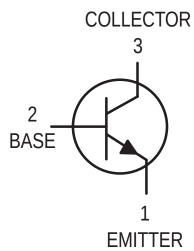
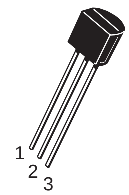


Figure 12. Temperature Coefficients

General Purpose Transistor
NPN Silicon

2N4264





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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}	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_B = 0)	$V_{(BR)CEO}$	15	—	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)	$V_{(BR)EBO}$	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

REV 2

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		25	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		40	160	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = –55°C)		20	—	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)		40	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)(1)		30	—	
(I_C = 200 mAdc, V_{CE} = 1.0 Vdc)(1)		20	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.22	
(I_C = 100 mAdc, I_B = 10 mAdc)(1)		—	0.35	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.65	0.8	
(I_C = 100 mAdc, I_B = 10 mAdc)(1)		0.75	0.95	
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

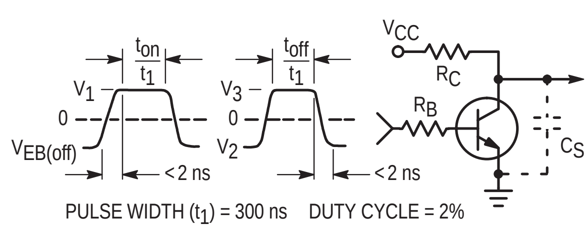
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
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

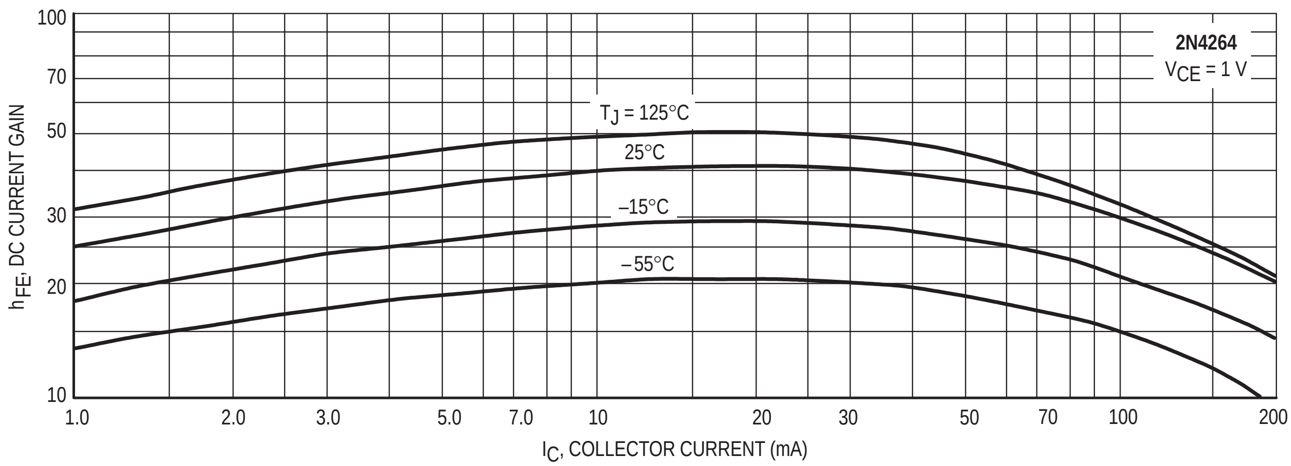


Figure 2. Minimum Current Gain

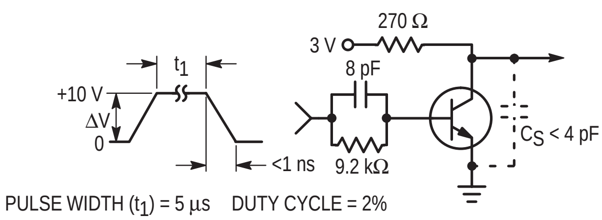


Figure 3. Q_T Test Circuit

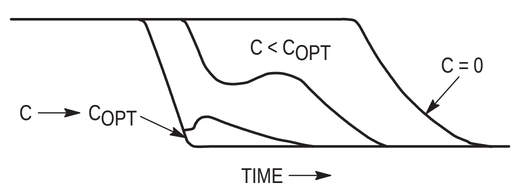


Figure 4. Turn–Off Waveform

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: $Q_S = Q_1 + Q_V + Q_X$.

Q_1 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_1 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: $C = Q_T/\Delta V$, where ΔV is defined in Figure 3.

"ON" CONDITION CHARACTERISTICS

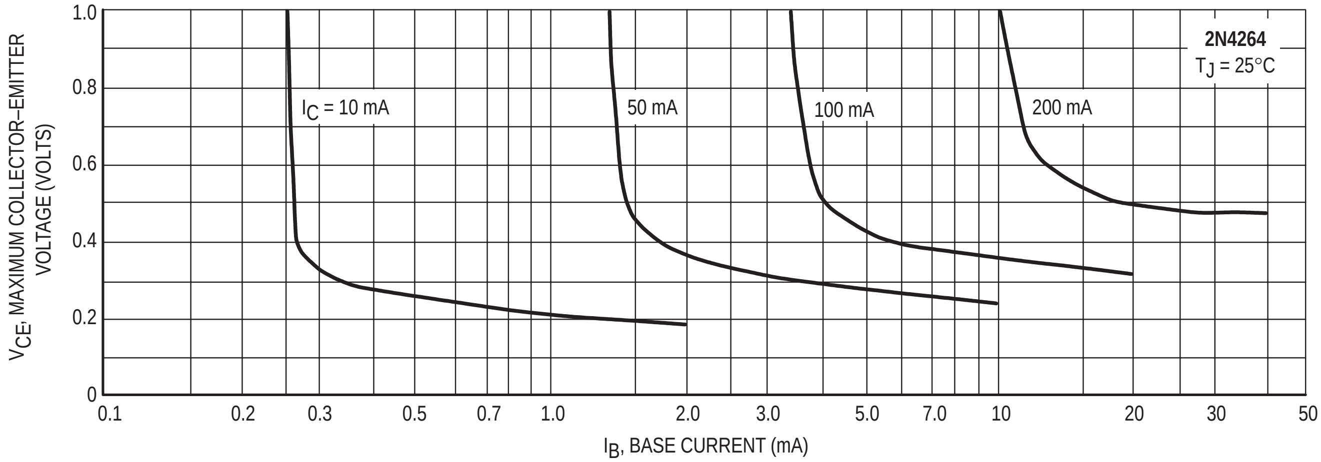


Figure 5. Collector Saturation Region

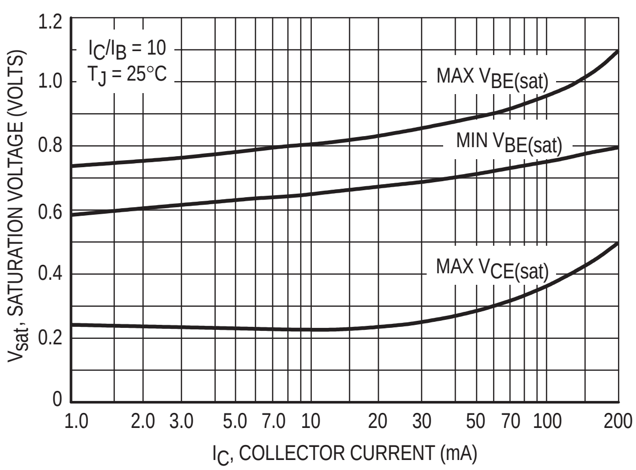


Figure 6. Saturation Voltage Limits

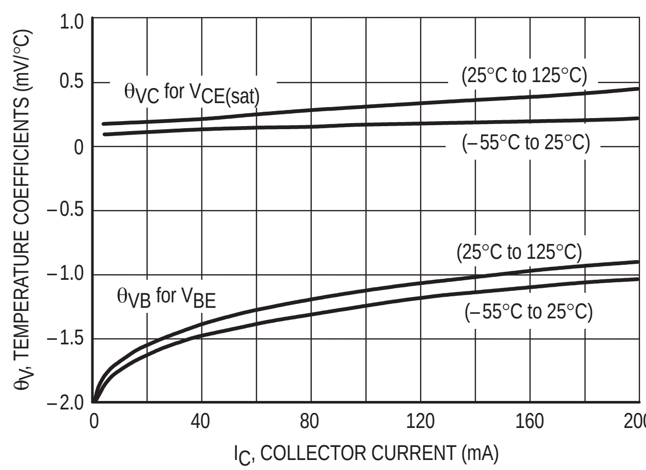


Figure 7. Temperature Coefficients

DYNAMIC CHARACTERISTICS

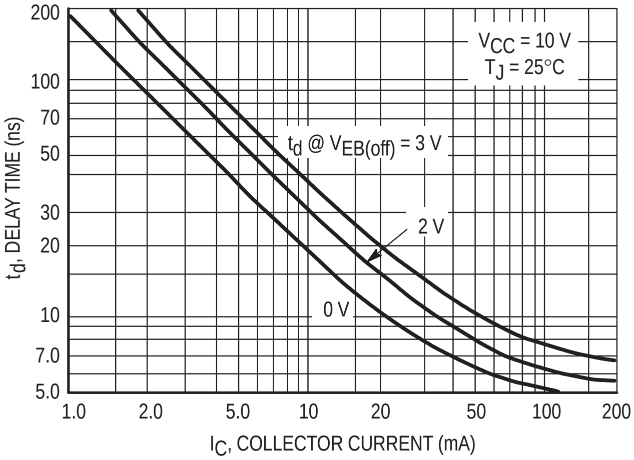


Figure 8. Delay Time

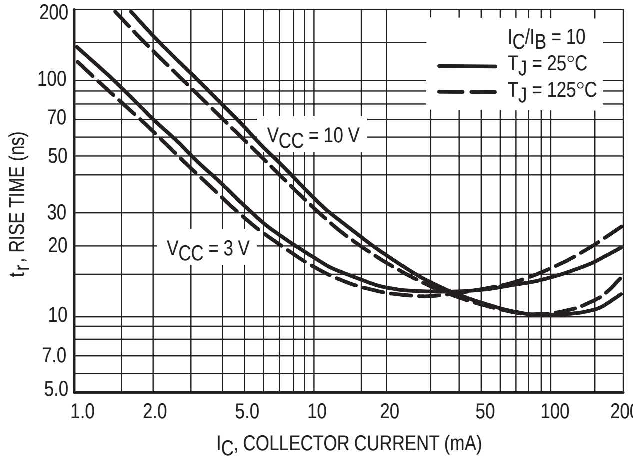


Figure 9. Rise Time

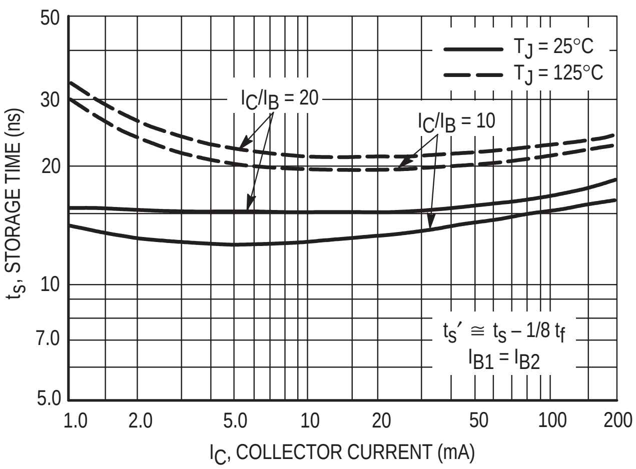


Figure 10. Storage Time

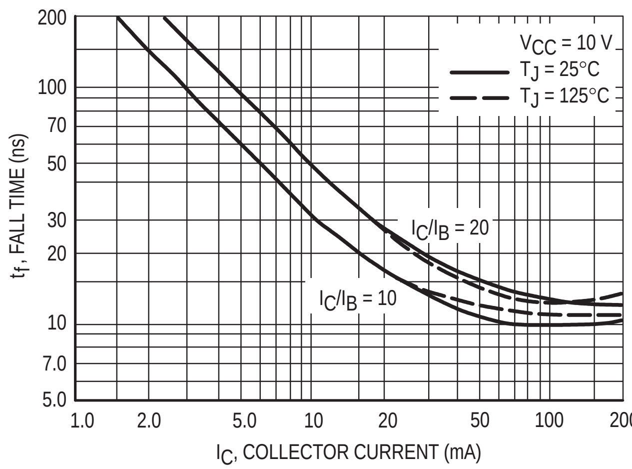


Figure 11. Fall Time

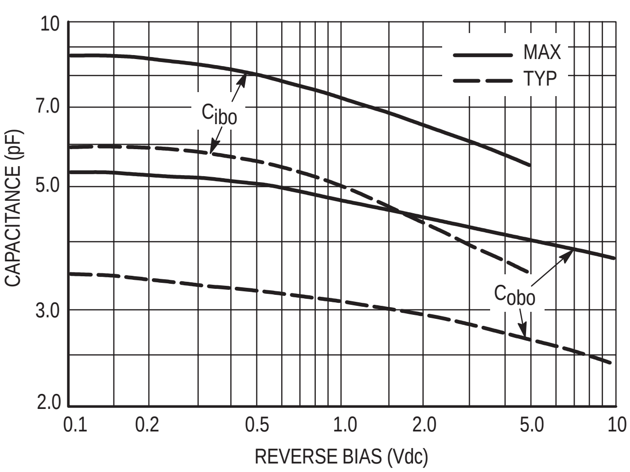


Figure 12. Junction Capacitance

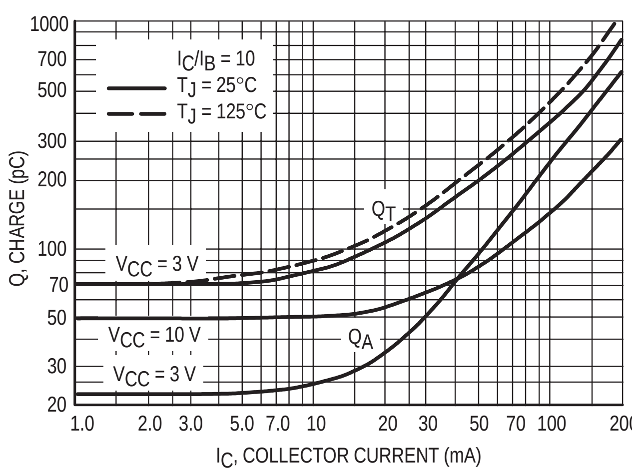
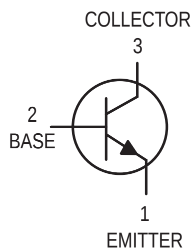


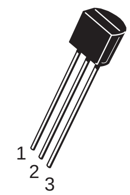
Figure 13. Maximum Charge Data

General Purpose Transistors
NPN Silicon

2N4400
2N4401*

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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	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 = 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

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

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

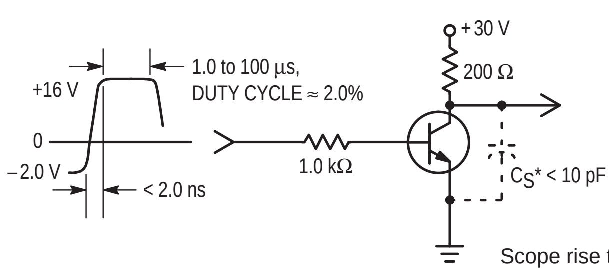
REV 1

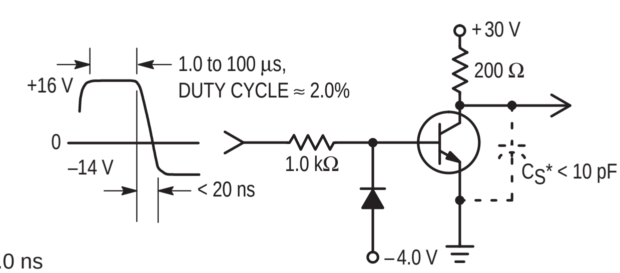
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N4401		20	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N4400		20	—	
	2N4401		40	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4400		40	—	
	2N4401		80	—	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N4400		50	150	
	2N4401		100	300	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N4400		20	—	
	2N4401		40	—	
Collector–Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.4	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.75	
Base–Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	0.75	0.95	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.2	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N4400		200	—	
	2N4401		250	—	
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		h_{ie}			k ohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400		0.5	7.5	
	2N4401		1.0	15	
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		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400		20	250	
	2N4401		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_{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





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

Figure 1. Turn–On Time **Figure 2. Turn–Off Time**

TRANSIENT CHARACTERISTICS

25°C — 100°C (dashed)

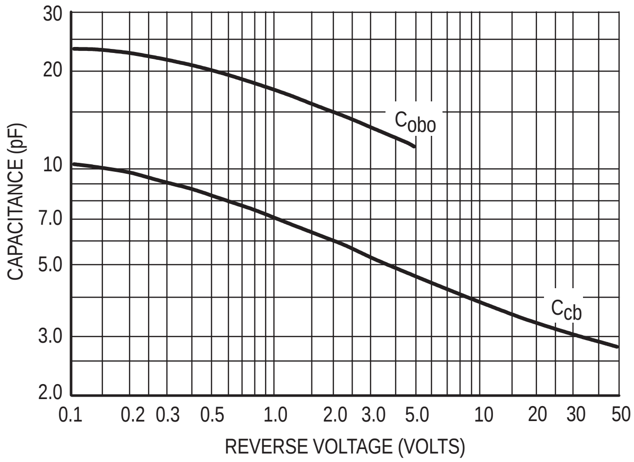


Figure 3. Capacitances

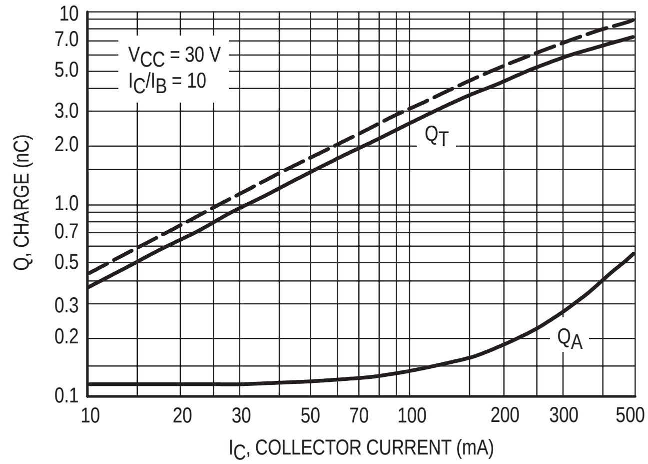


Figure 4. Charge Data

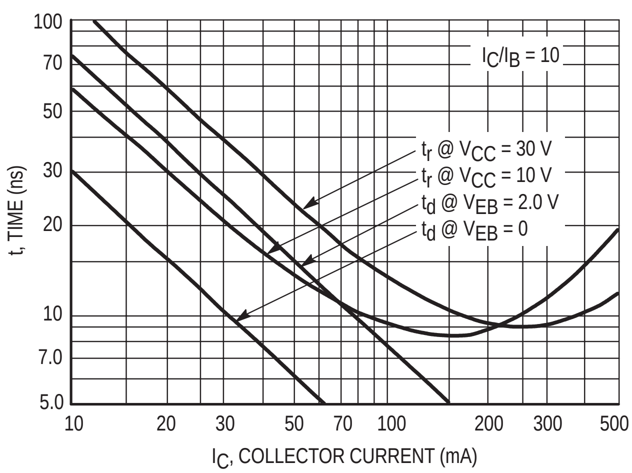


Figure 5. Turn–On Time

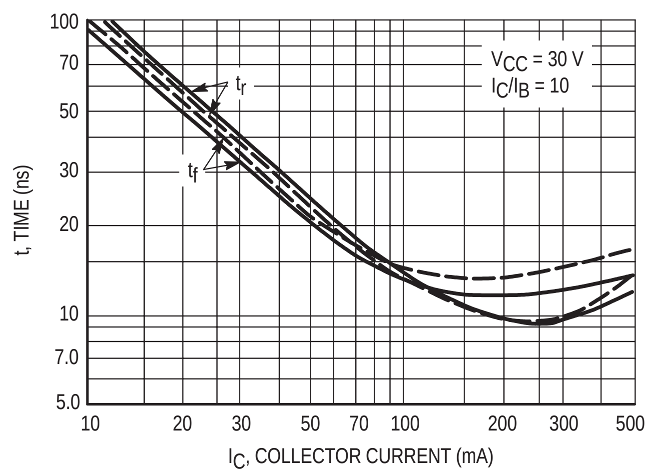


Figure 6. Rise and Fall Times

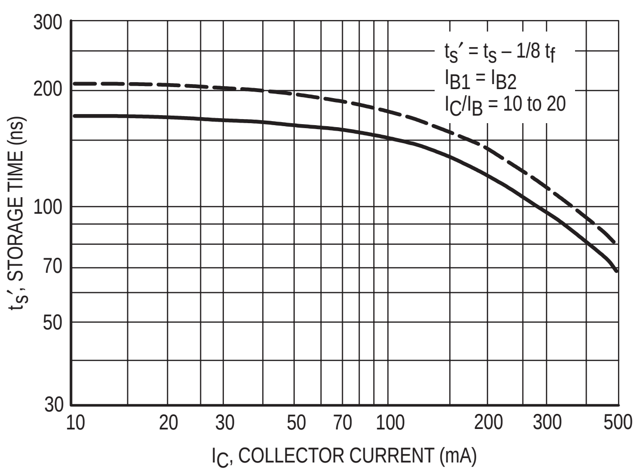


Figure 7. Storage Time

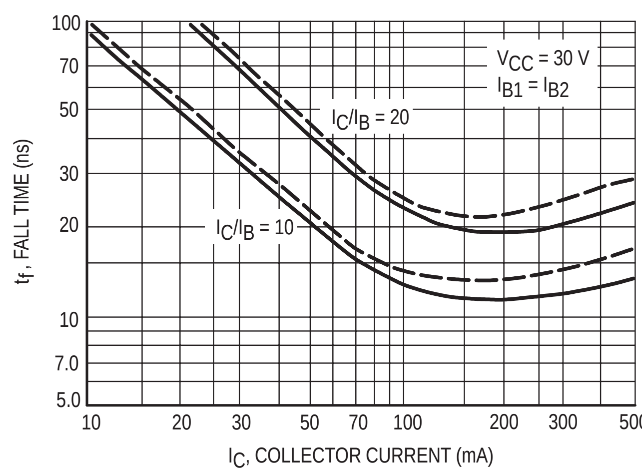


Figure 8. Fall Time

SMALL–SIGNAL CHARACTERISTICS

NOISE FIGURE

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

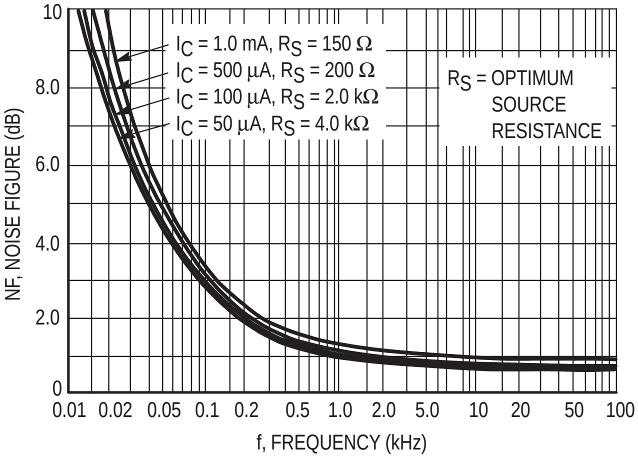


Figure 9. Frequency Effects

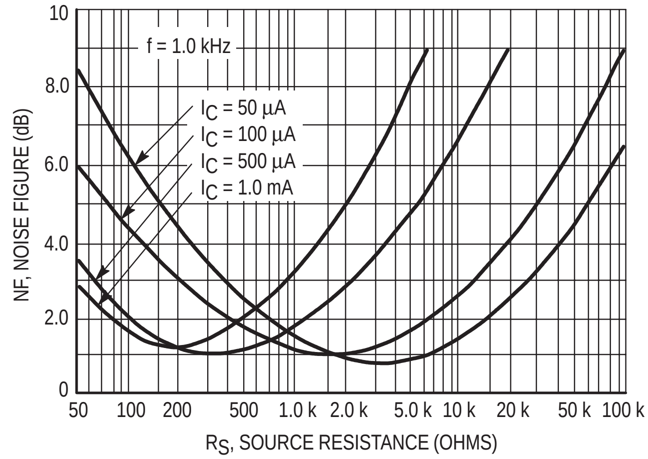


Figure 10. Source Resistance Effects

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.

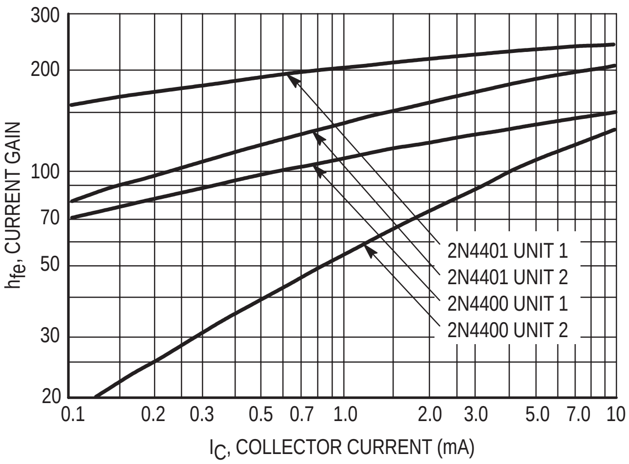


Figure 11. Current Gain

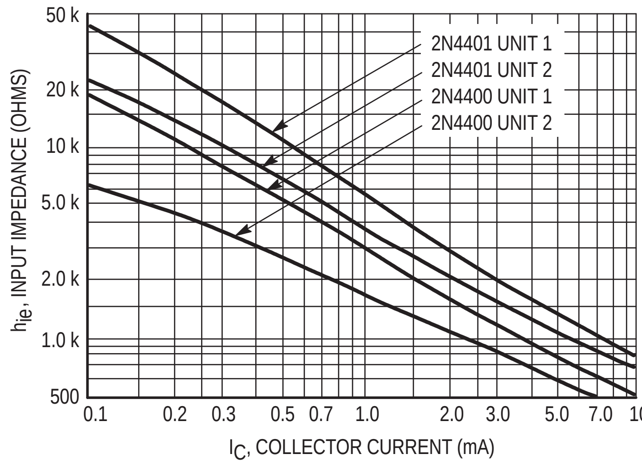


Figure 12. Input Impedance

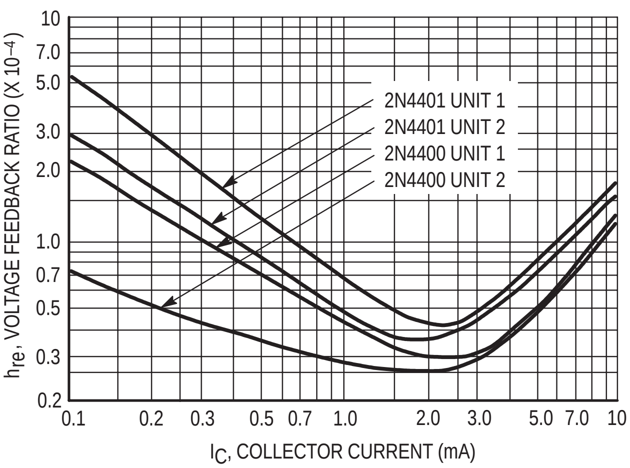


Figure 13. Voltage Feedback Ratio

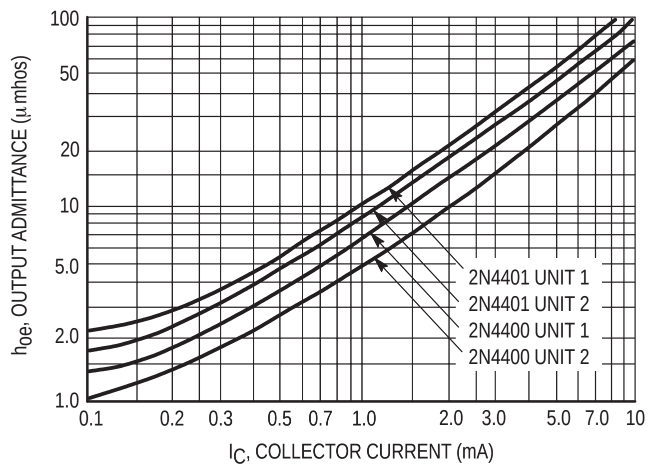


Figure 14. Output Admittance

STATIC CHARACTERISTICS

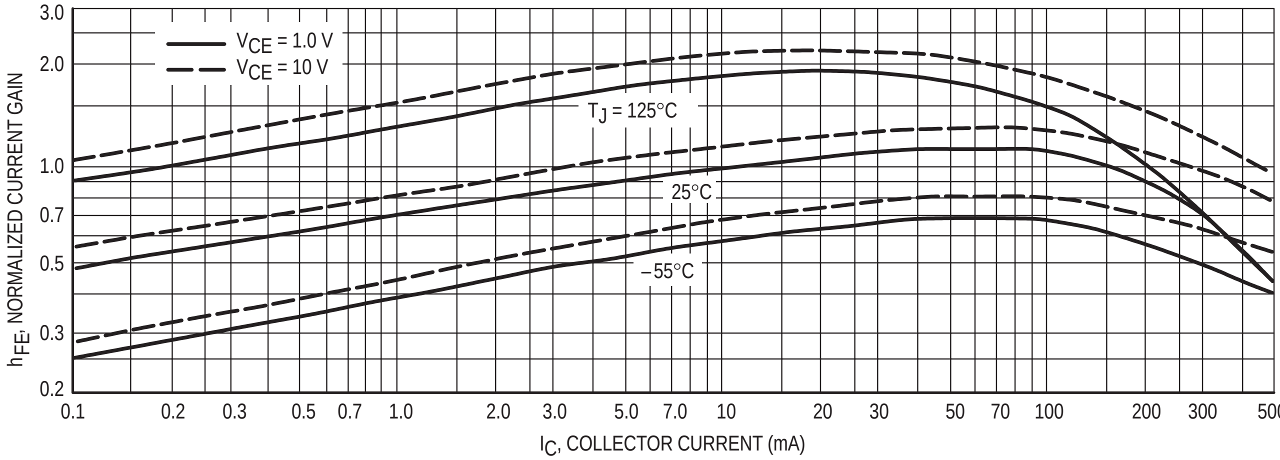


Figure 15. DC Current Gain

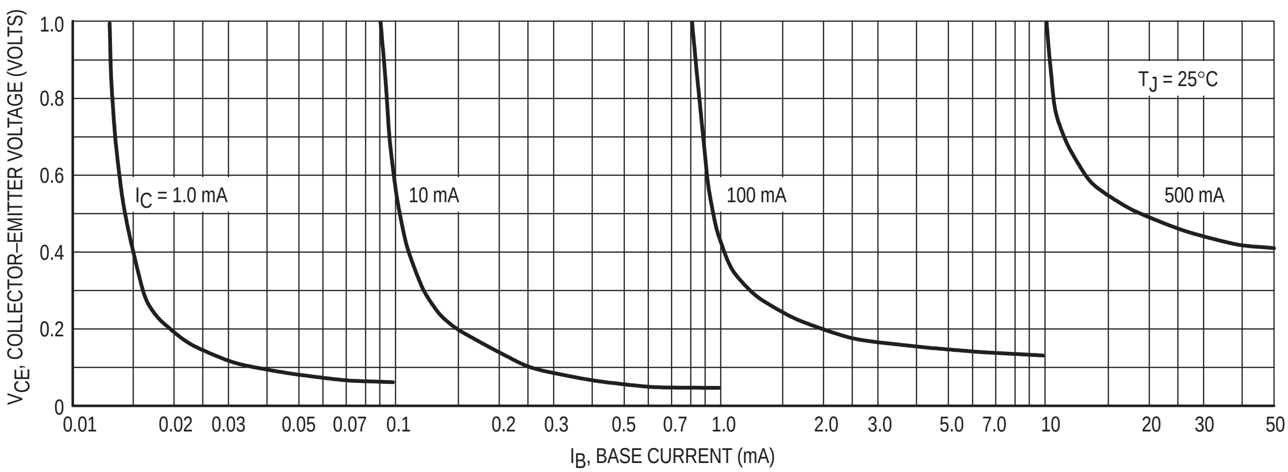


Figure 16. Collector Saturation Region

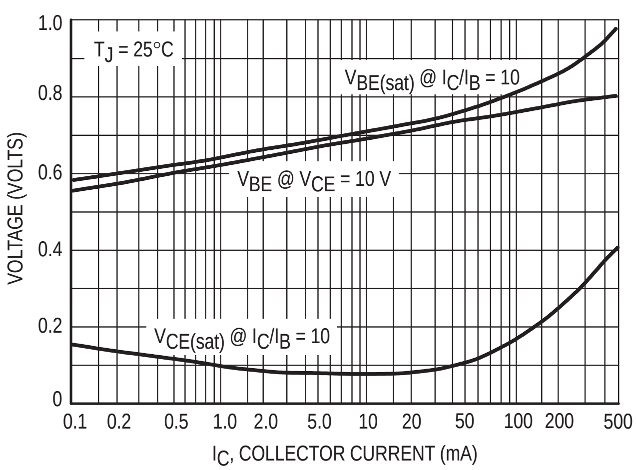


Figure 17. “On” Voltages

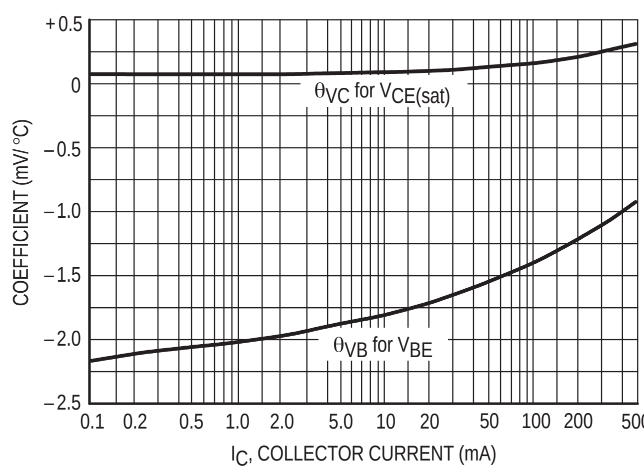
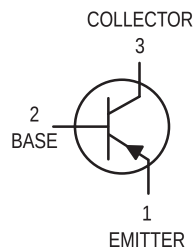


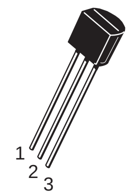
Figure 18. Temperature Coefficients

General Purpose Transistors
PNP Silicon

2N4402
2N4403*

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

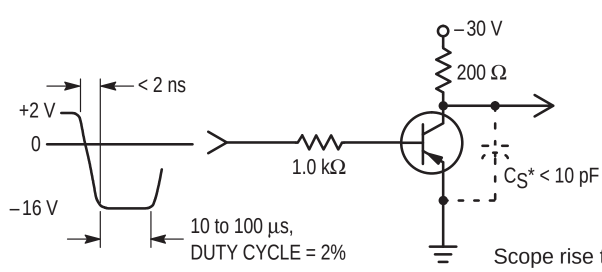
Preferred devices are Motorola recommended choices for future use and best overall value.

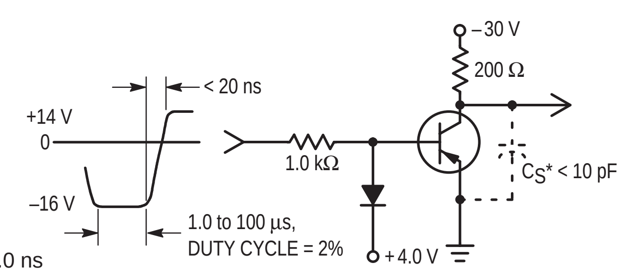
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N4403		30	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N4402		30	—	
	2N4403		60	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4402		50	—	
	2N4403		100	—	
(I_C = 150 mAdc, V_{CE} = 2.0 Vdc)(1)	2N4402		50	150	
	2N4403		100	300	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)(1)	Both		20	—	
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)			—	0.75	
Base–Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			0.75	0.95	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.3	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N4402		150	—	
	2N4403		200	—	
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		h_{ie}			ohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4402		750	7.5 k	
	2N4403		1.5 k	15 k	
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		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4402		30	250	
	2N4403		60	500	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	100	μmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, V_{BE} = +2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 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





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

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

TRANSIENT CHARACTERISTICS

—— 25°C   – – 100°C

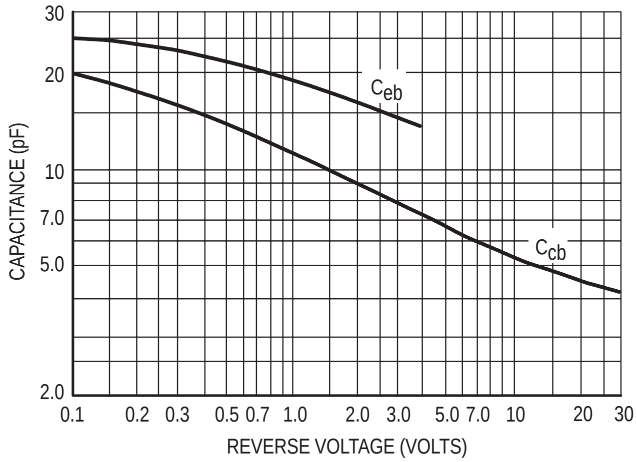


Figure 3. Capacitances

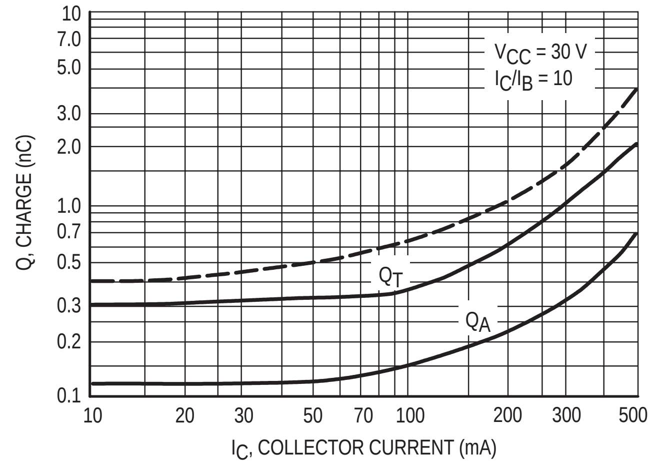


Figure 4. Charge Data

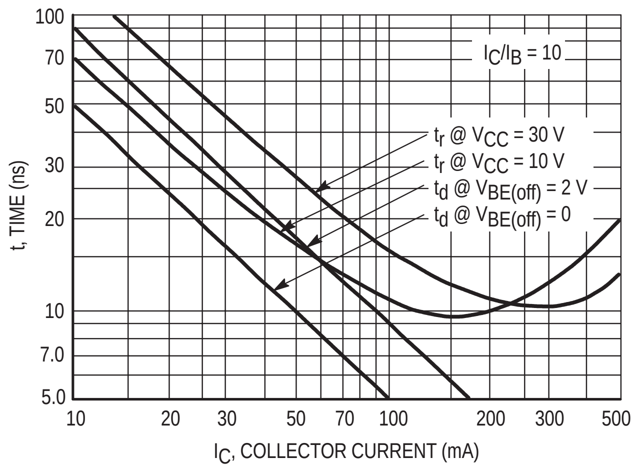


Figure 5. Turn–On Time

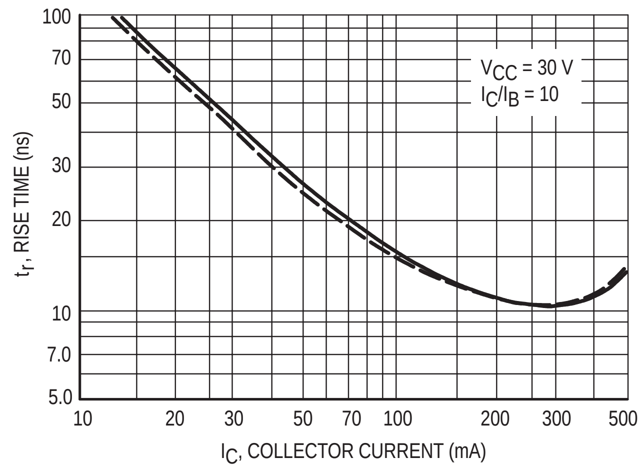


Figure 6. Rise Time

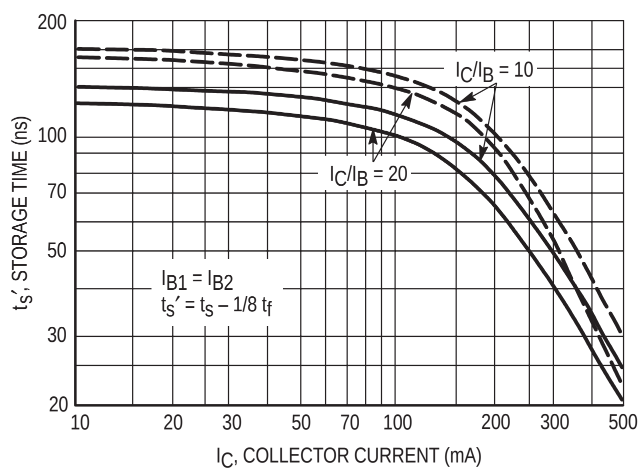


Figure 7. Storage Time

SMALL–SIGNAL CHARACTERISTICS

NOISE FIGURE

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

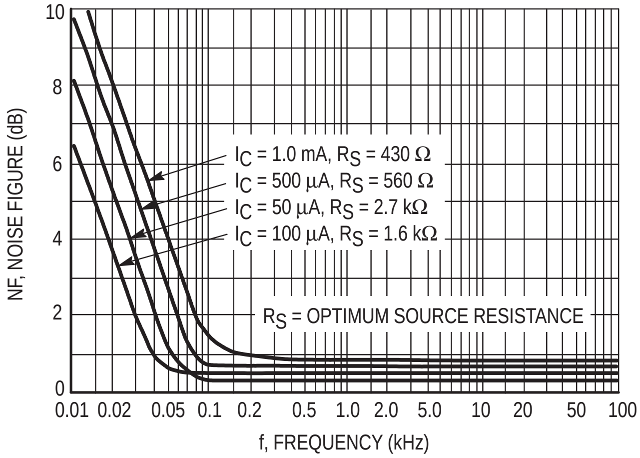


Figure 8. Frequency Effects

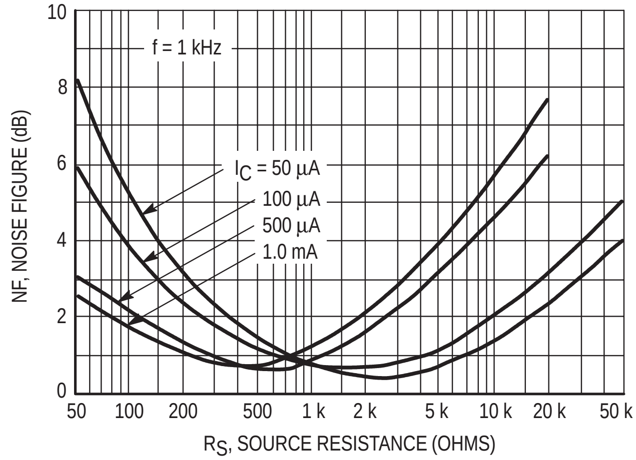


Figure 9. Source Resistance Effects

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.

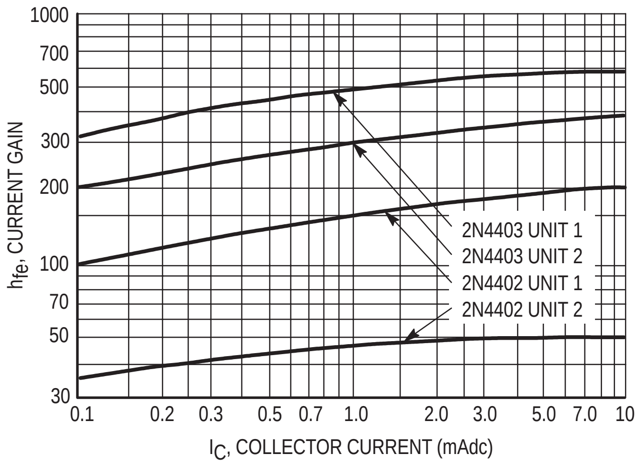


Figure 10. Current Gain

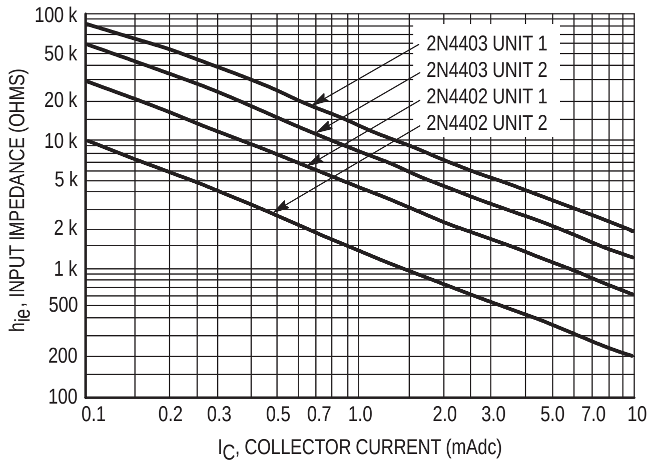


Figure 11. Input Impedance

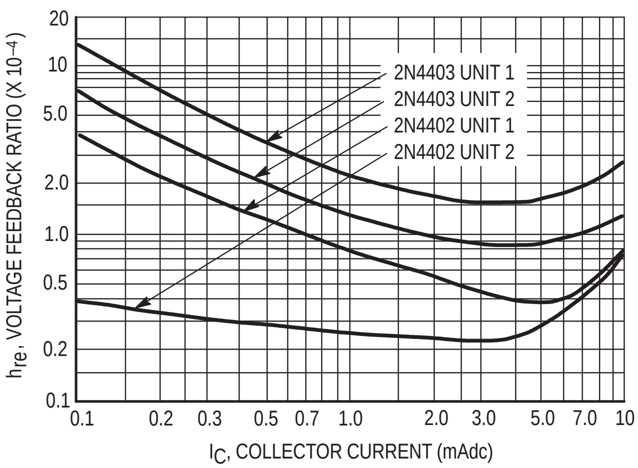


Figure 12. Voltage Feedback Ratio

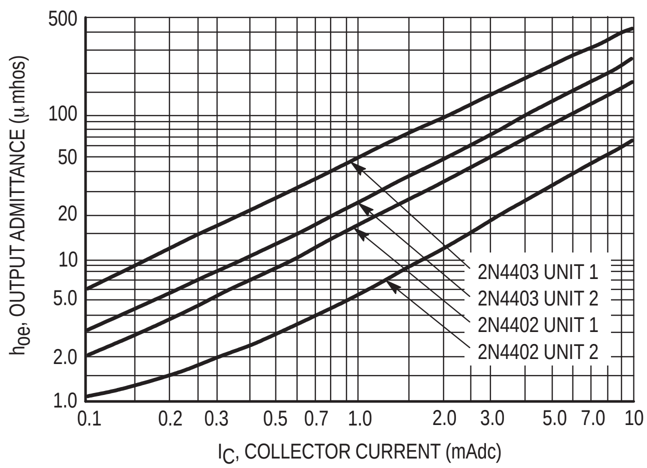


Figure 13. Output Admittance

STATIC CHARACTERISTICS

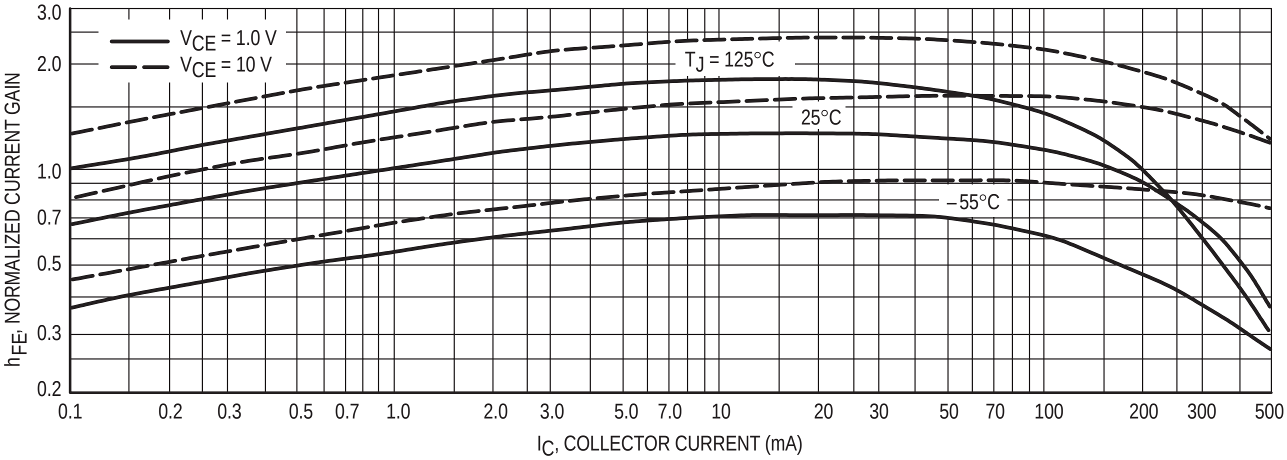


Figure 14. DC Current Gain

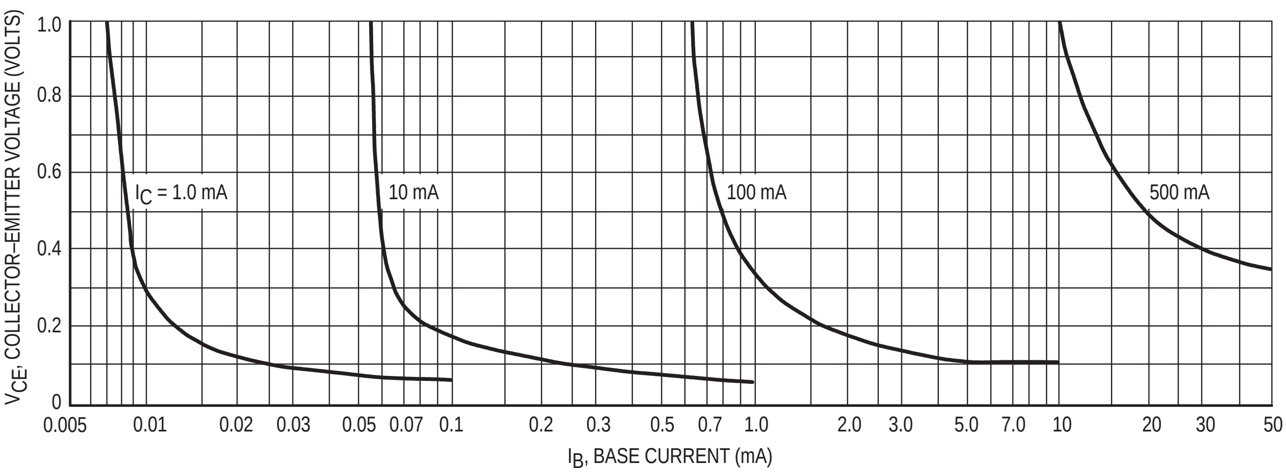


Figure 15. Collector Saturation Region

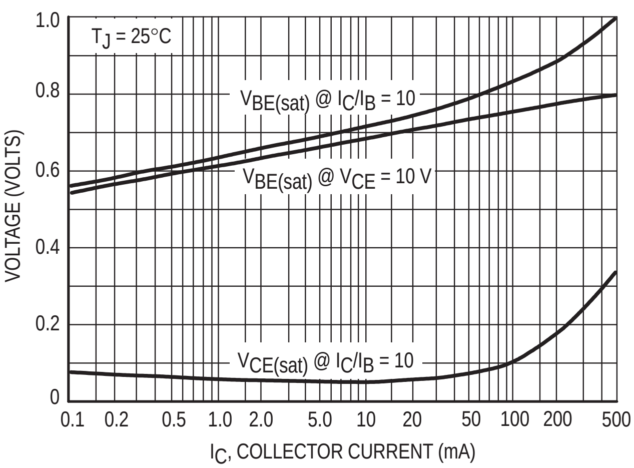


Figure 16. "On" Voltages

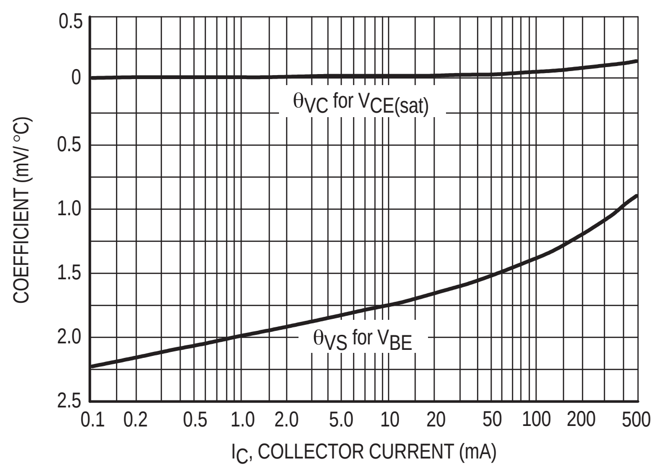
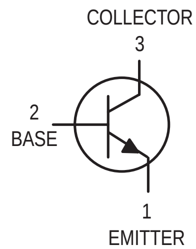
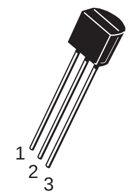


Figure 17. Temperature Coefficients

Amplifier Transistor
NPN Silicon

2N4410





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

REV 1

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

Characteristic	Symbol	Min	Max	Unit
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

2. $f_T = |h_{fe}| \bullet f_{test}$.

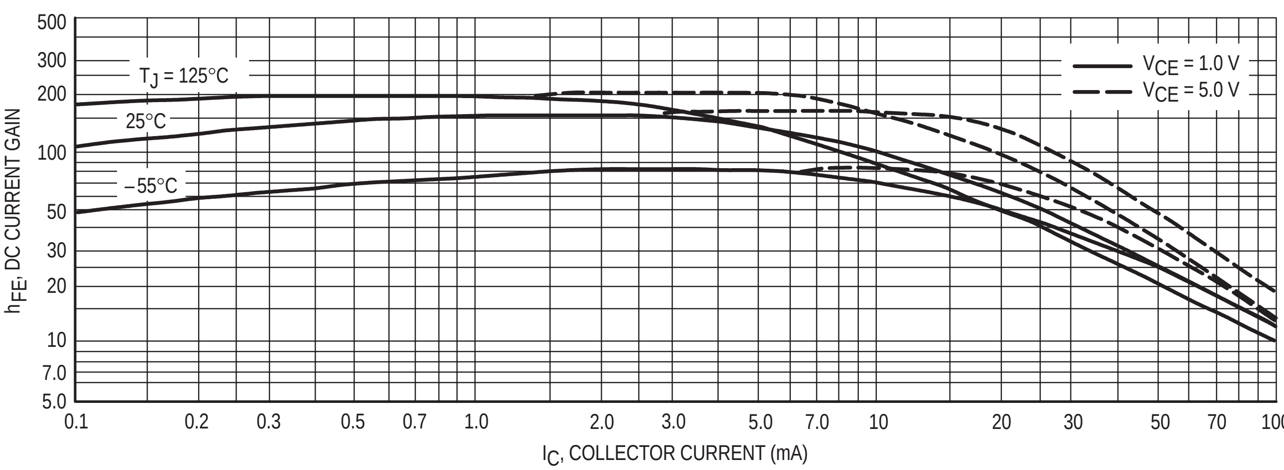


Figure 1. DC Current Gain

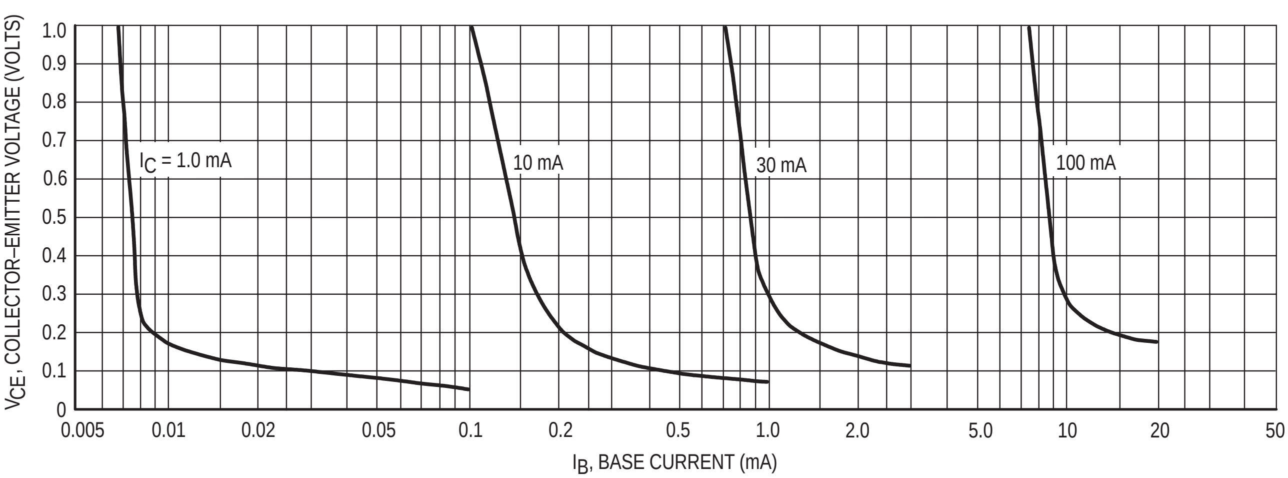


Figure 2. Collector Saturation Region

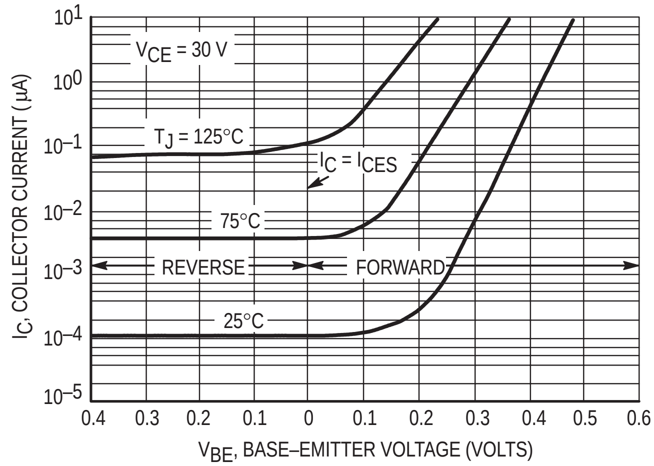


Figure 3. Collector Cut–Off Region

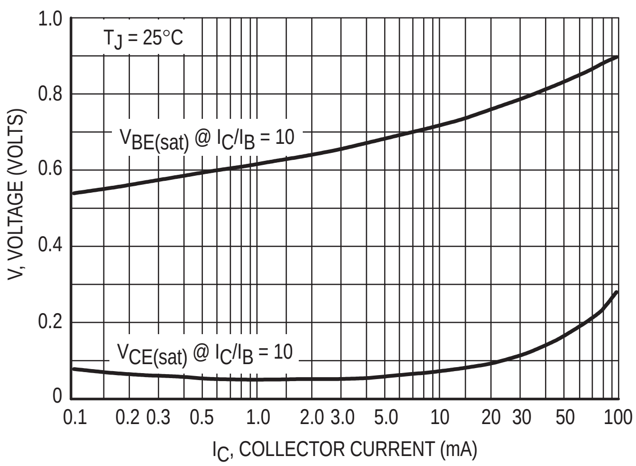


Figure 4. "On" Voltages

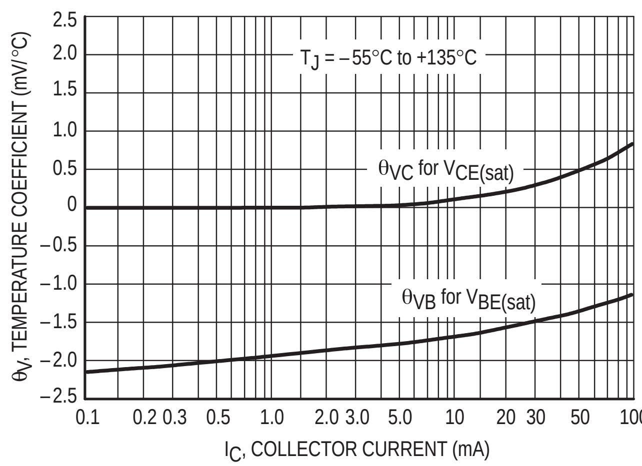
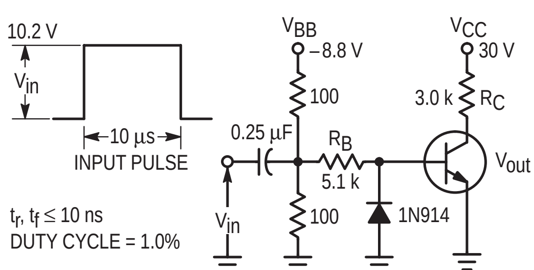


Figure 5. Temperature Coefficients



Values Shown are for I_C @ 10 mA

Figure 6. Switching Time Test Circuit

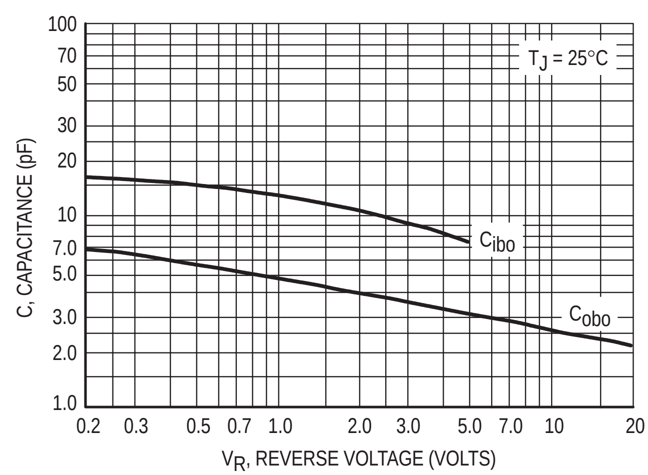


Figure 7. Capacitances

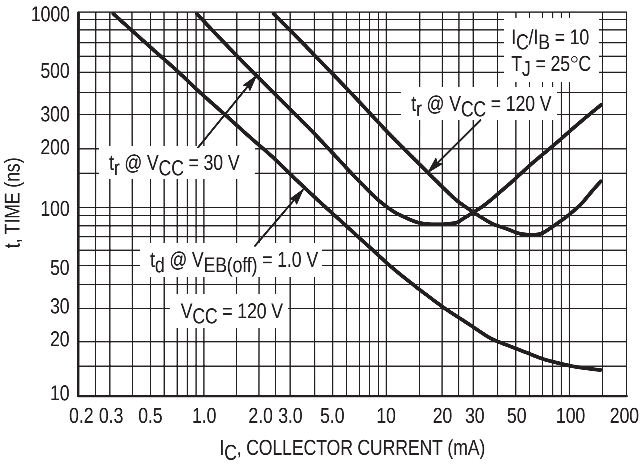


Figure 8. Turn–On Time

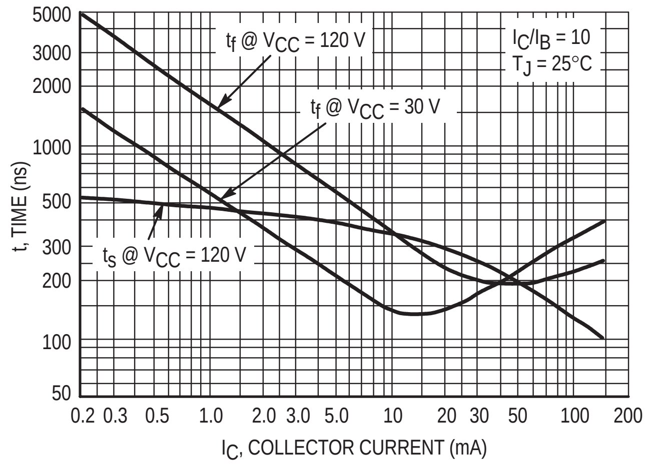
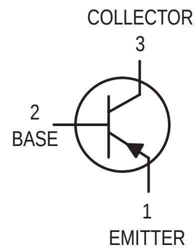


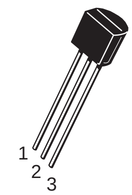
Figure 9. Turn–Off Time

Amplifier Transistor
PNP Silicon

2N5087

Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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(1) (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

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

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

(Replaces 2N5086/D)

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

Characteristic	Symbol	Min	Max	Unit
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)	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 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)	h_{fe}	250	900	—
Noise Figure (I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 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

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

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

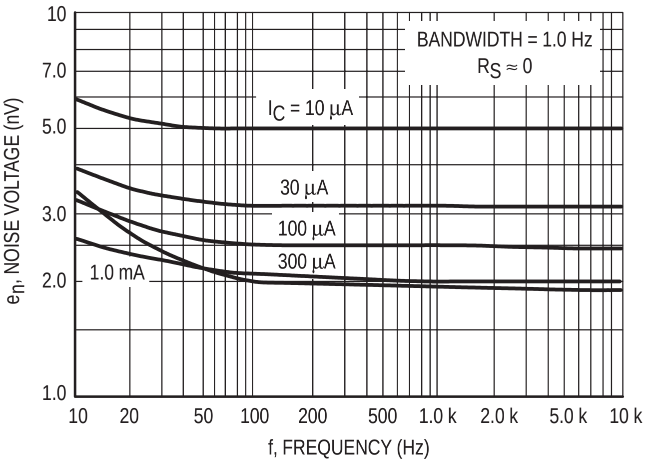


Figure 1. Noise Voltage

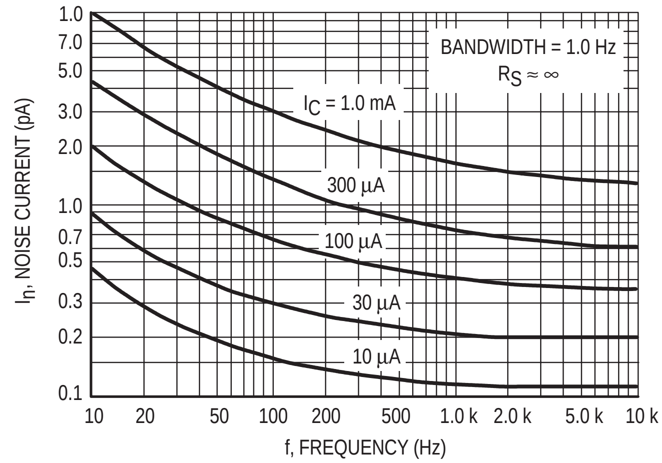


Figure 2. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

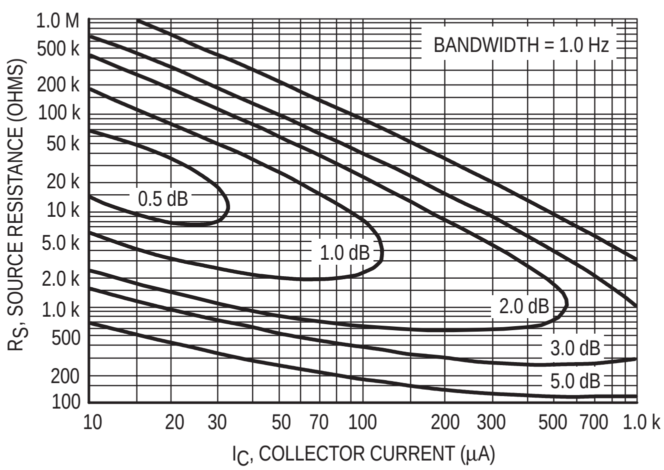


Figure 3. Narrow Band, 100 Hz

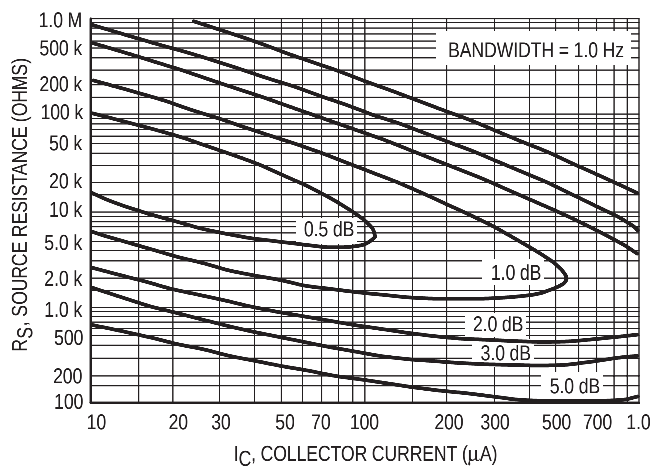


Figure 4. Narrow Band, 1.0 kHz

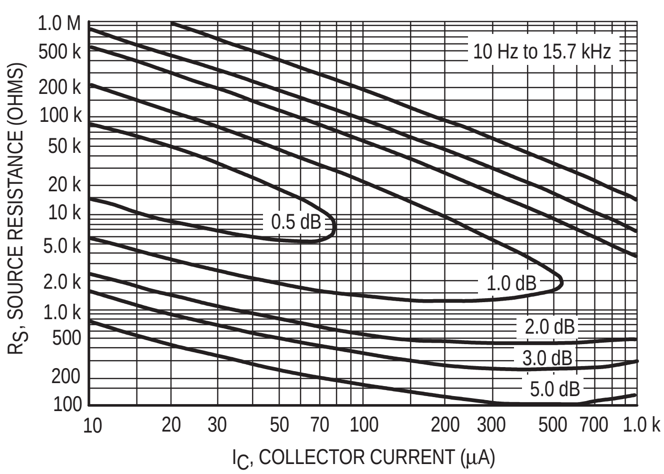


Figure 5. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

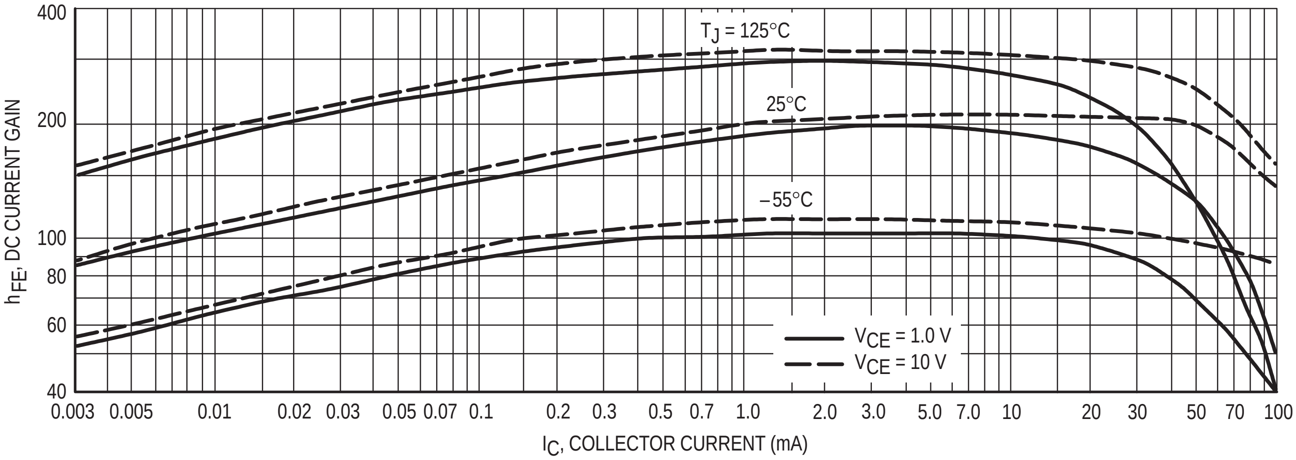


Figure 6. DC Current Gain

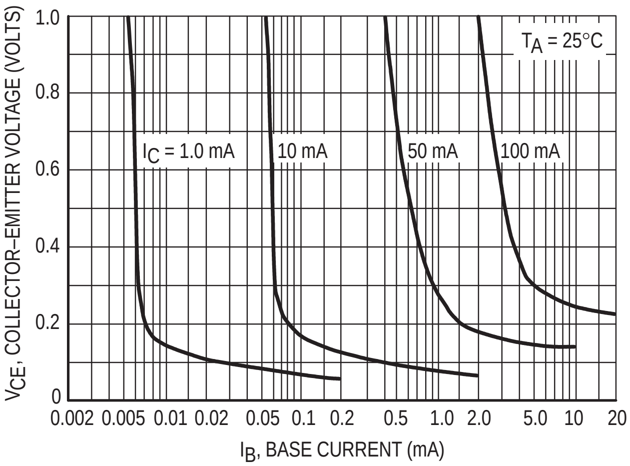


Figure 7. Collector Saturation Region

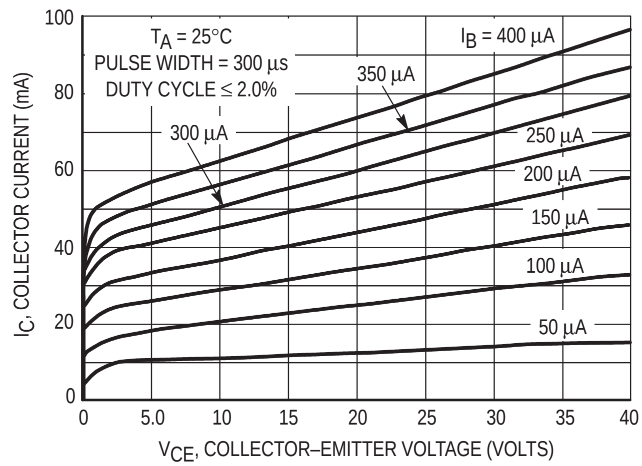


Figure 8. Collector Characteristics

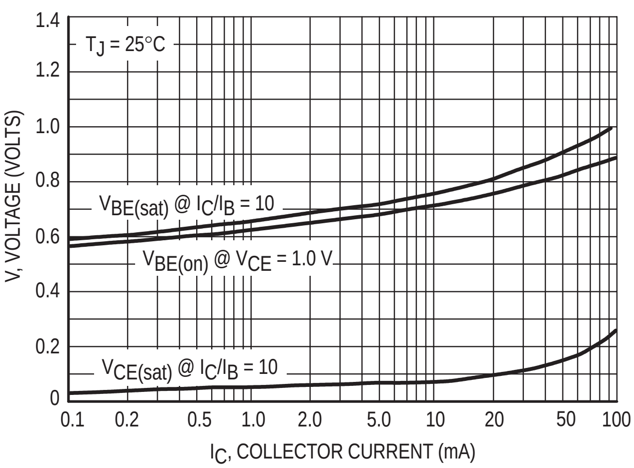


Figure 9. “On” Voltages

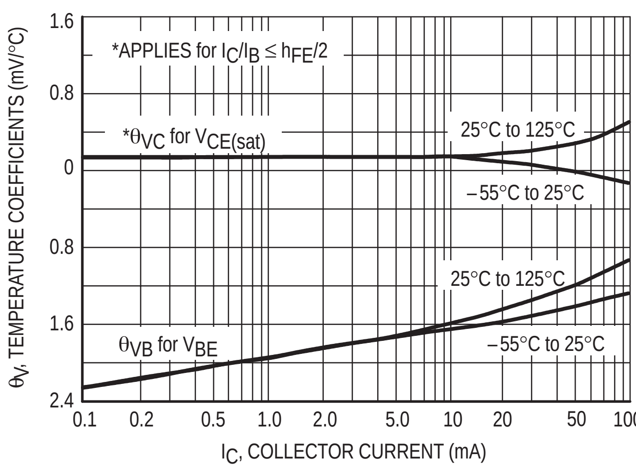


Figure 10. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

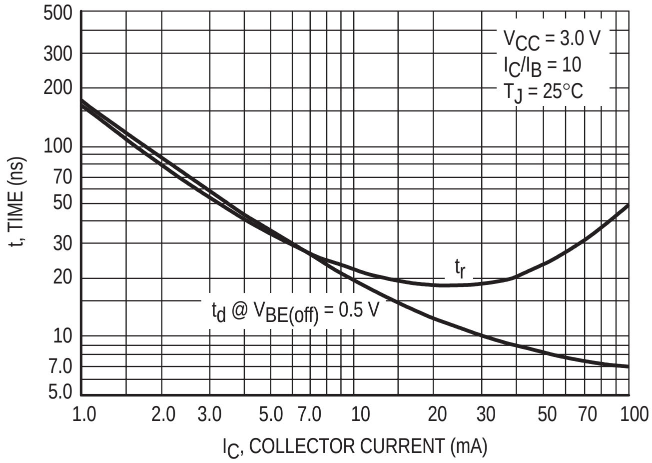


Figure 11. Turn–On Time

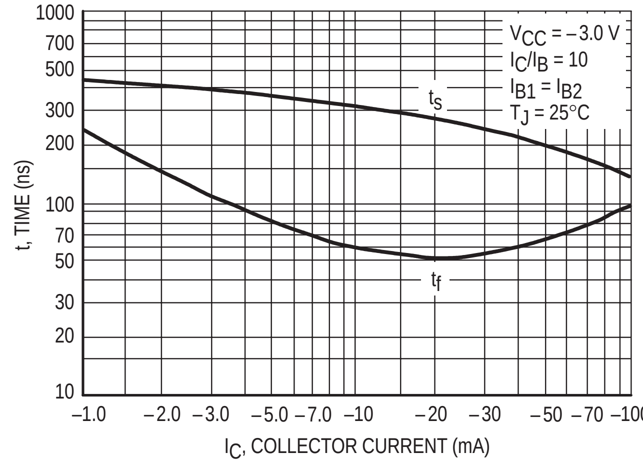


Figure 12. Turn–Off Time

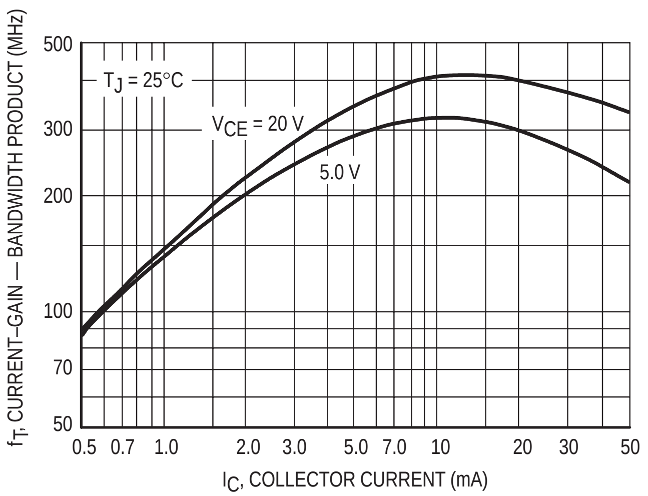


Figure 13. Current–Gain — Bandwidth Product

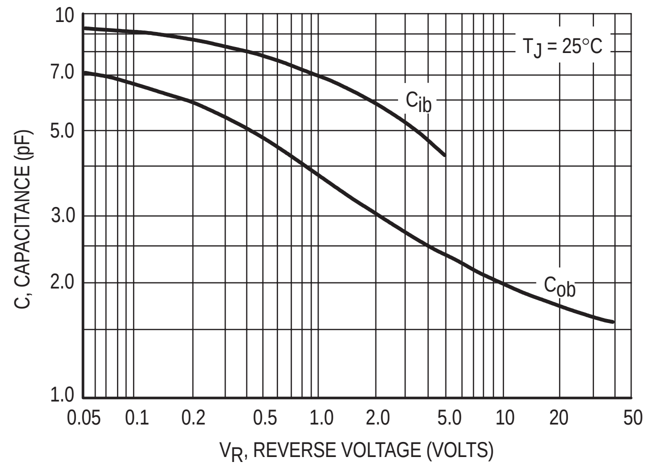


Figure 14. Capacitance

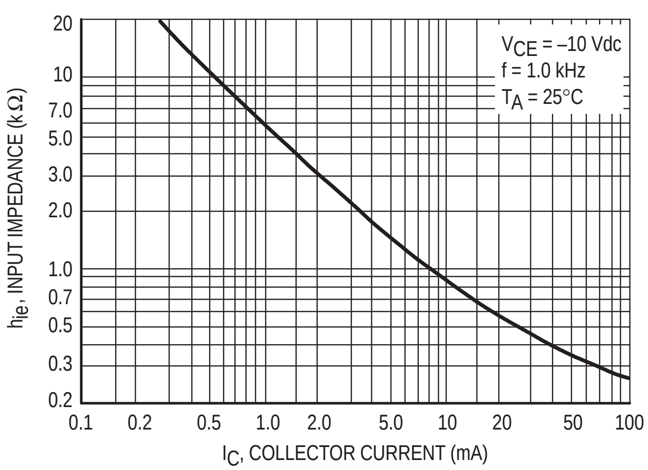


Figure 15. Input Impedance

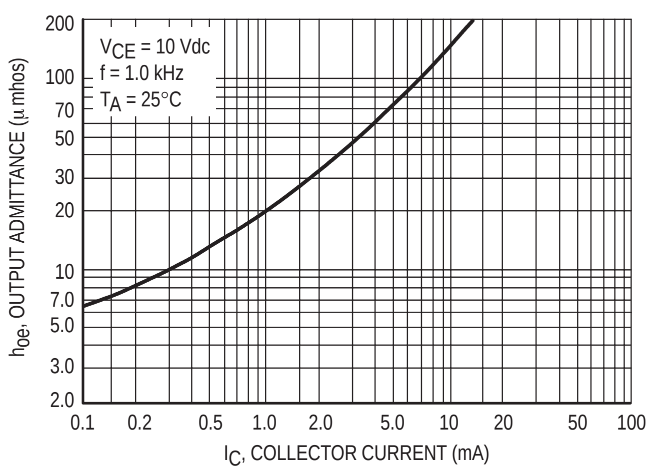


Figure 16. Output Admittance

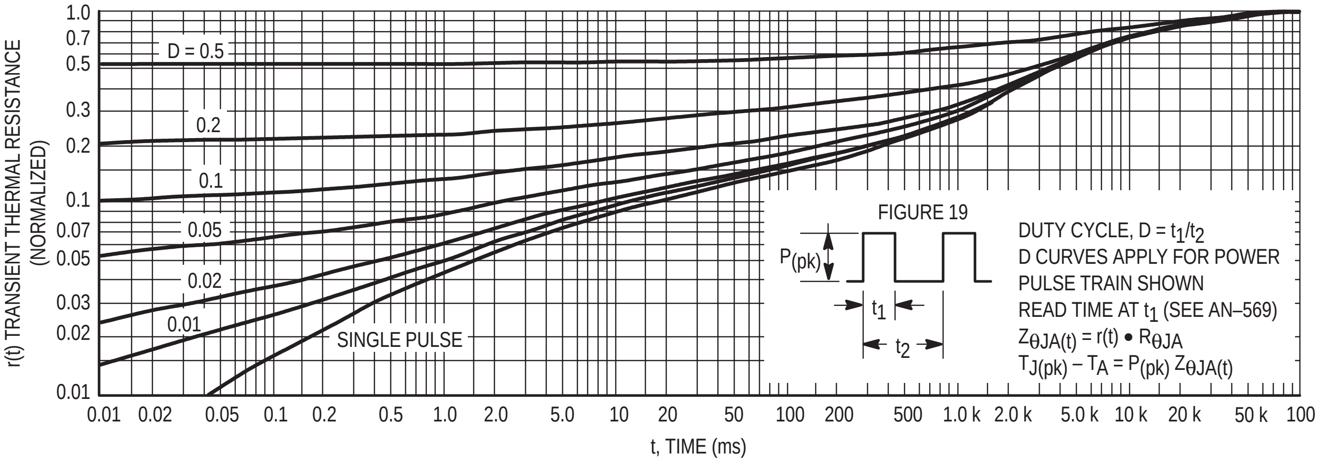


Figure 17. Thermal Response

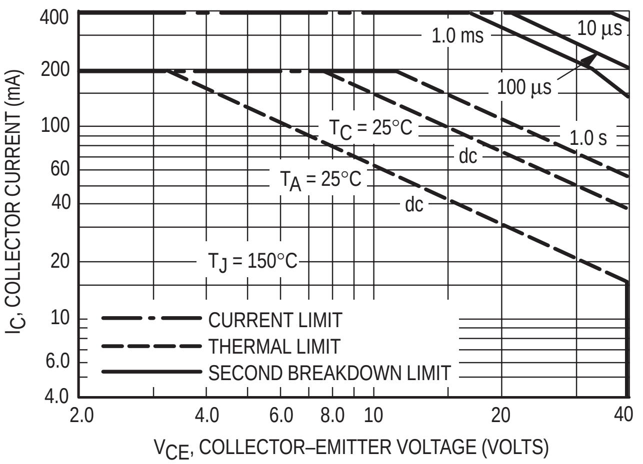


Figure 18. Active–Region Safe Operating Area

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 18 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 17. 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.

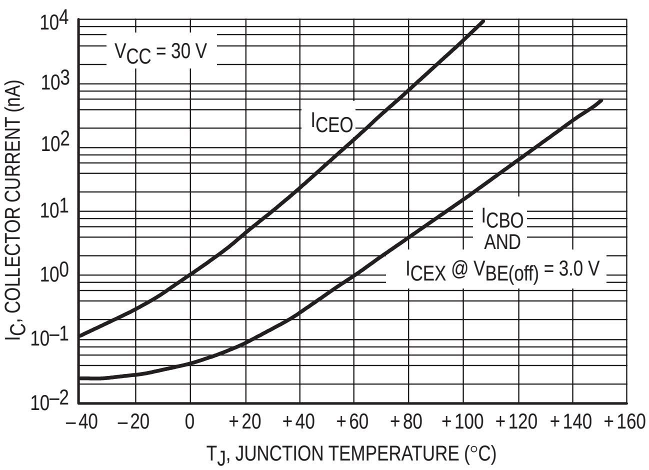


Figure 19. Typical Collector Leakage Current

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 17 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 17 by the steady state value $R_{\theta JA}$.

Example:

The 2N5087 is dissipating 2.0 watts peak under the following conditions:

$$t_1 = 1.0 \text{ ms}, t_2 = 5.0 \text{ ms} \ (D = 0.2)$$

Using Figure 17 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

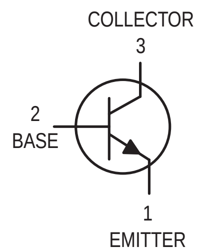
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C.$

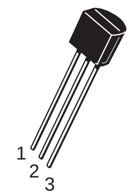
For more information, see AN–569.

Amplifier Transistors

NPN Silicon

2N5088
2N5089





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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		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 = 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

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%.

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5088		300	900	
	2N5089		400	1200	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5088		350	—	
	2N5089		450	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)	2N5088		300	—	
	2N5089		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		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5088		350	1400	
	2N5089		450	1800	
Noise Figure		NF			dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ,	2N5088		—	3.0	
f = 1.0 kHz)	2N5089		—	2.0	

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

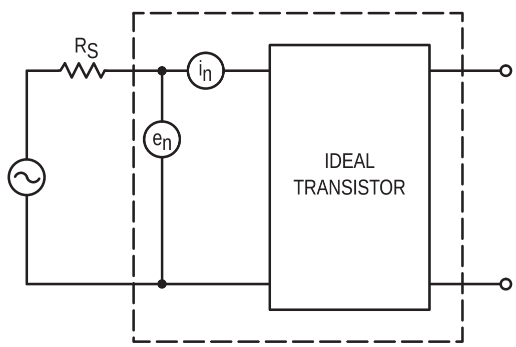


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

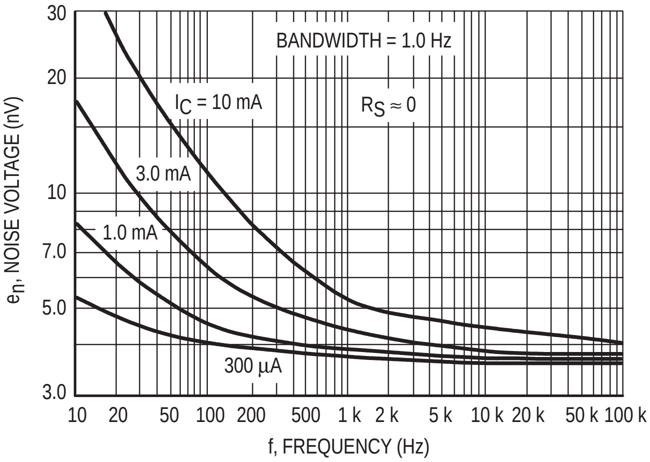


Figure 2. Effects of Frequency

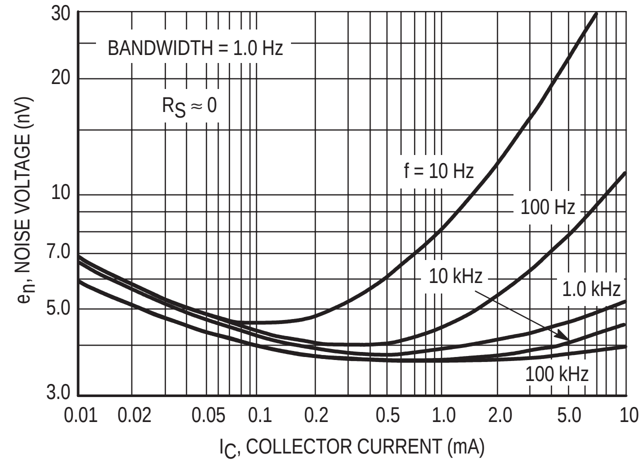


Figure 3. Effects of Collector Current

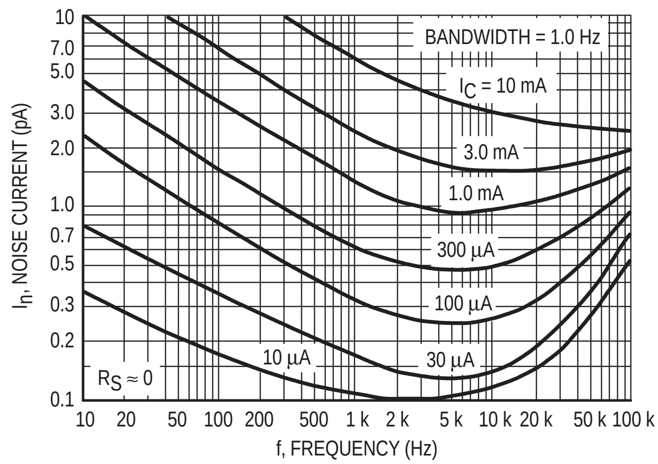


Figure 4. Noise Current

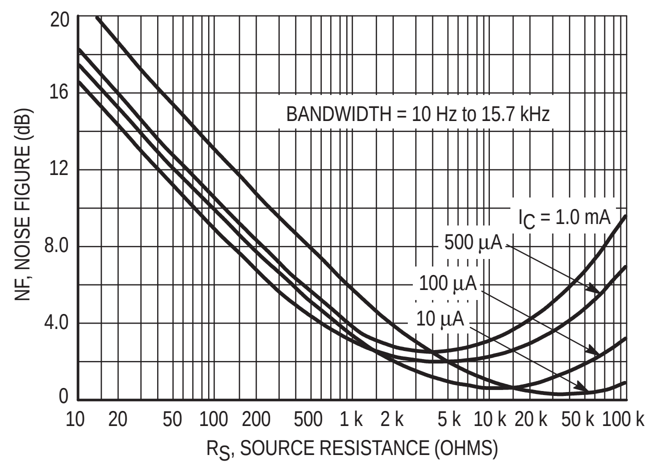


Figure 5. Wideband Noise Figure

100 Hz NOISE DATA

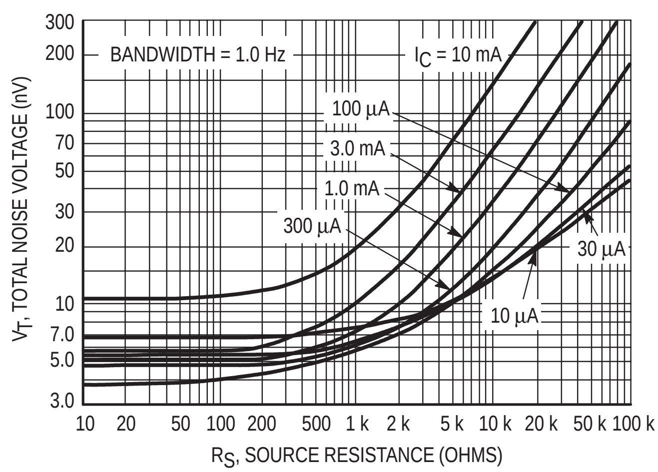


Figure 6. Total Noise Voltage

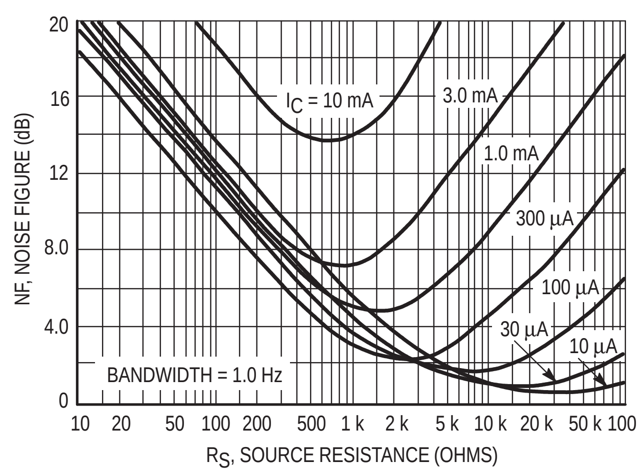


Figure 7. Noise Figure

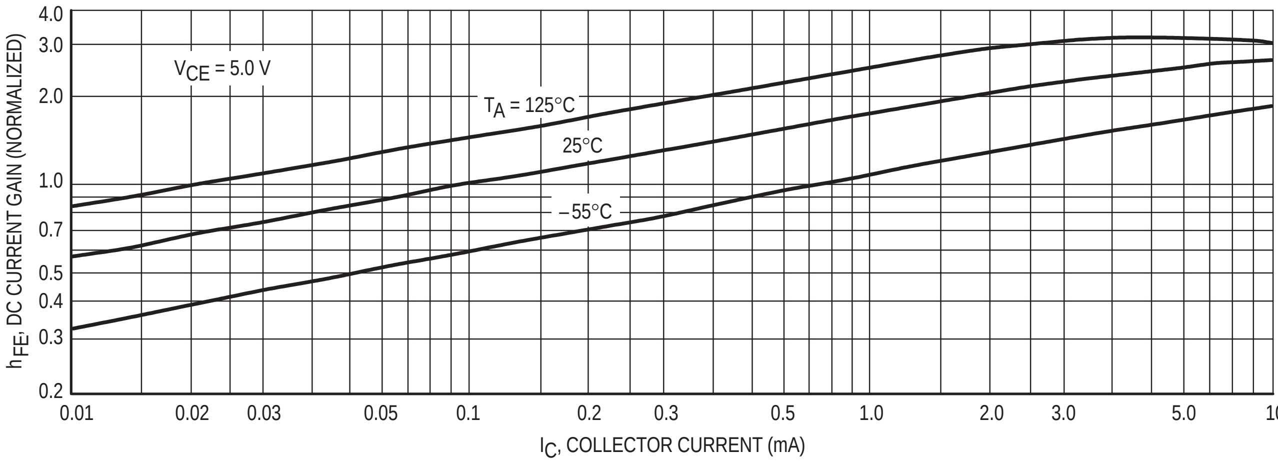


Figure 8. DC Current Gain

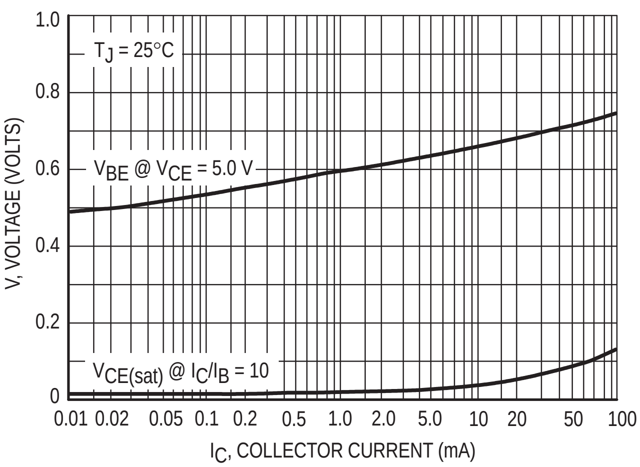


Figure 9. "On" Voltages

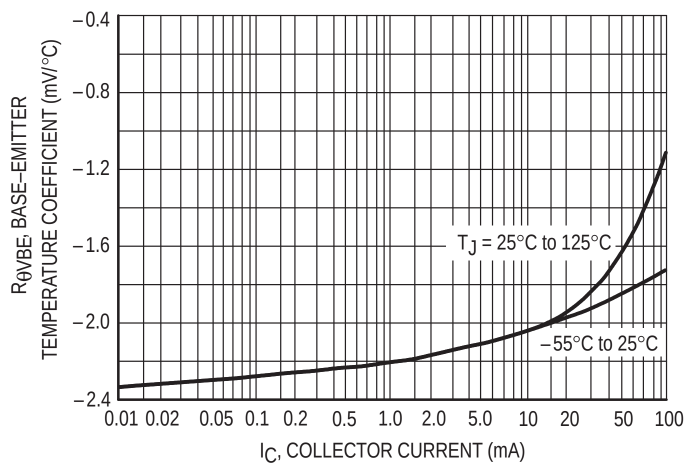


Figure 10. Temperature Coefficients

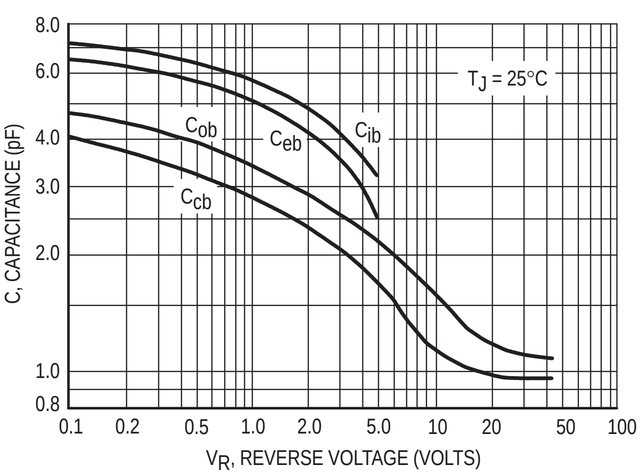


Figure 11. Capacitance

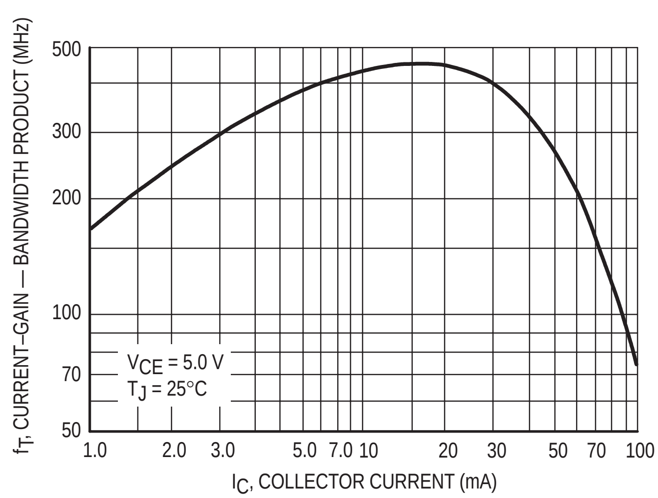
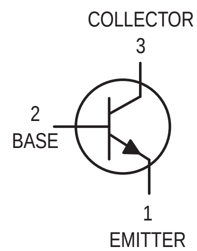
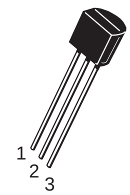


Figure 12. Current–Gain — Bandwidth Product

Amplifier Transistors
NPN Silicon

2N5209
2N5210





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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	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)	$V_{(BR)CBO}$	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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 µAdc, V_{CE} = 5.0 Vdc)	2N5209		100	300	
	2N5210		200	600	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5209		150	—	
	2N5210		250	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(1)	2N5209		150	—	
	2N5210		250	—	
Collector–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.7	Vdc
Base–Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 mAdc)		$V_{BE(on)}$	—	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		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5209		150	600	
	2N5210		250	900	
Noise Figure		NF			dB
(I_C = 20 µAdc, V_{CE} = 5.0 Vdc, R_S = 22 kΩ,	2N5209		—	3.0	
f = 1.0 kHz)	2N5210		—	2.0	
(I_C = 20 µAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ,	2N5209		—	4.0	
f = 1.0 kHz)	2N5210		—	3.0	

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

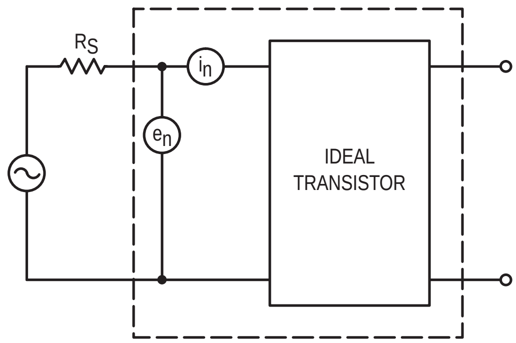


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

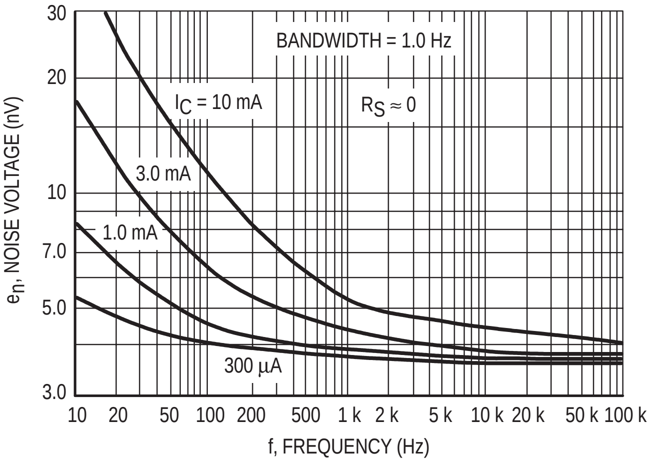


Figure 2. Effects of Frequency

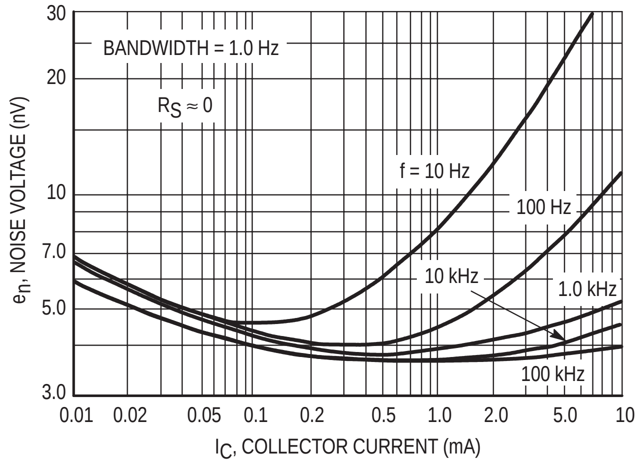


Figure 3. Effects of Collector Current

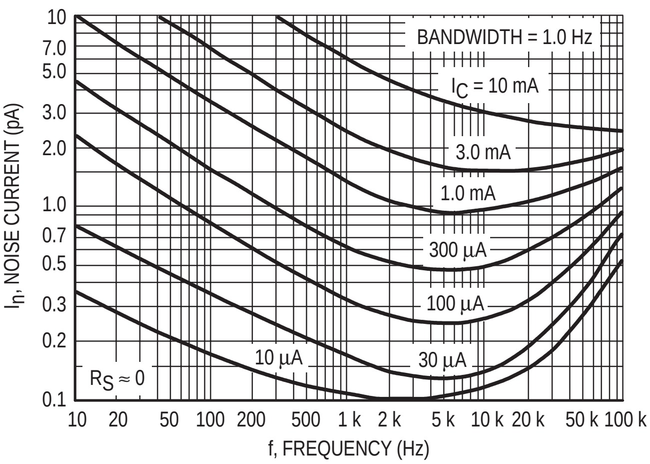


Figure 4. Noise Current

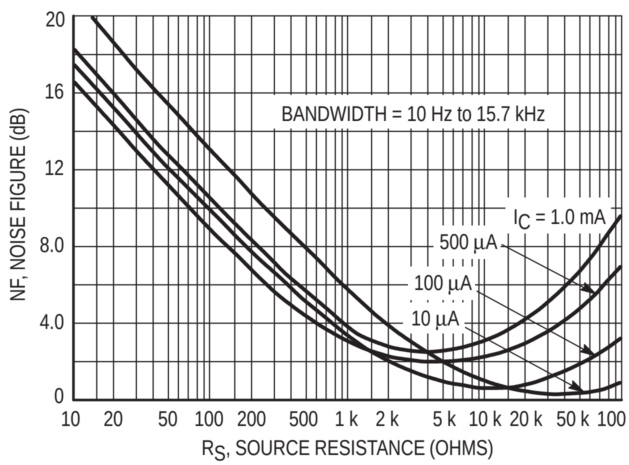


Figure 5. Wideband Noise Figure

100 Hz NOISE DATA

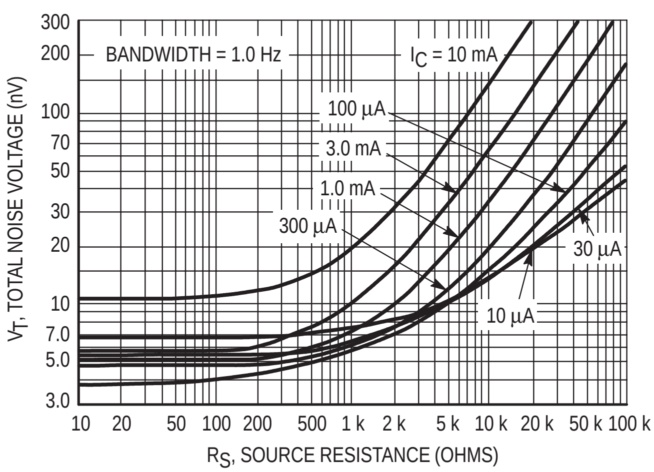


Figure 6. Total Noise Voltage

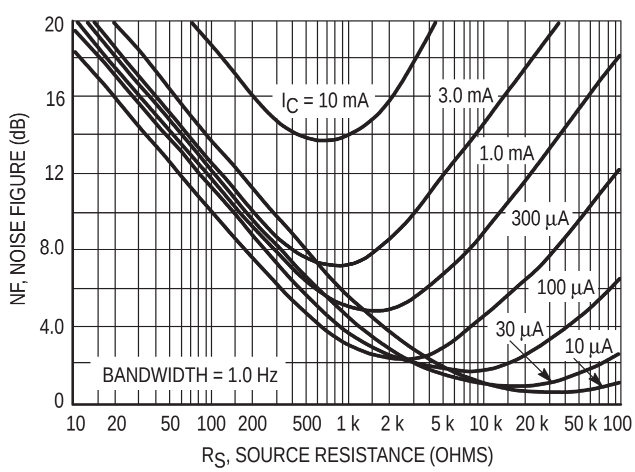


Figure 7. Noise Figure

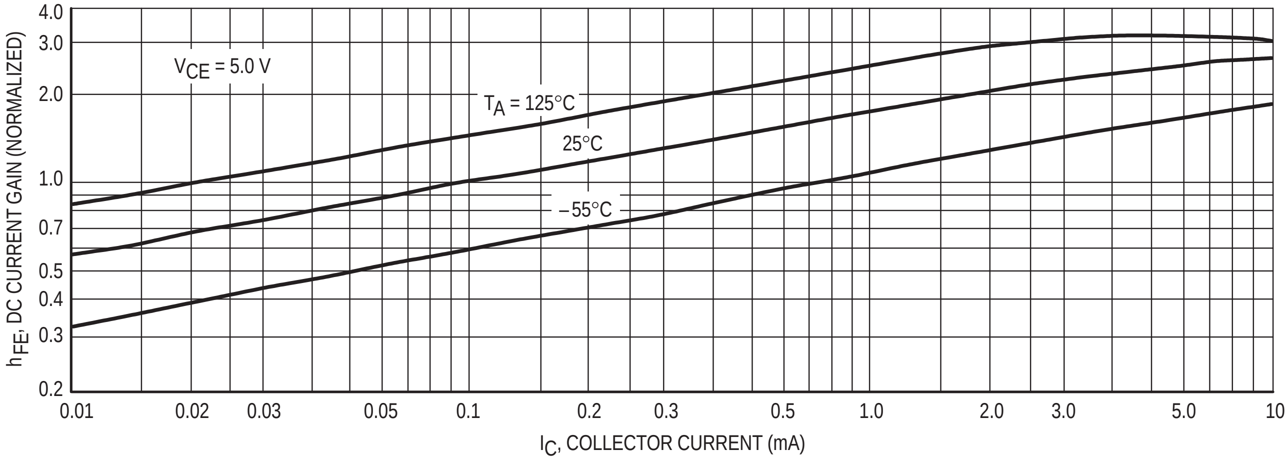


Figure 8. DC Current Gain

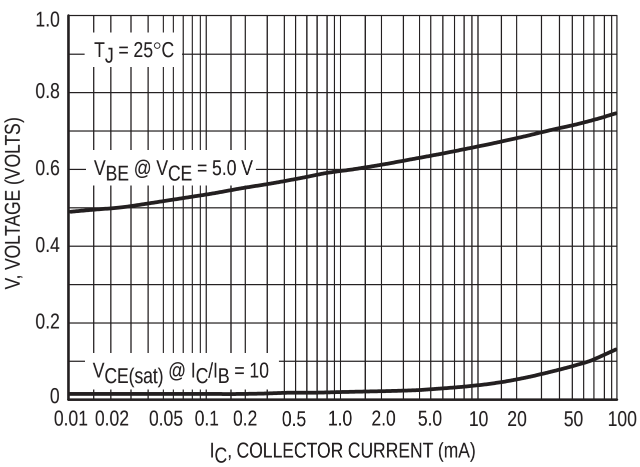


Figure 9. "On" Voltages

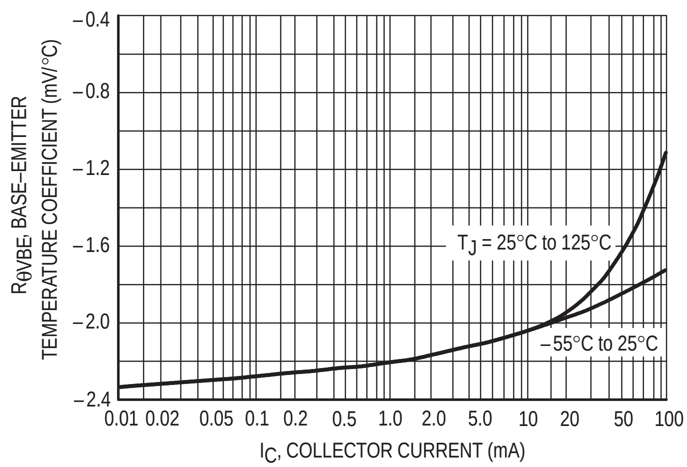


Figure 10. Temperature Coefficients

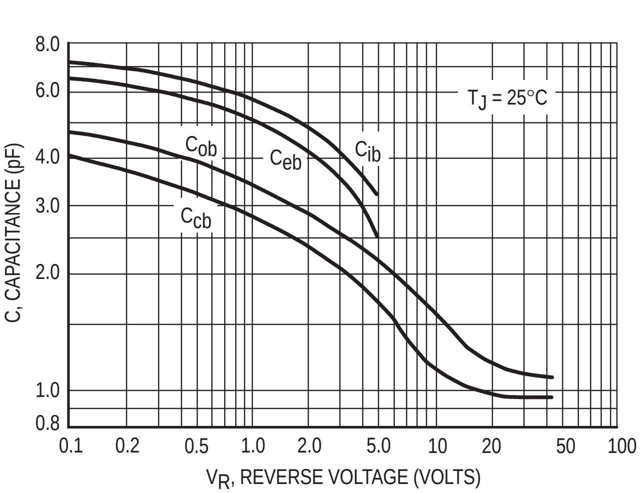


Figure 11. Capacitance

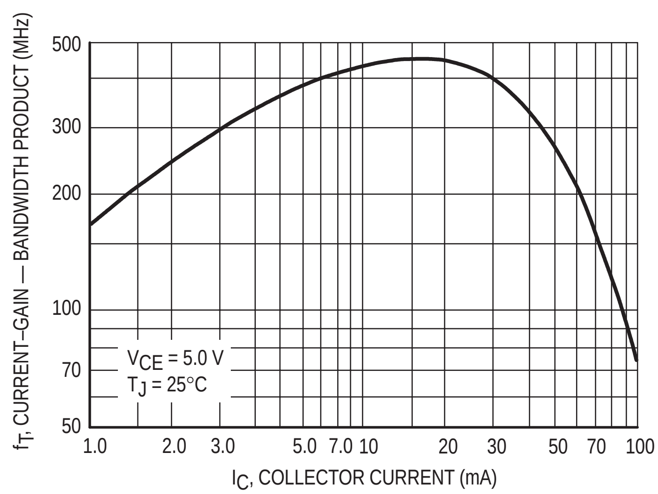
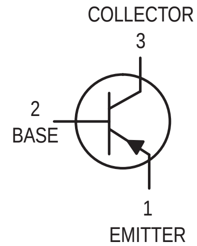


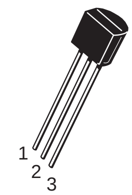
Figure 12. Current–Gain — Bandwidth Product

Amplifier Transistors
PNP Silicon

2N5400
2N5401*

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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		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)	 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

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

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5400		30	—	
	2N5401		50	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5400		40	180	
	2N5401		60	240	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	2N5400		40	—	
	2N5401		50	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.5	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	1.0	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	1.0	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N5400		100	400	
	2N5401		100	300	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Small–Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5400		30	200	
	2N5401		40	200	
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)		NF	—	8.0	dB

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

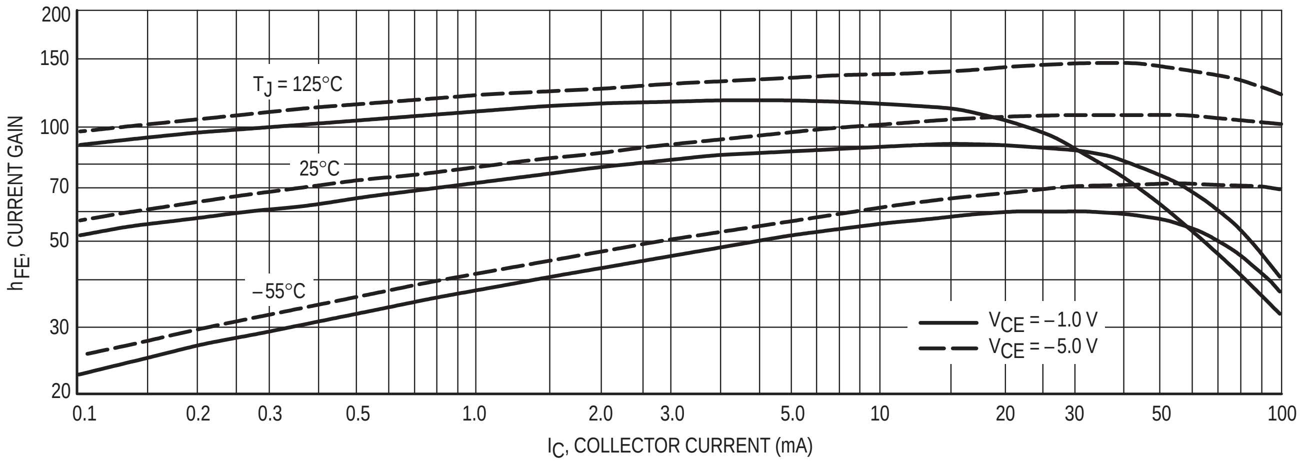


Figure 1. DC Current Gain

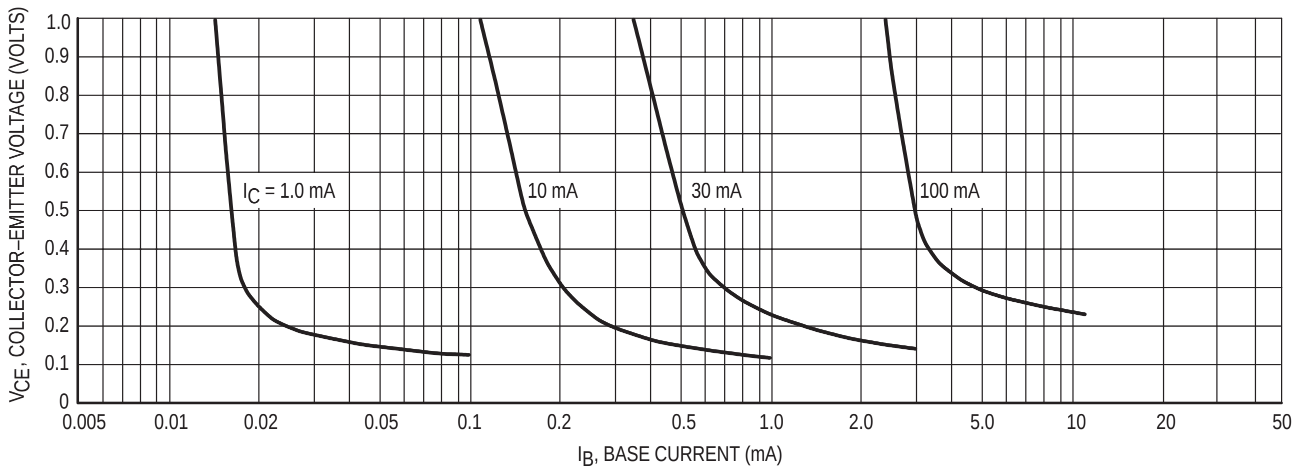


Figure 2. Collector Saturation Region

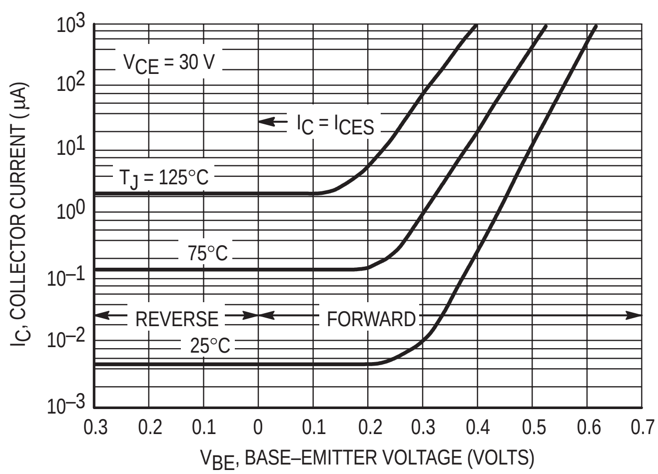


Figure 3. Collector Cut–Off Region

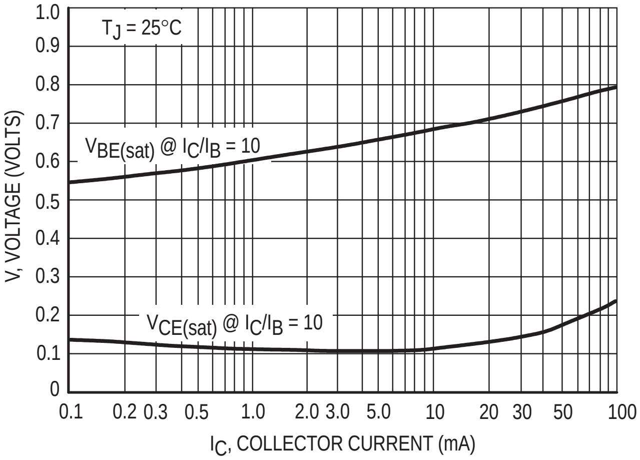


Figure 4. “On” Voltages

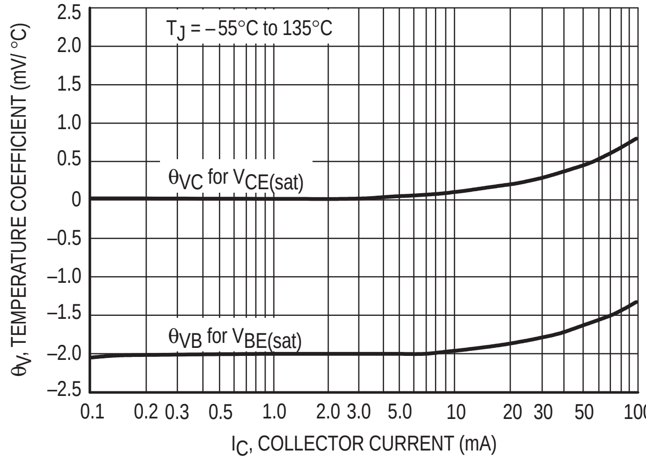
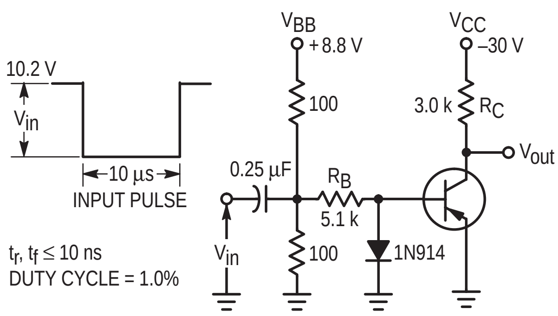


Figure 5. Temperature Coefficients



Values Shown are for I_C @ 10 mA

Figure 6. Switching Time Test Circuit

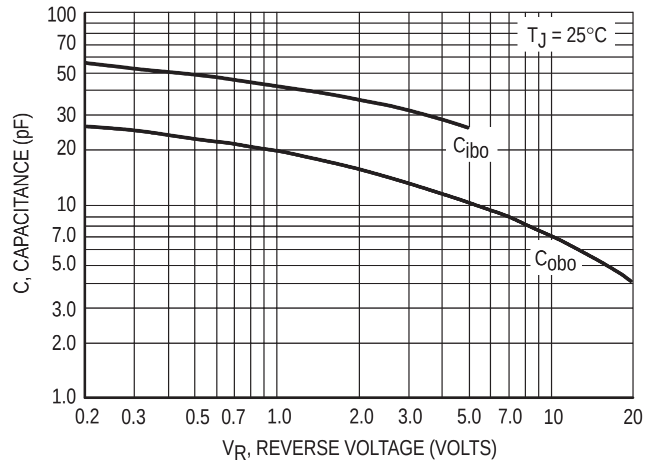


Figure 7. Capacitances

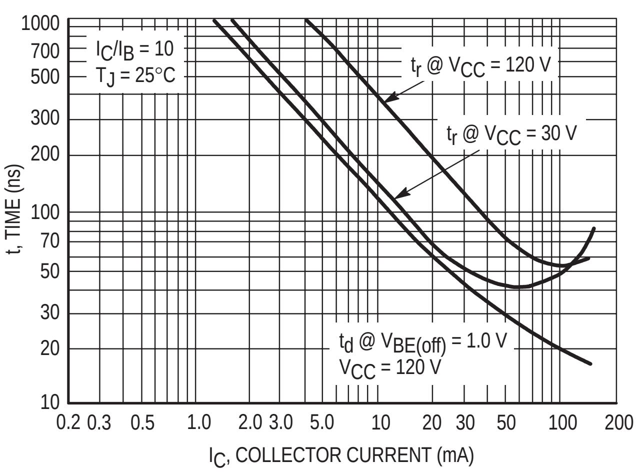


Figure 8. Turn–On Time

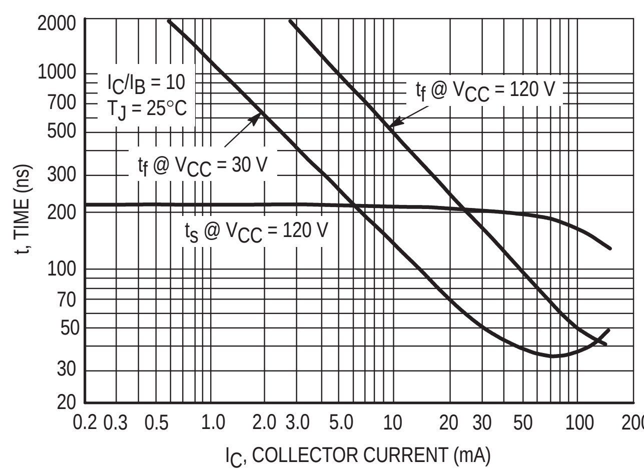
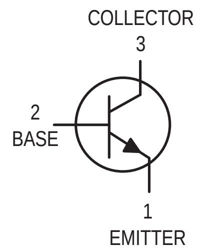


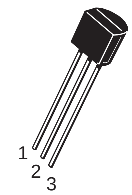
Figure 9. Turn–Off Time

Amplifier Transistors
NPN Silicon

2N5550
2N5551*

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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		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)	 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

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

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5550		60	—	
	2N5551		80	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5550		60	250	
	2N5551		80	250	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	2N5550		20	—	
	2N5551		30	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	Both Types		—	0.15	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N5550		—	0.25	
	2N5551		—	0.20	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	Both Types		—	1.0	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N5550		—	1.2	
	2N5551		—	1.0	
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		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N5550		—	30	
	2N5551		—	20	
Small–Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	50	200	—
Noise Figure		NF			dB
(I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ,	2N5550		—	10	
f = 1.0 kHz)	2N5551		—	8.0	

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

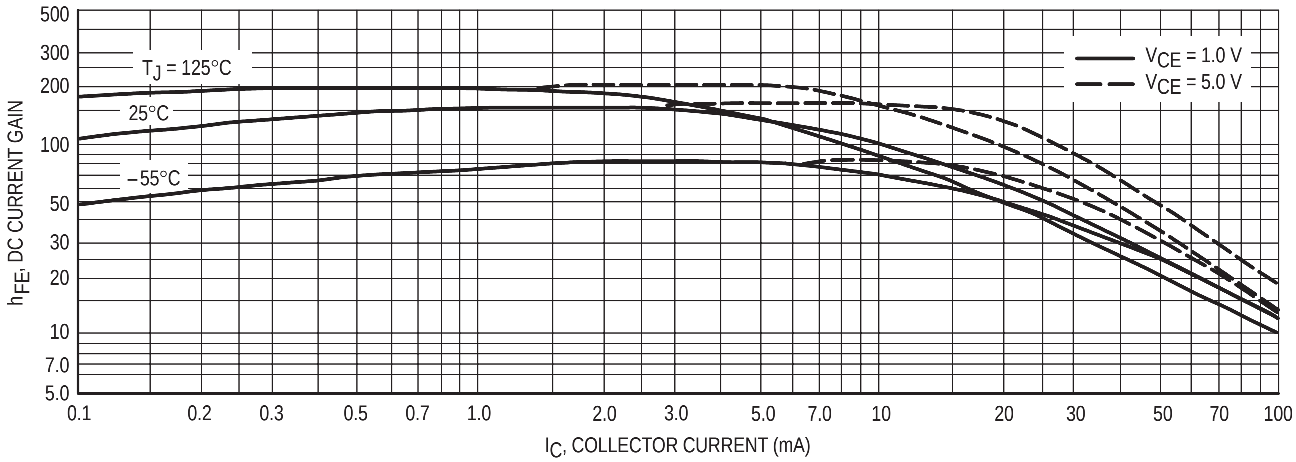


Figure 1. DC Current Gain

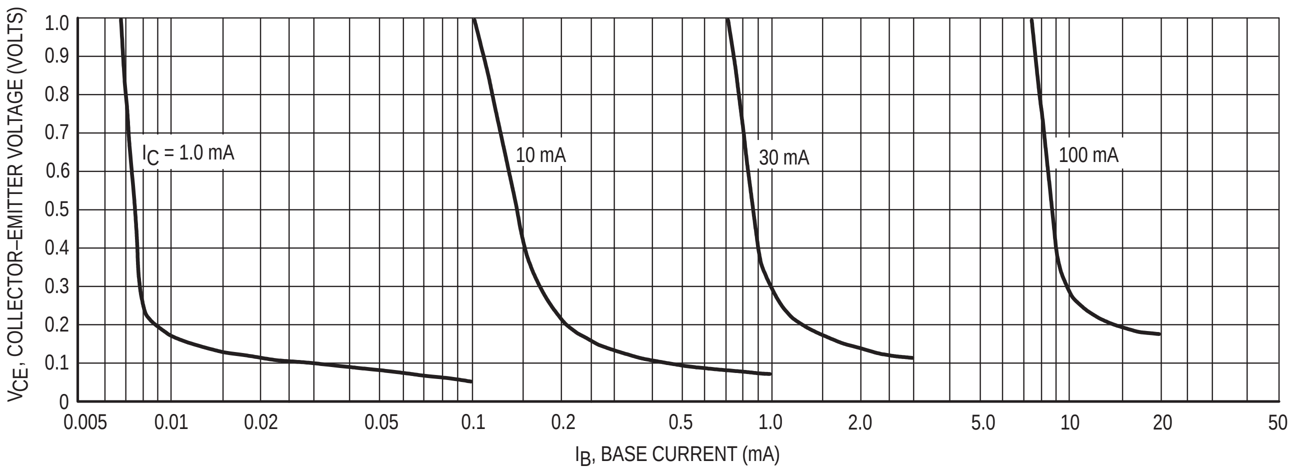


Figure 2. Collector Saturation Region

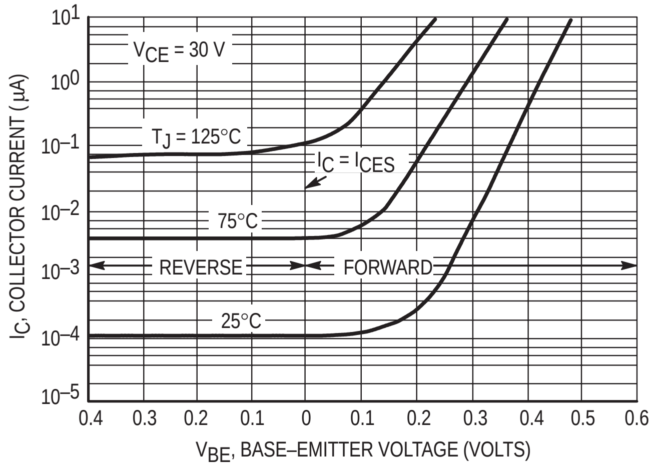


Figure 3. Collector Cut–Off Region

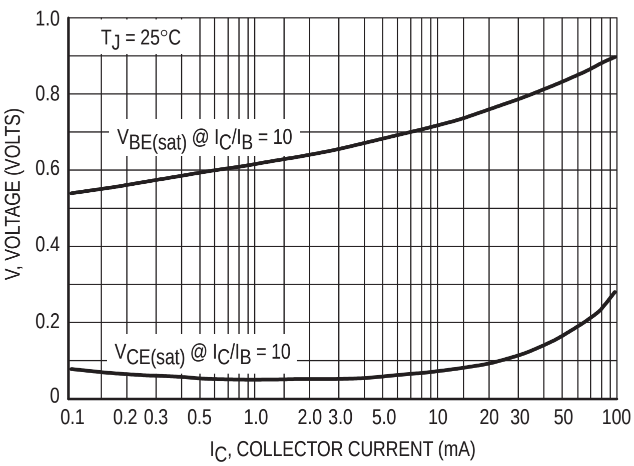


Figure 4. "On" Voltages

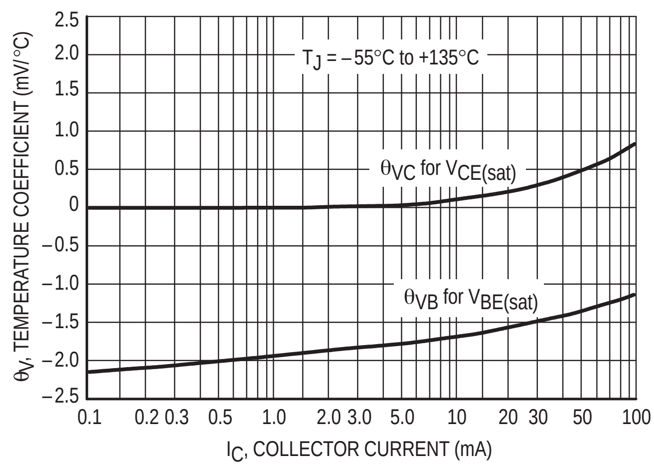
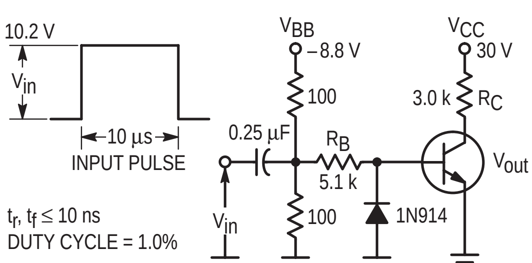


Figure 5. Temperature Coefficients



Values Shown are for I_C @ 10 mA

Figure 6. Switching Time Test Circuit

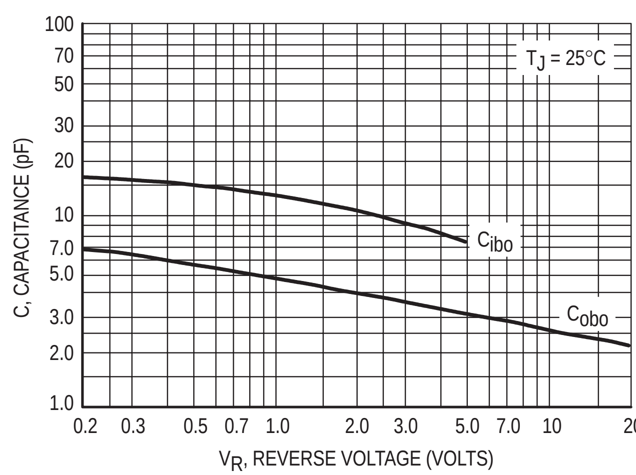


Figure 7. Capacitances

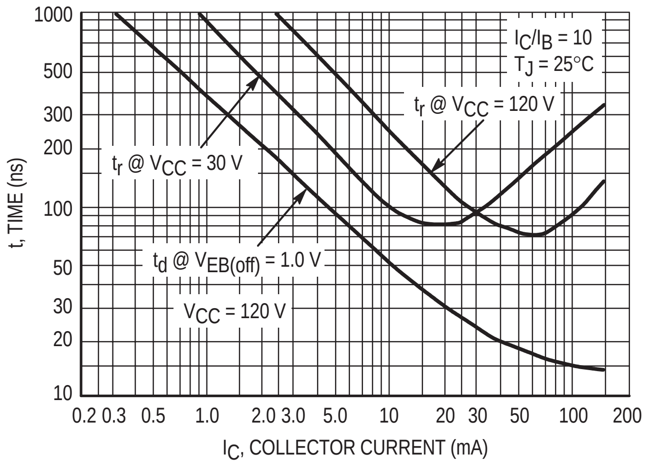


Figure 8. Turn–On Time

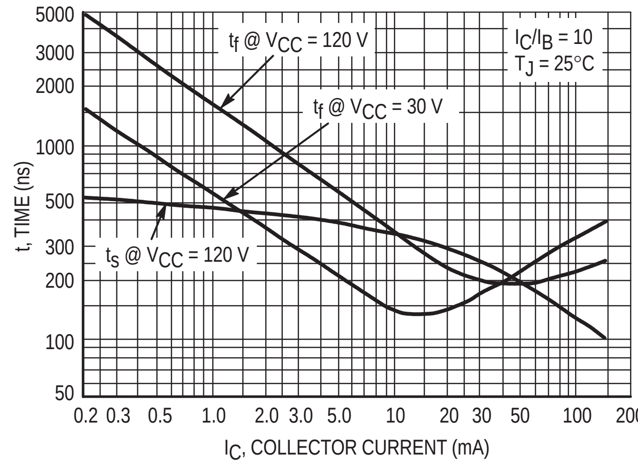
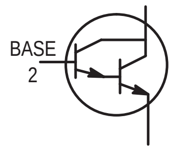


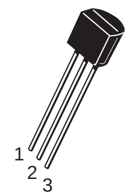
Figure 9. Turn–Off Time

Darlington Transistors
NPN Silicon

2N6426*
2N6427

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N6426		20,000	—	200,000	
	2N6427		10,000	—	100,000	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	2N6426		30,000	—	300,000	
	2N6427		20,000	—	200,000	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N6426		20,000	—	200,000	
	2N6427		14,000	—	140,000	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 50 mAdc, I_B = 0.5 mAdc)			—	0.71	1.2	
(I_C = 500 mAdc, I_B = 0.5 mAdc			—	0.9	1.5	
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
Input Impedance		h_{ie}				kΩ
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6426		100	—	2000	
	2N6427		50	—	1000	
Small–Signal Current Gain		h_{fe}				—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6426		20,000	—	—	
	2N6427		10,000	—	—	
Current–Gain — High Frequency		$\|h_{fe}\|$				—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	2N6426		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%.

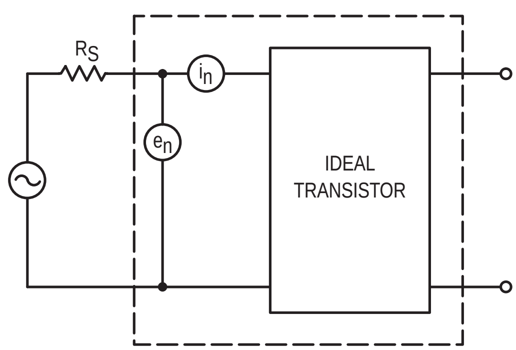


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

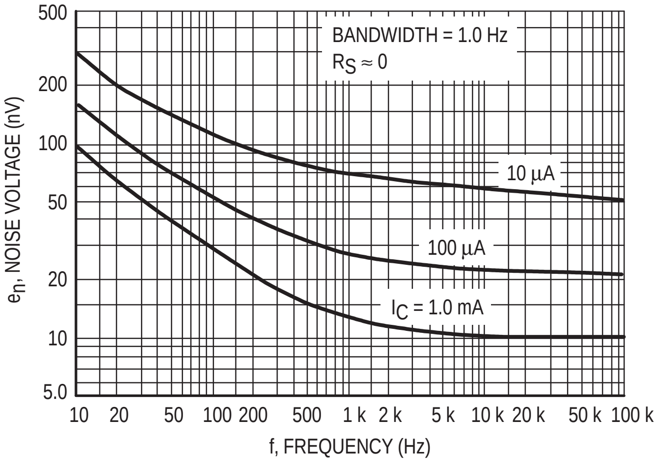


Figure 2. Noise Voltage

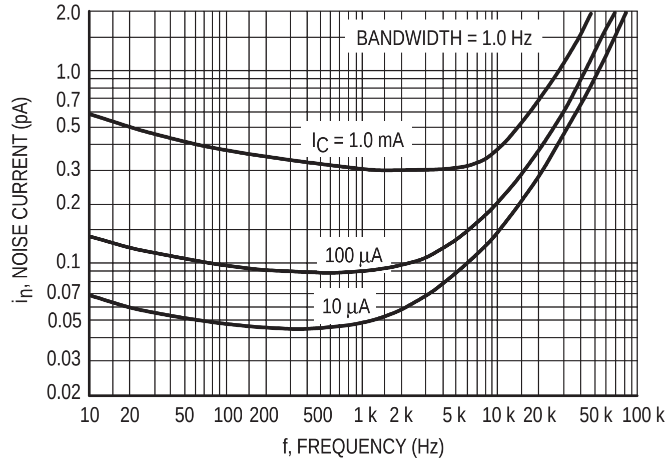


Figure 3. Noise Current

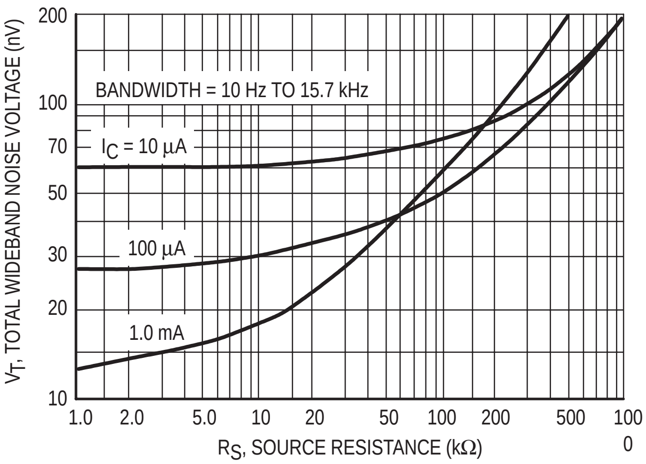


Figure 4. Total Wideband Noise Voltage

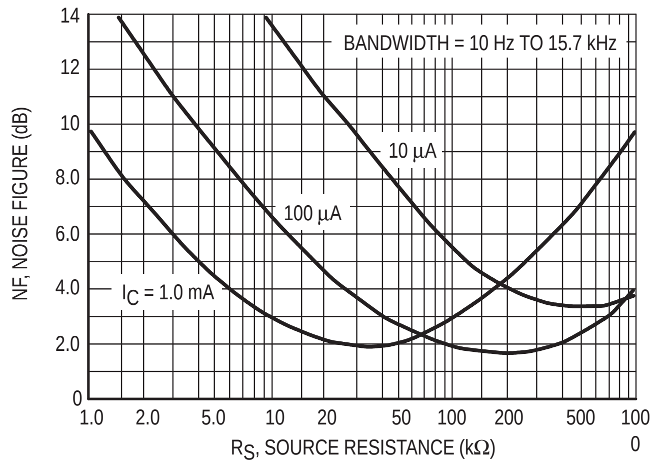


Figure 5. Wideband Noise Figure

SMALL–SIGNALCHARACTERISTICS

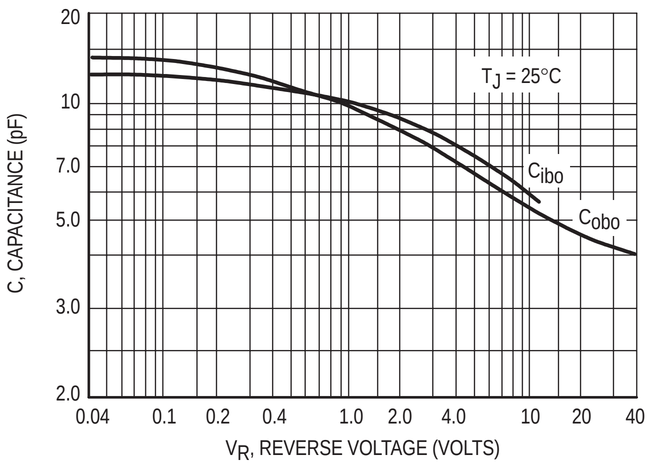


Figure 6. Capacitance

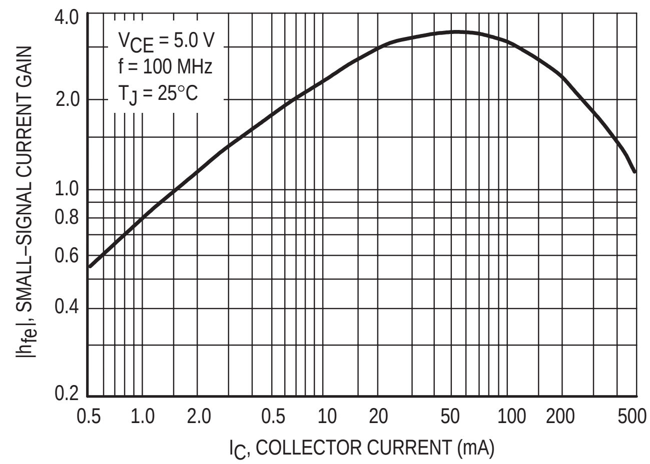


Figure 7. High Frequency Current Gain

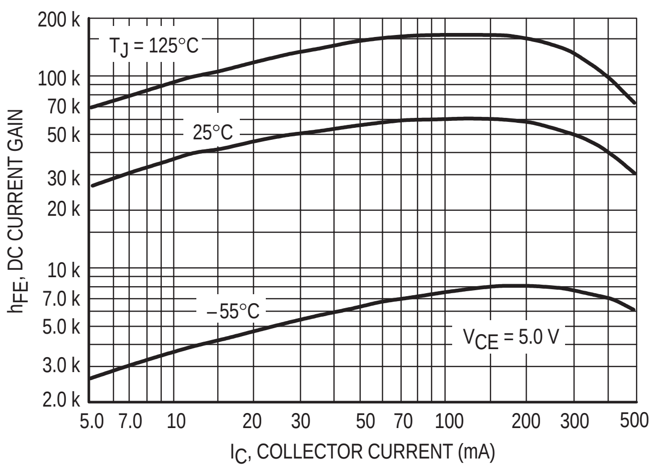


Figure 8. DC Current Gain

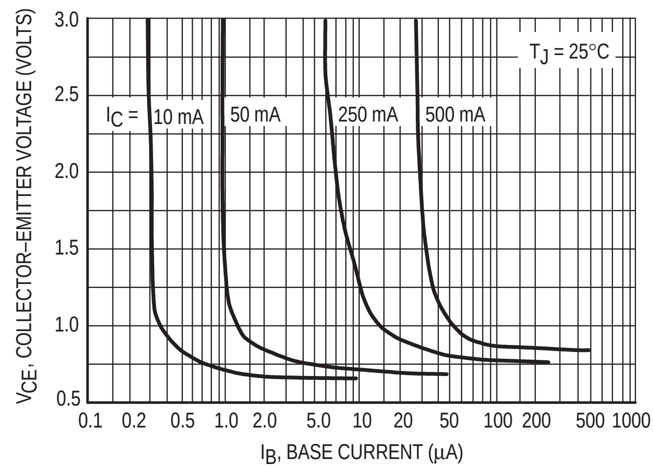


Figure 9. Collector Saturation Region

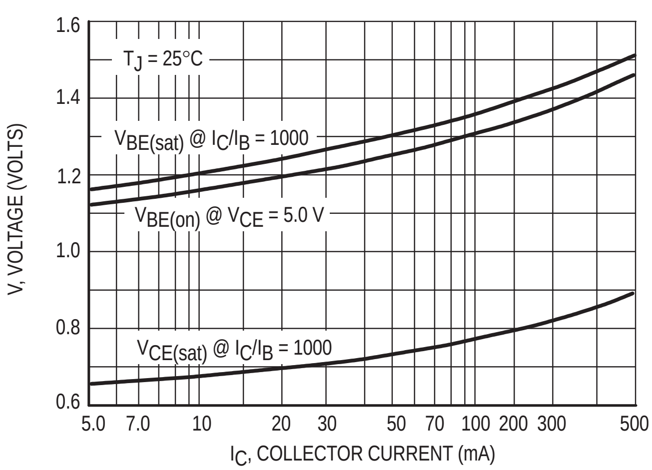


Figure 10. “On” Voltages

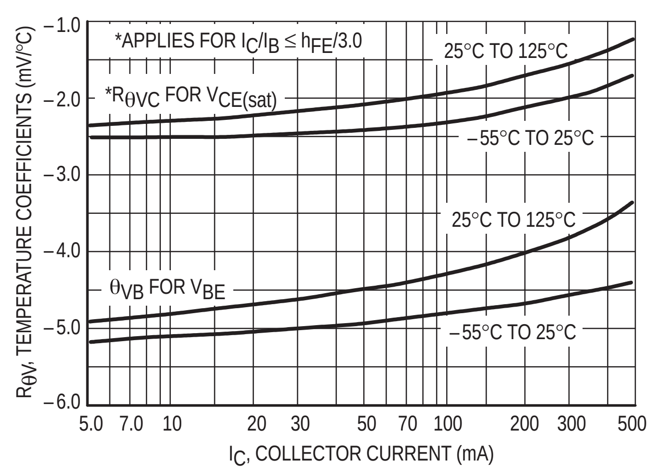


Figure 11. Temperature Coefficients

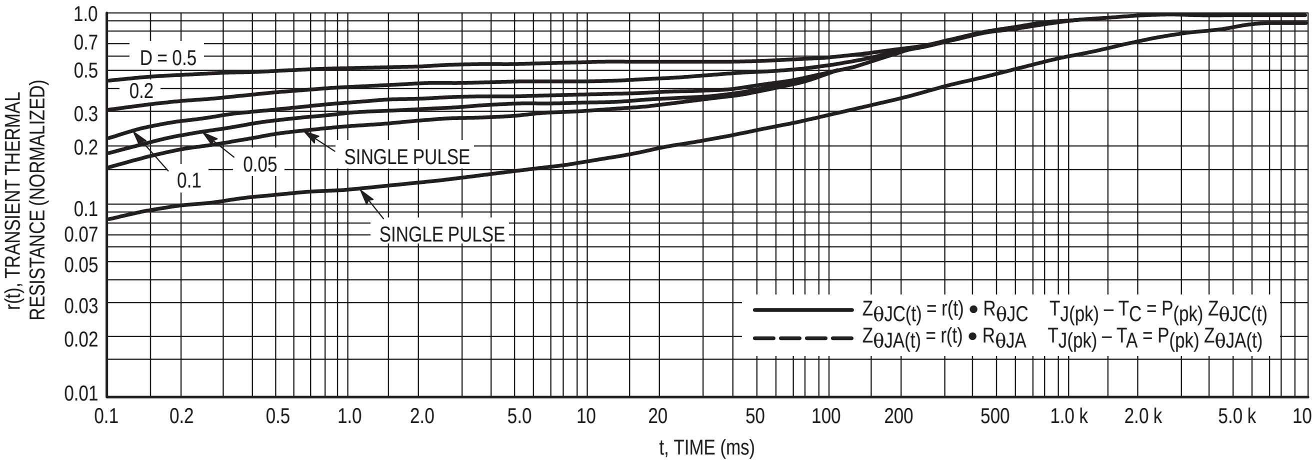


Figure 12. Thermal Response

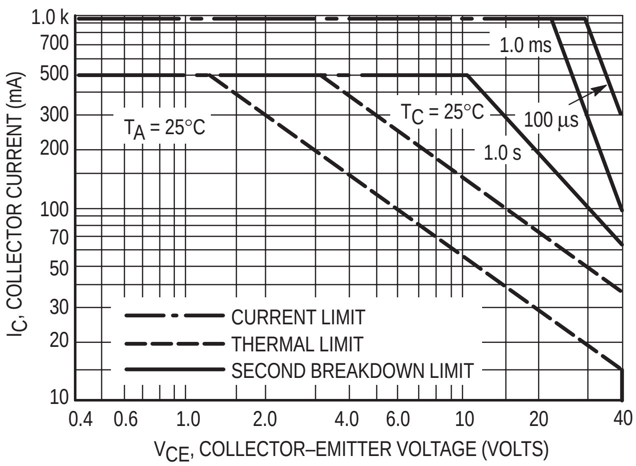
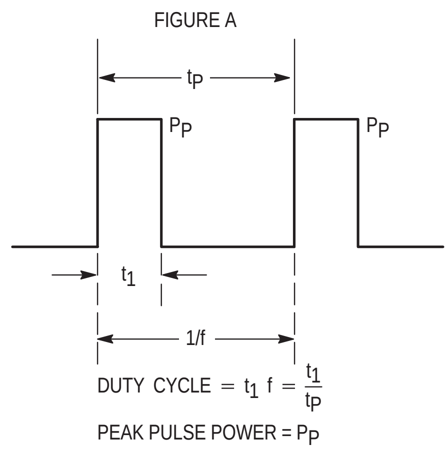
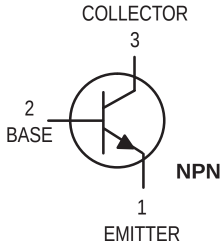


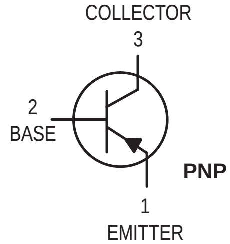
Figure 13. Active Region Safe Operating Area



Design Note: Use of Transient Thermal Resistance Data

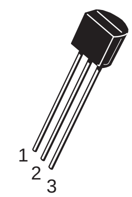
High Voltage Transistors





NPN
2N6515
2N6517
PNP
2N6519
2N6520

Voltage and current are negative for PNP transistors



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	2N6515	2N6519	2N6517 2N6520	Unit
Collector–Emitter Voltage	V_{CEO}	250	300	350	Vdc
Collector–Base Voltage	V_{CBO}	250	300	350	Vdc
Emitter–Base Voltage 2N6515, 2N6516, 2N6517 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

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 2N6519 2N6517, 2N6520	$V_{(BR)CEO}$	 250 300 350	 — — —	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N6515 2N6519 2N6517, 2N6520	$V_{(BR)CBO}$	 250 300 350	 — — —	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 2N6515, 2N6517 2N6519, 2N6520	$V_{(BR)EBO}$	 6.0 5.0	 — —	Vdc

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

REV 1

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS (Continued)					
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 150 Vdc, I_E = 0)	2N6515		—	50	
(V_{CB} = 200 Vdc, I_E = 0)	2N6519		—	50	
(V_{CB} = 250 Vdc, I_E = 0)	2N6517, 2N6520		—	50	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 5.0 Vdc, I_C = 0)	2N6515, 2N6517		—	50	
(V_{EB} = 4.0 Vdc, I_C = 0)	2N6519, 2N6520		—	50	
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N6515		35	—	
	2N6519		30	—	
	2N6517, 2N6520		20	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N6515		50	—	
	2N6519		45	—	
	2N6517, 2N6520		30	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)	2N6515		50	300	
	2N6519		45	270	
	2N6517, 2N6520		30	200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N6515		45	220	
	2N6519		40	200	
	2N6517, 2N6520		20	200	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N6515		25	—	
	2N6519		20	—	
	2N6517, 2N6520		15	—	
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, 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%.

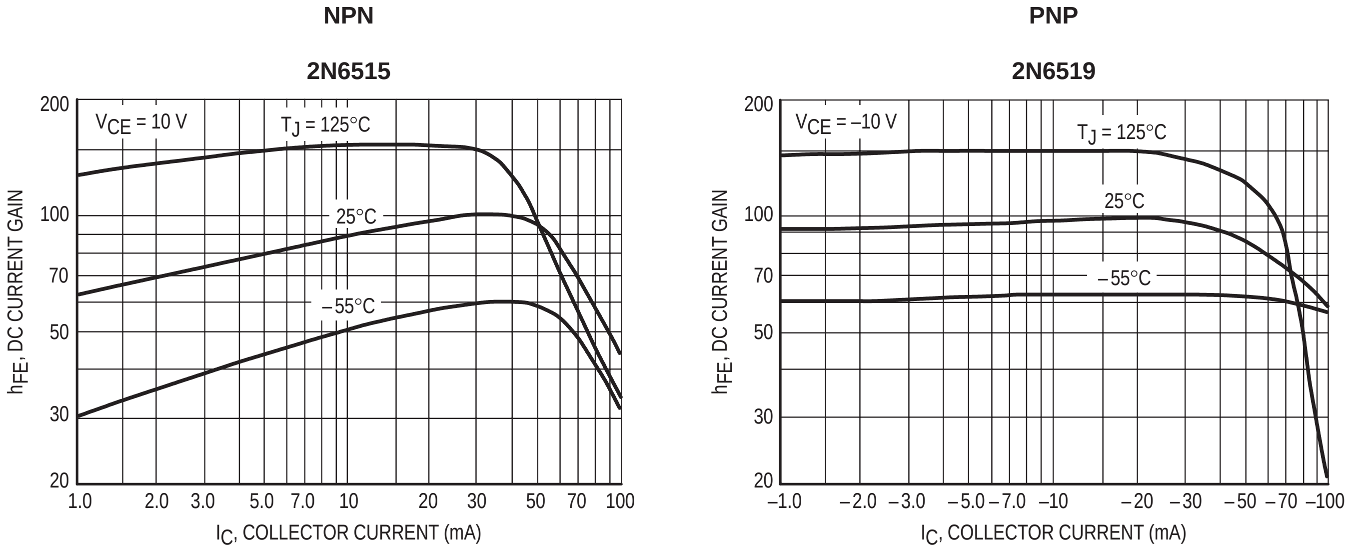


Figure 1. DC Current Gain

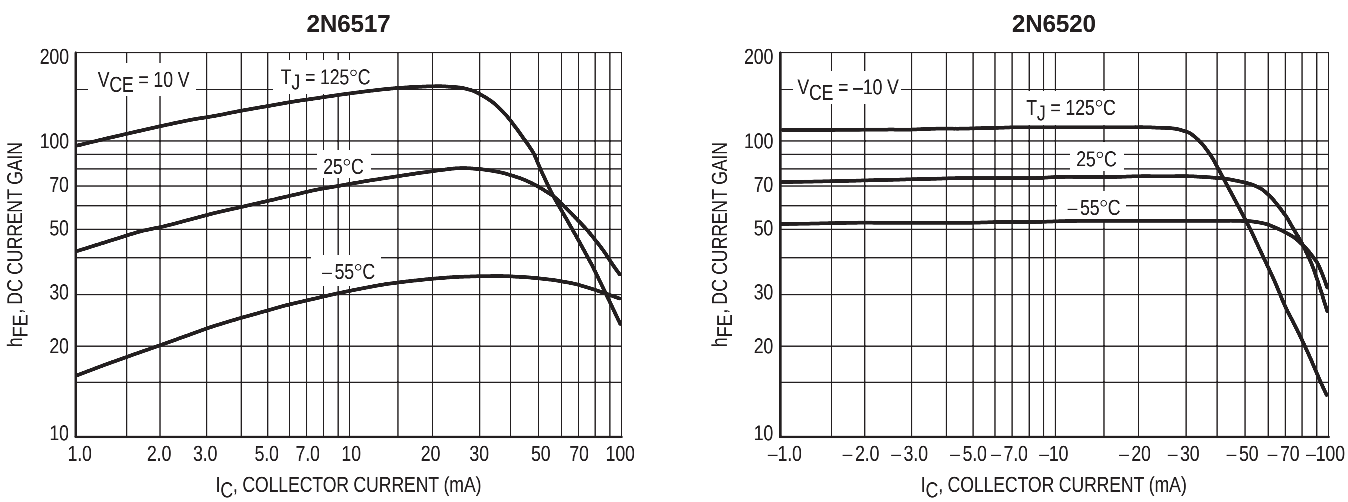


Figure 2. DC Current Gain

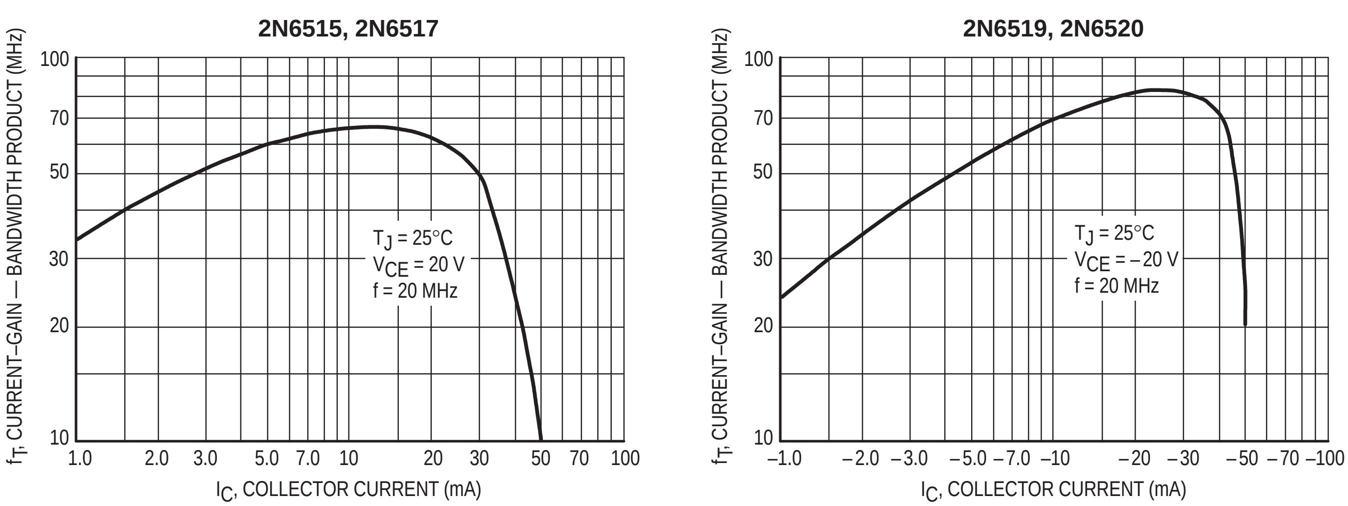


Figure 3. Current–Gain — Bandwidth Product

NPN | **PNP**

2N6515, 2N6517 | **2N6519, 2N6520**

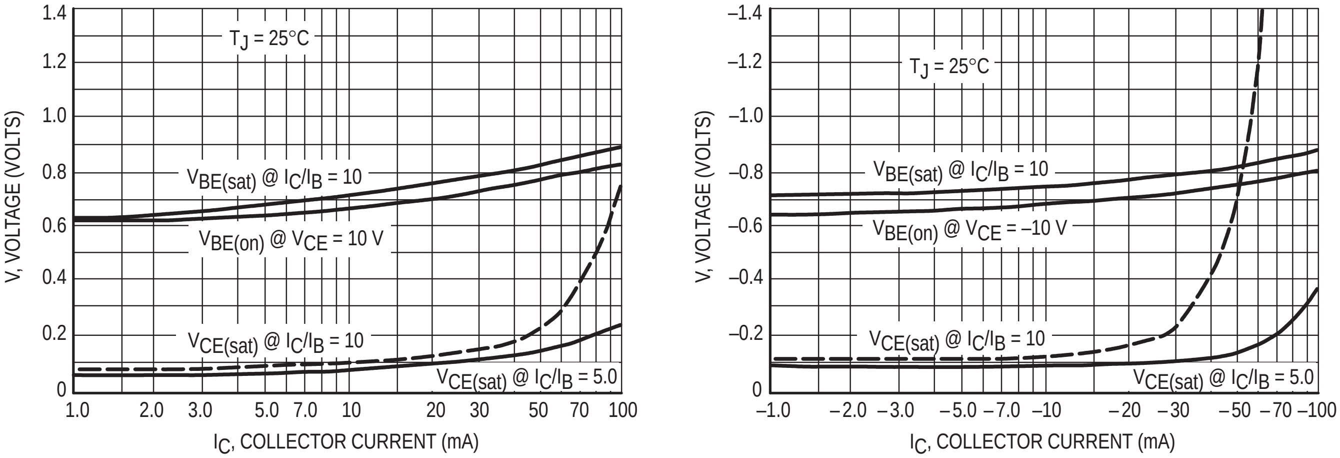


Figure 4. “On” Voltages

2N6515, 2N6517 | **2N6519, 2N6520**

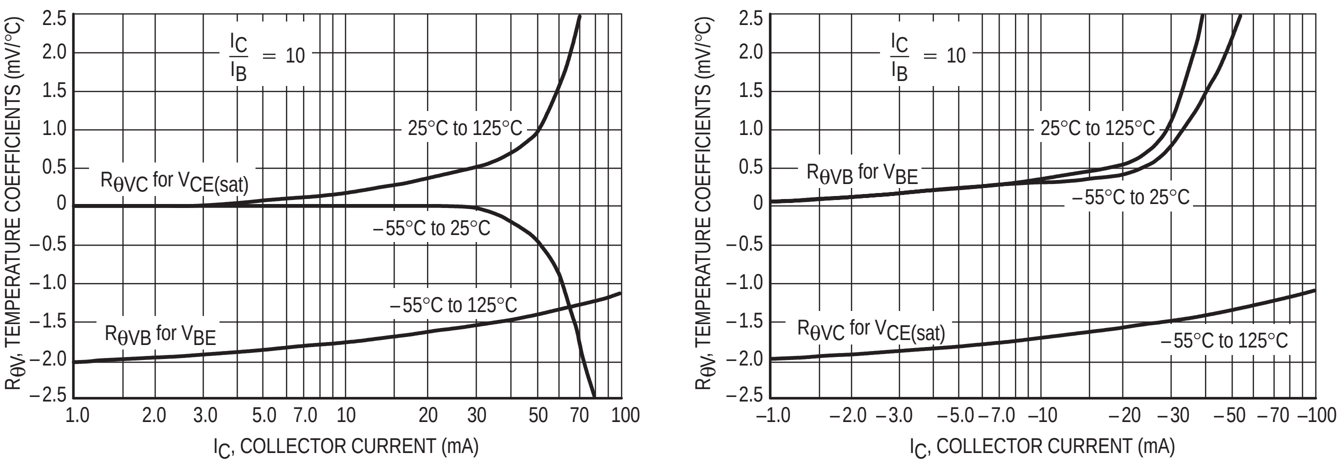


Figure 5. Temperature Coefficients

2N6515, 2N6517 | **2N6519, 2N6520**

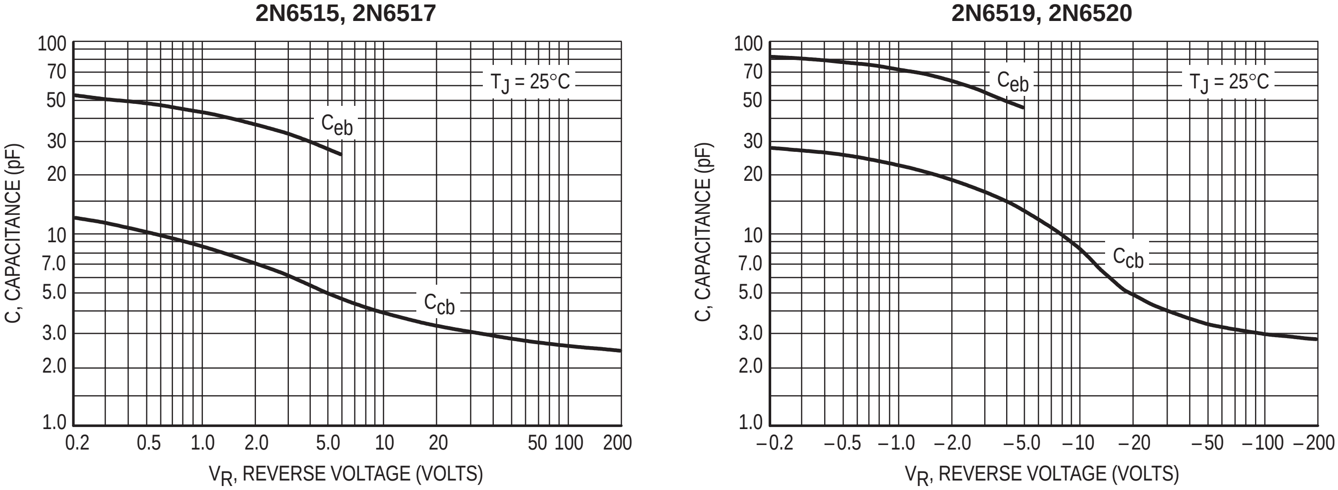


Figure 6. Capacitance

NPN | **PNP**

2N6515, 2N6517 | **2N6519, 2N6520**

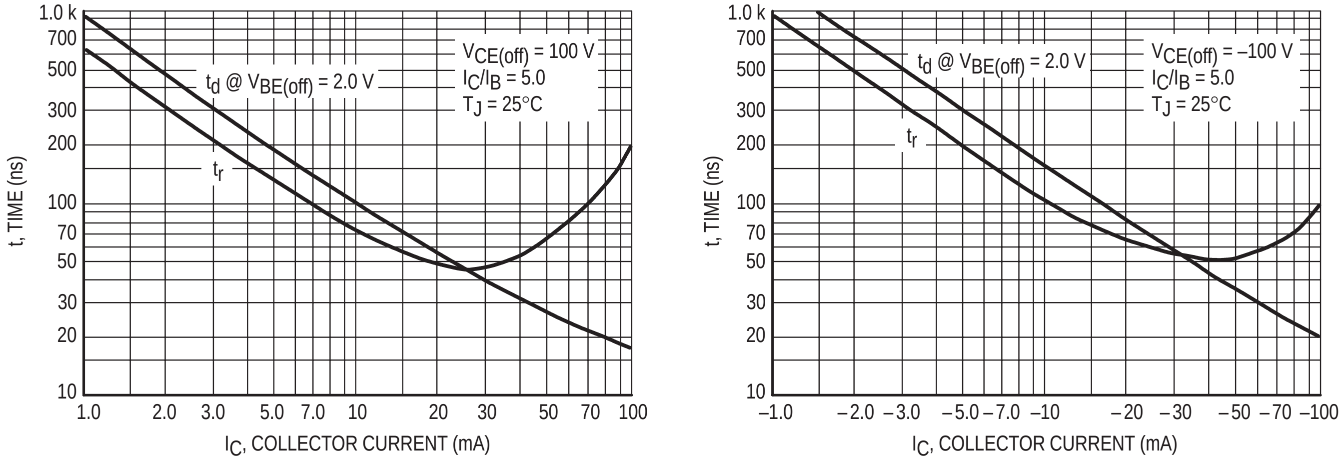


Figure 7. Turn–On Time

2N6515, 2N6517 | **2N6519, 2N6520**

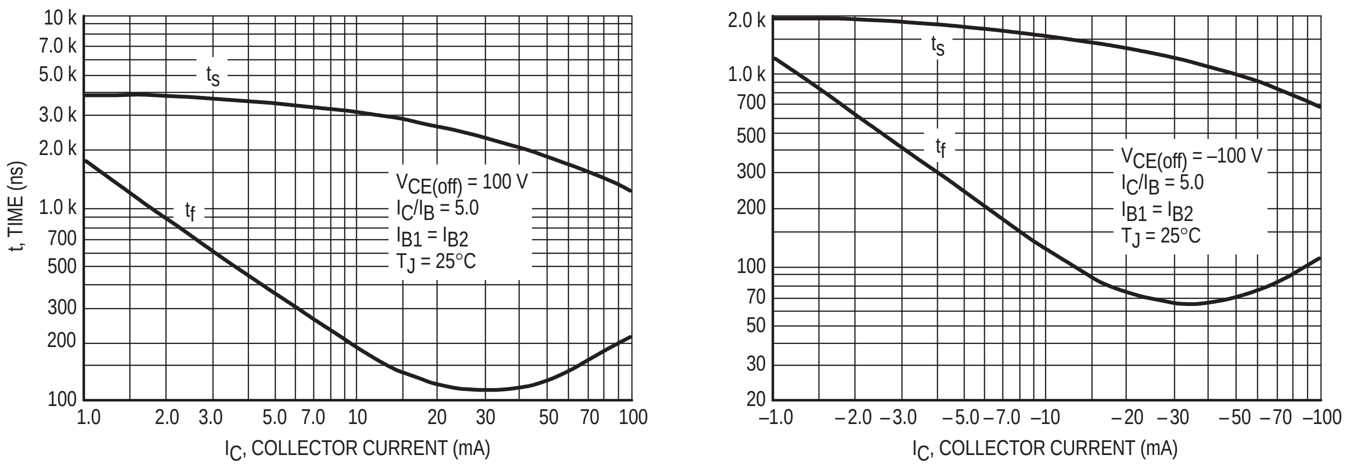


Figure 8. Turn–Off Time

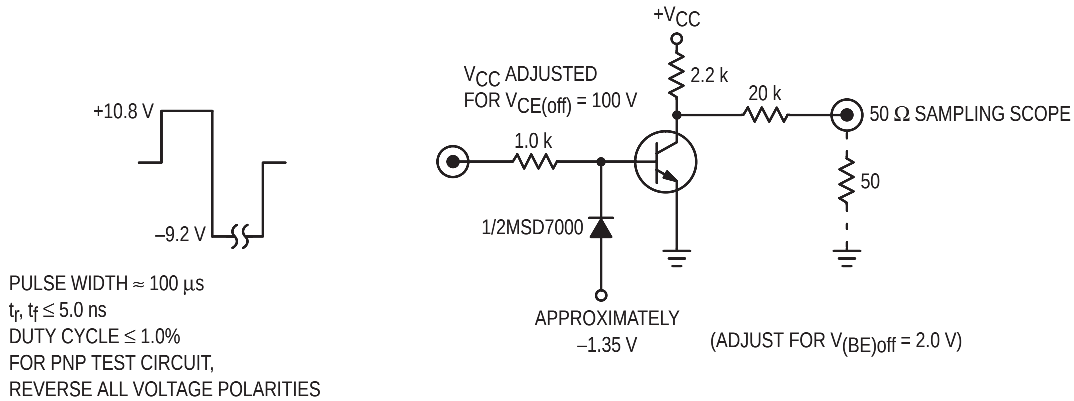


Figure 9. Switching Time Test Circuit

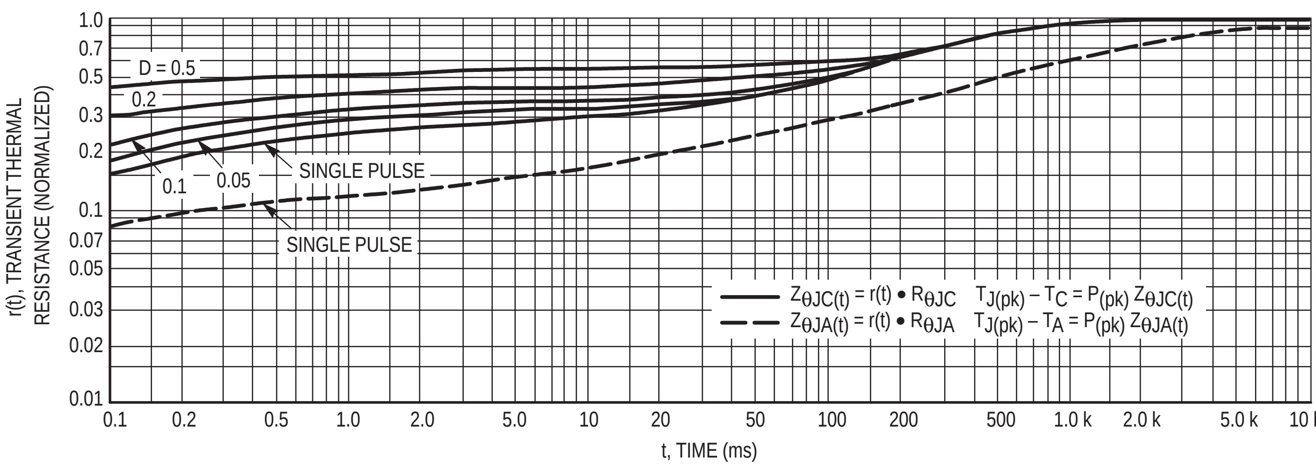


Figure 10. Thermal Response

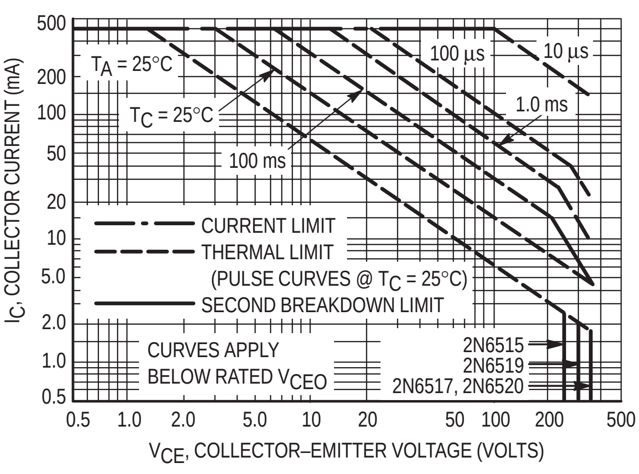
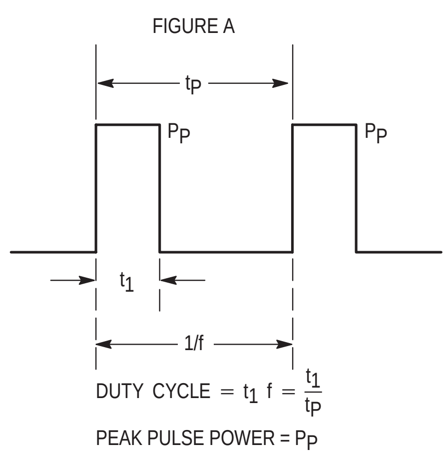


Figure 11. Active Region Safe Operating Area



Design Note: Use of Transient Thermal Resistance Data

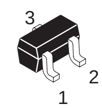
PNP Silicon General Purpose Amplifier Transistor

2SA1774

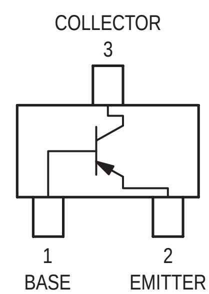
PNP GENERAL PURPOSE AMPLIFIER TRANSISTORS SURFACE MOUNT

This PNP transistor is designed for general purpose amplifier applications. This device is housed in the SOT–416/SC–90 package which is designed for low power surface mount applications, where board space is at a premium.

- Reduces Board Space
- High h_{FE}, 210 – 460 (typical)
- Low $V_{CE(sat)}$, < 0.5 V
- Available in 8 mm, 7–inch/3000 Unit Tape and Reel



CASE 463–01, STYLE 1
SOT–416/SC–90



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector–Base Voltage	$V_{(BR)CBO}$	–60	Vdc
Collector–Emitter Voltage	$V_{(BR)CEO}$	–50	Vdc
Emitter–Base Voltage	$V_{(BR)EBO}$	–6.0	Vdc
Collector Current — Continuous	I_C	–100	mAdc

DEVICE MARKING

2SA1774 = F9

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation(1)	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	Min	Typ	Max	Unit
Collector–Base Breakdown Voltage (I_C = –50 µAdc, I_E = 0)	$V_{(BR)CBO}$	–60	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = –1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	–50	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = –50 µAdc, I_E = 0)	$V_{(BR)EBO}$	–6.0	—	—	Vdc
Collector–Base Cutoff Current (V_{CB} = –30 Vdc, I_E = 0)	I_{CBO}	—	—	–0.5	nA
Emitter–Base Cutoff Current (V_{EB} = –5.0 Vdc, I_B = 0)	I_{EBO}	—	—	–0.5	µA
Collector–Emitter Saturation Voltage(2) (I_C = –50 mAdc, I_B = –5.0 mAdc)	$V_{CE(sat)}$	—	—	–0.5	Vdc
DC Current Gain(2) (V_{CE} = –6.0 Vdc, I_C = –1.0 mAdc)	h_{FE}	120	—	560	—
Transition Frequency (V_{CE} = –12 Vdc, I_C = –2.0 mAdc, f = 30 MHz)	f_T	—	140	—	MHz
Output Capacitance (V_{CB} = –12 Vdc, I_E = 0 Adc, f = 1 MHz)	C_{OB}	—	3.5	—	pF

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.
2. Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

REV 1

TYPICAL ELECTRICAL CHARACTERISTICS

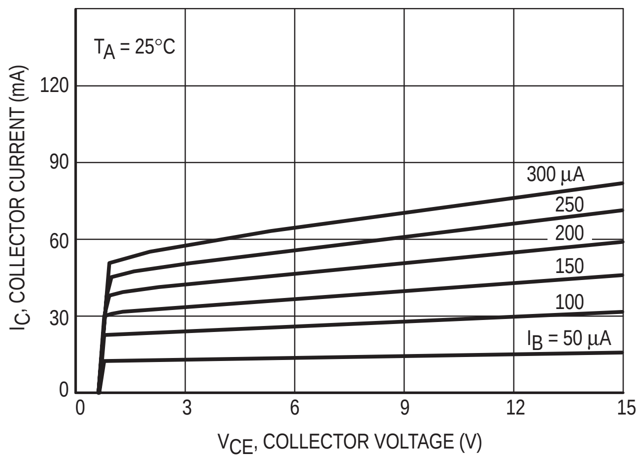


Figure 1. I_C – V_{CE}

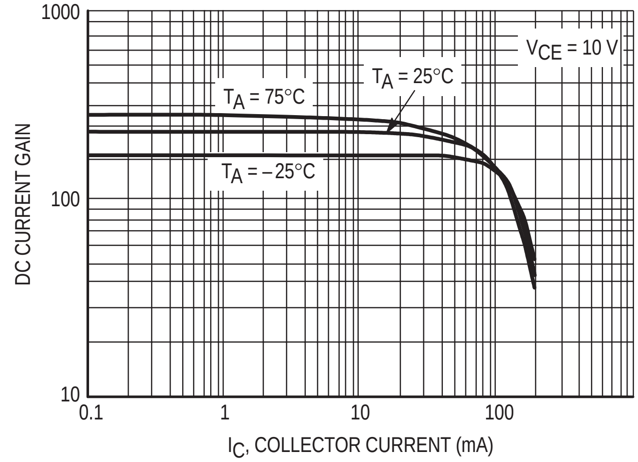


Figure 2. DC Current Gain

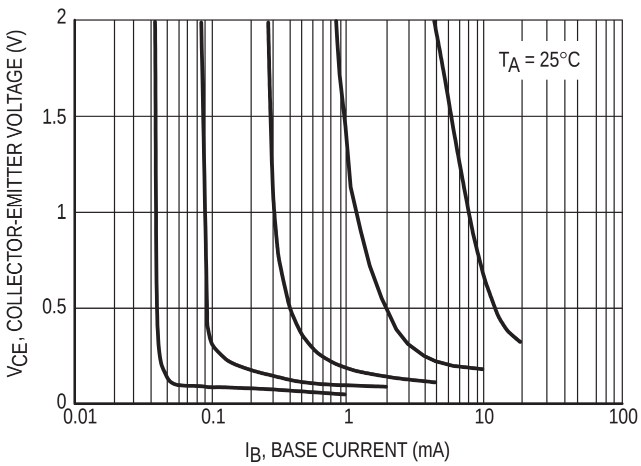


Figure 3. Collector Saturation Region

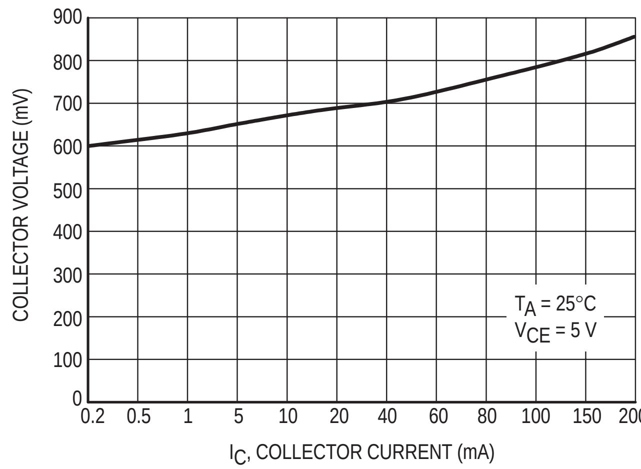


Figure 4. On Voltage

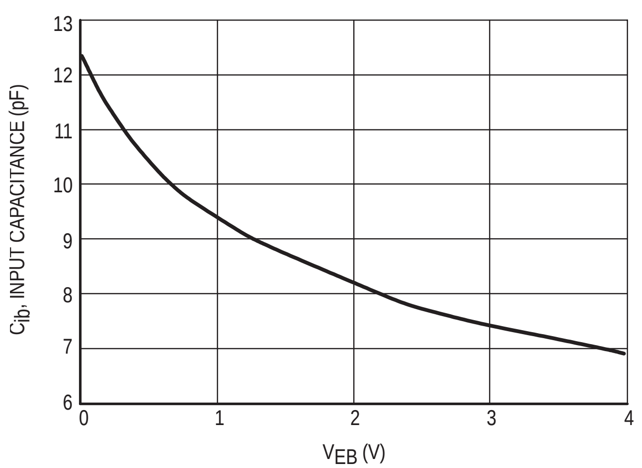


Figure 5. Capacitance

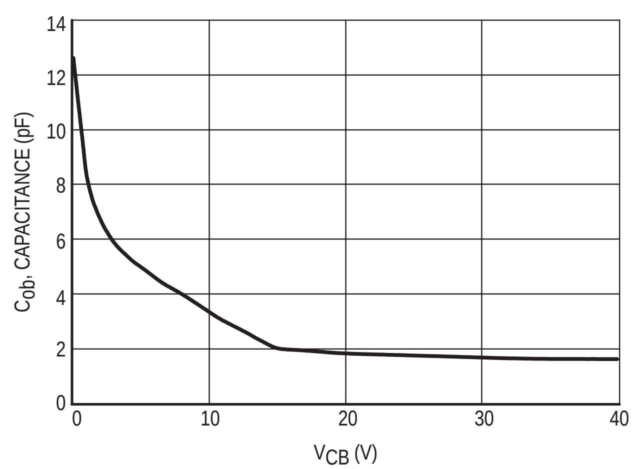


Figure 6. Capacitance

2SC4617

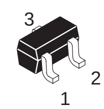
Preliminary Information

NPN Silicon General Purpose Amplifier Transistor

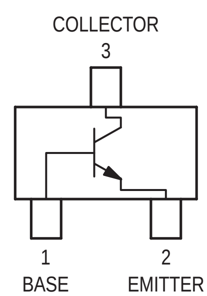
This NPN transistor is designed for general purpose amplifier applications. This device is housed in the SOT-416/SC–90 package which is designed for low power surface mount applications, where board space is at a premium.

- Reduces Board Space
- High h_{FE}, 210 – 460 (typical)
- Low $V_{CE(sat)}$, < 0.5 V
- Available in 8 mm, 7-inch/3000 Unit Tape and Reel

NPN GENERAL PURPOSE AMPLIFIER TRANSISTORS SURFACE MOUNT



CASE 463–01, STYLE 1
SOT–416/SC–90



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	50	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	50	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

DEVICE MARKING

2SC4617 = B9

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation(1)	P_D	125	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	– 55 ~ + 150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 50 µAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 50 µAdc, I_E = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	µA
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_B = 0)	I_{EBO}	—	—	0.5	µA
Collector-Emitter Saturation Voltage(2) (I_C = 60 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	—	0.4	Vdc
DC Current Gain(2) (V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc)	h_{FE}	120	—	560	—
Transition Frequency (V_{CE} = 12 Vdc, I_C = 2.0 mAdc, f = 30 MHz)	f_T	—	180	—	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_C = 0 Adc, f = 1 MHz)	C_{OB}	—	2.0	—	pF

1. Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.
2. Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

This document contains information on a product under development. Motorola reserves the right to change or discontinue this product without notice.

TYPICAL ELECTRICAL CHARACTERISTICS

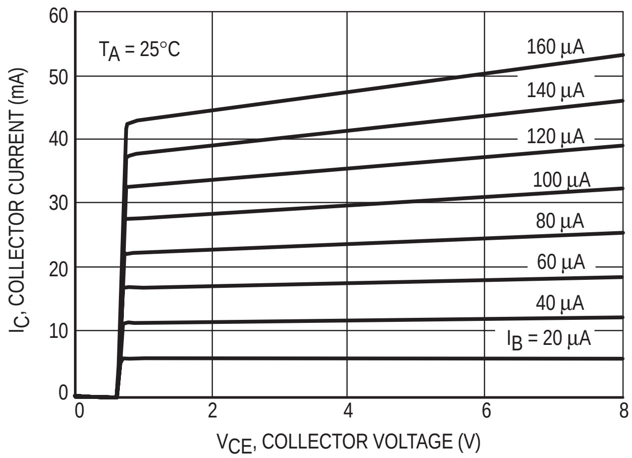


Figure 1. $I_C - V_{CE}$

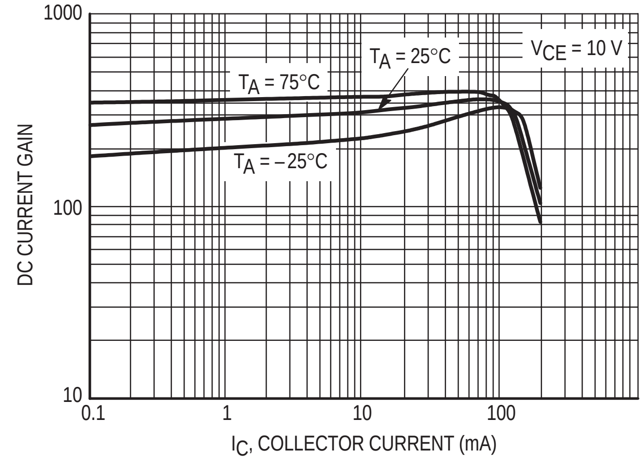


Figure 2. DC Current Gain

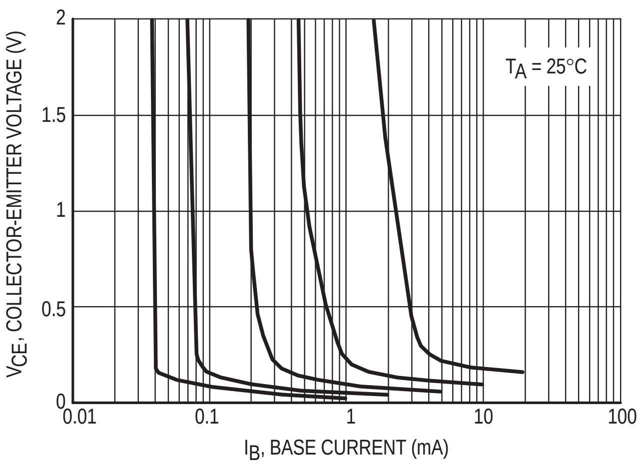


Figure 3. Collector Saturation Region

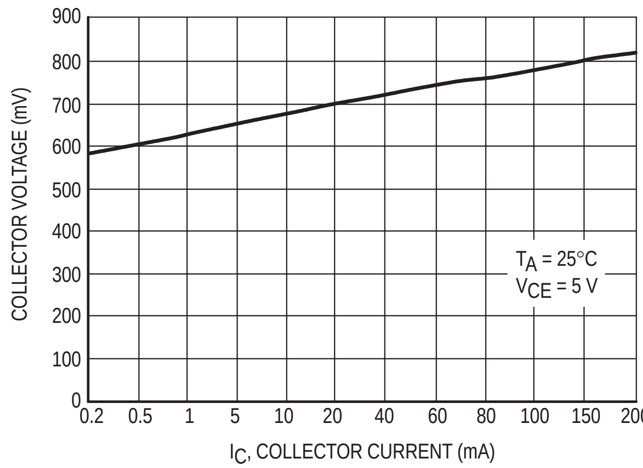


Figure 4. On Voltage

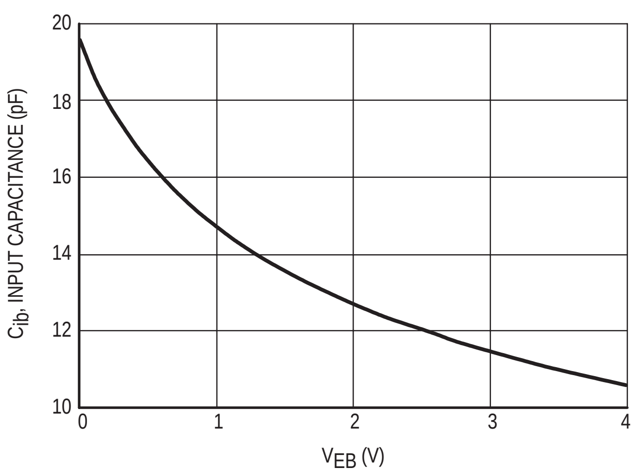


Figure 5. Capacitance

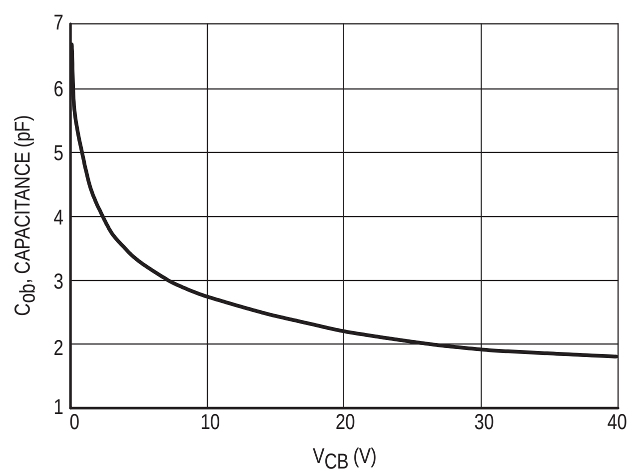
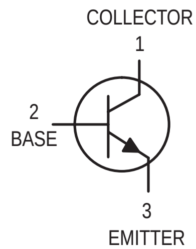


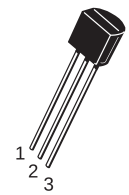
Figure 6. Capacitance

Amplifier Transistors

NPN Silicon

BC182,A,B
BC183
BC184





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC182	BC183	BC184	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			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 = 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

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 10 µA, V_{CE} = 5.0 V)	BC182		40	—	—	
	BC183		40	—	—	
	BC184		100	—	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC182		120	—	500	
	BC183		120	—	800	
	BC184		250	—	800	
(I_C = 100 mA, V_{CE} = 5.0 V)	BC182		80	—	—	
	BC183		80	—	—	
	BC184		130	—	—	
Collector–Emitter On Voltage		$V_{CE(sat)}$				V
(I_C = 10 mA, I_B = 0.5 mA)			—	0.07	0.25	
(I_C = 100 mA, I_B = 5.0 mA)(1)			—	0.2	0.6	
Base–Emitter Saturation Voltage (I_C = 100 mA, I_B = 5.0 mA)(1)		$V_{BE(sat)}$	—	—	1.2	V
Base–Emitter On Voltage		$V_{BE(on)}$				V
(I_C = 100 µA, V_{CE} = 5.0 V)			—	0.5	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)			0.55	0.62	0.7	
(I_C = 100 mA, V_{CE} = 5.0 V)(1)			—	0.83	—	
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 kΩ, f = 1.0 kHz)						
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 kΩ,	BC184		—	2.0	4.0	
f = 1.0 kHz, f = 200 Hz)	BC182		—	2.0	10	
	BC183		—	2.0	10	
	BC184		—	2.0	4.0	

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

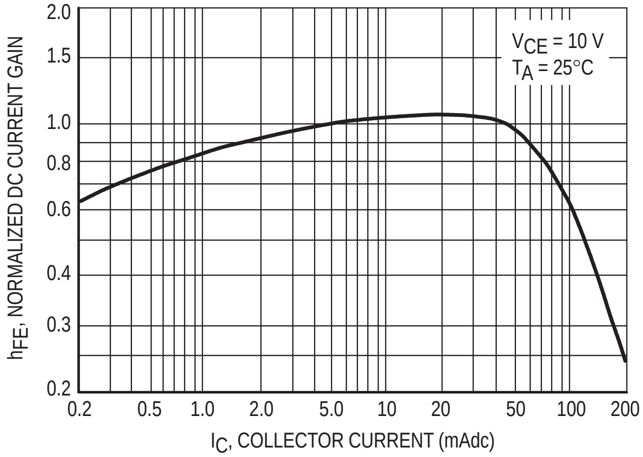


Figure 1. Normalized DC Current Gain

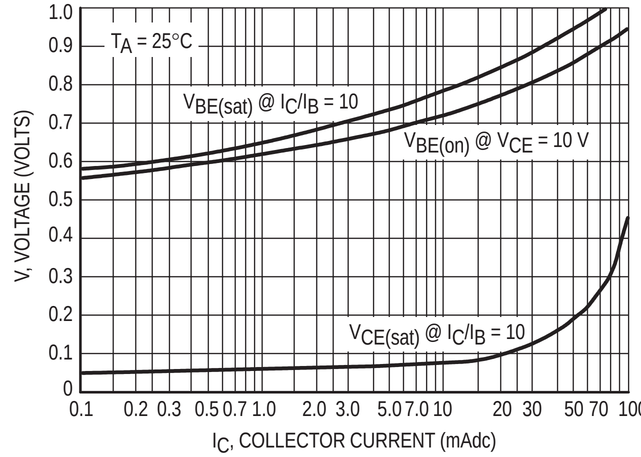


Figure 2. “Saturation” and “On” Voltages

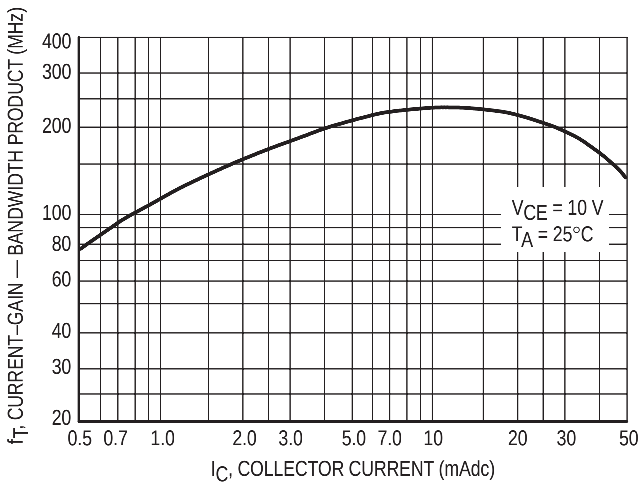


Figure 3. Current–Gain — Bandwidth Product

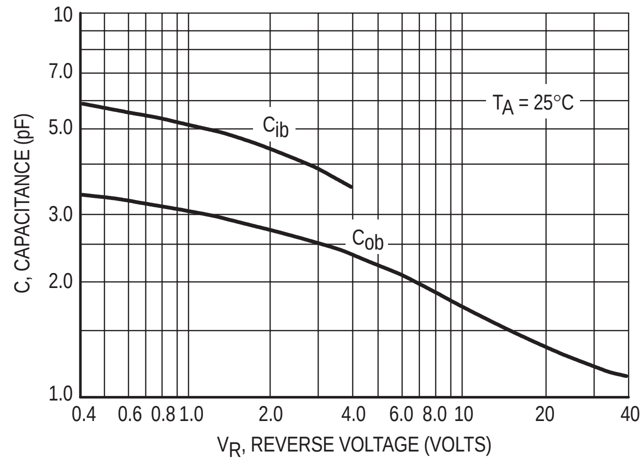


Figure 4. Capacitances

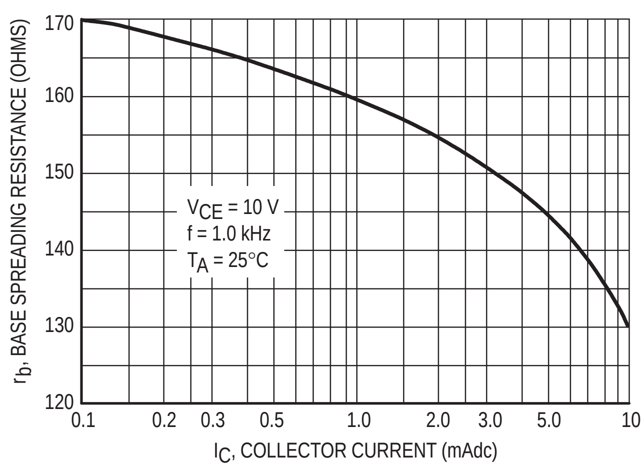
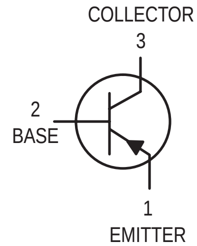
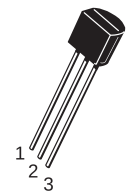


Figure 5. Base Spreading Resistance

Amplifier Transistors
PNP Silicon

BC212,B
BC213
BC214





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC212	BC213	BC214	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		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
Collector – Emitter Breakdown Voltage (I_C = –2.0 mAdc, I_B = 0)	BC212 BC213 BC214	$V_{(BR)CEO}$	–50 –30 –30	— — —	— — —	Vdc
Collector – Base Breakdown Voltage (I_C = –10 μA, I_E = 0)	BC212 BC213 BC214	$V_{(BR)CBO}$	–60 –45 –45	— — —	— — —	Vdc
Emitter – Base Breakdown Voltage (I_E = –10 μAdc, I_C = 0)	BC212 BC213 BC214	$V_{(BR)EBO}$	–5 –5 –5	— — —	— — —	Vdc
Collector–Emitter Leakage Current (V_{CB} = –30 V)	BC212 BC213 BC214	I_{CBO}	— — —	— — —	–15 –15 –15	nAdc
Emitter–Base Leakage Current (V_{EB} = –4.0 V, I_C = 0)	BC212 BC213 BC214	I_{EBO}	— — —	— — —	–15 –15 –15	nAdc

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

Characteristic		Symbol	Min	Typ	Max	Unit
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)(1)	BC212, BC214		—	120	—	
	BC213		—	140	—	
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)(1)			—	–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		f_T				MHz
(I_C = –10 mAdc, V_{CE} = –5.0 Vdc, f = 100 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 kΩ , f = 1.0 kHz)	BC214		—	—	2	
(I_C = –0.2 mAdc, V_{CE} = –5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, f = 200 Hz)	BC212, BC213		—	—	10	
Small–Signal Current Gain		h_{fe}				—
(I_C = –2.0 mAdc, V_{CE} = –5.0 Vdc, f = 1.0 kHz)	BC212		60	—	—	
	BC213		80	—	—	
	BC214		140	—	—	
	BC212B		200	—	400	

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

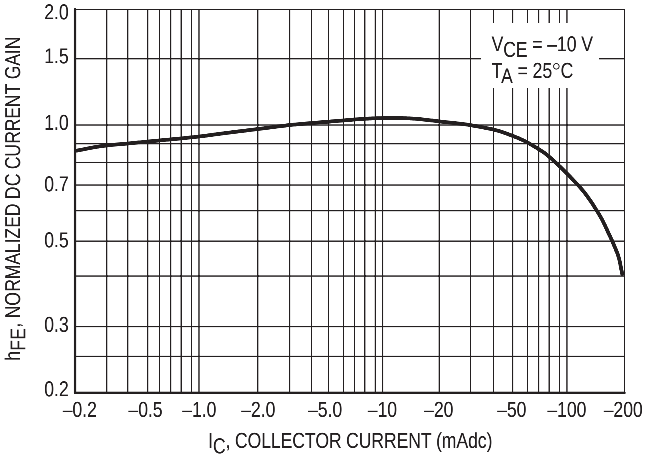


Figure 1. Normalized DC Current Gain

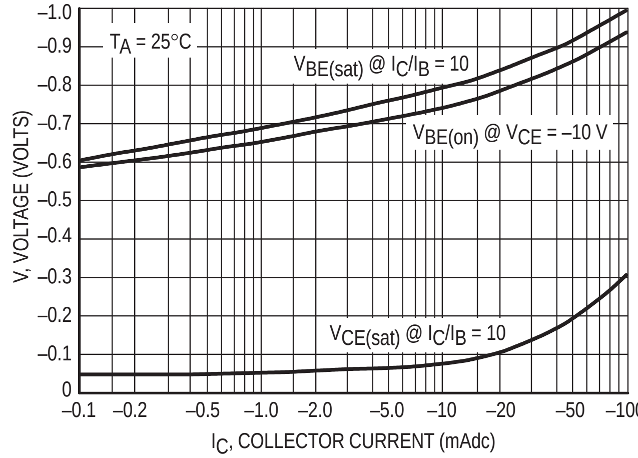


Figure 2. “Saturation” and “On” Voltages

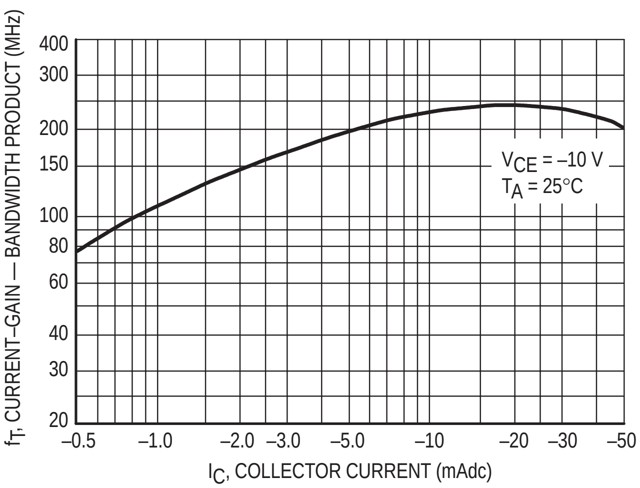


Figure 3. Current–Gain — Bandwidth Product

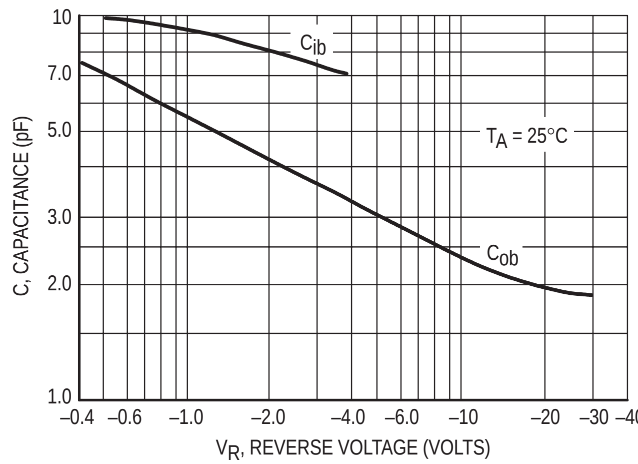


Figure 4. Capacitances

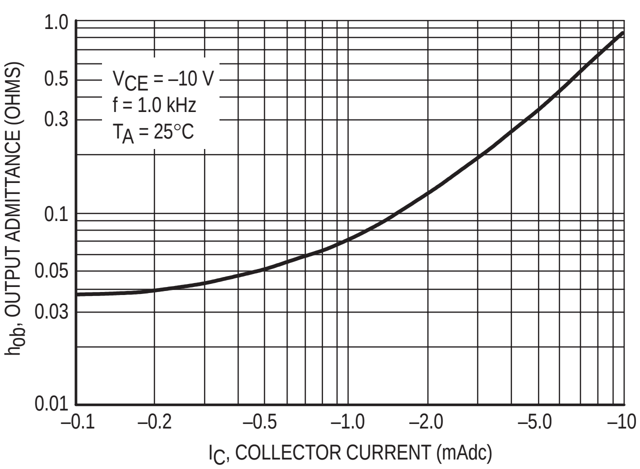


Figure 5. Output Admittance

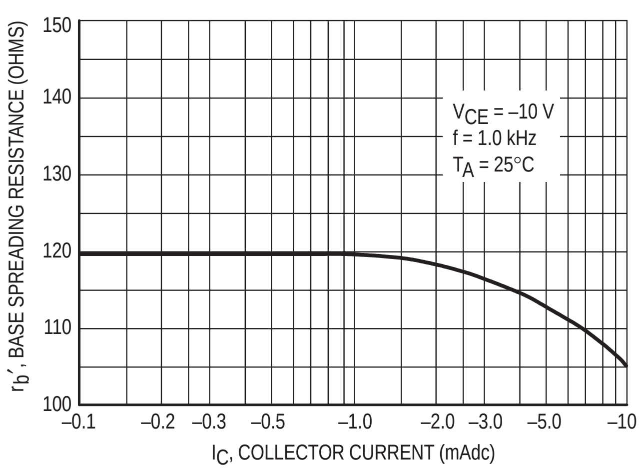
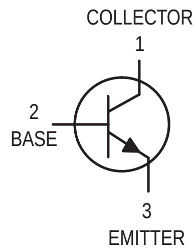
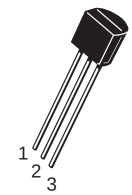


Figure 6. Base Spreading Resistance

Amplifier Transistors
NPN Silicon

BC237,A,B,C
BC238B,C
BC239,C





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC237	BC238	BC239	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			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 = 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	$V_{(BR)EBO}$	6.0 5.0 5.0	— — —	— — —	V
Collector Cutoff Current		I_{CES}				
(V_{CE} = 30 V, V_{BE} = 0)	BC238 BC239		— —	0.2 0.2	15 15	nA
(V_{CE} = 50 V, V_{BE} = 0)	BC237		—	0.2	15	
(V_{CE} = 30 V, V_{BE} = 0) T_A = 125°C	BC238 BC239		— —	0.2 0.2	4.0 4.0	μA
(V_{CE} = 50 V, V_{BE} = 0) T_A = 125°C	BC237		—	0.2	4.0	

REV 1

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 10 µA, V_{CE} = 5.0 V)	BC237A		—	90	—	
	BC237B/238B		—	150	—	
	BC237C/238C/239C		—	270	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC237		120	—	800	
	BC239		120	—	800	
	BC237A		120	170	220	
	BC237B/238B		200	290	460	
	BC237C/238C/239C		380	500	800	
(I_C = 100 mA, V_{CE} = 5.0 V)	BC237A		—	120	—	
	BC237B/238B		—	180	—	
	BC237C/238C/239C		—	300	—	
Collector–Emitter On Voltage		$V_{CE(sat)}$				V
(I_C = 10 mA, I_B = 0.5 mA)	BC237/BC238/BC239		—	0.07	0.2	
(I_C = 100 mA, I_B = 5.0 mA)	BC237/BC239		—	0.2	0.6	
	BC238				0.8	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$				V
(I_C = 10 mA, I_B = 0.5 mA)			—	0.6	0.83	
(I_C = 100 mA, I_B = 5.0 mA)			—	—	1.05	
Base–Emitter On Voltage		$V_{BE(on)}$				V
(I_C = 100 µA, V_{CE} = 5.0 V)			—	0.5	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)			0.55	0.62	0.7	
(I_C = 100 mA, V_{CE} = 5.0 V)			—	0.83	—	
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}	—	—	4.5	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 kΩ, f = 1.0 kHz)	BC239		—	2.0	4.0	
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 kΩ, f = 1.0 kHz, Δf = 200 Hz)	BC237		—	2.0	10	
	BC238		—	2.0	10	
	BC239		—	2.0	4.0	

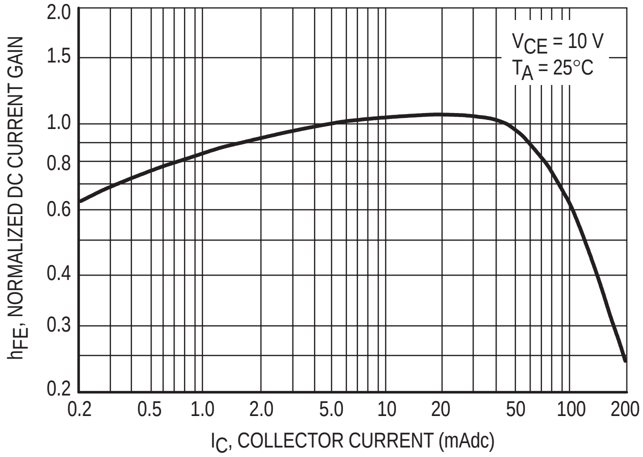


Figure 1. Normalized DC Current Gain

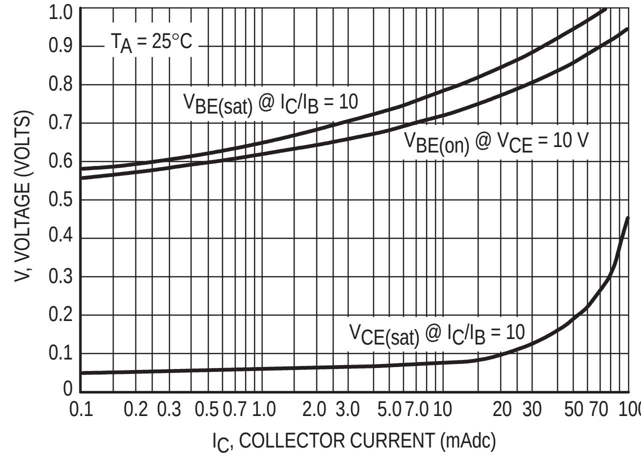


Figure 2. “Saturation” and “On” Voltages

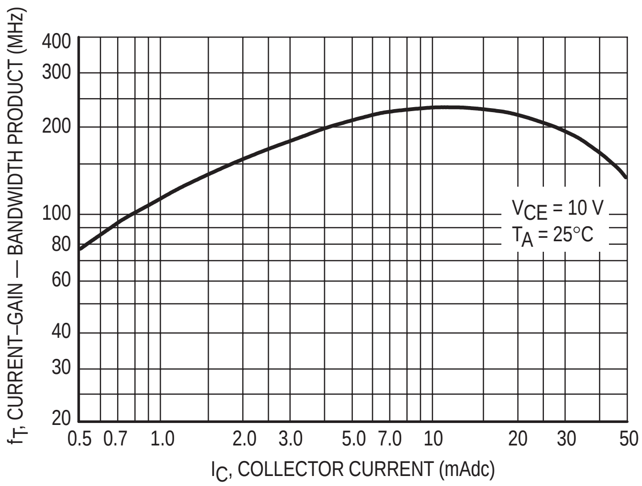


Figure 3. Current–Gain — Bandwidth Product

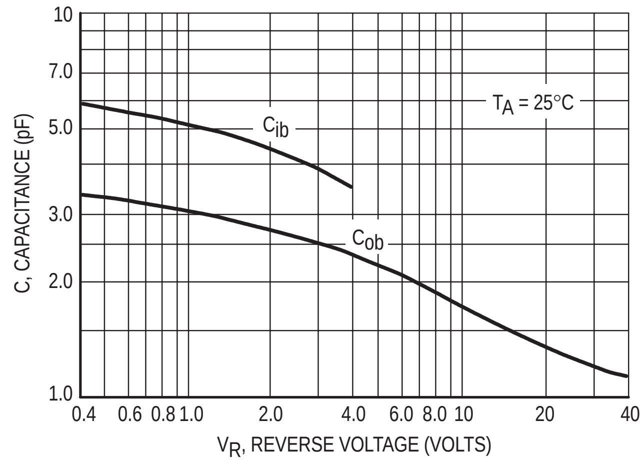


Figure 4. Capacitances

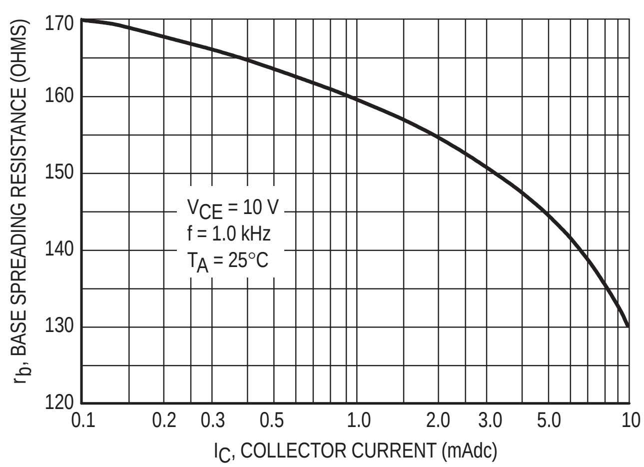
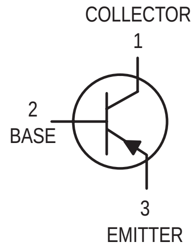
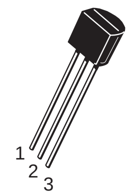


Figure 5. Base Spreading Resistance

Amplifier Transistors
PNP Silicon

BC307
BC307B
BC307C
BC308C





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC307, B, C	BC308C	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	–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		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 = –2.0 mAdc, I_B = 0)	BC307,B,C BC308C	$V_{(BR)CEO}$	–45 –25	— —	— —	Vdc
Emitter – Base Breakdown Voltage (I_E = –100 μAdc, I_C = 0)	BC307,B,C BC308C	$V_{(BR)EBO}$	–5.0 –5.0	— —	— —	Vdc
Collector–Emitter Leakage Current (V_{CES} = –50 V, V_{BE} = 0) (V_{CES} = –30 V, V_{BE} = 0) (V_{CES} = –50 V, V_{BE} = 0) T_A = 125°C (V_{CES} = –30 V, V_{BE} = 0) T_A = 125°C	 BC307,B,C BC308C BC307,B,C BC308C	I_{CES}	 — — — —	 –0.2 –0.2 –0.2 –0.2	 –15 –15 –4.0 –4.0	 nAdc μA

REV 1

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = –10 µAdc, V_{CE} = –5.0 Vdc)	BC307B		—	150	—	
	BC307C/308C		—	270	—	
(I_C = –2.0 mAdc, V_{CE} = –5.0 Vdc)	BC307		120	—	800	
	BC307B/308B		200	290	460	
	BC307C/308C		420	500	800	
(I_C = –100 mAdc, V_{CE} = –5.0 Vdc)	BC307B		—	180	—	
	BC307C/308C		—	300	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = –10 mAdc, I_B = –0.5 mAdc)			—	–0.10	–0.3	
(I_C = –10 mAdc, I_B = see Note 1)			—	–0.30	–0.6	
(I_C = –100 mAdc, I_B = –5.0 mAdc)			—	–0.25	—	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(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 (I_C = –2.0 mAdc, V_{CE} = –5.0 Vdc)		$V_{BE(on)}$	–0.55	–0.62	–0.7	Vdc
DYNAMIC CHARACTERISTICS						
Current–Gain — Bandwidth Product		f_T				MHz
(I_C = –10 mAdc, V_{CE} = –5.0 Vdc, f = 100 MHz)	BC307,B,C		—	280	—	
	BC308C		—	320	—	
Common Base Capacitance (V_{CB} = –10 Vdc, I_C = 0, f = 1.0 MHz)		C_{cbo}	—	—	6.0	pF
Noise Figure		NF				dB
(I_C = –0.2 mAdc, V_{CE} = –5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz)	BC307,B,C		—	2.0	10	
(I_C = –0.2 mAdc, V_{CE} = –5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, f = 200 Hz)	BC308C		—	2.0	10	

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

TYPICAL CHARACTERISTICS

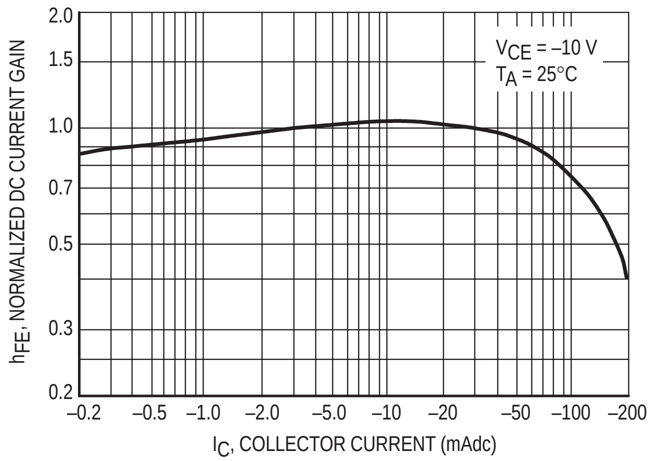


Figure 1. Normalized DC Current Gain

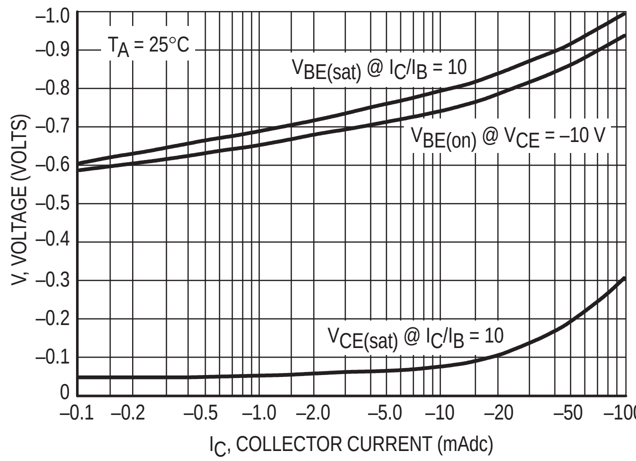


Figure 2. "Saturation" and "On" Voltages

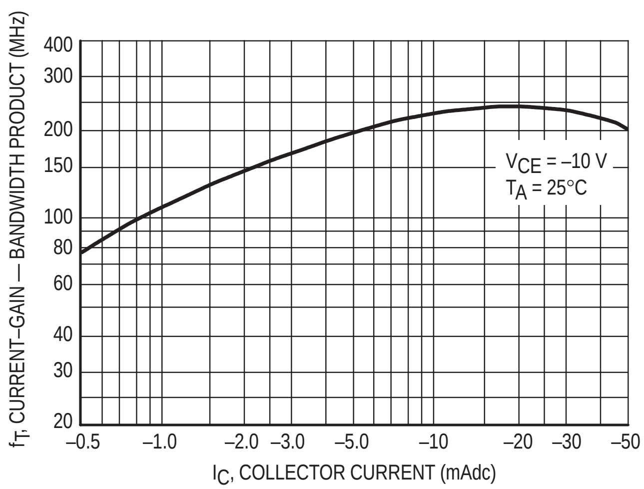


Figure 3. Current–Gain — Bandwidth Product

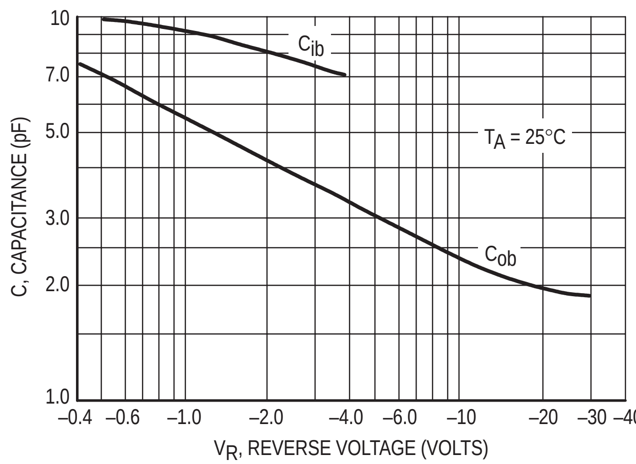


Figure 4. Capacitances

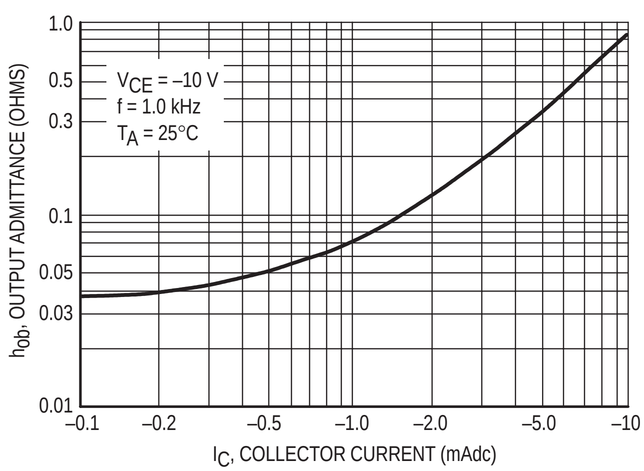


Figure 5. Output Admittance

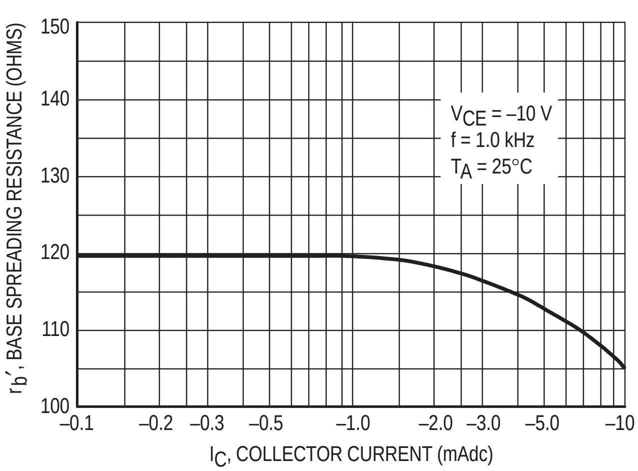
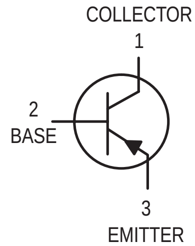
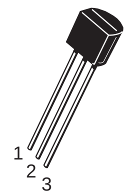


Figure 6. Base Spreading Resistance

Amplifier Transistors
PNP Silicon

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





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

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

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = –100 mA, V_{CE} = –1.0 V)	BC327/BC328		100	—	630	
	BC327–16/BC328–16		100	—	250	
	BC327–25/BC328–25		160	—	400	
(I_C = –300 mA, V_{CE} = –1.0 V)			40	—	—	
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

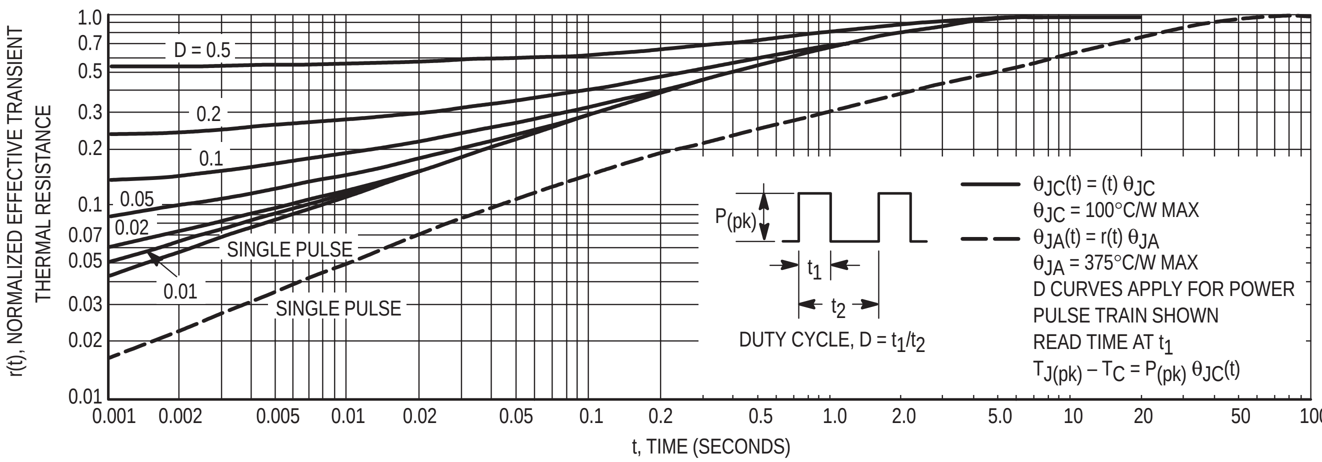


Figure 1. Thermal Response

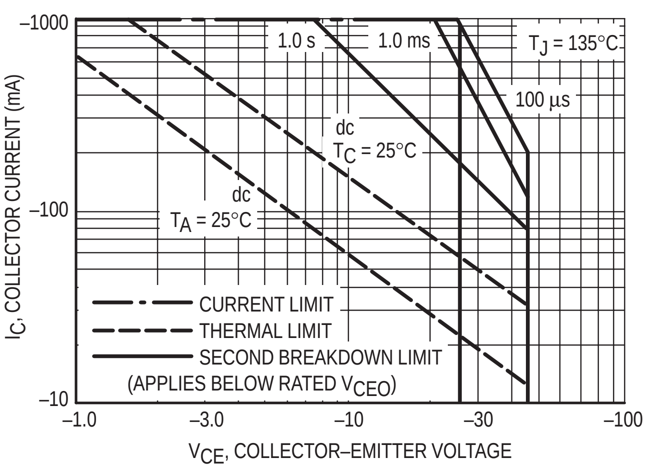


Figure 2. Active Region — Safe Operating Area

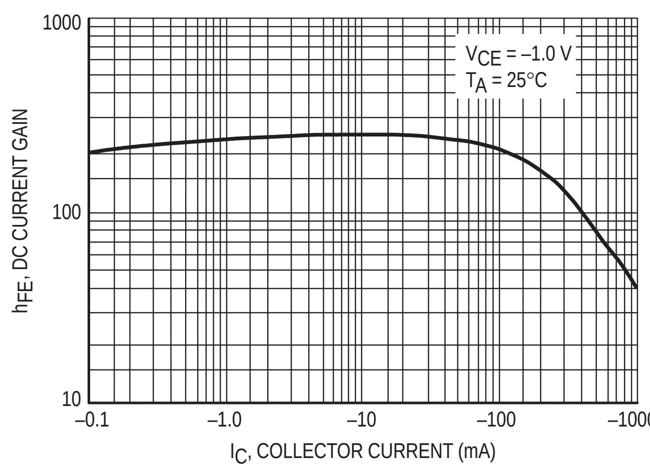


Figure 3. DC Current Gain

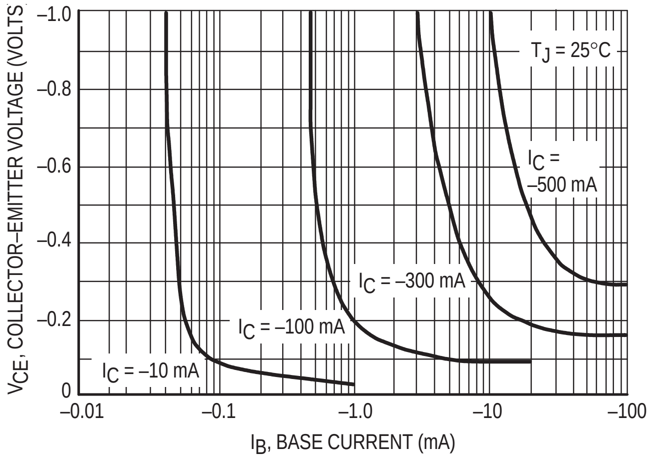


Figure 4. Saturation Region

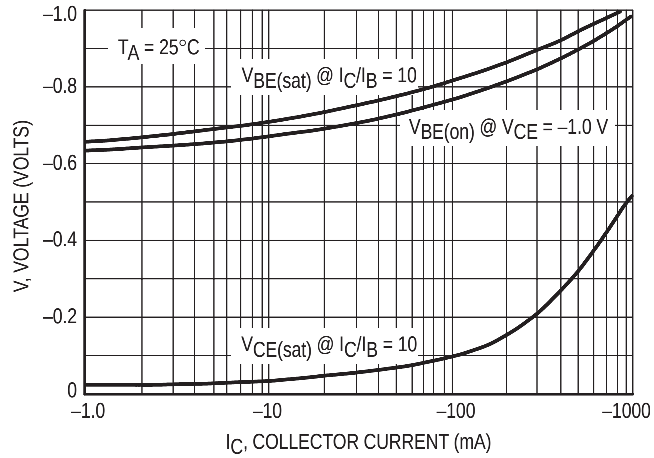


Figure 5. “On” Voltages

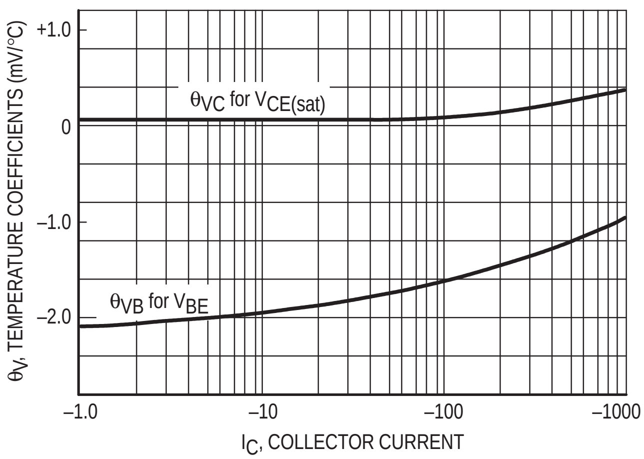


Figure 6. Temperature Coefficients

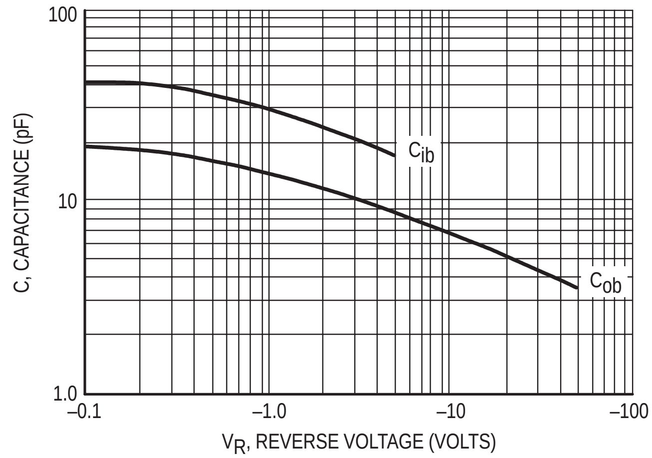
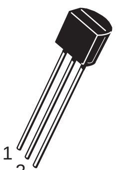


Figure 7. Capacitances

Amplifier Transistors
NPN Silicon

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



CASE 29–04, STYLE 17
TO–92 (TO–226AA)

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) BC337 (V_{CB} = 20 V, I_E = 0) BC338	I_{CBO}	 — —	 — —	 100 100	nAdc
Collector Cutoff Current (V_{CE} = 45 V, V_{BE} = 0) BC337 (V_{CE} = 25 V, V_{BE} = 0) BC338	I_{CES}	 — —	 — —	 100 100	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 V, I_C = 0)	I_{EBO}	—	—	100	nAdc

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 100 mA, V_{CE} = 1.0 V)	BC337/BC338		100	—	630	
	BC337–16/BC338–16		100	—	250	
	BC337–25/BC338–25		160	—	400	
	BC337–40/BC338–40		250	—	630	
(I_C = 300 mA, V_{CE} = 1.0 V)			60	—	—	
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

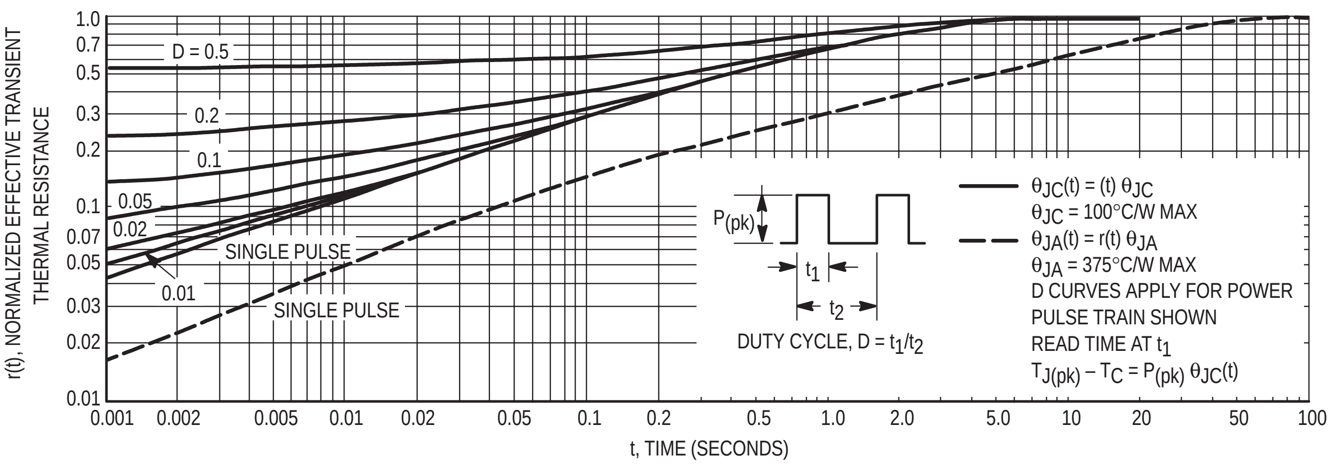


Figure 1. Thermal Response

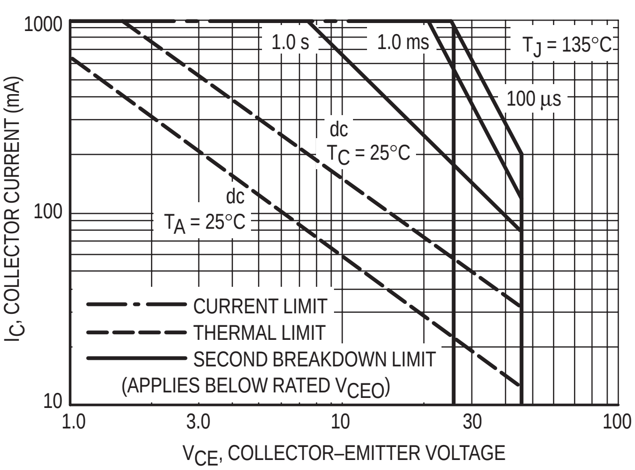


Figure 2. Active Region — Safe Operating Area

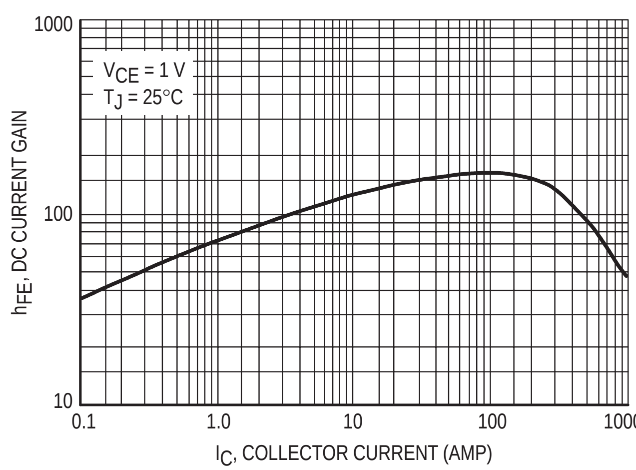


Figure 3. DC Current Gain

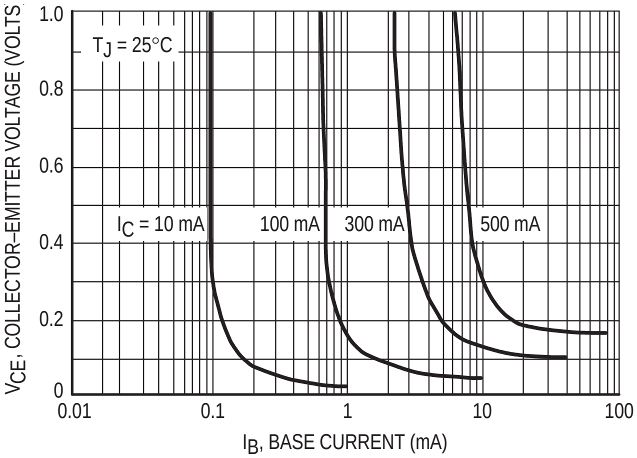


Figure 4. Saturation Region

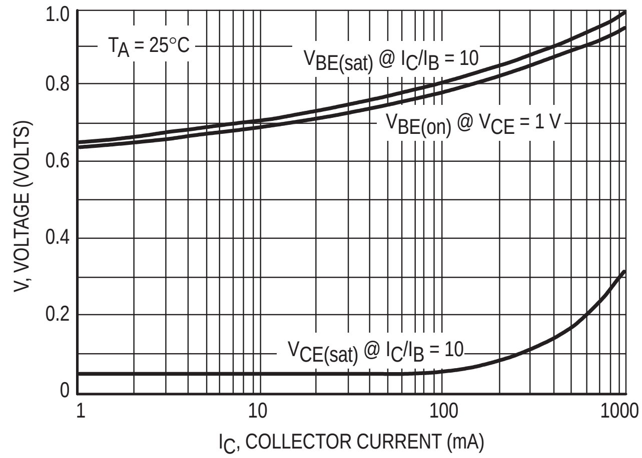


Figure 5. "On" Voltages

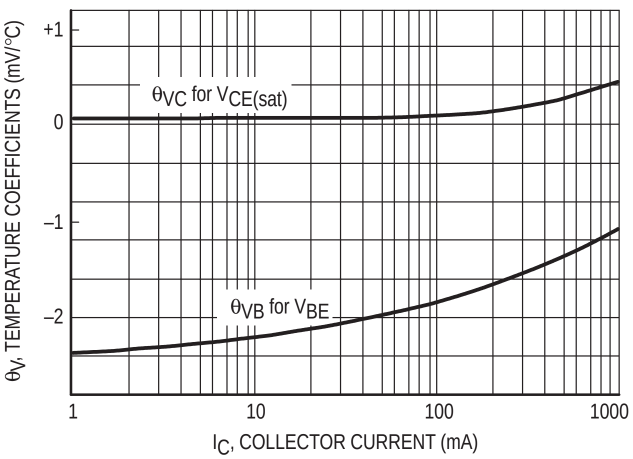


Figure 6. Temperature Coefficients

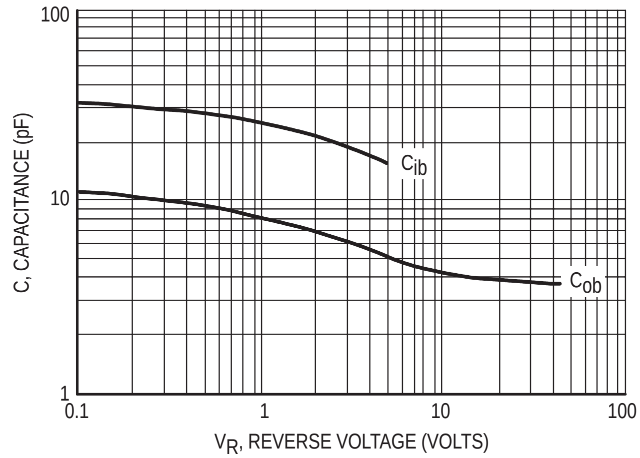
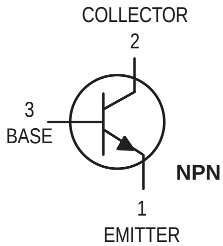
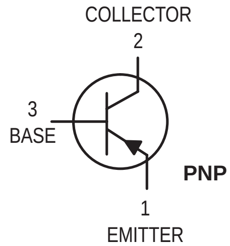


Figure 7. Capacitances

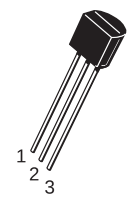
Amplifier Transistors





NPN
BC368
PNP
BC369

Voltage and current are negative for PNP transistors



CASE 29–04, STYLE 14
TO–92 (TO–226AA)

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

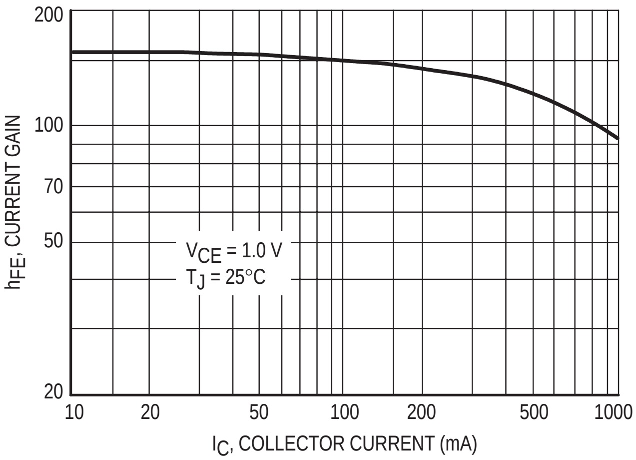


Figure 1. DC Current Gain

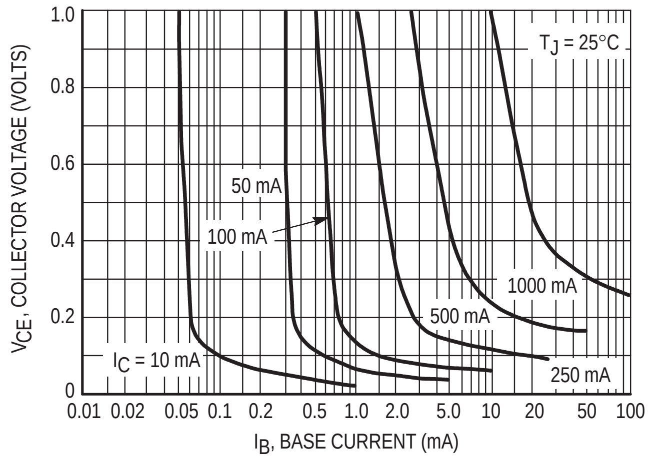


Figure 2. Collector Saturation Region

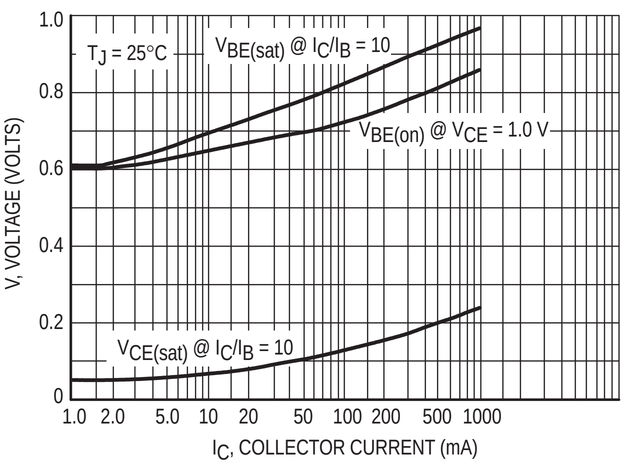


Figure 3. “On” Voltages

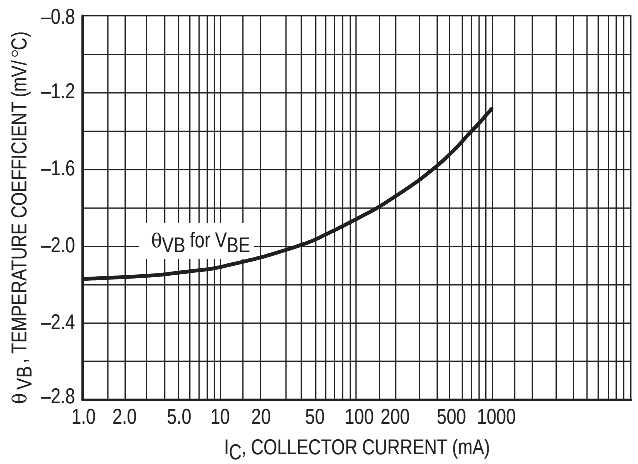


Figure 4. Temperature Coefficient

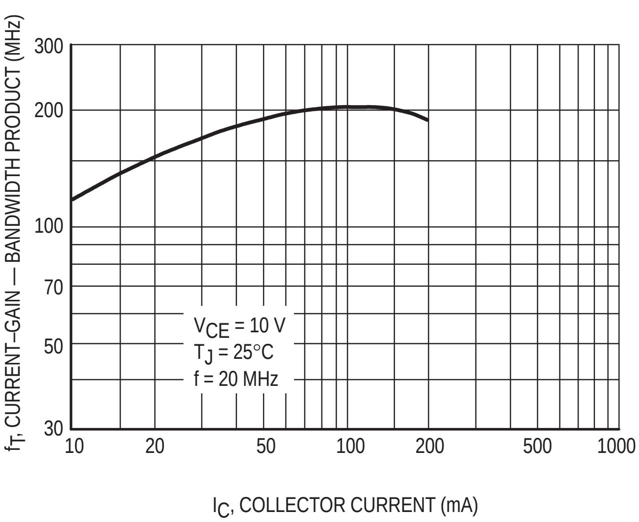


Figure 5. Current–Gain — Bandwidth Product

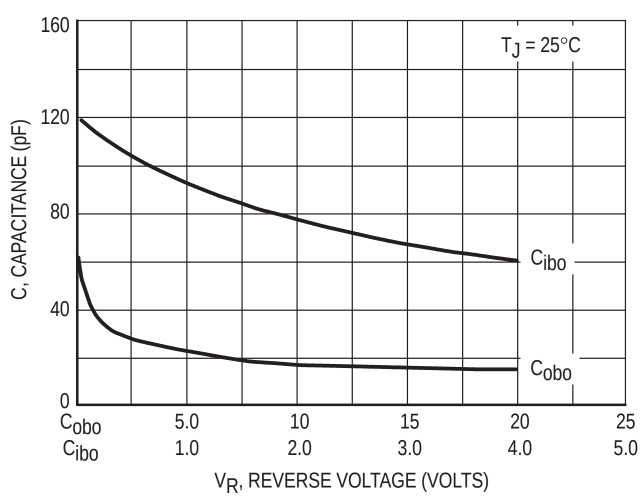
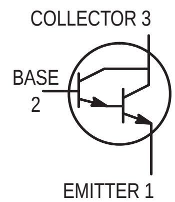
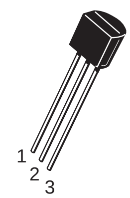


Figure 6. Capacitance

High Voltage Darlington Transistors
NPN Silicon

BC372
BC373





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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(1) (I_C = 100 μAdc, I_B = 0)	 BC372 BC373	$V_{(BR)CES}$	 100 80	 — —	 — —	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 BC372 BC373	$V_{(BR)CBO}$	 100 80	 — —	 — —	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	 BC372 BC373	I_{CBO}	 — —	 — —	 100 100	nAdc
Emitter Cutoff Current (V_{EB} = 10 V, I_C = 0)		I_{EBO}	—	—	100	nAdc

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 8.0 10	 — —	 — 160	K
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

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

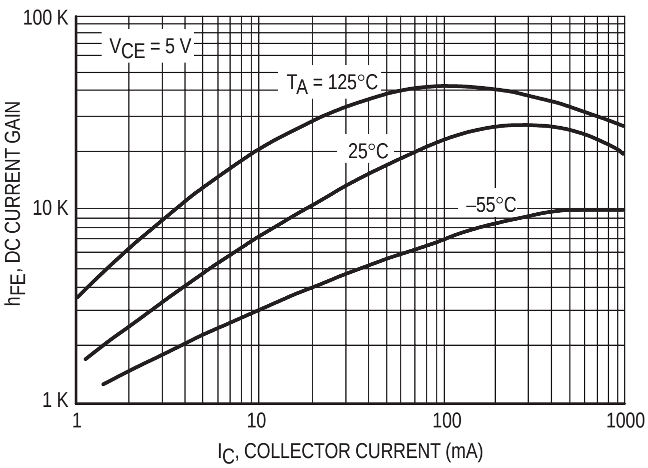


Figure 1. DC Current Gain

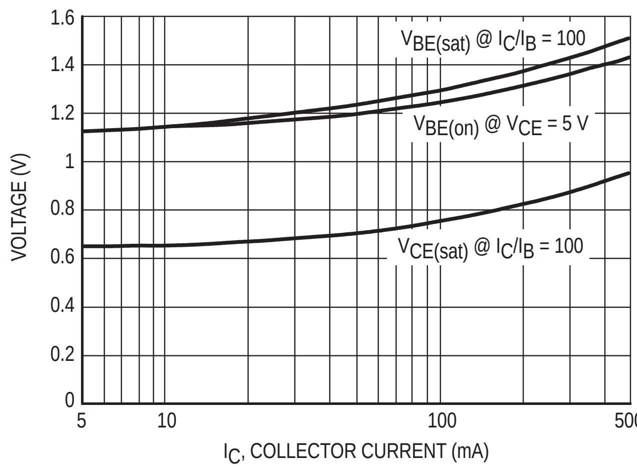


Figure 2. "Saturation" and "On" Voltages

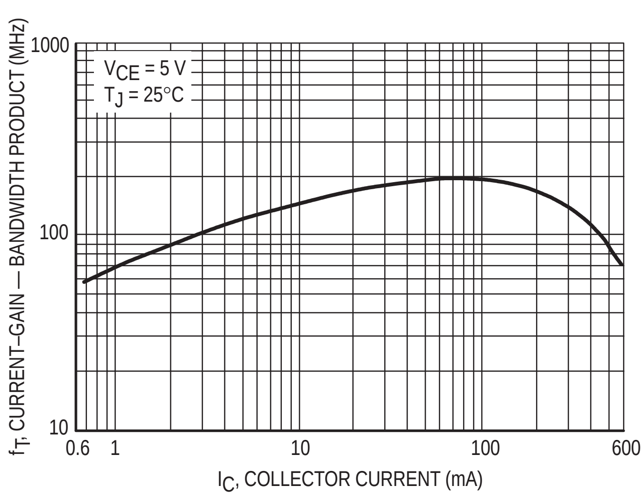


Figure 3. Current–Gain — Bandwidth Product

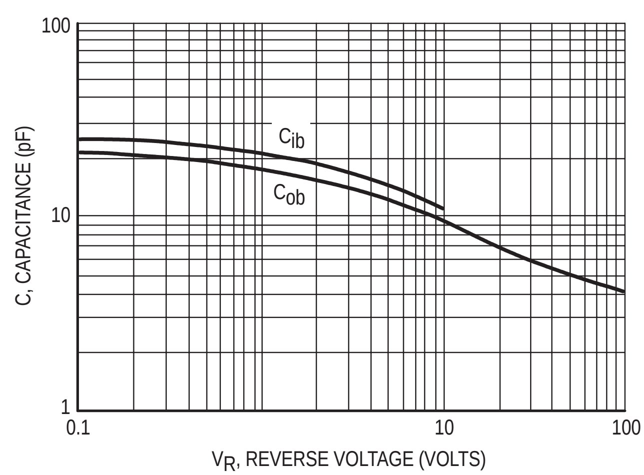
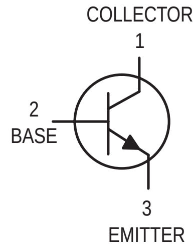
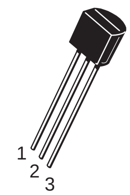


Figure 4. Capacitances

High Current Transistors
NPN Silicon

BC489,A,B





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

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)

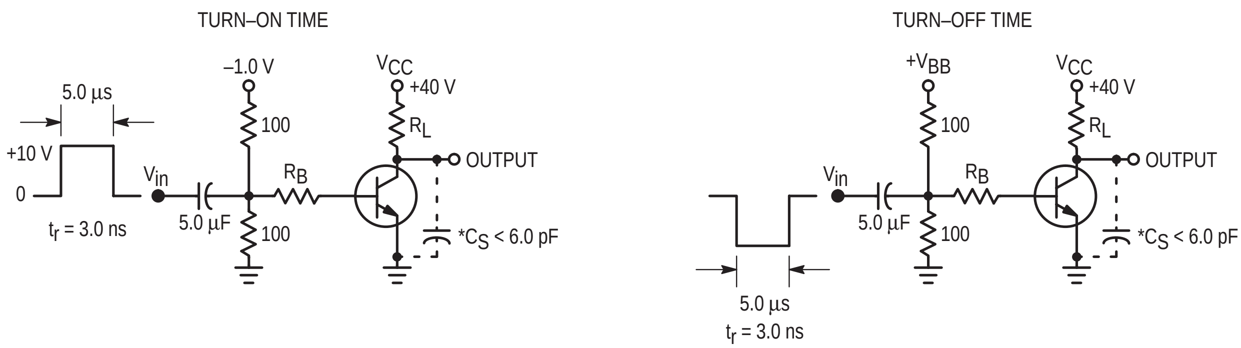
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	80	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	80	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	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	—	—	

1. Pulse Test: Pulse Width = 300 μs, Duty Cycle 2%.

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS* (Continued)					
Collector – Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.2	0.5	
(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	1.2	
(I_C = 1.0 Adc, I_B = 100 mAdc)(1)		—	0.9	—	
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

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



* Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

Figure 1. Switching Time Test Circuits

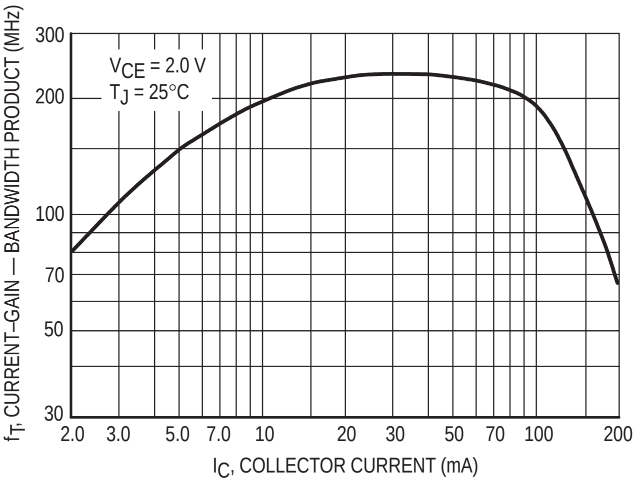


Figure 2. Current–Gain — Bandwidth Product

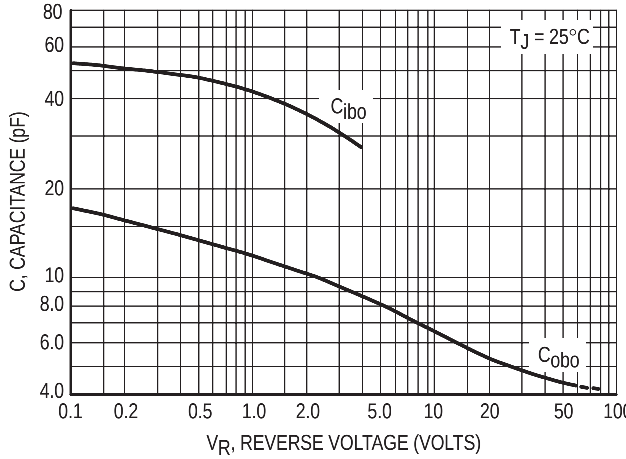


Figure 3. Capacitance

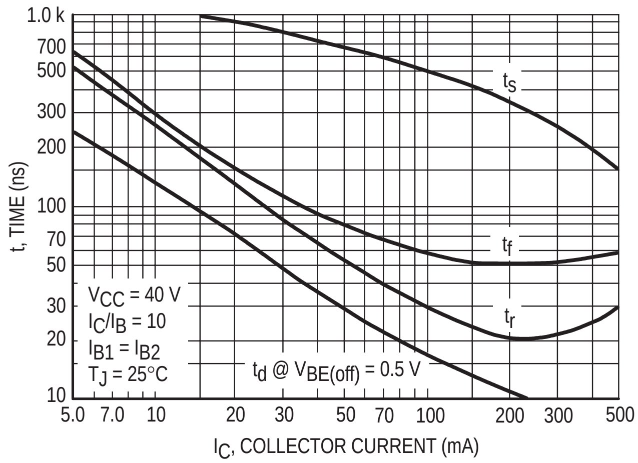


Figure 4. Switching Time

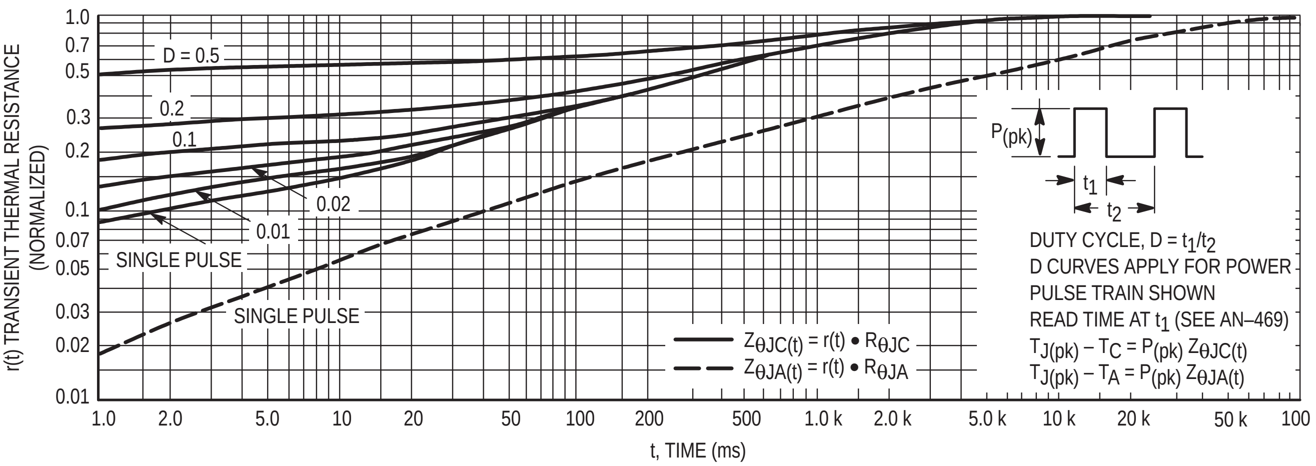


Figure 5. Thermal Response

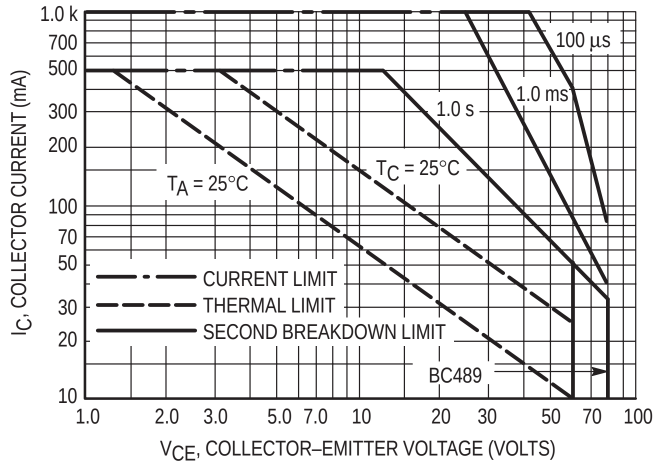


Figure 6. Active Region — Safe Operating Area

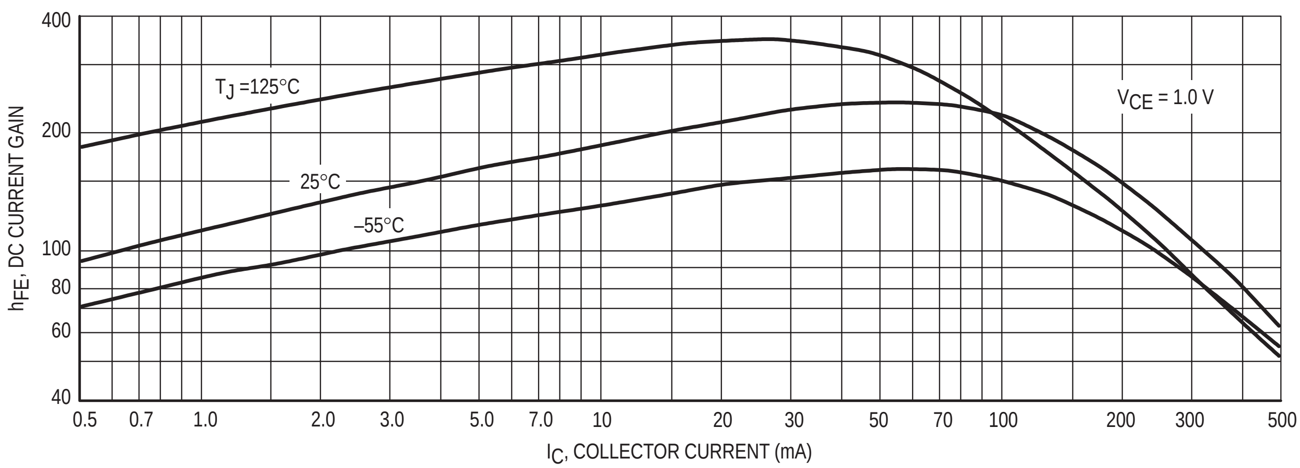


Figure 7. DC Current Gain

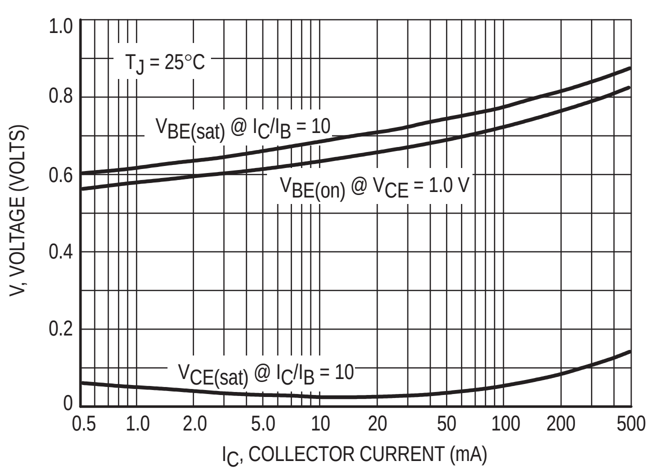


Figure 8. "On" Voltages

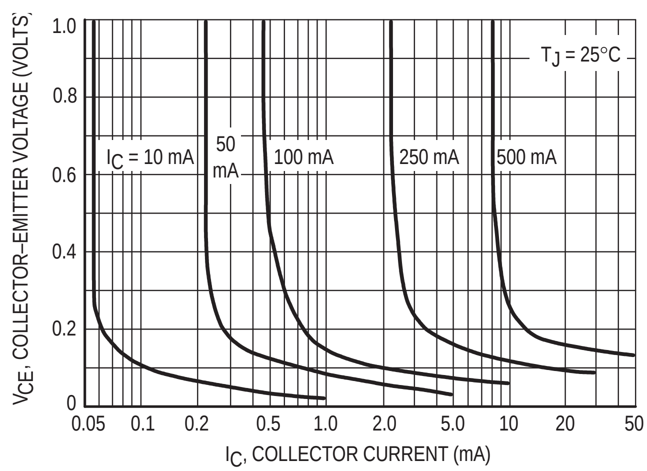


Figure 9. Collector Saturation Region

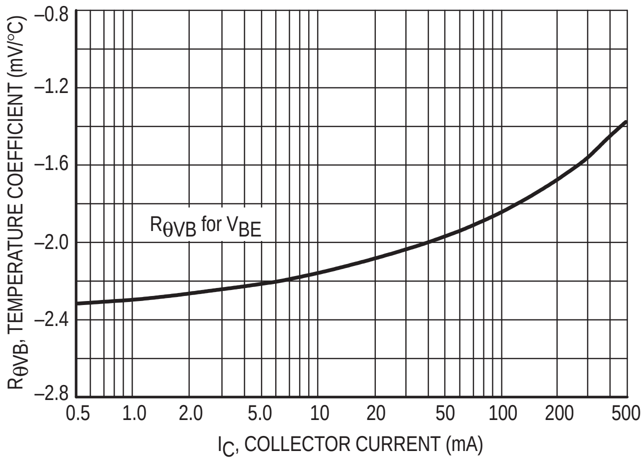


Figure 10. Base–Emitter Temperature Coefficient

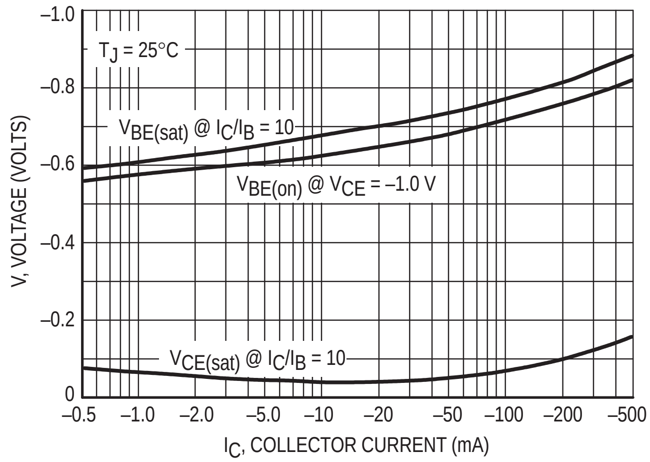


Figure 11. "On" Voltages

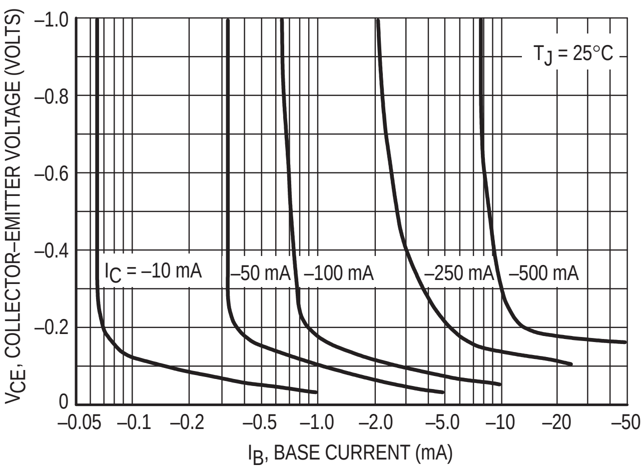


Figure 12. Collector Saturation Region

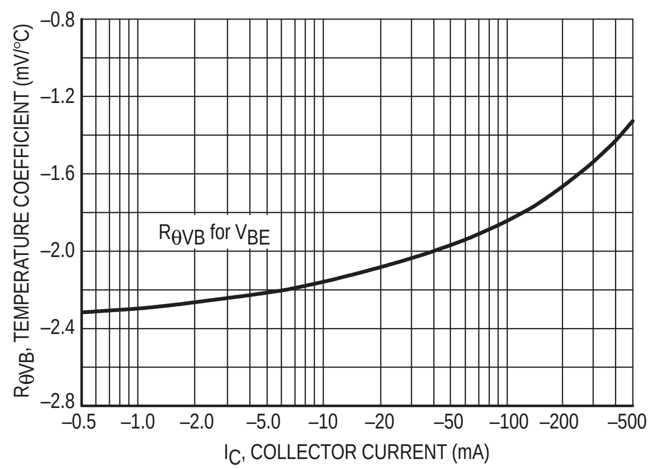
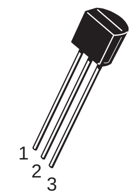


Figure 13. Base–Emitter Temperature Coefficient

High Current Transistors
PNP Silicon

BC490,A



CASE 29–04, STYLE 17
TO–92 (TO–226AA)

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)

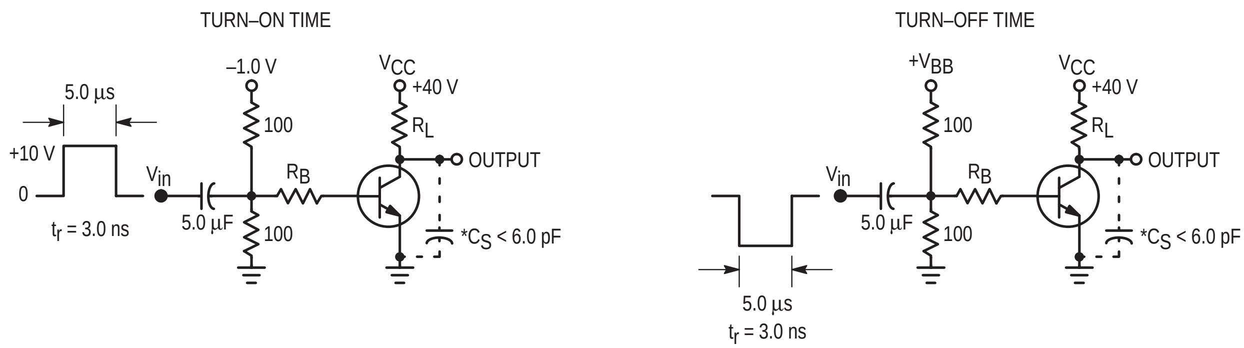
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage(1) (I_C = –10 mAdc, I_B = 0)		$V_{(BR)CEO}$	–80	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = –100 μAdc, I_E = 0)		$V_{(BR)CBO}$	–80	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = –10 μAdc, I_C = 0)		$V_{(BR)EBO}$	–4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = –60 Vdc, I_E = 0)		I_{CBO}	—	—	–100	nAdc
ON CHARACTERISTICS*						
DC Current Gain		h_{FE}				—
(I_C = –10 mAdc, V_{CE} = –2.0 Vdc)			40	—	—	
(I_C = –100 mAdc, V_{CE} = –2.0 Vdc)	BC490		60	—	400	
	BC490A		100	140	250	
(I_C = –1.0 Adc, V_{CE} = –5.0 Vdc)			15	—	—	

1. Pulse Test: Pulse Width = 300 μs, Duty Cycle 2%.

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

Characteristic	Symbol	Min	Min	Max	Unit
ON CHARACTERISTICS[1] (Continued)					
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 –0.5	 –0.5 —	Vdc
Base–Emitter Saturation Voltage (I_C = –500 mAdc, I_B = –50 mAdc) (I_C = –1.0 Adc, I_B = –100 mAdc)	$V_{BE(sat)}$	 — —	 –0.9 –1.0	 –1.2 —	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

1. Pulse Test: Pulse Width = 300 μs, Duty Cycle 2%.



* Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

Figure 1. Switching Time Test Circuits

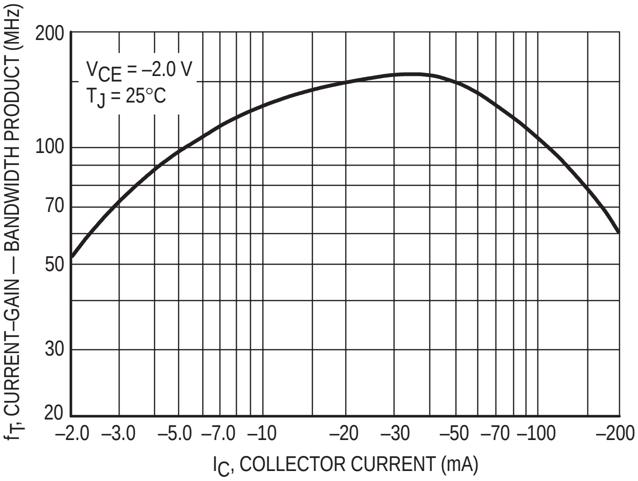


Figure 2. Current–Gain — Bandwidth Product

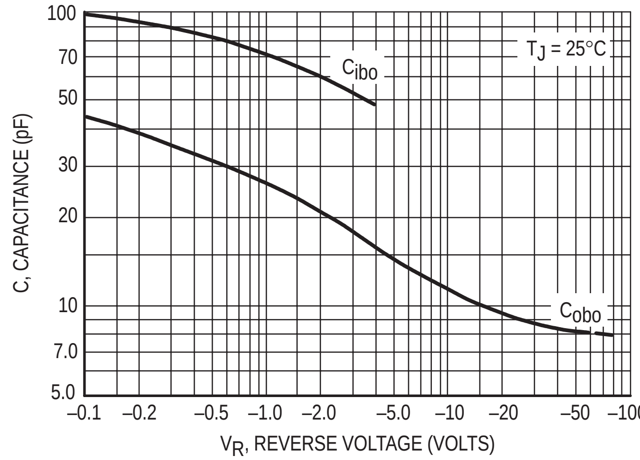


Figure 3. Capacitance

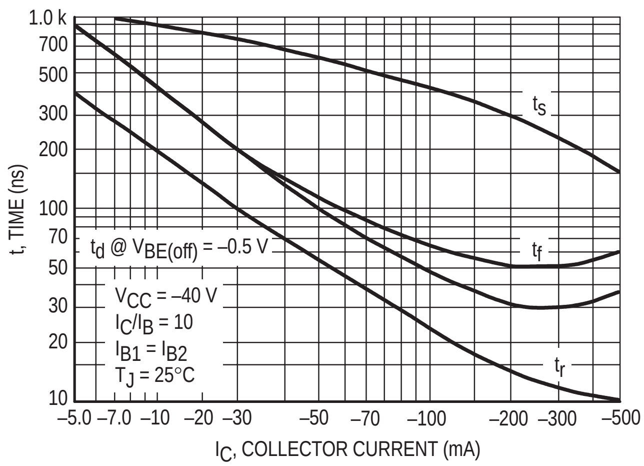


Figure 4. Switching Time

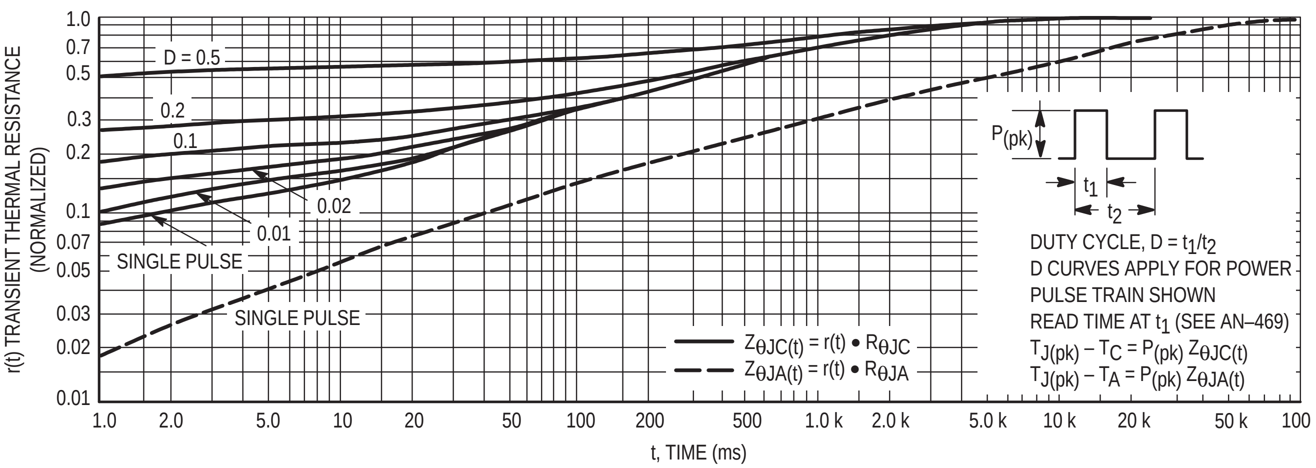


Figure 5. Thermal Response

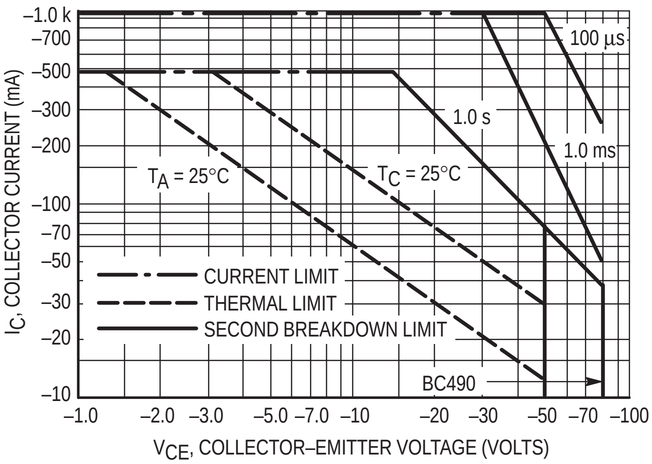


Figure 6. Active Region, Safe Operating Area

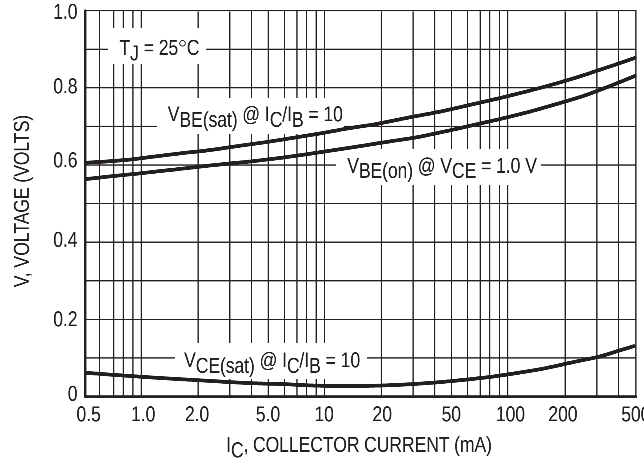


Figure 7. "On" Voltages

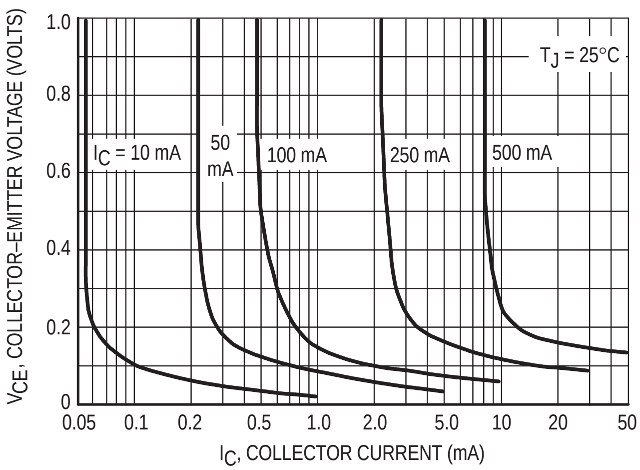


Figure 8. Collector Saturation Region

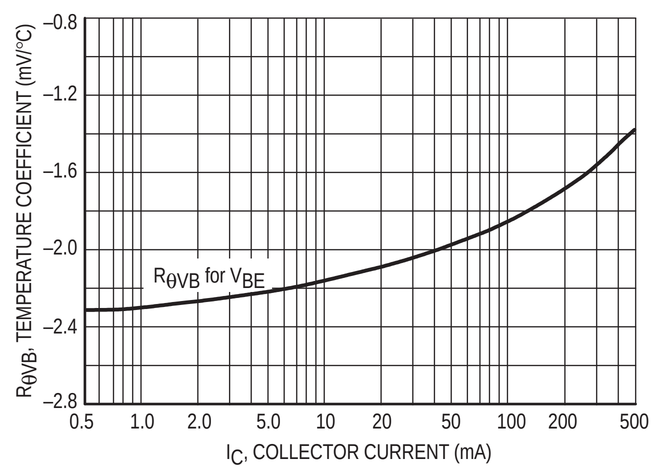


Figure 9. Base–Emitter Temperature Coefficient

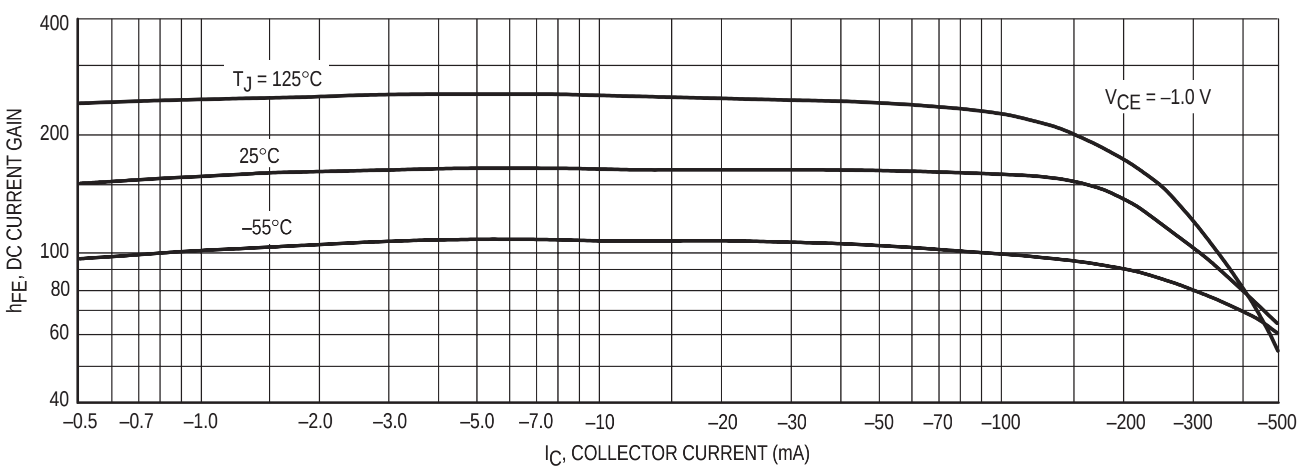


Figure 10. DC Current Gain

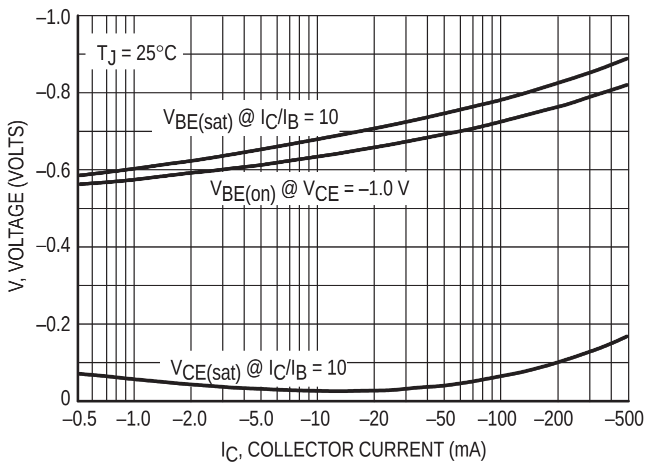


Figure 11. "On" Voltages

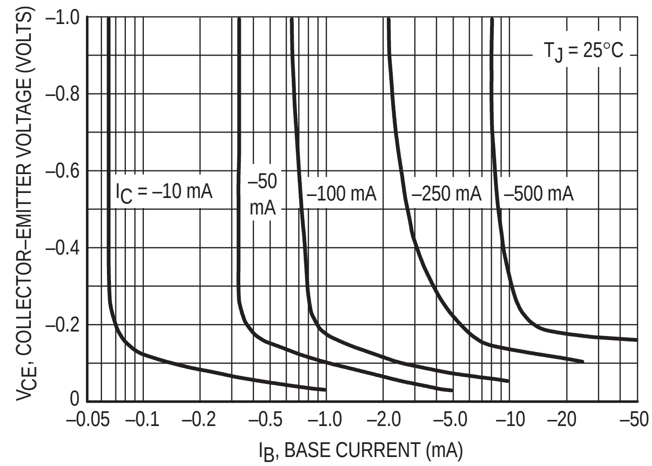


Figure 12. Collector Saturation Region

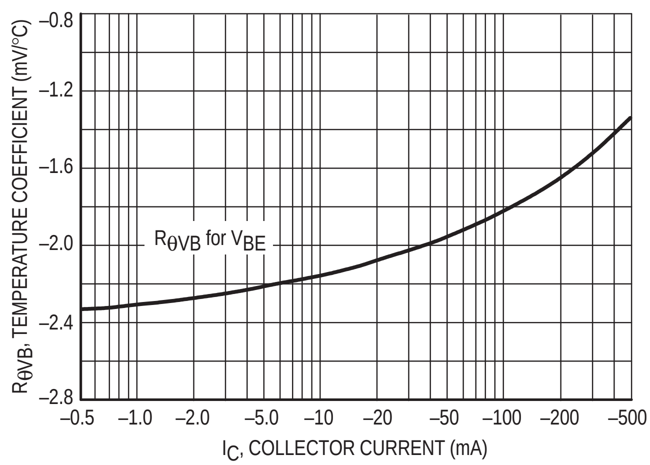
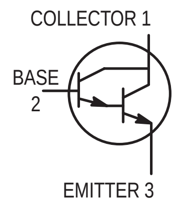


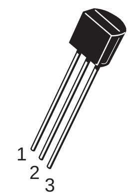
Figure 13. Base–Emitter Temperature Coefficient

Darlington Transistors

NPN Silicon



BC517



CASE 29–04, STYLE 17
TO–92 (TO–226AA)

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 μAdc, 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 Vdc)	I_{CES}	—	—	500	nAdc
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

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)	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. $f_T = |h_{fe}| \bullet f_{test}$

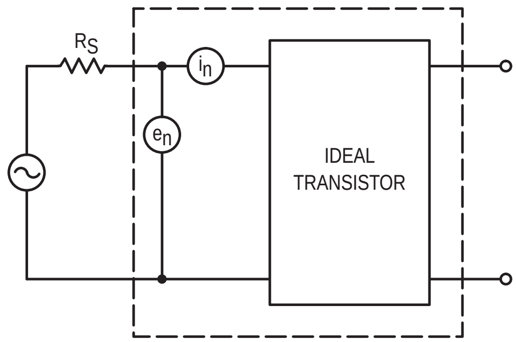


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

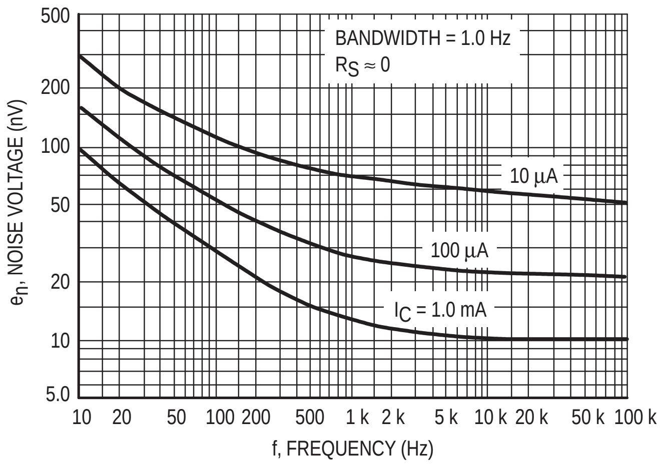


Figure 2. Noise Voltage

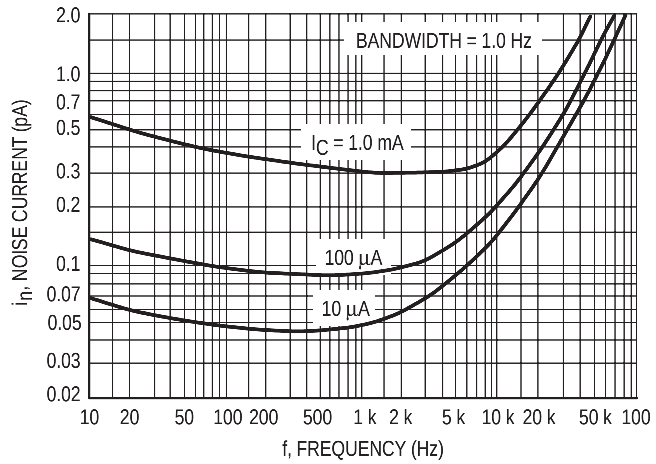


Figure 3. Noise Current

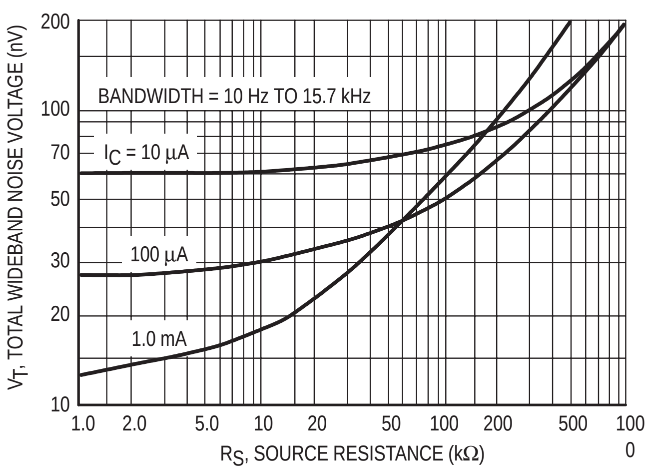


Figure 4. Total Wideband Noise Voltage

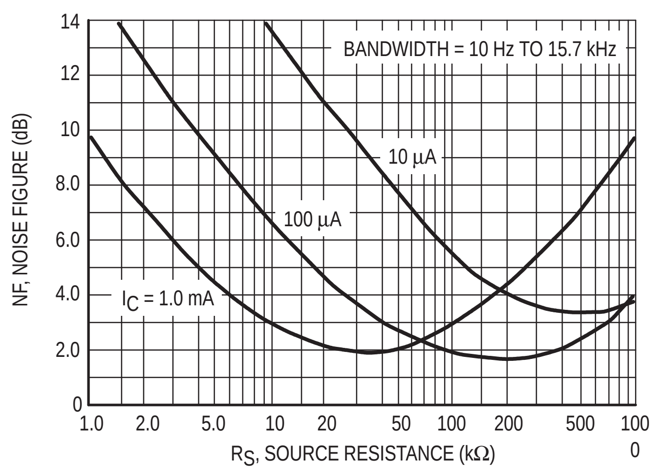


Figure 5. Wideband Noise Figure

SMALL–SIGNAL CHARACTERISTICS

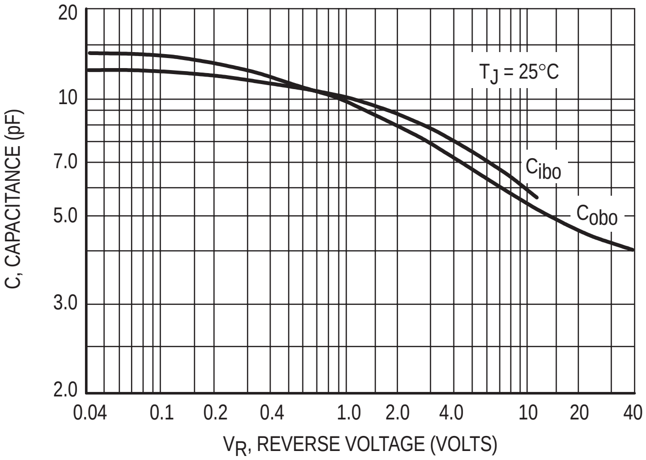


Figure 6. Capacitance

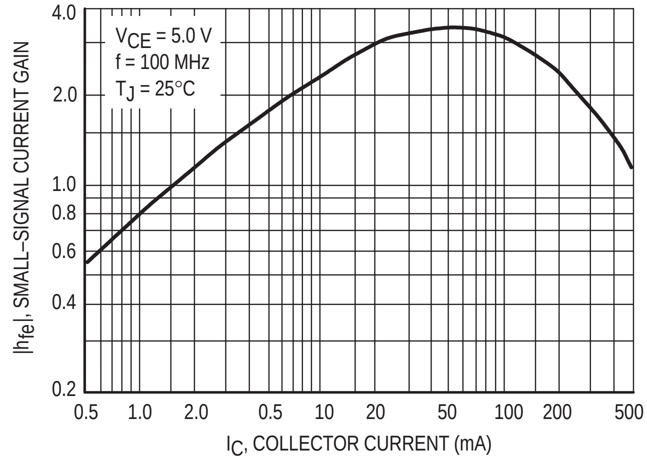


Figure 7. High Frequency Current Gain

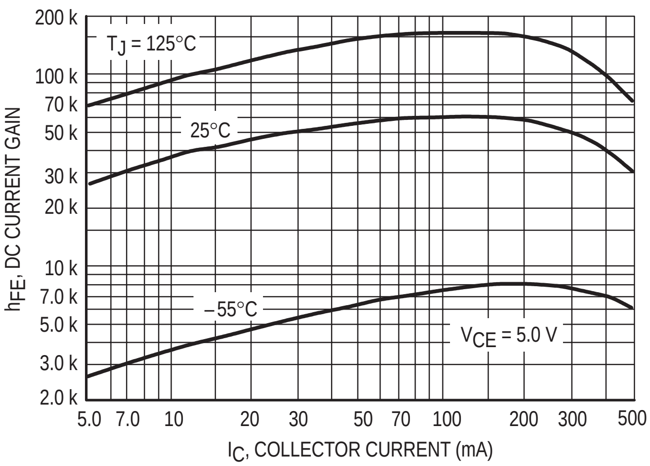


Figure 8. DC Current Gain

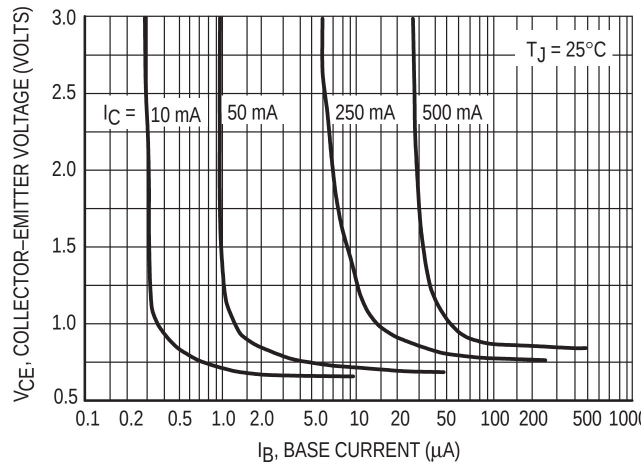


Figure 9. Collector Saturation Region

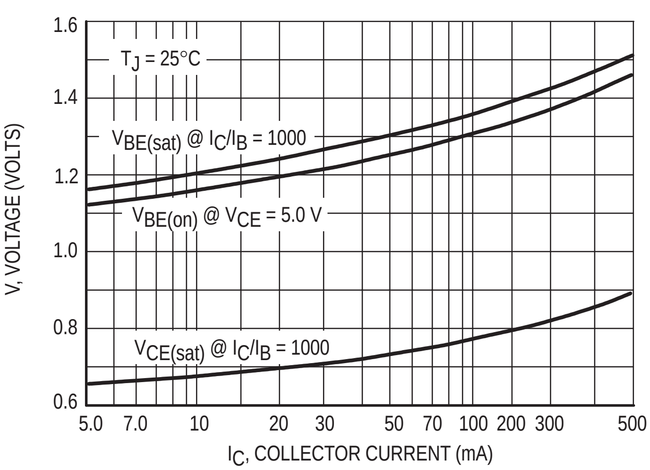


Figure 10. “On” Voltages

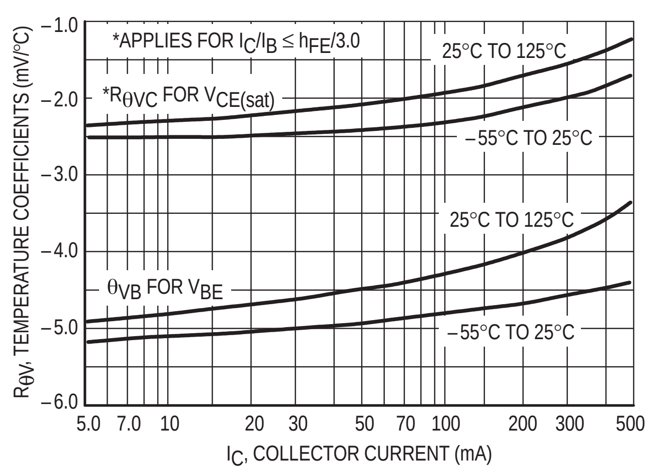


Figure 11. Temperature Coefficients

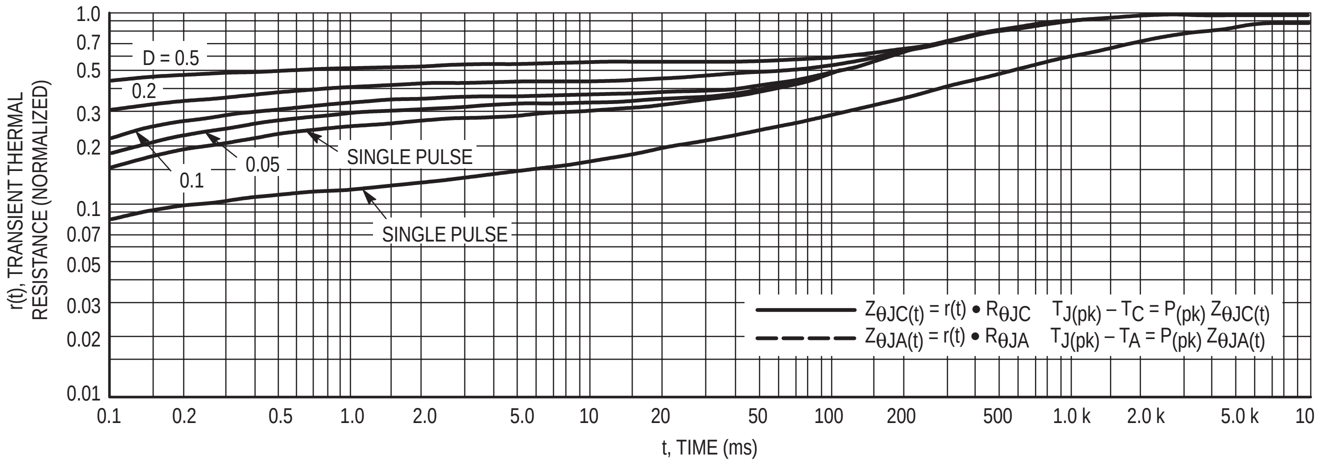


Figure 12. Thermal Response

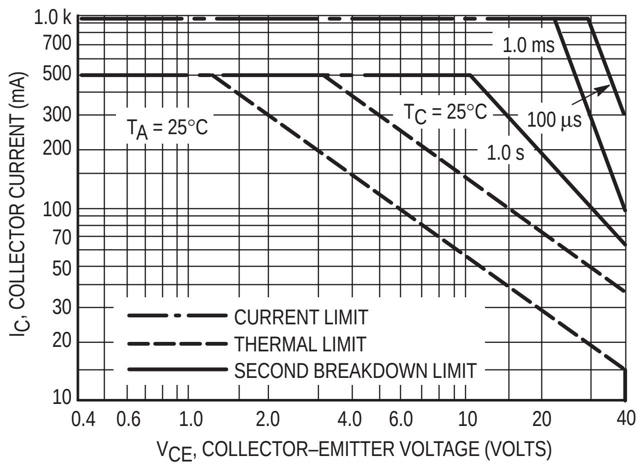
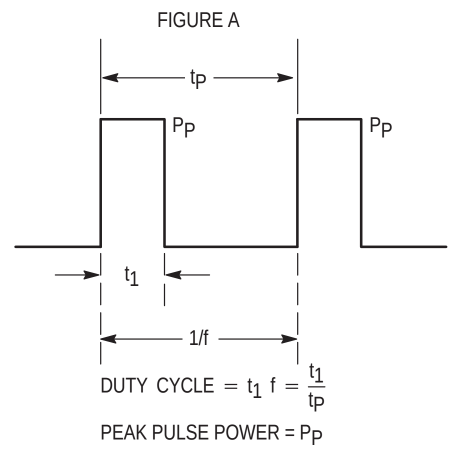


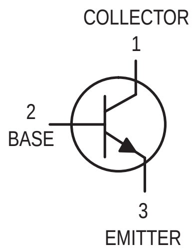
Figure 13. Active Region Safe Operating Area

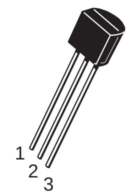


Design Note: Use of Transient Thermal Resistance Data

Amplifier Transistors
NPN Silicon

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





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC546	BC547	BC548	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 BC547 BC548	$V_{(BR)CEO}$	65 45 30	— — —	— — —	V
Collector–Base Breakdown Voltage (I_C = 100 μAdc)	BC546 BC547 BC548	$V_{(BR)CBO}$	80 50 30	— — —	— — —	V
Emitter–Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BC546 BC547 BC548	$V_{(BR)EBO}$	6.0 6.0 6.0	— — —	— — —	V
Collector Cutoff Current (V_{CE} = 70 V, V_{BE} = 0) (V_{CE} = 50 V, V_{BE} = 0) (V_{CE} = 35 V, V_{BE} = 0) (V_{CE} = 30 V, T_A = 125°C)	 BC546 BC547 BC548 BC546/547/548	I_{CES}	 — — — —	 0.2 0.2 0.2 —	 15 15 15 4.0	 nA μA

REV 1

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 10 µA, V_{CE} = 5.0 V)	BC547A/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	
	BC547A/548A		110	180	220	
	BC546B/547B/548B		200	290	450	
	BC547C/BC548C		420	520	800	
(I_C = 100 mA, V_{CE} = 5.0 V)	BC547A/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	
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	
	BC547A/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 kΩ,	BC546		—	2.0	10	
f = 1.0 kHz, Δf = 200 Hz)	BC547		—	2.0	10	
	BC548		—	2.0	10	

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

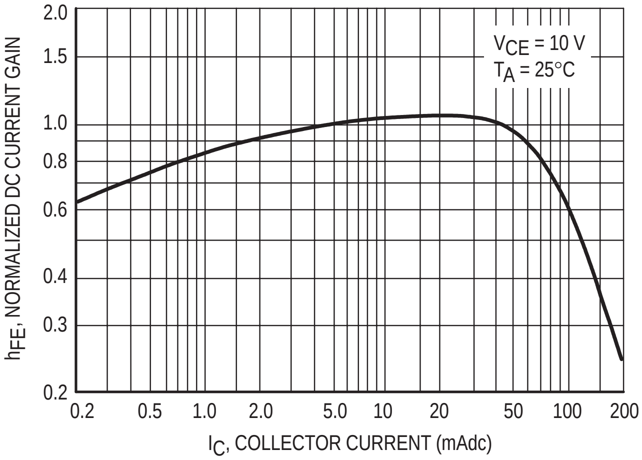


Figure 1. Normalized DC Current Gain

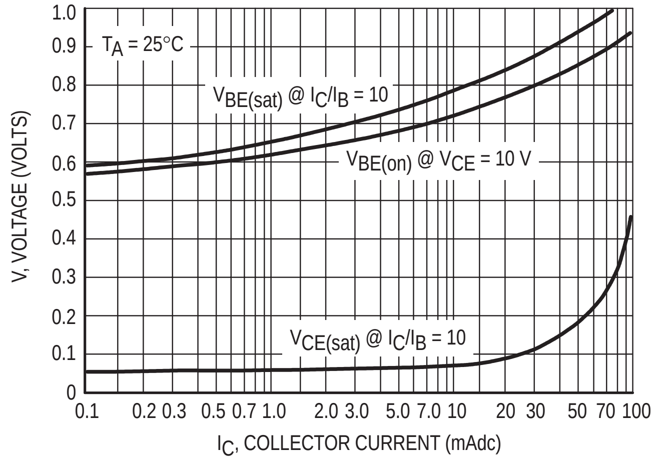


Figure 2. “Saturation” and “On” Voltages

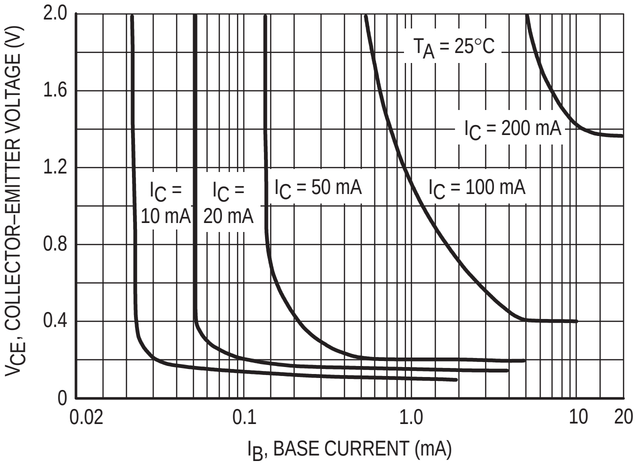


Figure 3. Collector Saturation Region

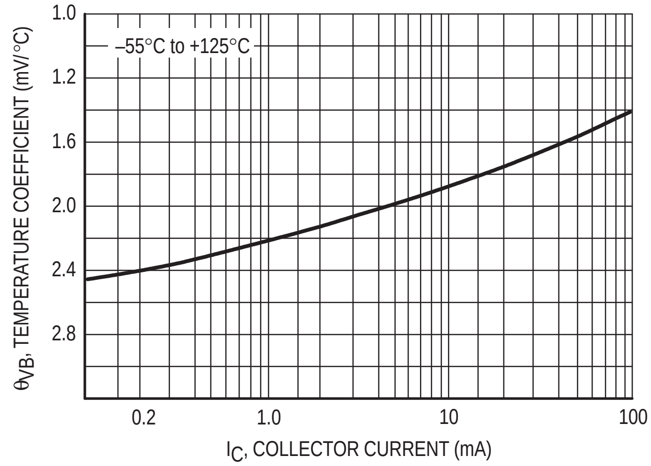


Figure 4. Base–Emitter Temperature Coefficient

BC547/BC548

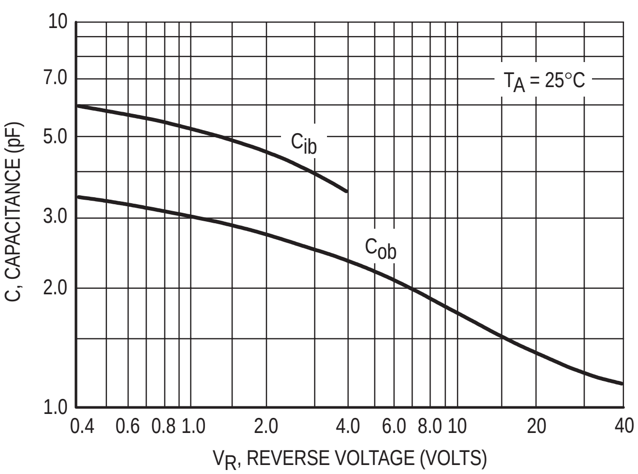


Figure 5. Capacitances

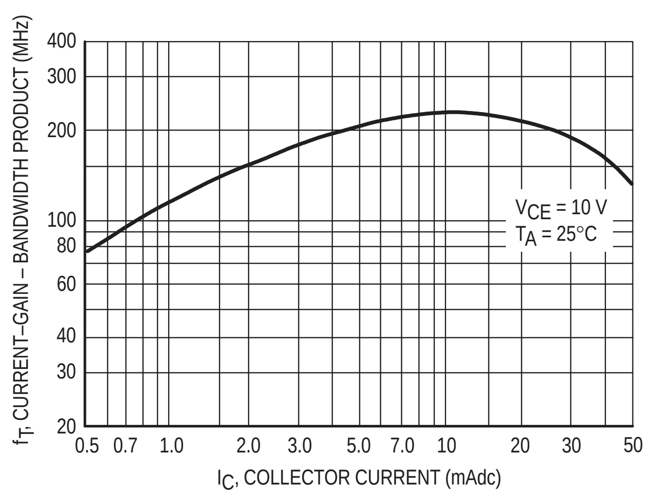


Figure 6. Current–Gain – Bandwidth Product

BC547/BC548

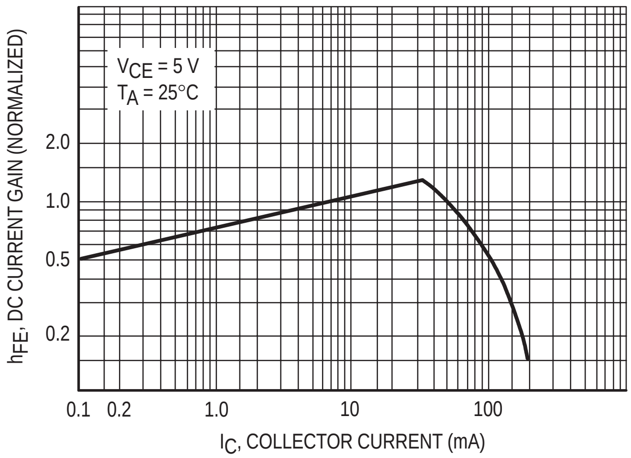


Figure 7. DC Current Gain

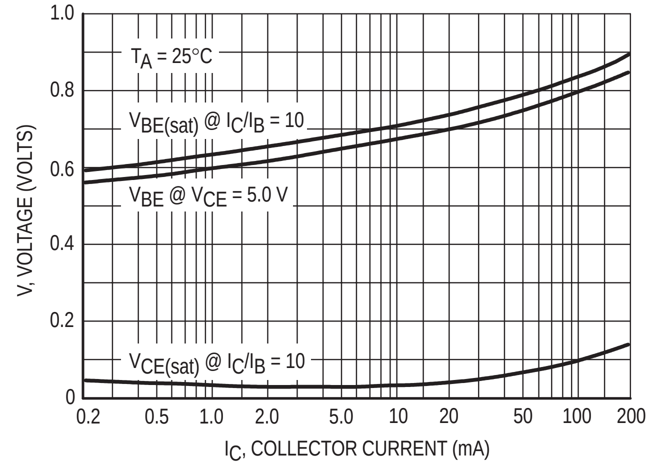


Figure 8. “On” Voltage

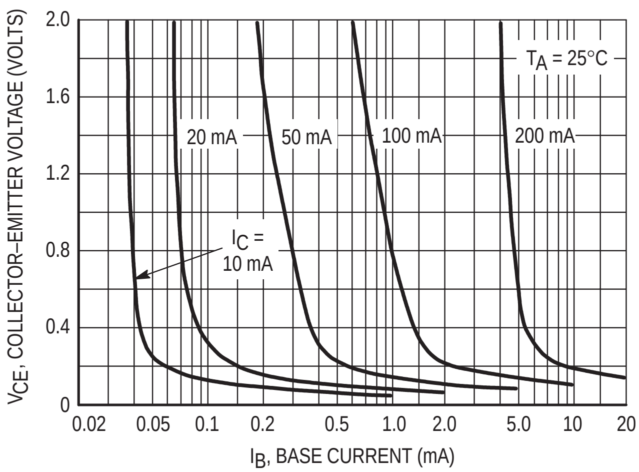


Figure 9. Collector Saturation Region

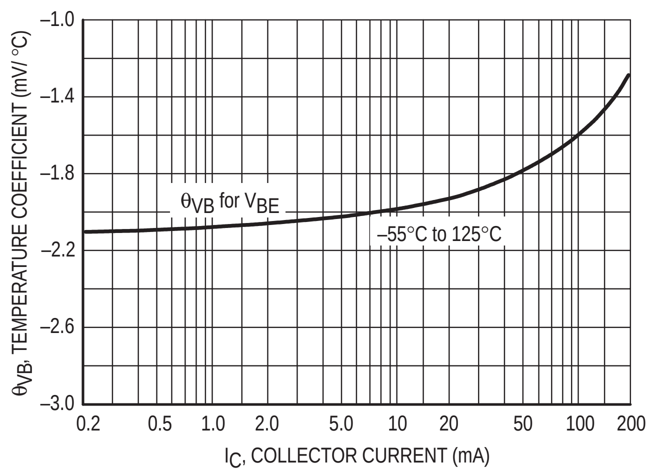


Figure 10. Base–Emitter Temperature Coefficient

BC546

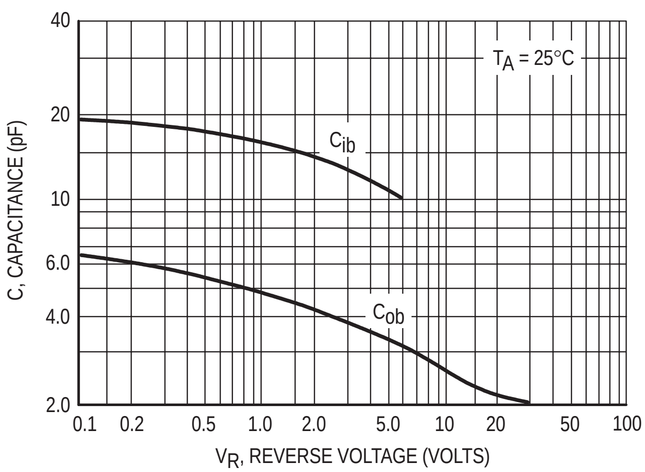


Figure 11. Capacitance

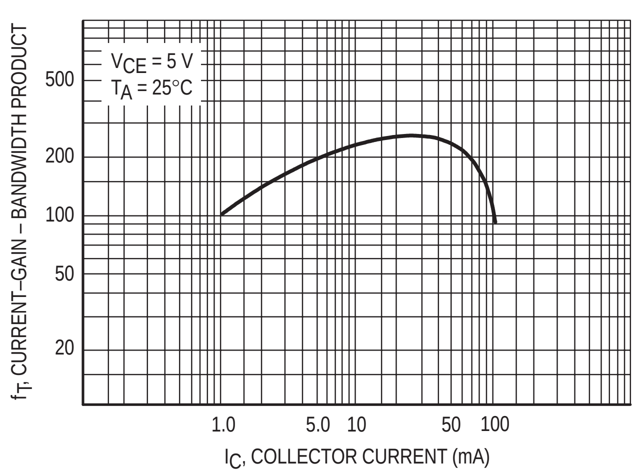
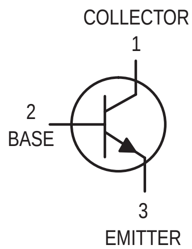
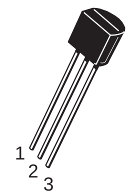


Figure 12. Current–Gain – Bandwidth Product

Low Noise Transistors
NPN Silicon

BC549B,C
BC550B,C





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC549	BC550	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)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 V, I_E = 0) (V_{CB} = 30 V, I_E = 0, T_A = +125°C)		I_{CBO}	 — —	 — —	 15 5.0	 nAdc µAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	15	nAdc

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	BC549B/550B		100	150	—	
	BC549C/550C		100	270	—	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BC549B/550B		200	290	450	
	BC549C/550C		420	500	800	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)			—	0.075	0.25	
(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	0.6	
Base–Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	—	1.1	—	Vdc
Base–Emitter On Voltage		$V_{BE(on)}$				Vdc
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)			—	0.52	—	
(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		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	

NOTES:
1. I_B is value for which I_C = 11 mA at V_{CE} = 1.0 V.
2. Pulse test = 300 μs – Duty cycle = 2%.

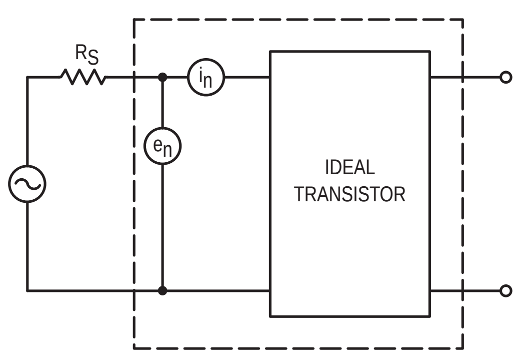


Figure 1. Transistor Noise Model

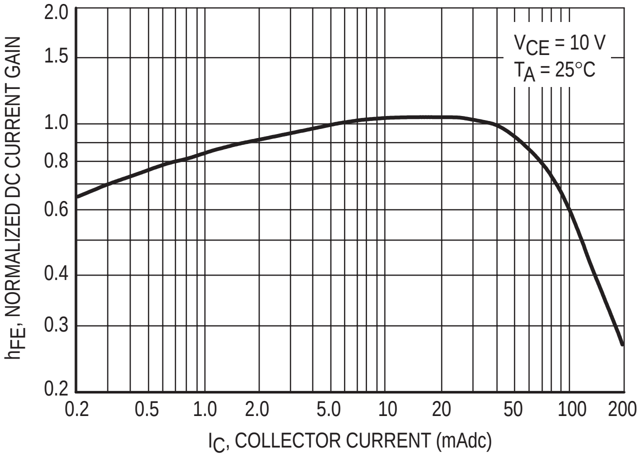


Figure 2. Normalized DC Current Gain

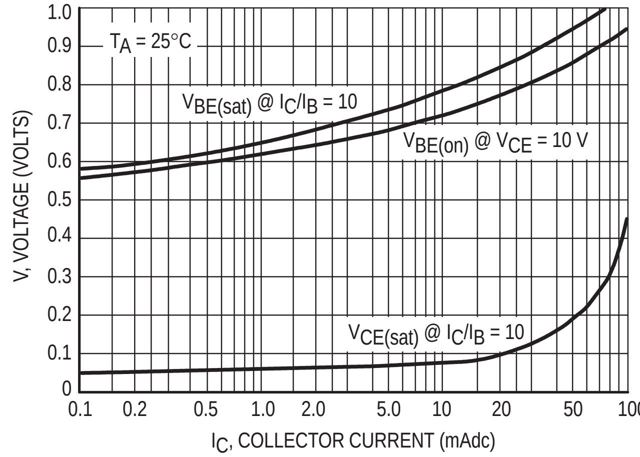


Figure 3. "Saturation" and "On" Voltages

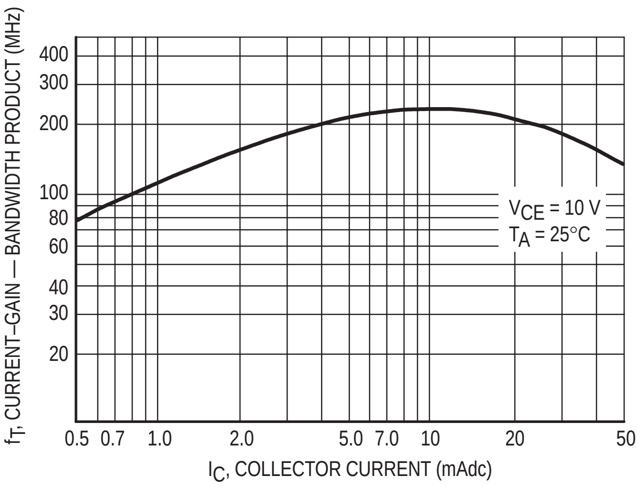


Figure 4. Current–Gain — Bandwidth Product

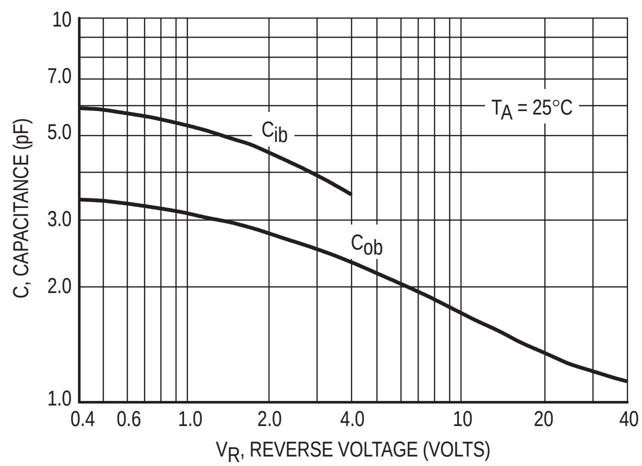


Figure 5. Capacitance

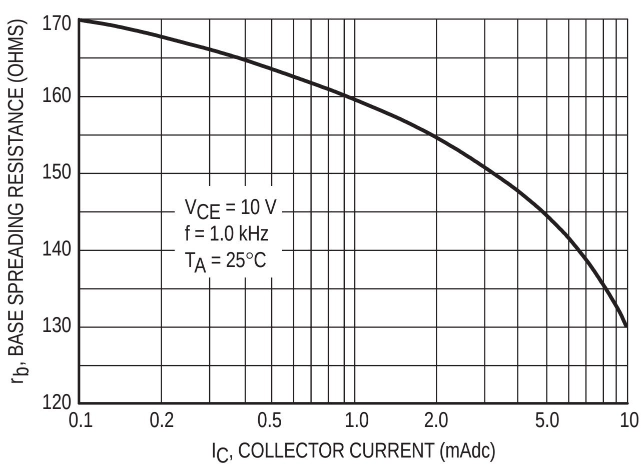
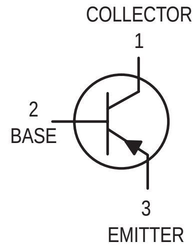
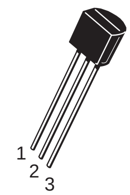


Figure 6. Base Spreading Resistance

Amplifier Transistors
PNP Silicon

BC556,B
BC557,A,B,C
BC558B





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

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 (I_C = –2.0 mAdc, I_B = 0)	BC556 BC557 BC558	$V_{(BR)CEO}$	–65 –45 –30	— — —	— — —	V
Collector–Base Breakdown Voltage (I_C = –100 μAdc)	BC556 BC557 BC558	$V_{(BR)CBO}$	–80 –50 –30	— — —	— — —	V
Emitter–Base Breakdown Voltage (I_E = –100 μAdc, I_C = 0)	BC556 BC557 BC558	$V_{(BR)EBO}$	–5.0 –5.0 –5.0	— — —	— — —	V
Collector–Emitter Leakage Current (V_{CES} = –40 V) (V_{CES} = –20 V)	BC556 BC557 BC558	I_{CES}	— — —	–2.0 –2.0 –2.0	–100 –100 –100	nA
(V_{CES} = –20 V, T_A = 125°C)	BC556 BC557 BC558		— — —	— — —	–4.0 –4.0 –4.0	μA

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

Characteristic		Symbol	Min	Typ	Max	Unit
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	
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 = 2.0 kΩ, 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	

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.

BC557/BC558

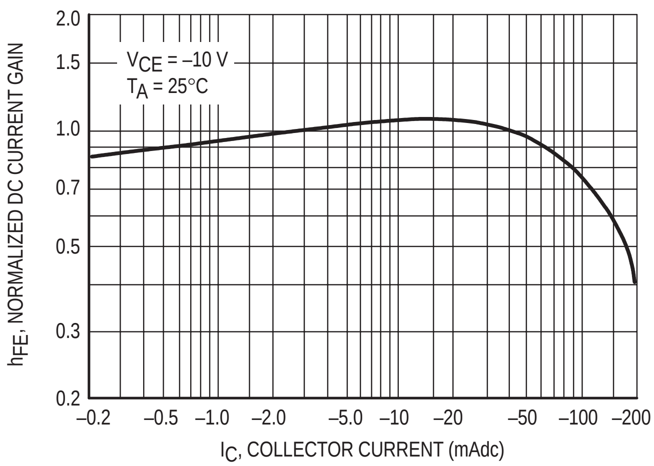


Figure 1. Normalized DC Current Gain

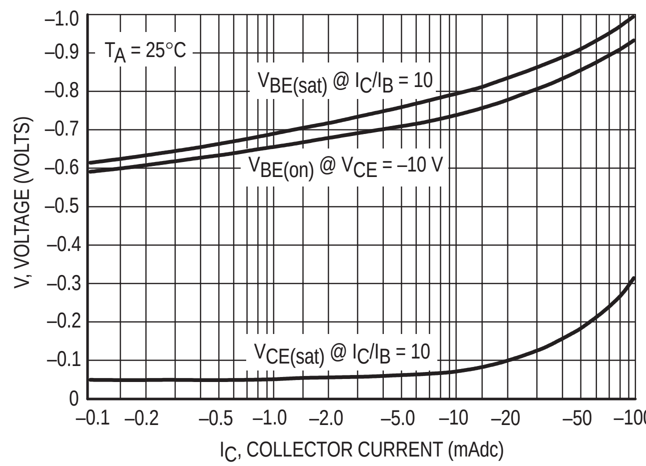


Figure 2. "Saturation" and "On" Voltages

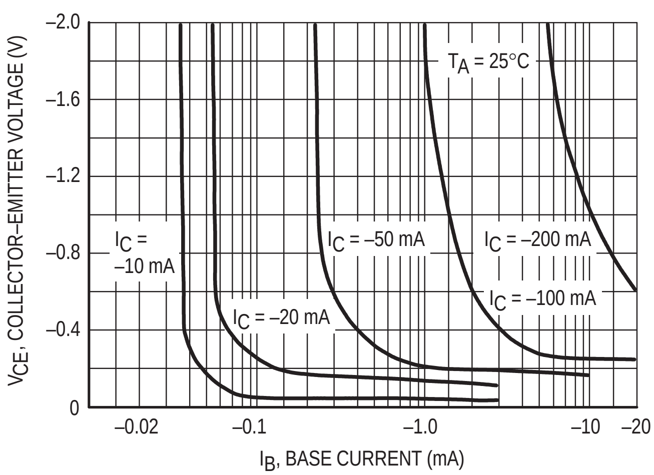


Figure 3. Collector Saturation Region

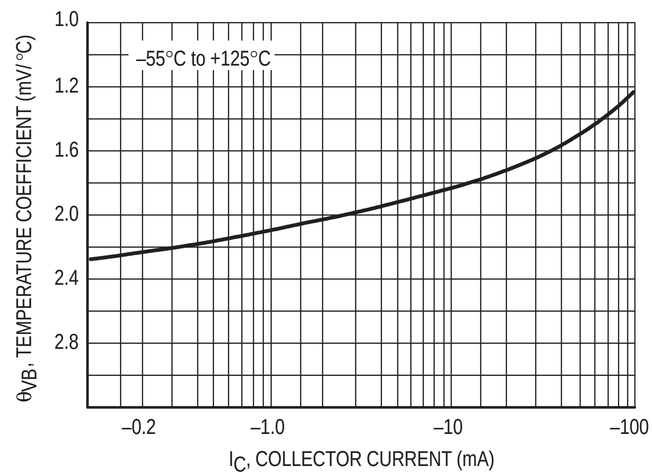


Figure 4. Base–Emitter Temperature Coefficient

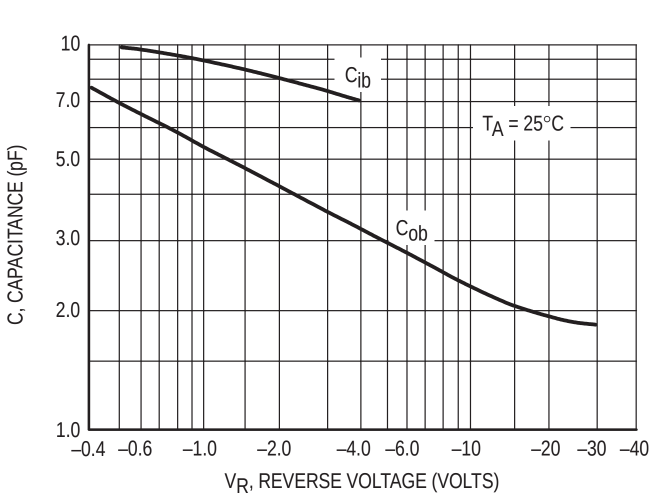


Figure 5. Capacitances

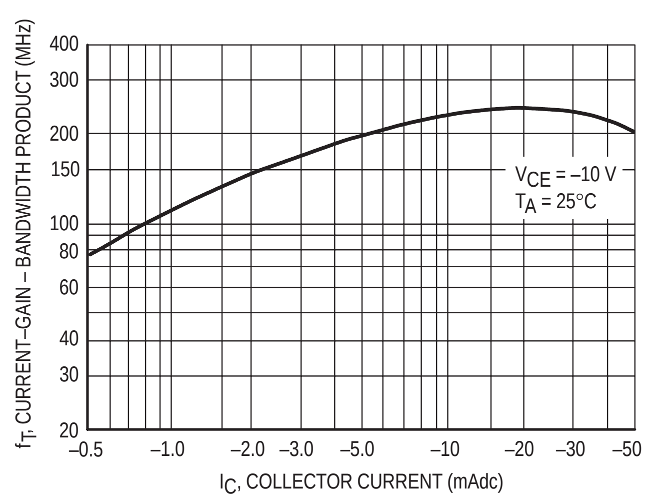


Figure 6. Current–Gain – Bandwidth Product

BC556

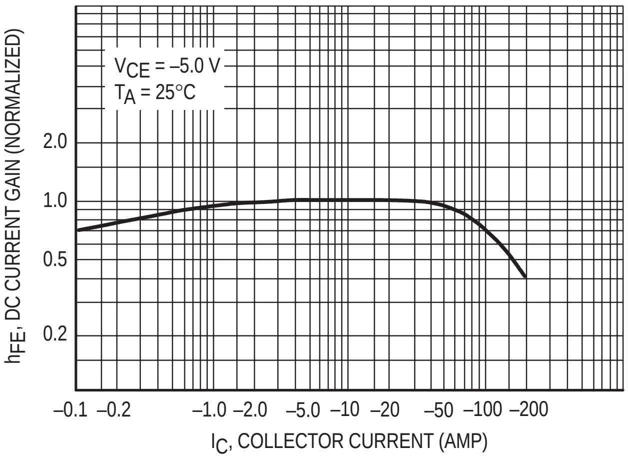


Figure 7. DC Current Gain

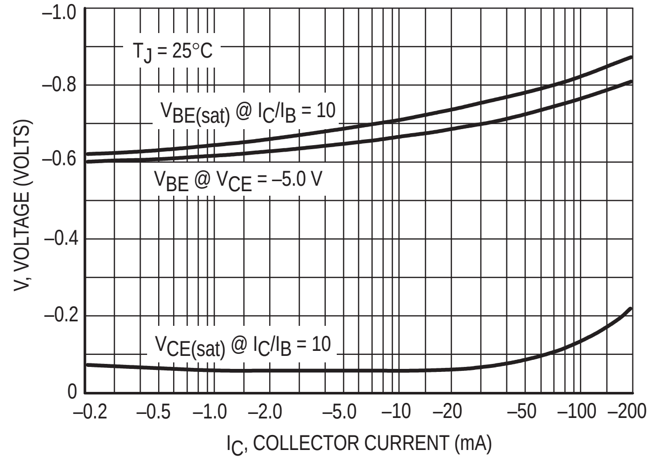


Figure 8. “On” Voltage

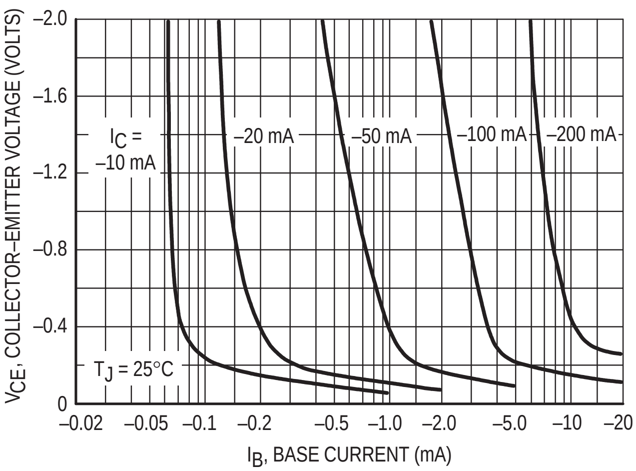


Figure 9. Collector Saturation Region

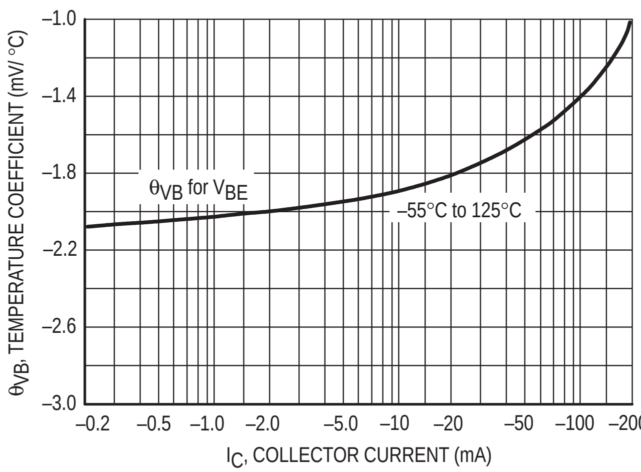


Figure 10. Base–Emitter Temperature Coefficient

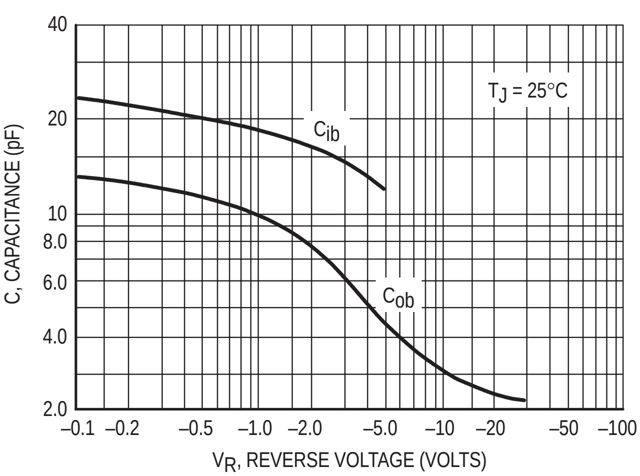


Figure 11. Capacitance

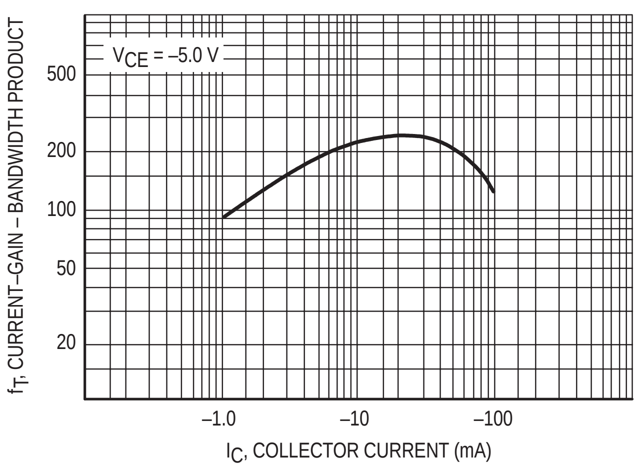


Figure 12. Current–Gain – Bandwidth Product

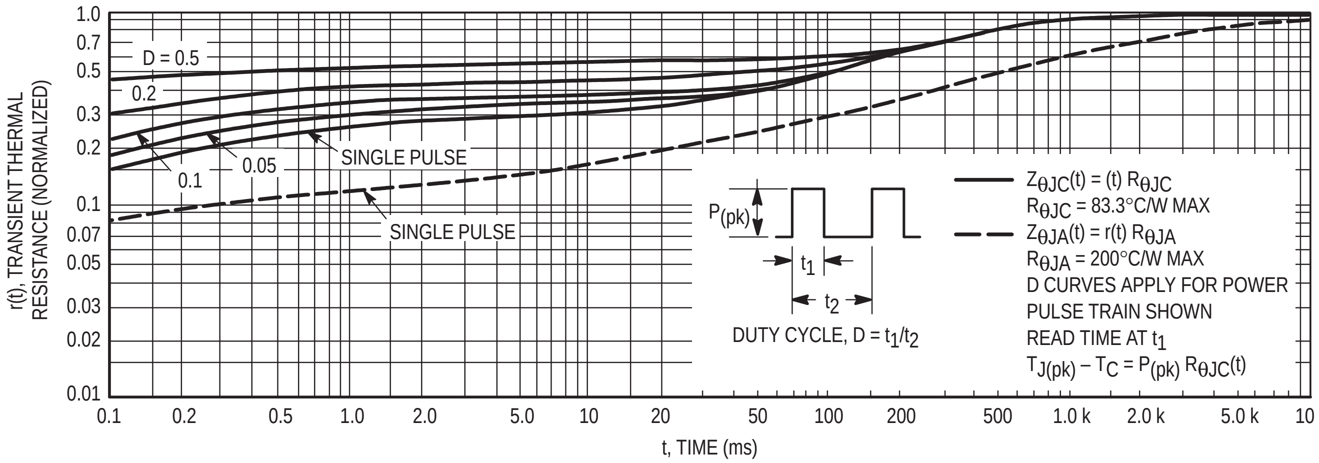


Figure 13. Thermal Response

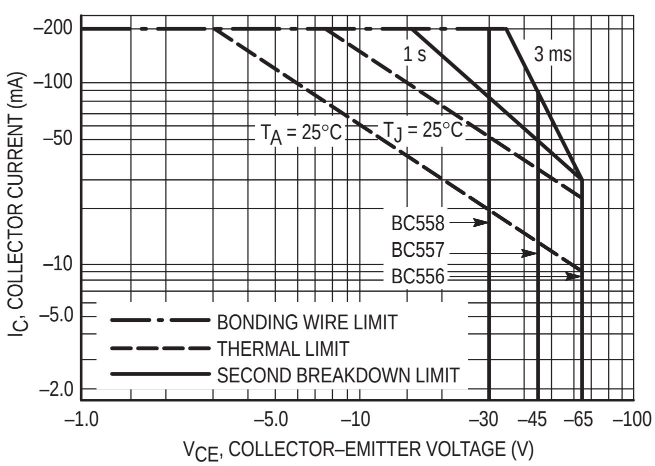


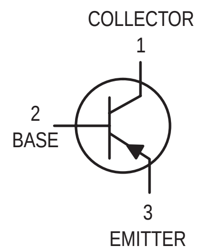
Figure 14. Active Region — Safe Operating Area

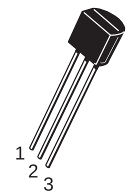
The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

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 in Figure 13. 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.

Low Noise Transistors
PNP Silicon

BC559B
BC559C
BC560C





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC559x	BC560C	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)	 BC559B, C BC560C	$V_{(BR)CEO}$	 –30 –45	 — —	 — —	Vdc
Collector – Base Breakdown Voltage (I_C = –10 µAdc, I_E = 0)	 BC559B, C BC560C	$V_{(BR)CBO}$	 –30 –50	 — —	 — —	Vdc
Emitter – Base Breakdown Voltage (I_E = –10 µAdc, I_C = 0)		$V_{(BR)EBO}$	–5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = –30 Vdc, I_E = 0) (V_{CB} = –30 Vdc, I_E = 0, T_A = +125°C)		I_{CBO}	 — —	 — —	 –15 –5.0	 nAdc µAdc
Emitter Cutoff Current (V_{EB} = –4.0 Vdc, I_C = 0)		I_{EBO}	—	—	–15	nAdc

replaces BC559/D

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = –10 µAdc, V_{CE} = –5.0 Vdc)	BC559B		100	150	—	
	BC559C/560C		100	270	—	
(I_C = –2.0 mAdc, V_{CE} = –5.0 Vdc)	BC559B		180	290	460	
	BC559C/560C		380	500	800	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = –10 mAdc, I_B = –0.5 mAdc)			—	–0.075	–0.25	
(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		$V_{BE(on)}$				Vdc
(I_C = –10 µAdc, V_{CE} = –5.0 Vdc)			—	–0.52	—	
(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		h_{fe}				—
(I_C = –2.0 mAdc, V_{CE} = –5.0 V, f = 1.0 kHz)	BC559B		240	330	500	
	BC559C/BC560C		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	—	0.5	2.0	
(I_C = –200 µAdc, V_{CE} = –5.0 Vdc, R_S = 100 kΩ, f = 1.0 kHz, Δf = 200 kHz)		NF_2	—	—	10	

NOTES:
1. I_B is value for which I_C = –11 mA at V_{CE} = –1.0 V.
2. Pulse test = 300 µs – Duty cycle = 2%.

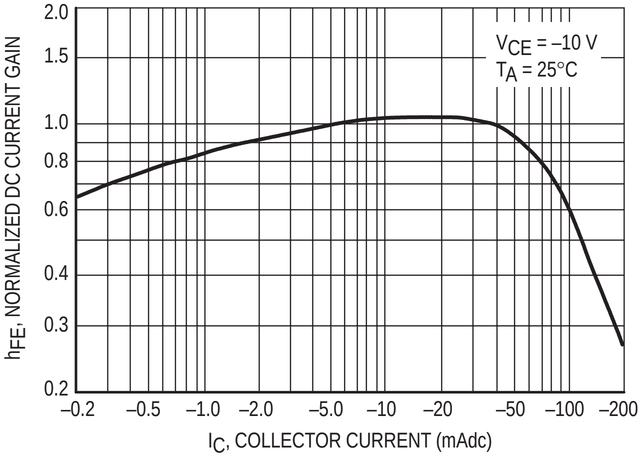


Figure 1. Normalized DC Current Gain

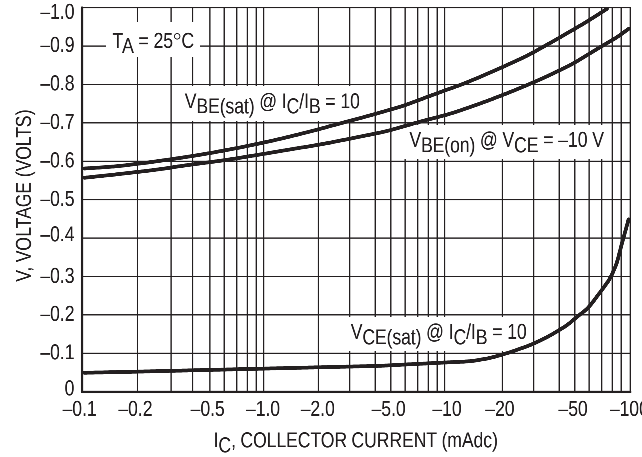


Figure 2. "Saturation" and "On" Voltages

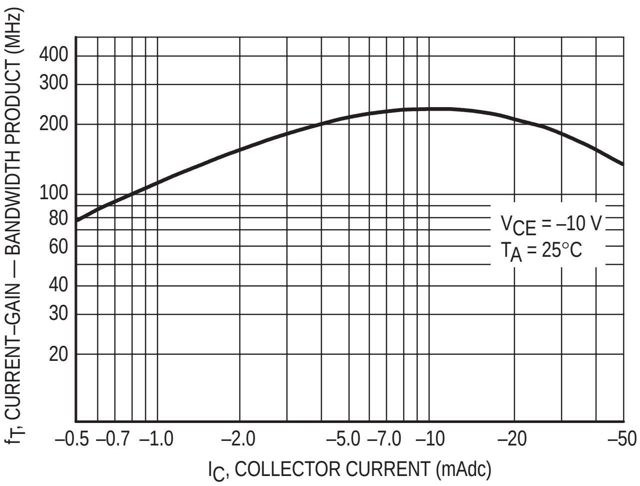


Figure 3. Current–Gain — Bandwidth Product

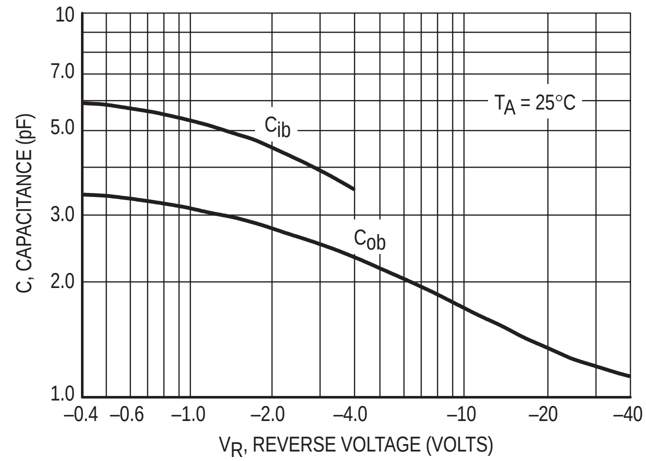


Figure 4. Capacitance

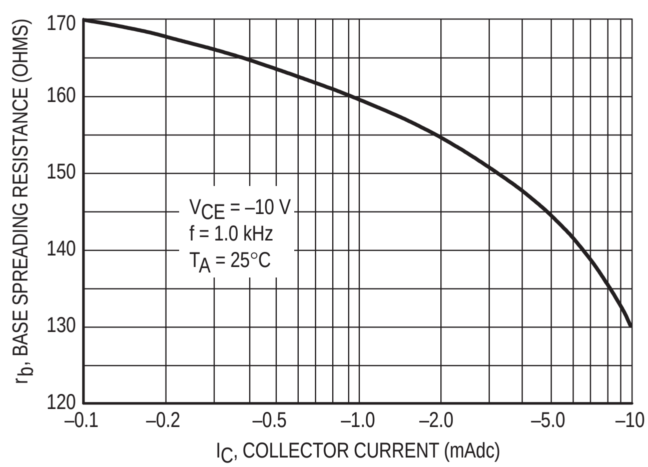
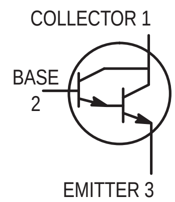
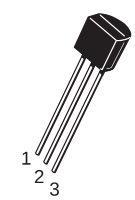


Figure 5. Base Spreading Resistance

Darlington Transistors
NPN Silicon

BC618





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

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	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 = 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

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

Characteristic	Symbol	Min	Typ	Max	Unit
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
DC Current Gain	h_{FE}				—
(I_C = 100 μA, V_{CE} = 5.0 Vdc)		2000	—	—	
(I_C = 10 mA, V_{CE} = 5.0 Vdc)		4000	—	—	
(I_C = 200 mA, V_{CE} = 5.0 Vdc)		10000	—	50000	
(I_C = 1.0 A, V_{CE} = 5.0 Vdc)		4000	—	—	
DYNAMIC CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 500 mA, V_{CE} = 5.0 Vdc, 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

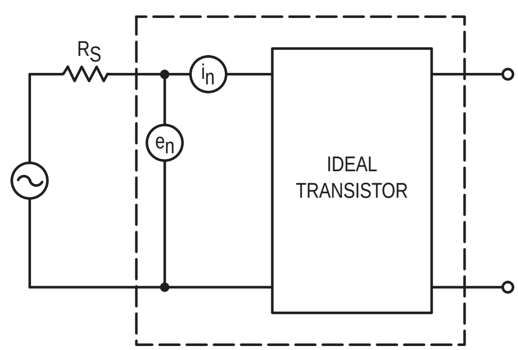


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

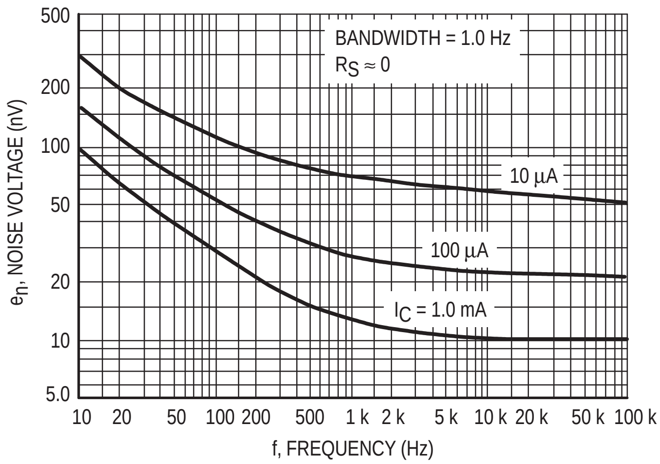


Figure 2. Noise Voltage

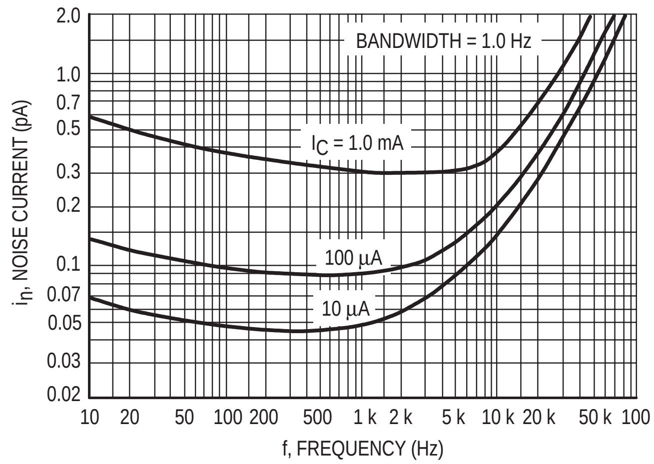


Figure 3. Noise Current

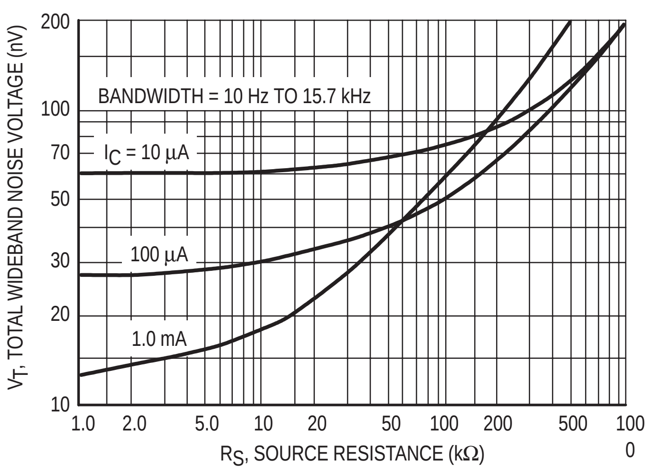


Figure 4. Total Wideband Noise Voltage

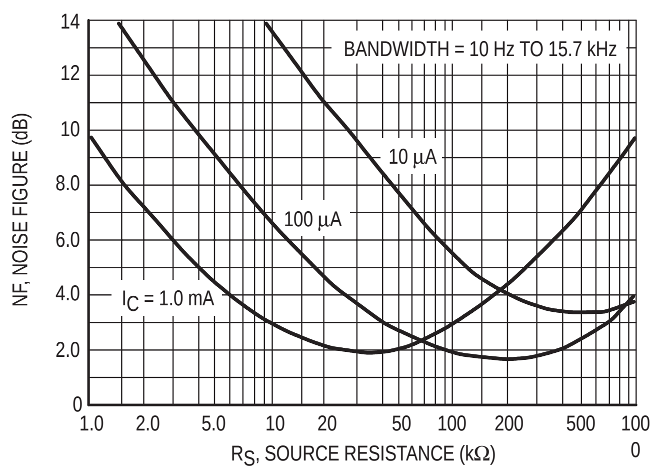


Figure 5. Wideband Noise Figure

SMALL–SIGNAL CHARACTERISTICS

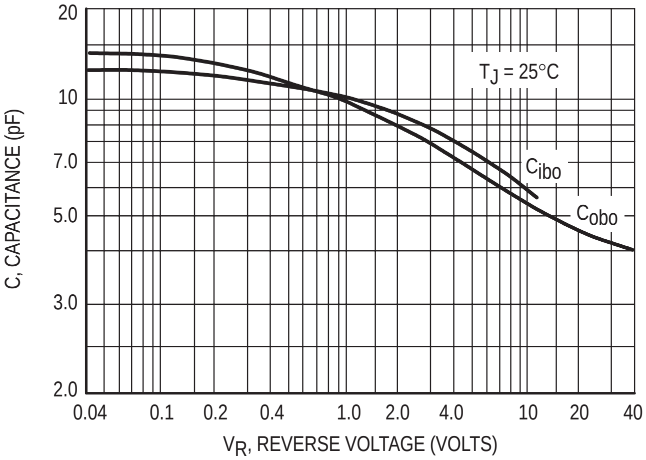


Figure 6. Capacitance

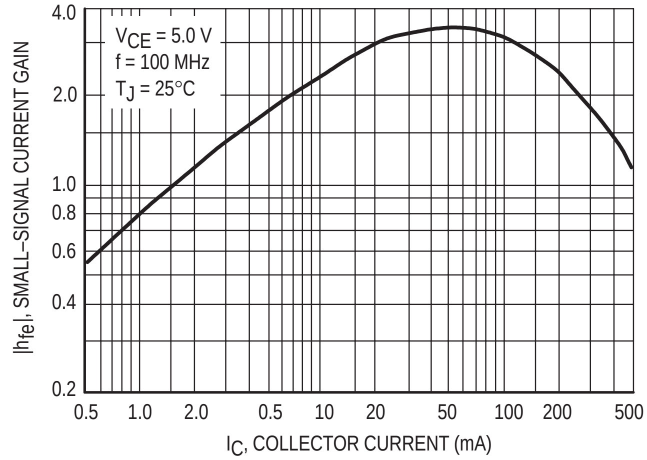


Figure 7. High Frequency Current Gain

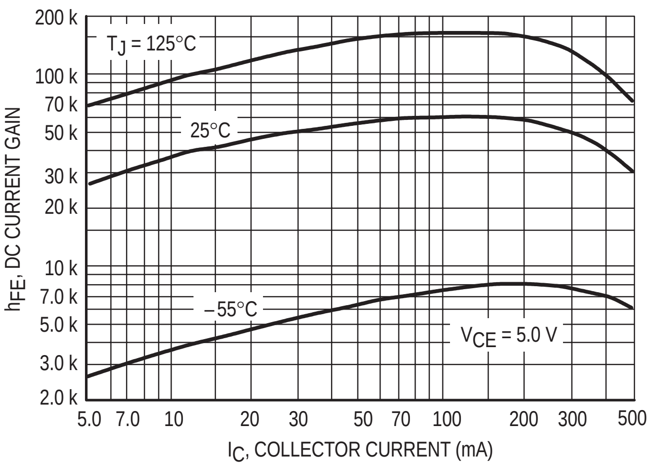


Figure 8. DC Current Gain

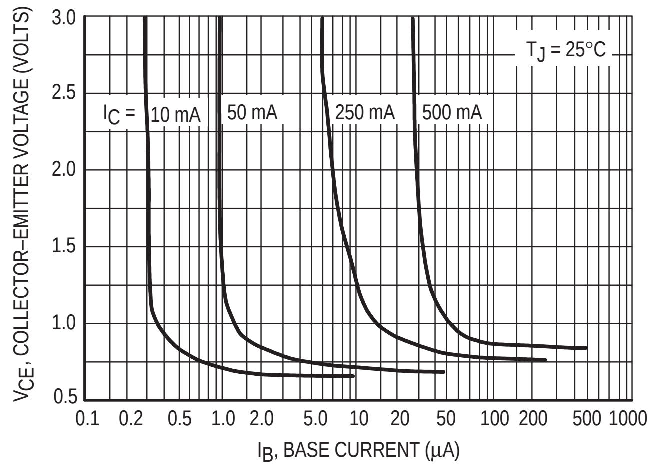


Figure 9. Collector Saturation Region

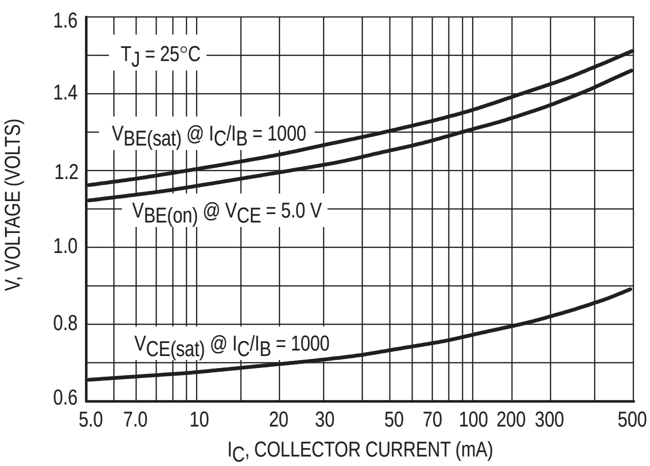


Figure 10. “On” Voltages

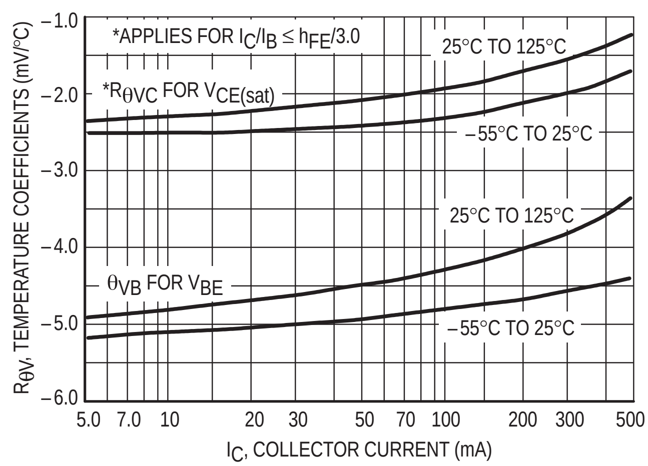


Figure 11. Temperature Coefficients

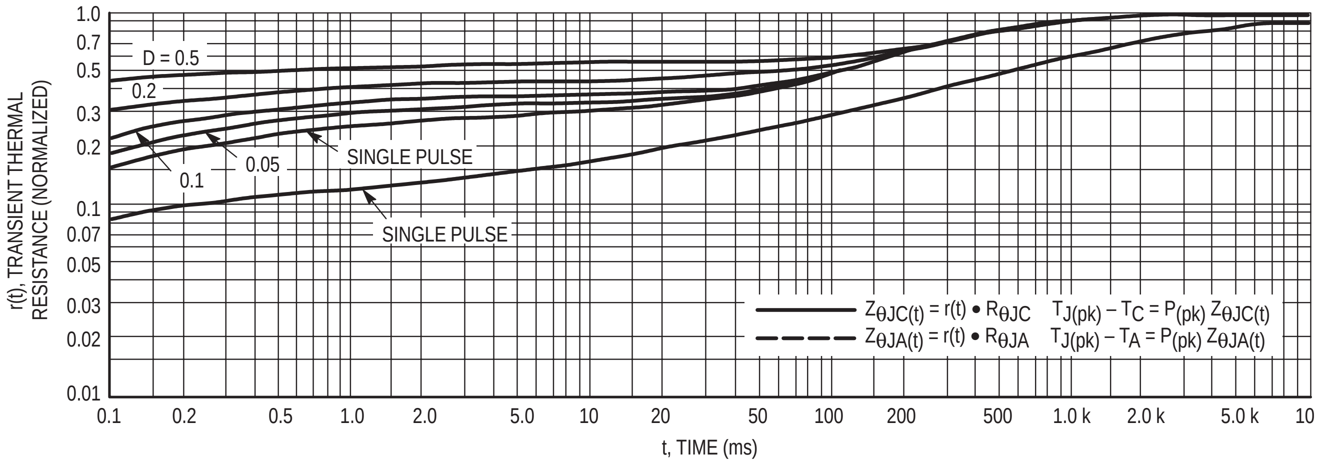


Figure 12. Thermal Response

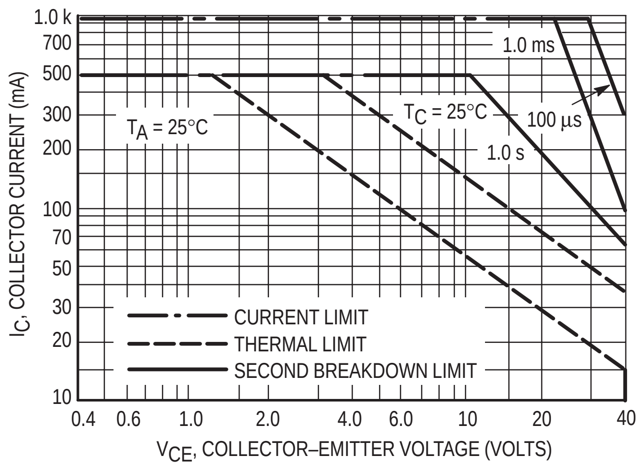
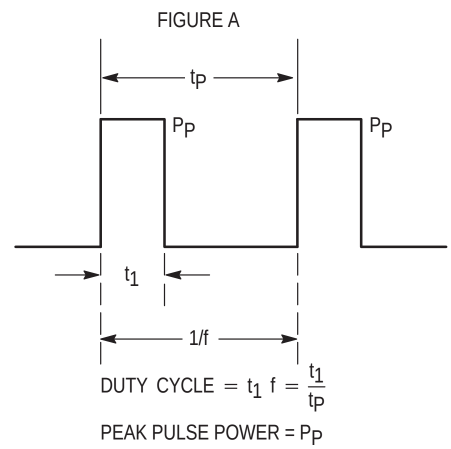


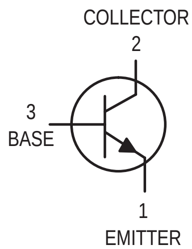
Figure 13. Active Region Safe Operating Area

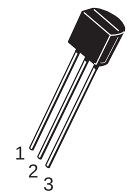


Design Note: Use of Transient Thermal Resistance Data

High Current Transistors
NPN Silicon

BC635
BC637
BC639





CASE 29–04, STYLE 14
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC635	BC637	BC639	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(1) (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

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

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS[1]						
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)	BC635		40	—	250	
	BC637		40	—	160	
	BC639		40	—	160	
(I_C = 500 mA, V_{CE} = 2.0 V)			25	—	—	
Collector–Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	—	0.5	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

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

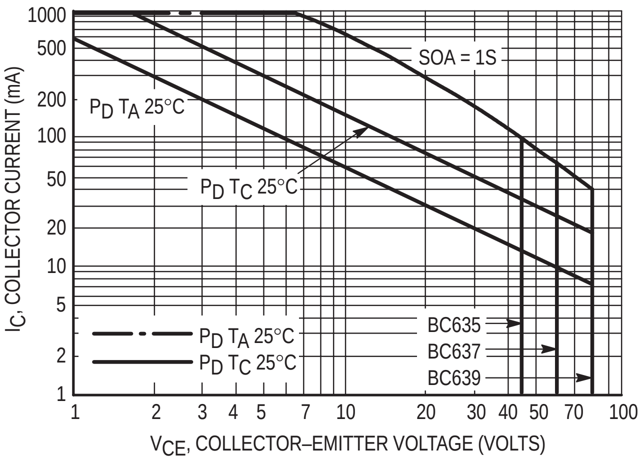


Figure 1. Active Region Safe Operating Area

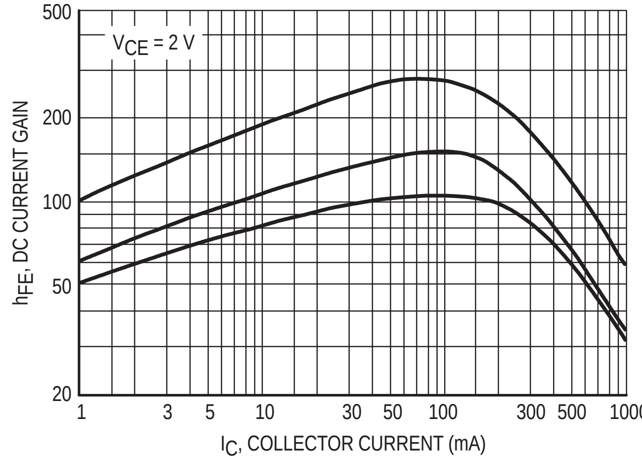


Figure 2. DC Current Gain

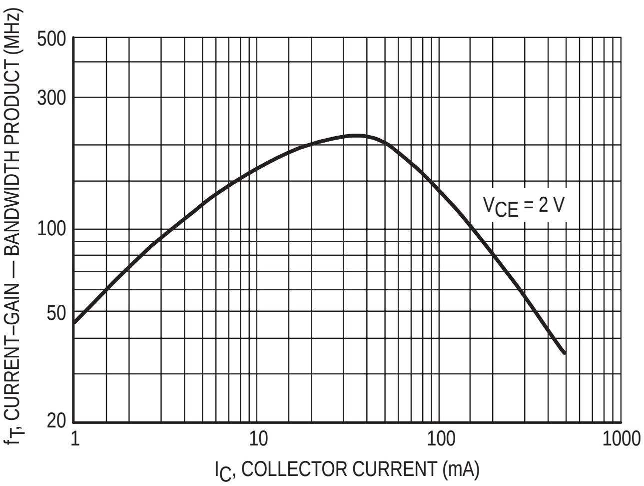


Figure 3. Current–Gain — Bandwidth Product

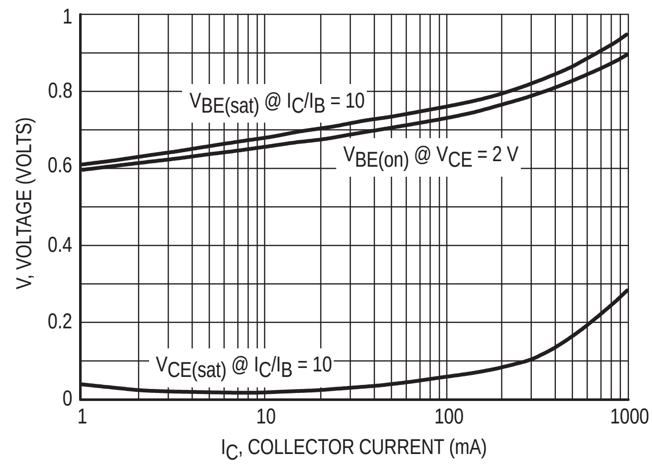


Figure 4. “Saturation” and “On” Voltages

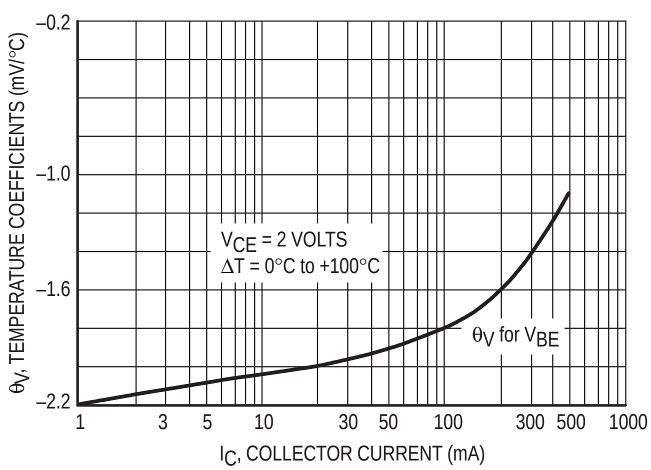
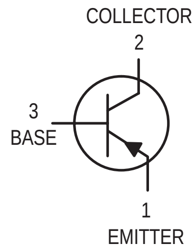


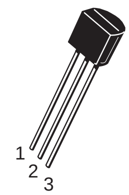
Figure 5. Temperature Coefficients

High Current Transistors

PNP Silicon

BC636
BC638
BC640





CASE 29–04, STYLE 14
TO–92 (TO–226AA)

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* (I_C = –10 mAdc, I_B = 0)		$V_{(BR)CEO}$				Vdc
	BC636		–45	—	—	
	BC638		–60	—	—	
	BC640		–80	—	—	
Collector–Base Breakdown Voltage (I_C = –100 μAdc, I_E = 0)		$V_{(BR)CBO}$				Vdc
	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

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

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS[1]						
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

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

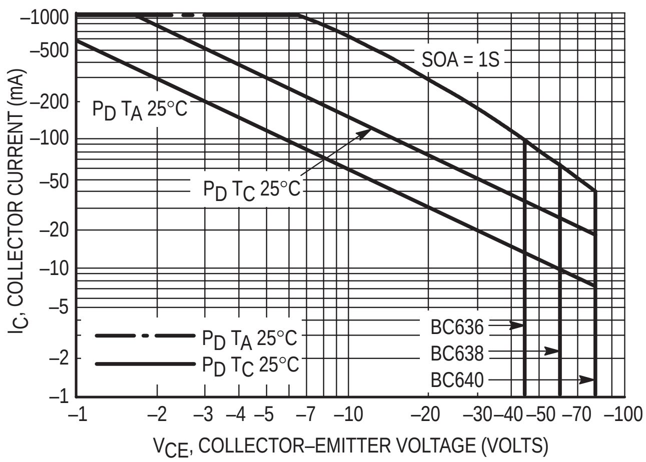


Figure 1. Active Region Safe Operating Area

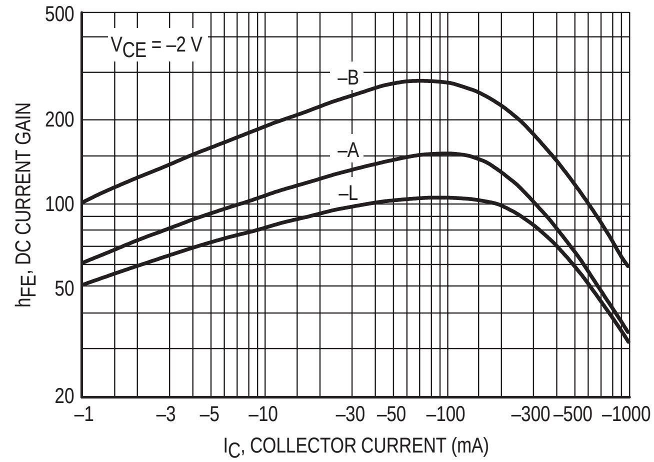


Figure 2. DC Current Gain

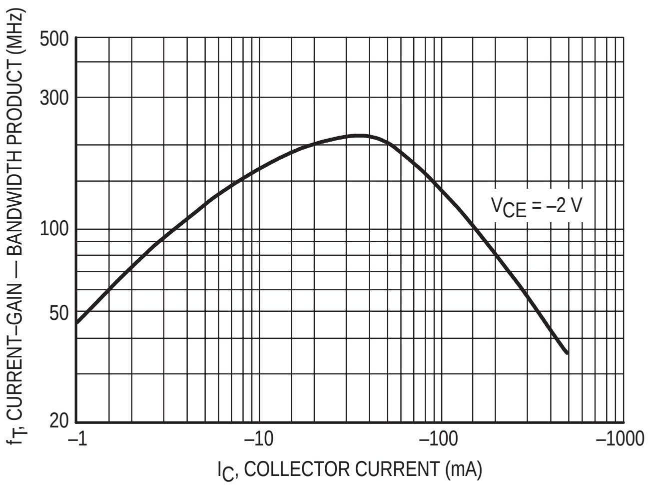


Figure 3. Current Gain Bandwidth Product

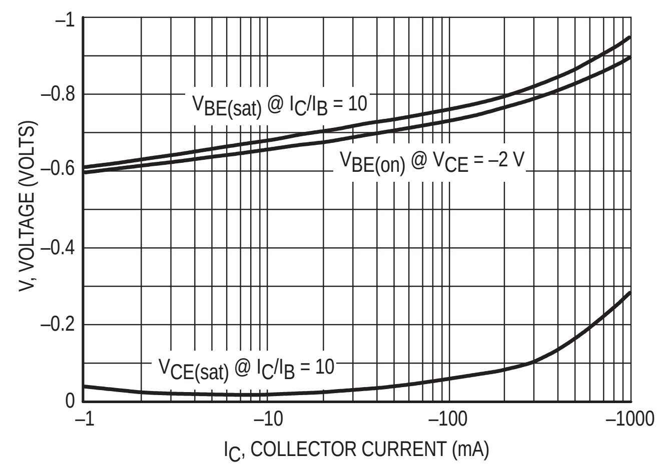


Figure 4. “Saturation” and “On” Voltages

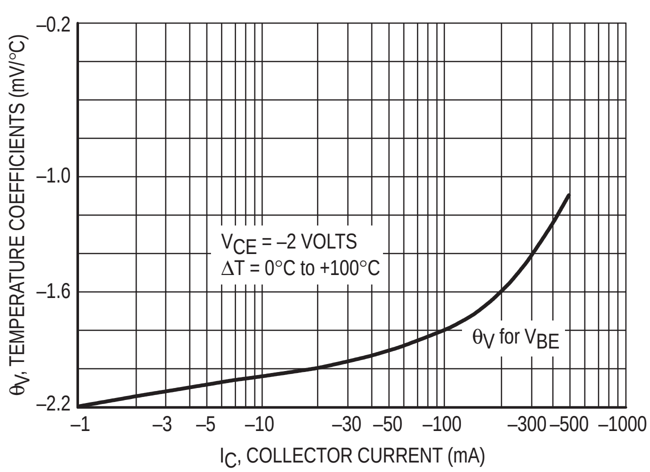
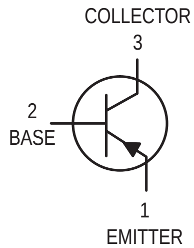
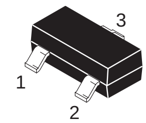


Figure 5. Temperature Coefficients

General Purpose Transistors
PNP Silicon

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





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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, (1) 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, (2) 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

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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

REV 1

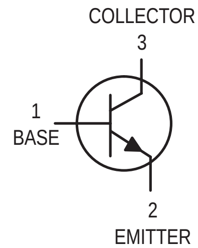
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

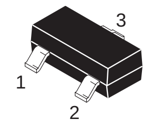
Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
(I_C = –100 mA, V_{CE} = –1.0 V) BC807–16		100	—	250	
BC807–25		160	—	400	
BC807–40		250	—	600	
(I_C = –500 mA, V_{CE} = –1.0 V)		40	—	—	
Collector–Emitter Saturation Voltage (I_C = –500 mA, I_B = –50 mA)	$V_{CE(sat)}$	—	—	–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	100	—	—	MHz
Output Capacitance (V_{CB} = –10 V, f = 1.0 MHz)	C_{obo}	—	10	—	pF

General Purpose Transistors

NPN Silicon

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





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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, (1) 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, (2) 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

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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

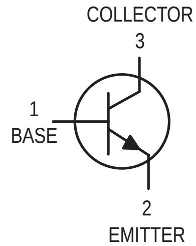
REV 2

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 100 mA, V_{CE} = 1.0 V)	BC817–16		100	—	250	
	BC817–25		160	—	400	
	BC817–40		250	—	600	
(I_C = 500 mA, V_{CE} = 1.0 V)			40	—	—	
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	100	—	—	MHz
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)		C_{obo}	—	10	—	pF

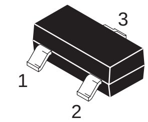
General Purpose Transistors

NPN Silicon



BC846ALT1,BLT1
BC847ALT1,
BLT1,CLT1 thru
BC850BLT1,CLT1

BC846, BC847 and BC848 are Motorola Preferred Devices



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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, (1) 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, (2) 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

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 (I_C = 10 mA)	BC846A,B BC847A,B,C, BC850B,C BC848A,B,C, BC849B,C	$V_{(BR)CEO}$	65 45 30	— — —	— — —	V
Collector–Emitter Breakdown Voltage (I_C = 10 µA, V_{EB} = 0)	BC846A,B BC847A,B,C, BC850B,C BC848A,B,C, BC849B,C	$V_{(BR)CES}$	80 50 30	— — —	— — —	V
Collector–Base Breakdown Voltage (I_C = 10 µA)	BC846A,B BC847A,B,C, BC850B,C BC848A,B,C, BC849B,C	$V_{(BR)CBO}$	80 50 30	— — —	— — —	V
Emitter–Base Breakdown Voltage (I_E = 1.0 µA)	BC846A,B BC847A,B,C BC848A,B,C, BC849B,C, BC850B,C	$V_{(BR)EBO}$	6.0 6.0 5.0	— — —	— — —	V
Collector Cutoff Current (V_{CB} = 30 V) (V_{CB} = 30 V, T_A = 150°C)		I_{CBO}	— —	— —	15 5.0	nA µA

1. FR–5 = 1.0 x 0.75 x 0.062 in 2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

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

REV 1

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5.0 V)	BC846A, BC847A, BC848A	h_{FE}	—	90	—	—
	BC846B, BC847B, BC848B		—	150	—	
	BC847C, BC848C		—	270	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC846A, BC847A, BC848A		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	NF				dB
V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ,	BC846B, BC847B, BC848B					
f = 1.0 kHz, BW = 200 Hz)	BC847C, BC848C		—	—	10	
	BC849B,C, BC850B,C		—	—	4.0	

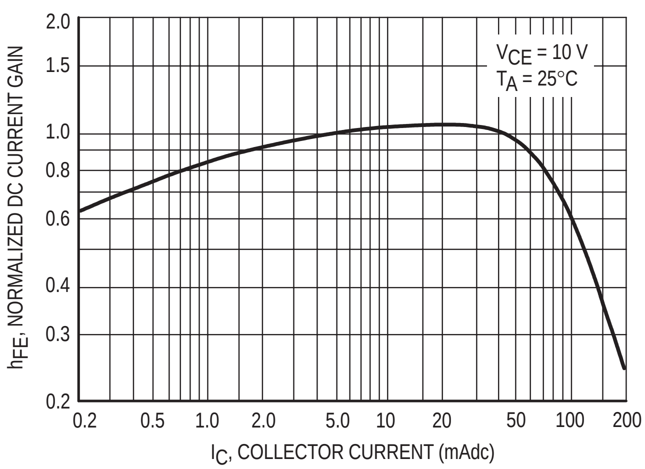


Figure 1. Normalized DC Current Gain

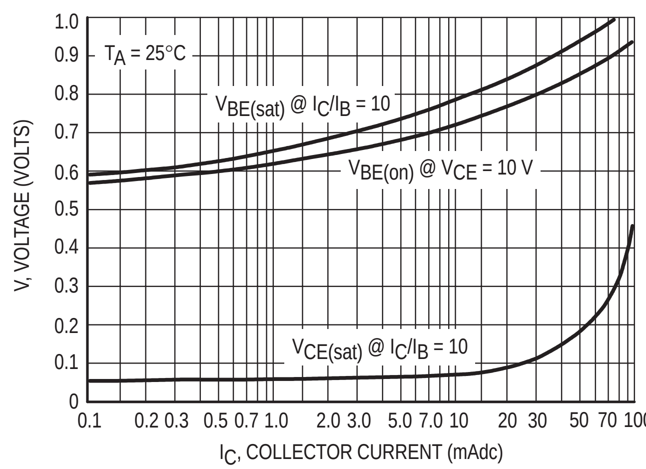


Figure 2. "Saturation" and "On" Voltages

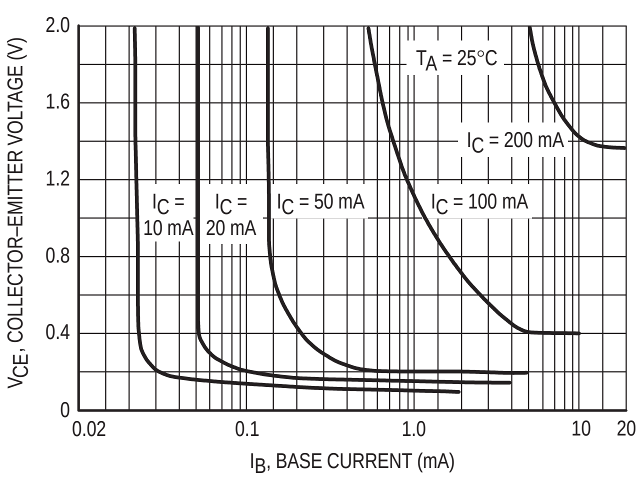


Figure 3. Collector Saturation Region

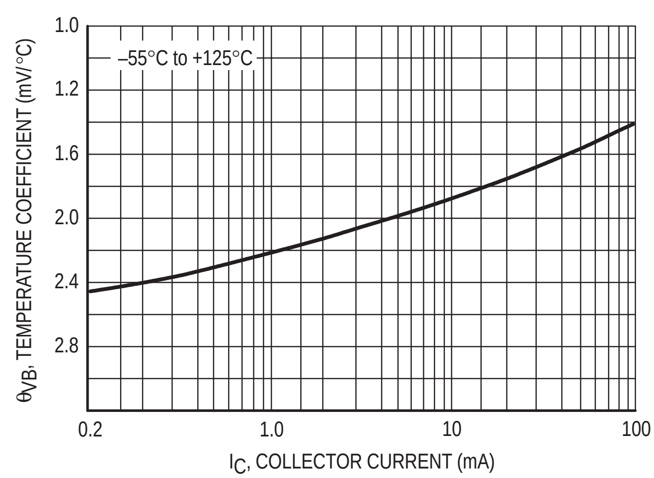


Figure 4. Base–Emitter Temperature Coefficient

BC847/BC848

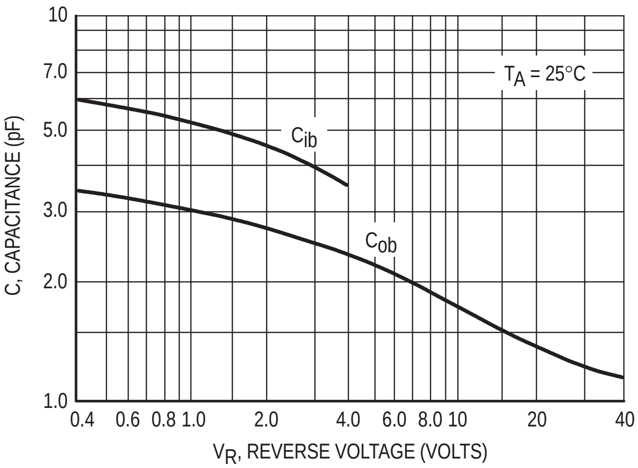


Figure 5. Capacitances

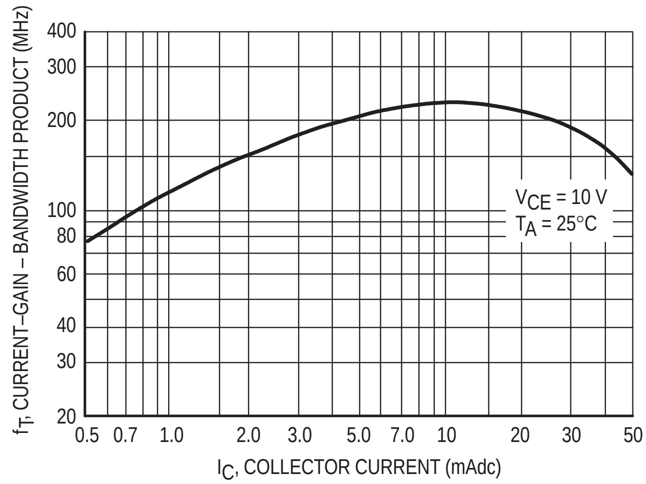


Figure 6. Current–Gain – Bandwidth Product

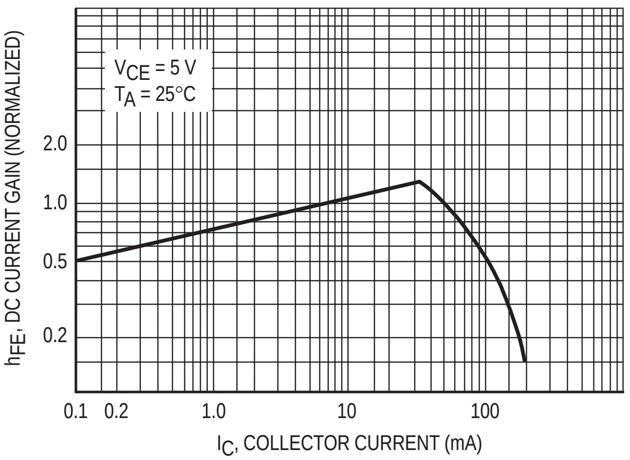


Figure 7. DC Current Gain

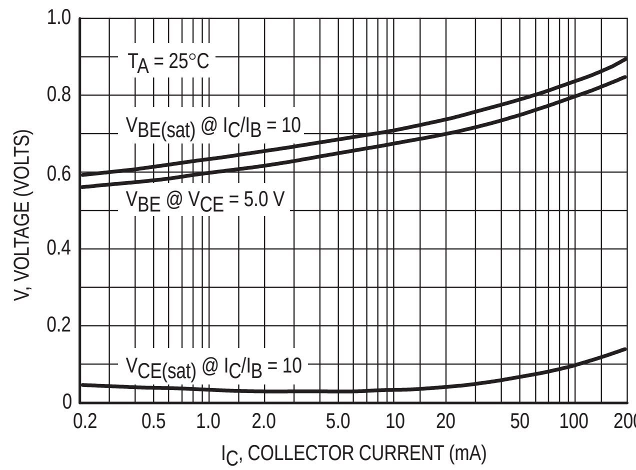


Figure 8. "On" Voltage

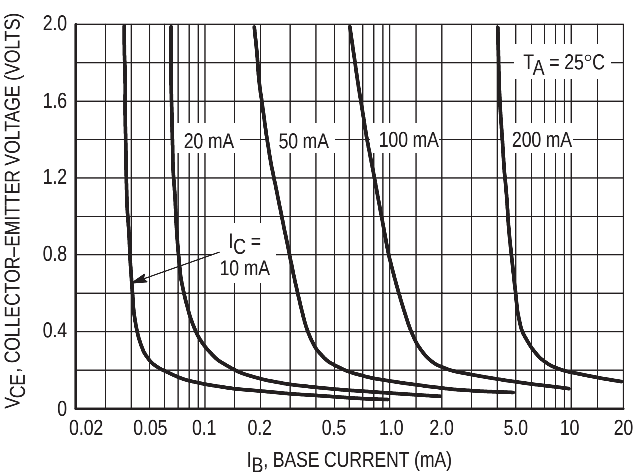


Figure 9. Collector Saturation Region

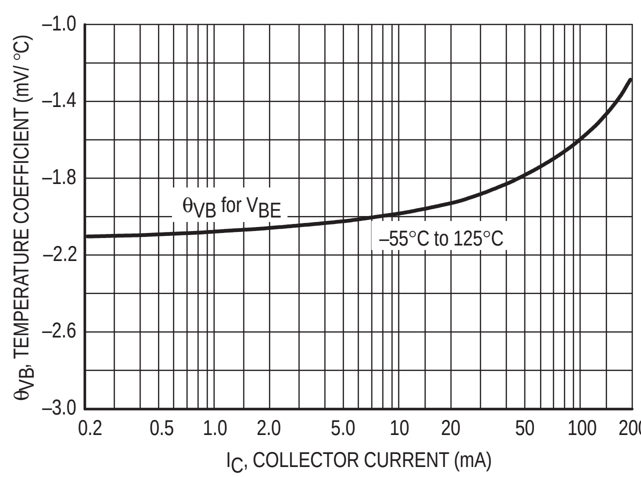


Figure 10. Base–Emitter Temperature Coefficient

BC846

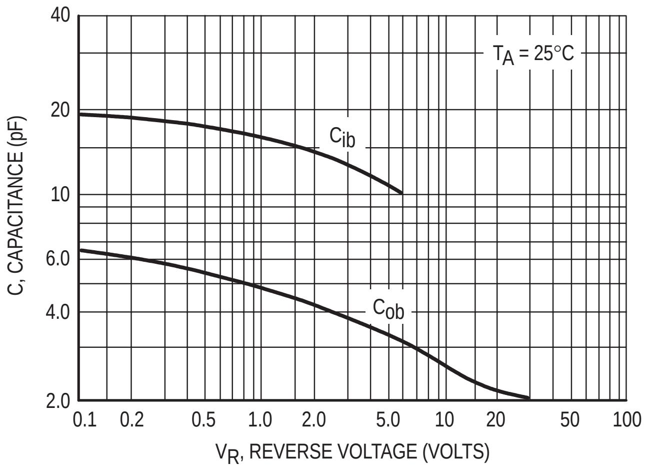


Figure 11. Capacitance

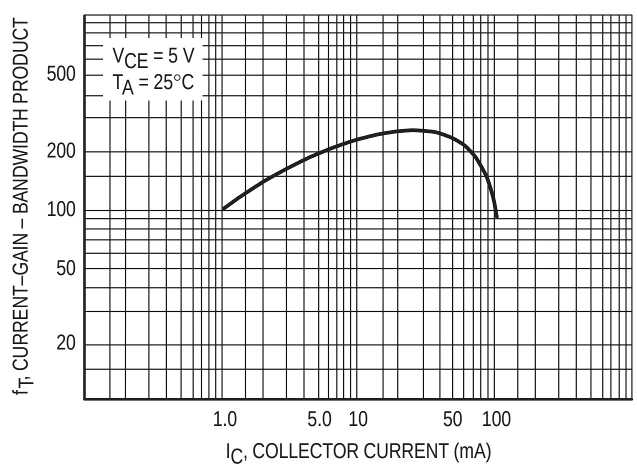
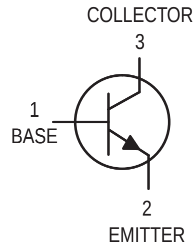


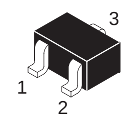
Figure 12. Current–Gain – Bandwidth Product

General Purpose Transistors
NPN Silicon

These transistors are designed for general purpose amplifier applications. They are housed in the SOT–323/SC–70 which is designed for low power surface mount applications.



BC846AWT1,BWT1
BC847AWT1,BWT1,
CWT1
BC848AWT1,BWT1,
CWT1



CASE 419–02, STYLE 3
SOT–323/SC–70

MAXIMUM RATINGS

Rating	Symbol	BC846	BC847	BC848	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, (1) T_A = 25°C	P_D	150	mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	833	°C/W
Total Device Dissipation	P_D	2.4	mW/°C
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

DEVICE MARKING

BC846AWT1 = 1A; BC846BWT1 = 1B; BC847AWT1 = 1E; BC847BWT1 = 1F;
BC847CWT1 = 1G; BC848AWT1 = 1J; BC848BWT1 = 1K; BC848CWT1 = 1L

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)	BC846 Series BC847 Series BC848 Series	$V_{(BR)CEO}$	65 45 30	— — —	— — —	V
Collector–Emitter Breakdown Voltage (I_C = 10 µA, V_{EB} = 0)	BC846 Series BC847 Series BC848 Series	$V_{(BR)CES}$	80 50 30	— — —	— — —	V
Collector–Base Breakdown Voltage (I_C = 10 µA)	BC846 Series BC847 Series BC848 Series	$V_{(BR)CBO}$	80 50 30	— — —	— — —	V
Emitter–Base Breakdown Voltage (I_E = 1.0 µA)	BC846 Series BC847 Series BC848 Series	$V_{(BR)EBO}$	6.0 6.0 5.0	— — —	— — —	V
Collector Cutoff Current (V_{CB} = 30 V) (V_{CB} = 30 V, T_A = 150°C)		I_{CBO}	— —	— —	15 5.0	nA µA

1. FR–5 = 1.0 x 0.75 x 0.062 in

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5.0 V)	BC846A, BC847A, BC848A	h_{FE}	—	90	—	—
	BC846B, BC847B, BC848B		—	150	—	
	BC847C, BC848C		—	270	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC846A, BC847A, BC848A		110	180	220	
	BC846B, BC847B, BC848B		200	290	450	
	BC847C, BC848C		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, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	BC846A, BC847A, BC848A	NF				dB
	BC846B, BC847B, BC848B		—	—	10	
	BC847C, BC848C		—	—	4.0	

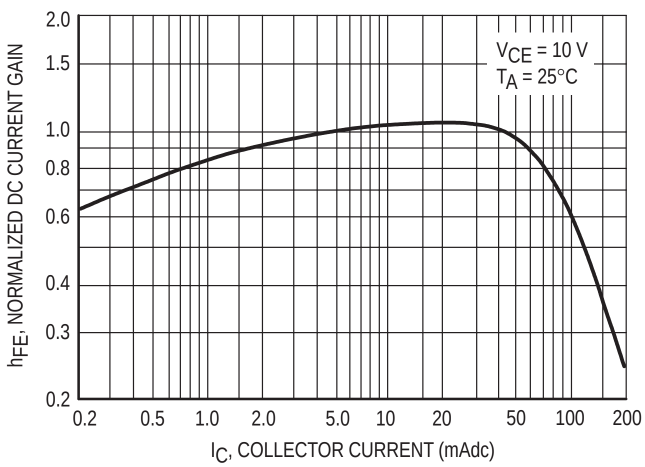


Figure 1. Normalized DC Current Gain

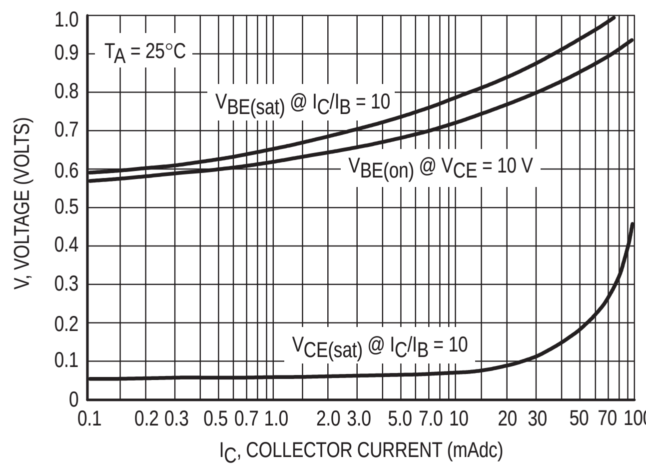


Figure 2. "Saturation" and "On" Voltages

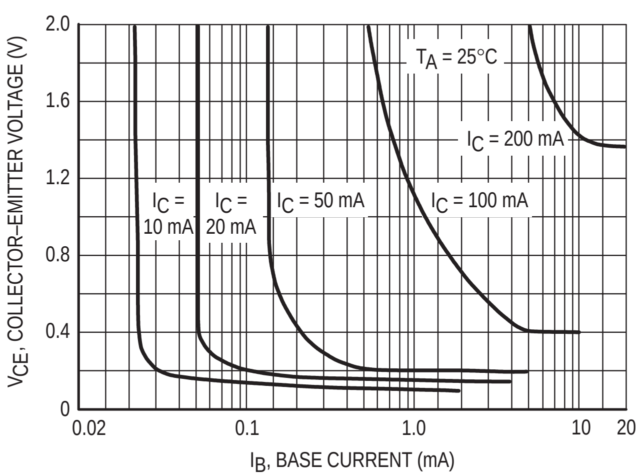


Figure 3. Collector Saturation Region

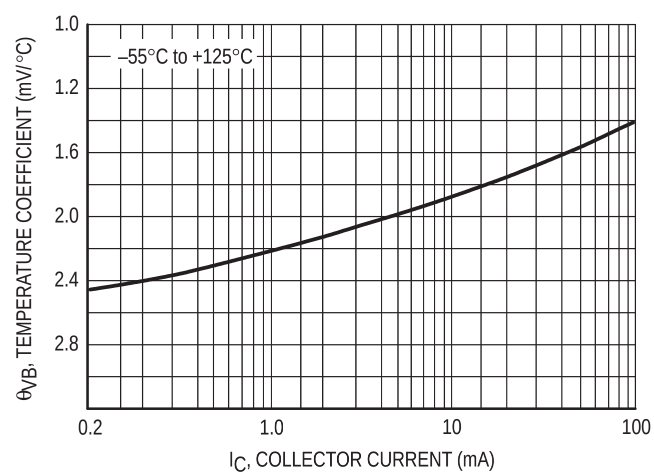


Figure 4. Base–Emitter Temperature Coefficient

BC847/BC848

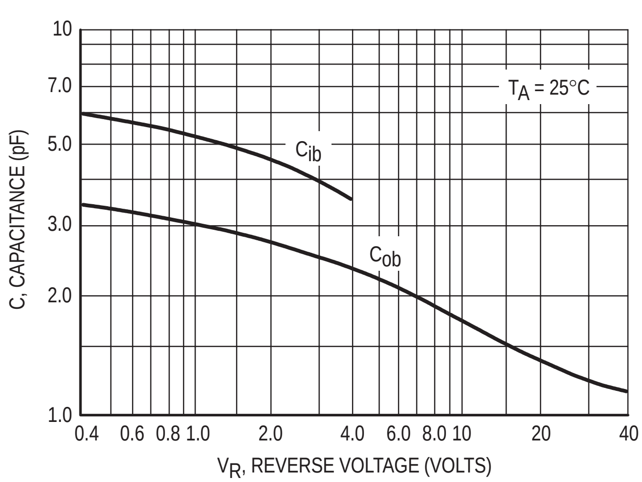


Figure 5. Capacitances

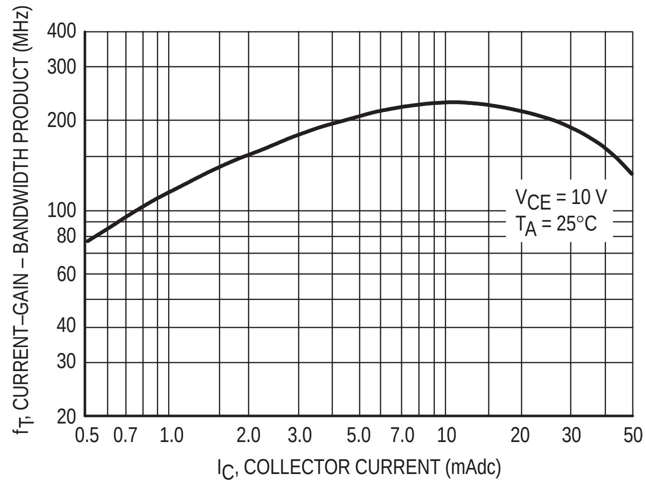


Figure 6. Current–Gain – Bandwidth Product

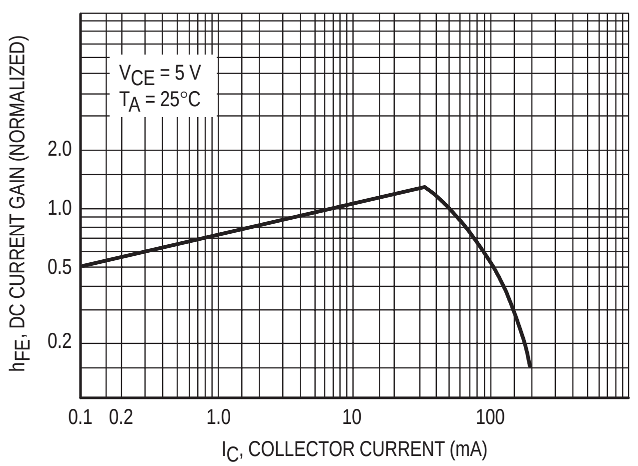


Figure 7. DC Current Gain

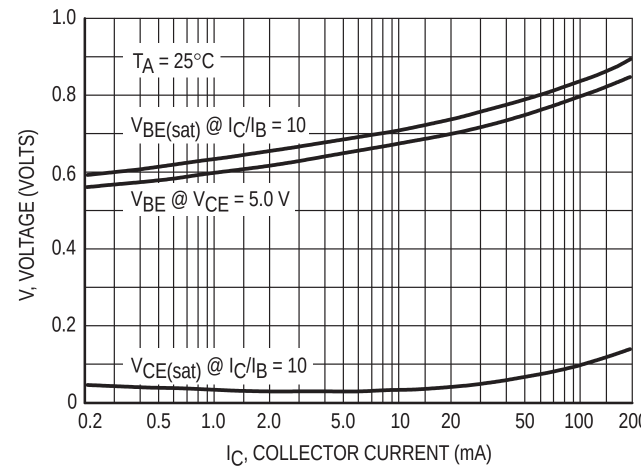


Figure 8. “On” Voltage

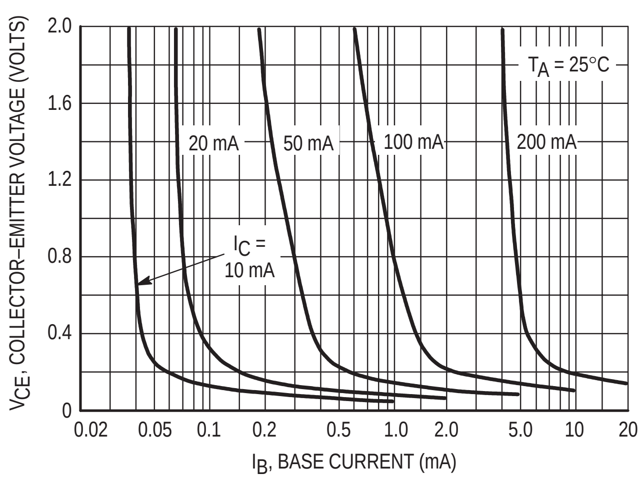


Figure 9. Collector Saturation Region

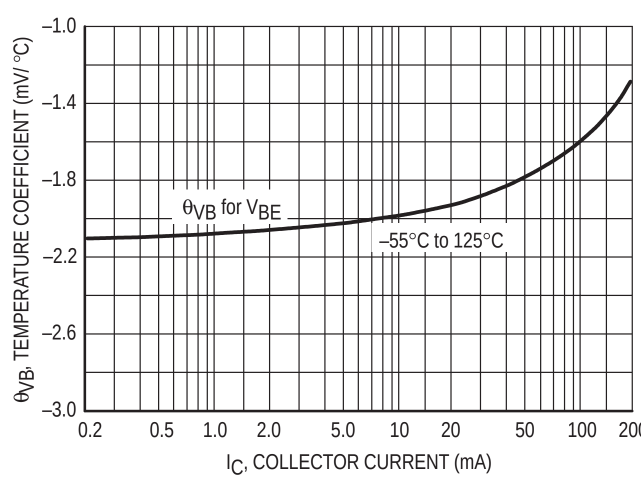


Figure 10. Base–Emitter Temperature Coefficient

BC846

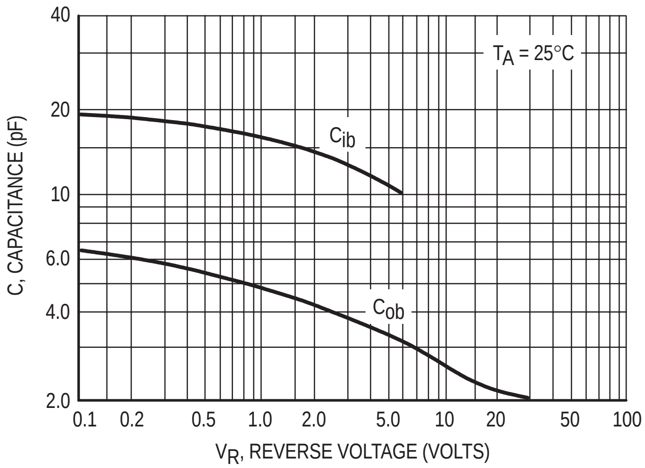


Figure 11. Capacitance

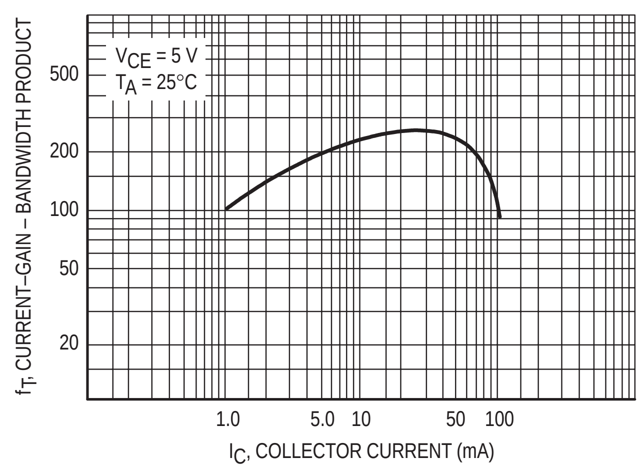


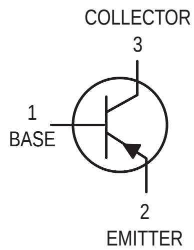
Figure 12. Current–Gain – Bandwidth Product

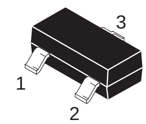
General Purpose Transistors

PNP Silicon

BC856ALT1,BLT1
BC857ALT1,BLT1
BC858ALT1,BLT1,
CLT1

Motorola Preferred Devices





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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 CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board, (1) 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, (2) 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

DEVICE MARKING

BC856ALT1 = 3A; BC856BLT1 = 3B; BC857ALT1 = 3E; BC857BLT1 = 3F;
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 BC857 Series BC858 Series	$V_{(BR)CEO}$	–65 –45 –30	— — —	— — —	V
Collector–Emitter Breakdown Voltage (I_C = –10 µA, V_{EB} = 0)	BC856 Series BC857 Series BC858 Series	$V_{(BR)CES}$	–80 –50 –30	— — —	— — —	V
Collector–Base Breakdown Voltage (I_C = –10 µA)	BC856 Series BC857 Series BC858 Series	$V_{(BR)CBO}$	–80 –50 –30	— — —	— — —	V
Emitter–Base Breakdown Voltage (I_E = –1.0 µA)	BC856 Series BC857 Series BC858 Series	$V_{(BR)EBO}$	–5.0 –5.0 –5.0	— — —	— — —	V
Collector Cutoff Current (V_{CB} = –30 V) (V_{CB} = –30 V, T_A = 150°C)		I_{CBO}	— —	— —	–15 –4.0	nA µA

1. FR–5 = 1.0 x 0.75 x 0.062 in 2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

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

REV 1

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain	BC856A, BC857A, BC585A	h_{FE}	—	90	—	—
(I_C = –10 µA, V_{CE} = –5.0 V)	BC856A, BC857A, BC858A		—	150	—	
	BC858C		—	270	—	
(I_C = –2.0 mA, V_{CE} = –5.0 V)	BC856A, BC857A, BC858A		125	180	250	
	BC856B, BC857B, BC858B		220	290	475	
	BC858C		420	520	800	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$				V
(I_C = –10 mA, I_B = –0.5 mA)			—	—	–0.3	
(I_C = –100 mA, I_B = –5.0 mA)			—	—	–0.65	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$				V
(I_C = –10 mA, I_B = –0.5 mA)			—	–0.7	—	
(I_C = –100 mA, I_B = –5.0 mA)			—	–0.9	—	
Base–Emitter On Voltage		$V_{BE(on)}$				V
(I_C = –2.0 mA, V_{CE} = –5.0 V)			–0.6	—	–0.75	
(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

BC857/BC858

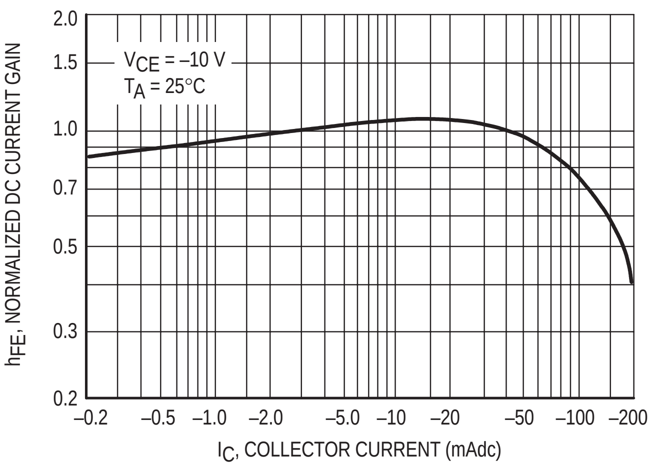


Figure 1. Normalized DC Current Gain

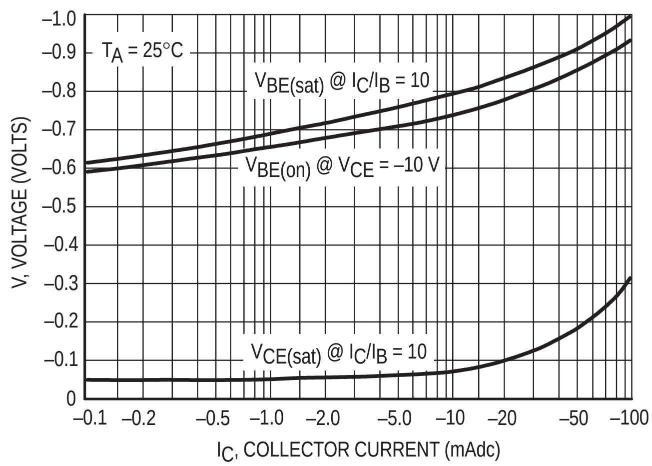


Figure 2. "Saturation" and "On" Voltages

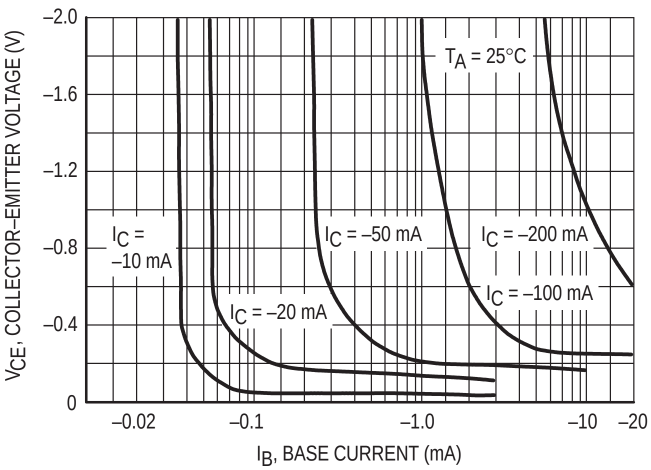


Figure 3. Collector Saturation Region

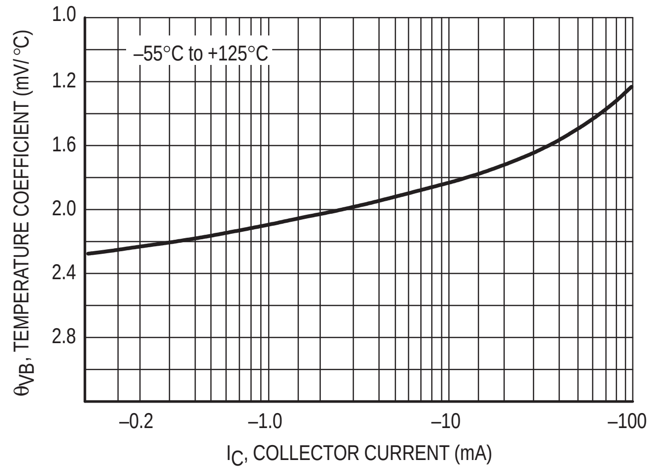


Figure 4. Base–Emitter Temperature Coefficient

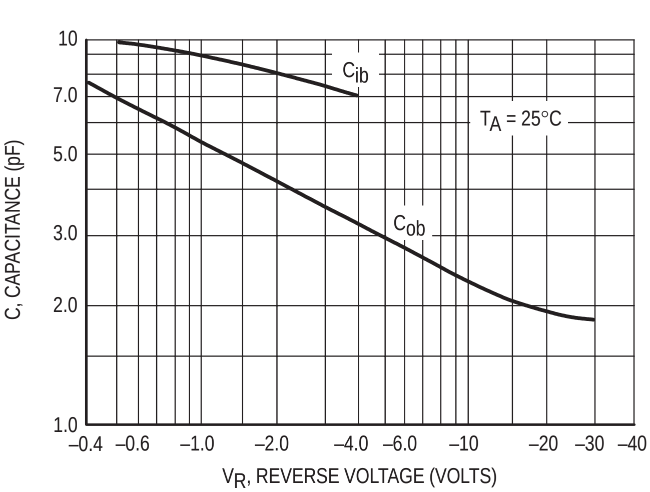


Figure 5. Capacitances

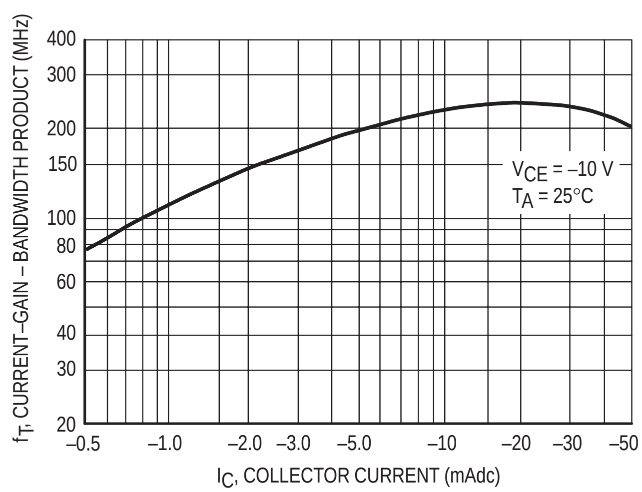


Figure 6. Current–Gain – Bandwidth Product

BC856

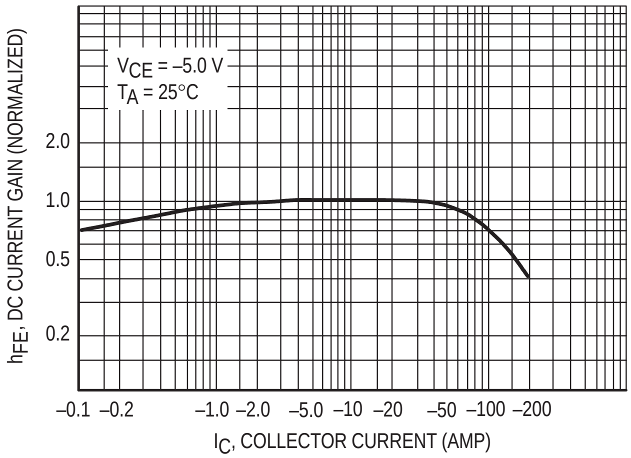


Figure 7. DC Current Gain

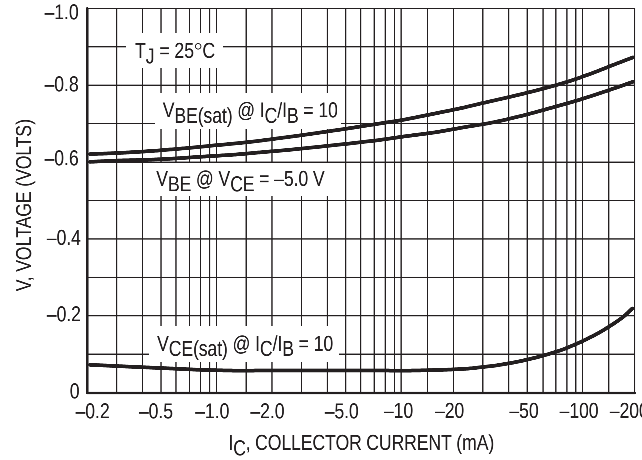


Figure 8. "On" Voltage

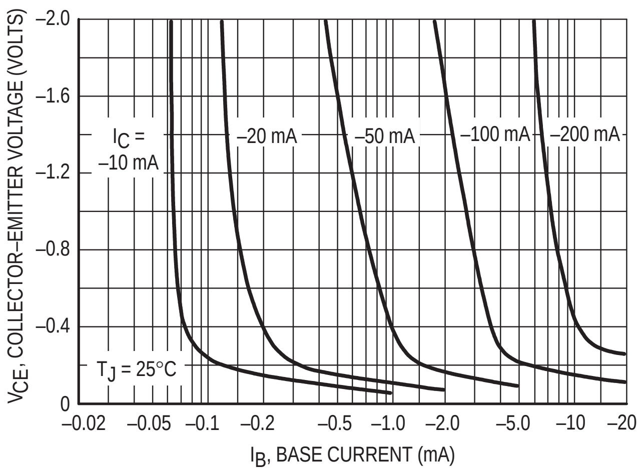


Figure 9. Collector Saturation Region

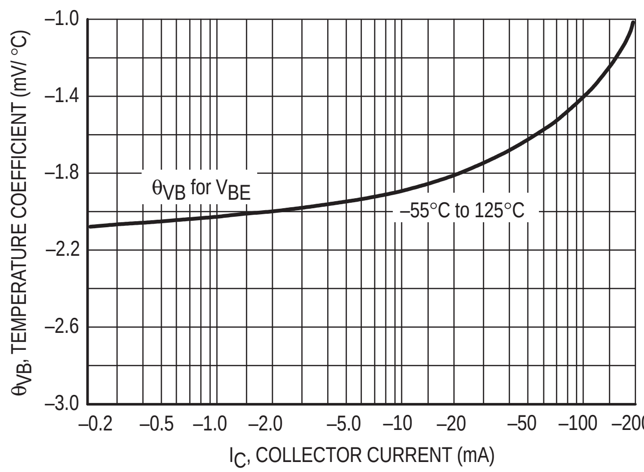


Figure 10. Base–Emitter Temperature Coefficient

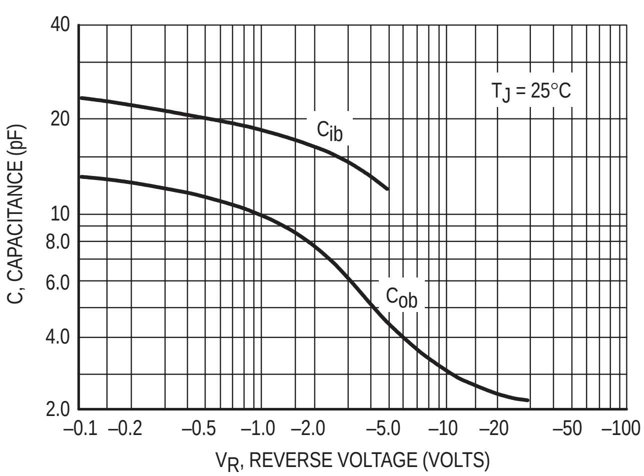


Figure 11. Capacitance

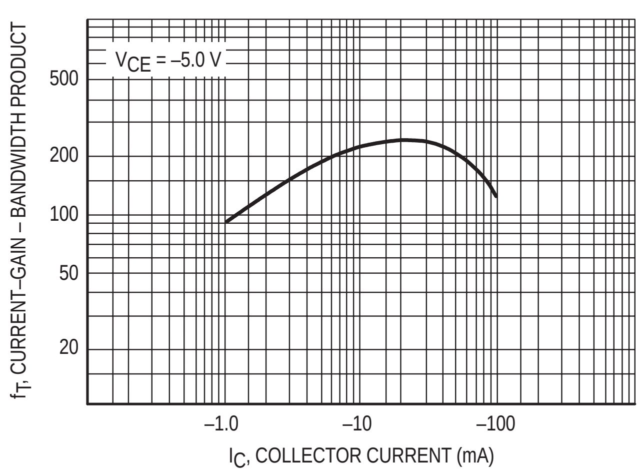


Figure 12. Current–Gain – Bandwidth Product

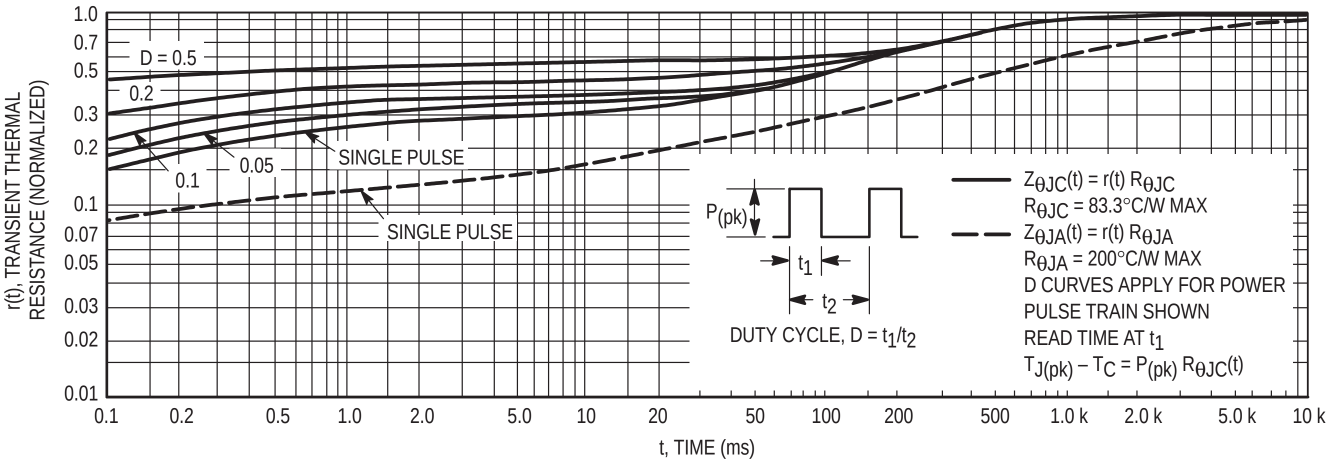


Figure 13. Thermal Response

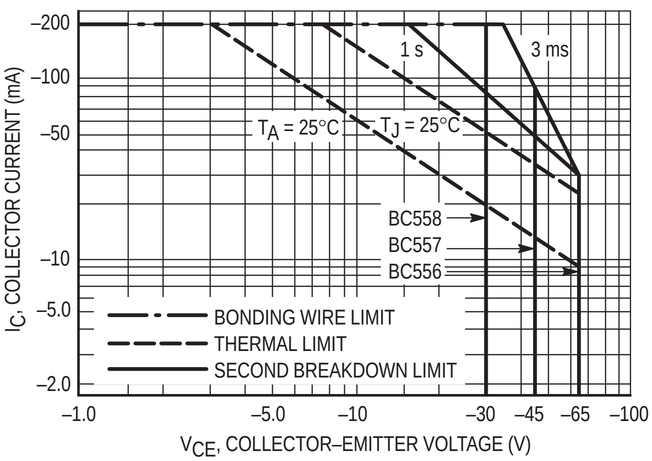


Figure 14. Active Region Safe Operating Area

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 in 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.

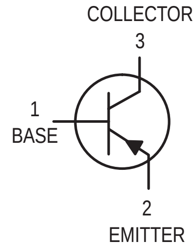
General Purpose Transistors

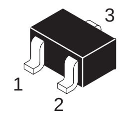
PNP Silicon

These transistors are designed for general purpose amplifier applications. They are housed in the SOT–323/SC–70 which is designed for low power surface mount applications.

BC856AWT1,BWT1
BC857AWT1,BWT1
BC858AWT1,BWT1,
CWT1

Motorola Preferred Devices





CASE 419–02, STYLE 3
SOT–323/SC–70

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 CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board, (1) T_A = 25°C	P_D	150	mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	833	°C/W
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

DEVICE MARKING

BC856AWT1 = 3A; BC856BWT1 = 3B; BC857AWT1 = 3E; BC857BWT1 = 3F;
BC858AWT1 = 3J; BC858BWT1 = 3K; BC858CWT1 = 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 BC857 Series BC858 Series	$V_{(BR)CEO}$	–65 –45 –30	— — —	— — —	V
Collector–Emitter Breakdown Voltage (I_C = –10 µA, V_{EB} = 0)	BC856 Series BC857 Series BC858 Series	$V_{(BR)CES}$	–80 –50 –30	— — —	— — —	V
Collector–Base Breakdown Voltage (I_C = –10 µA)	BC856 Series BC857 Series BC858 Series	$V_{(BR)CBO}$	–80 –50 –30	— — —	— — —	V
Emitter–Base Breakdown Voltage (I_E = –1.0 µA)	BC856 Series BC857 Series BC858 Series	$V_{(BR)EBO}$	–5.0 –5.0 –5.0	— — —	— — —	V
Collector Cutoff Current (V_{CB} = –30 V) (V_{CB} = –30 V, T_A = 150°C)		I_{CBO}	— —	— —	–15 –4.0	nA µA

1. FR–5 = 1.0 x 0.75 x 0.062 in

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

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = –10 μA, V_{CE} = –5.0 V)	BC856A, BC857A, BC585A	h_{FE}	—	90	—	—
	BC856A, BC857A, BC858A		—	150	—	
	BC858C		—	270	—	
(I_C = –2.0 mA, V_{CE} = –5.0 V)	BC856A, BC857A, BC858A		125	180	250	
	BC856B, BC857B, BC858B		220	290	475	
	BC858C		420	520	800	
Collector–Emitter Saturation Voltage (I_C = –10 mA, I_B = –0.5 mA)		$V_{CE(sat)}$	—	—	–0.3	V
(I_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

BC857/BC858

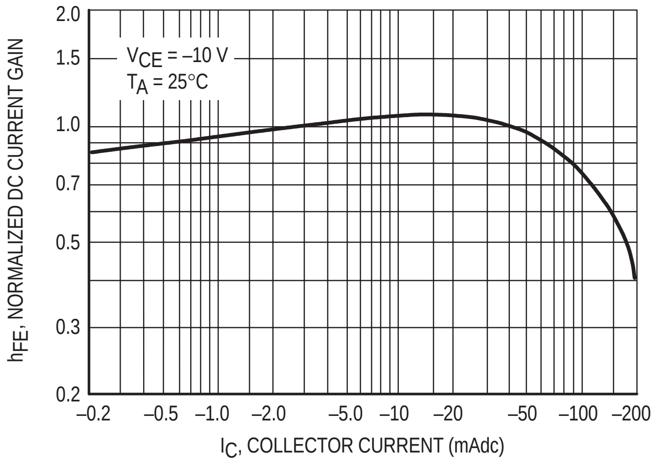


Figure 1. Normalized DC Current Gain

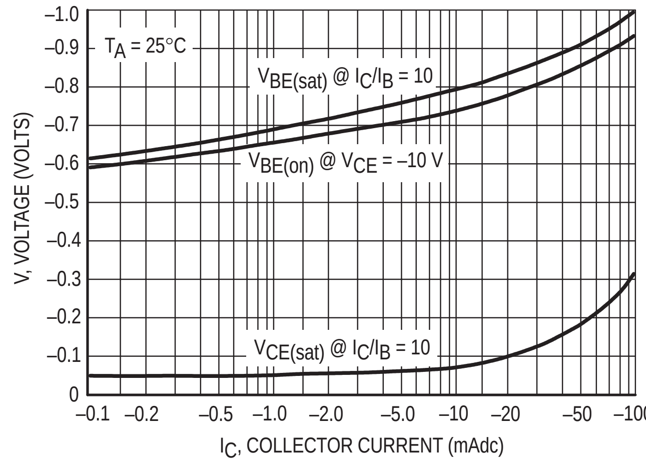


Figure 2. “Saturation” and “On” Voltages

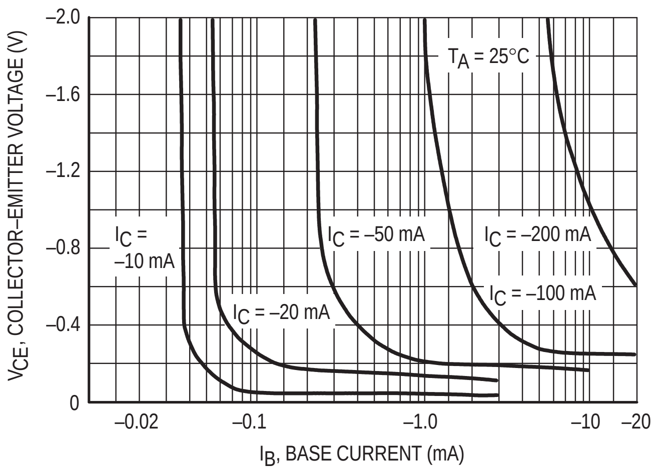


Figure 3. Collector Saturation Region

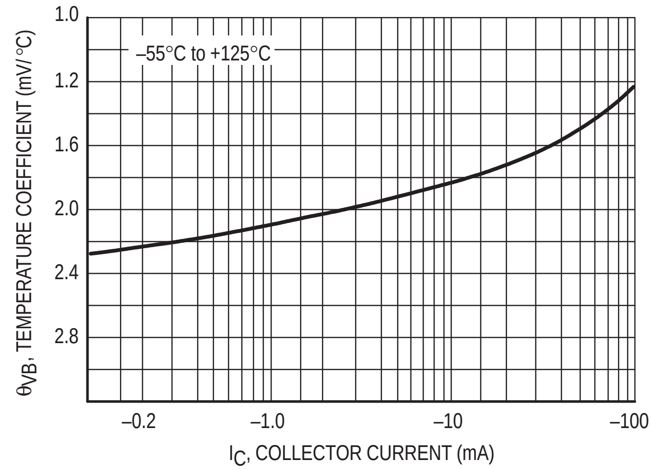


Figure 4. Base–Emitter Temperature Coefficient

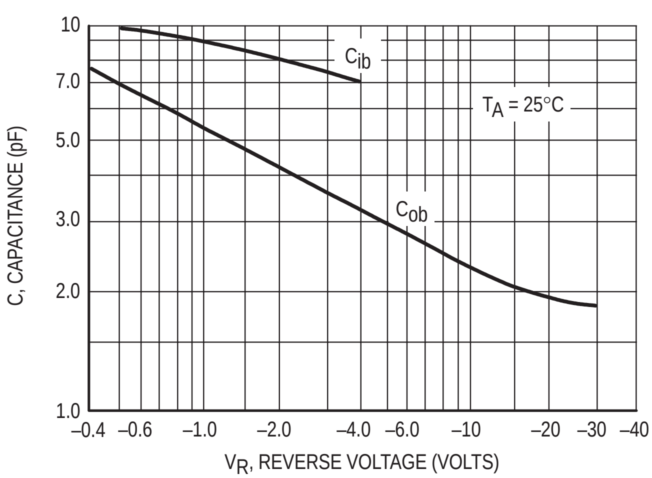


Figure 5. Capacitances

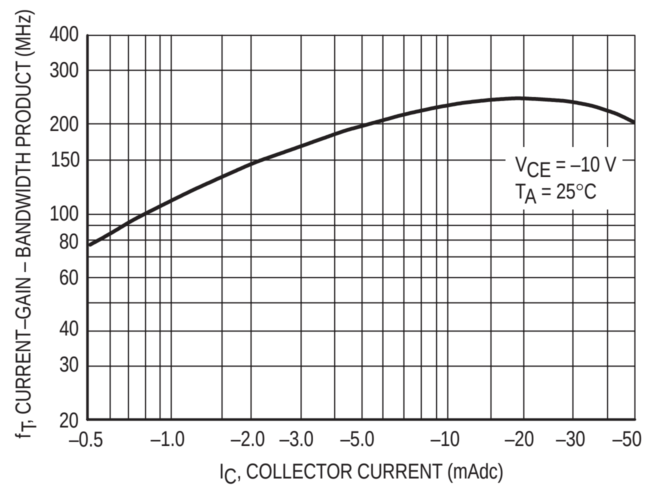


Figure 6. Current–Gain – Bandwidth Product

BC856

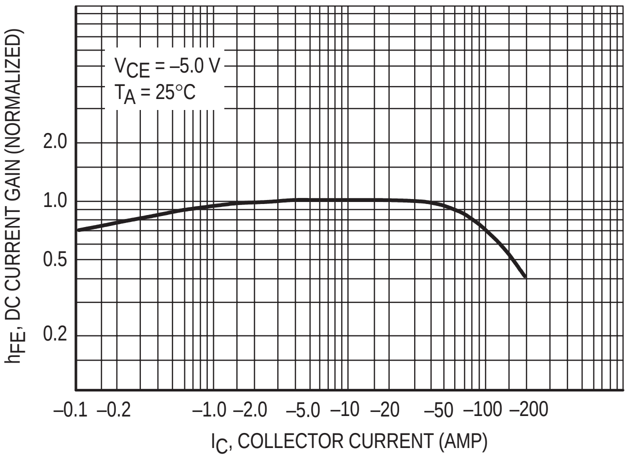


Figure 7. DC Current Gain

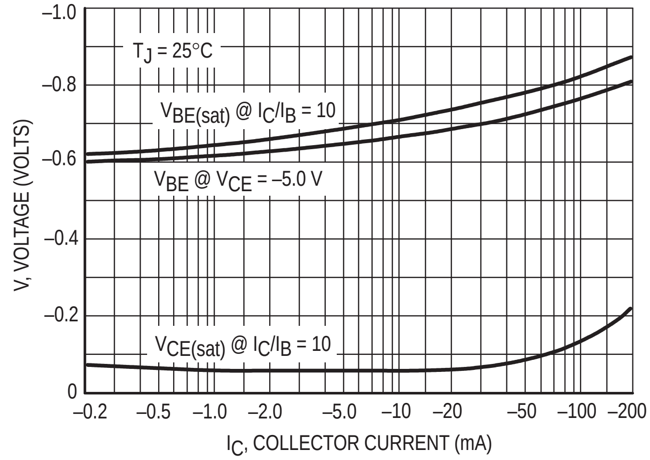


Figure 8. "On" Voltage

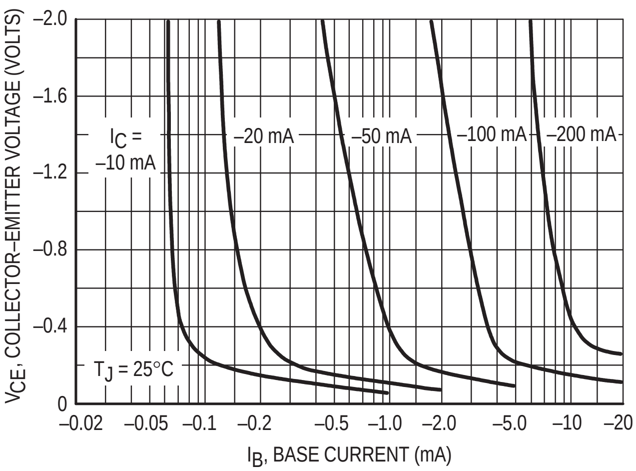


Figure 9. Collector Saturation Region

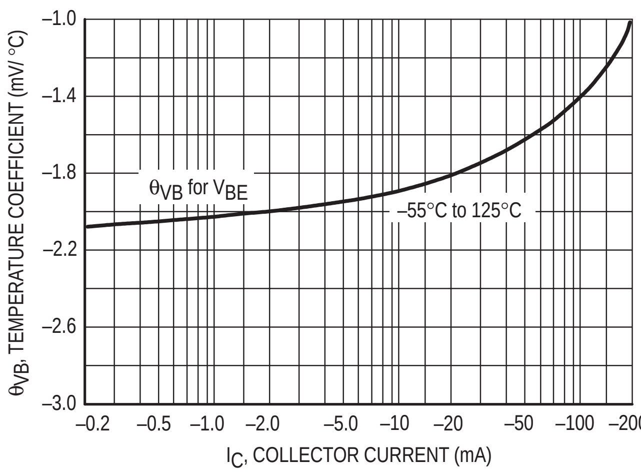


Figure 10. Base–Emitter Temperature Coefficient

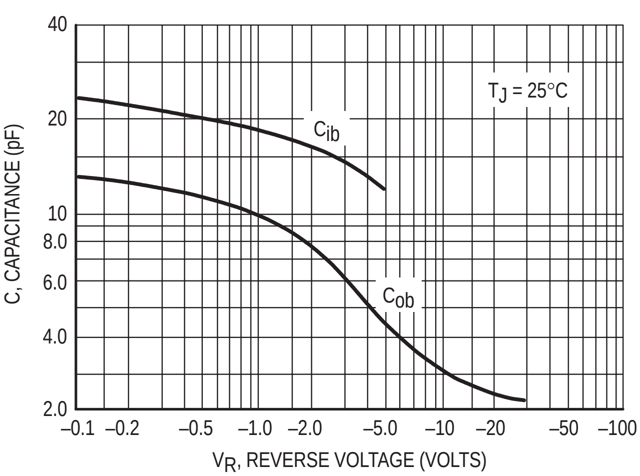


Figure 11. Capacitance

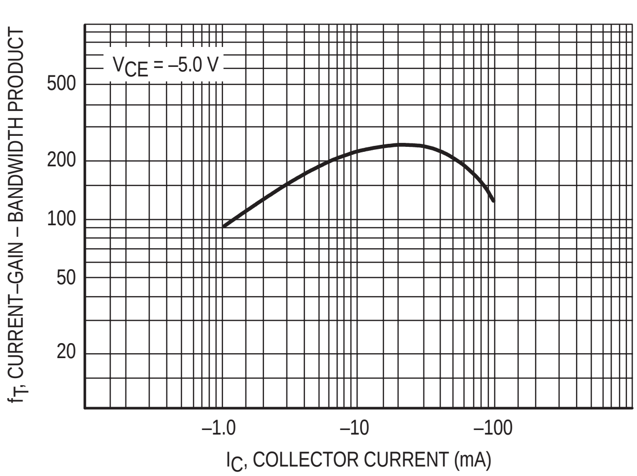


Figure 12. Current–Gain – Bandwidth Product

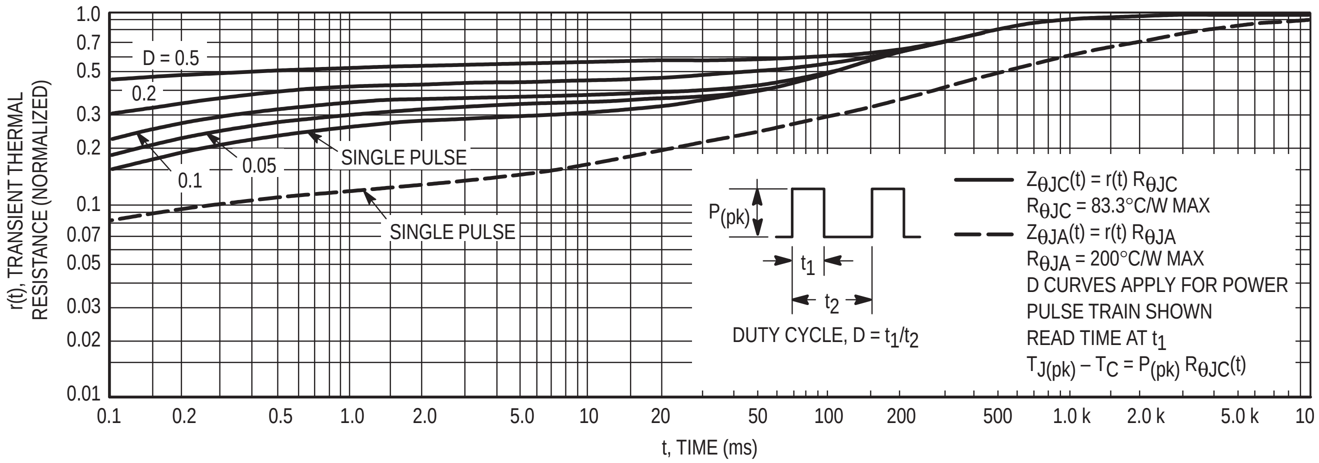


Figure 13. Thermal Response

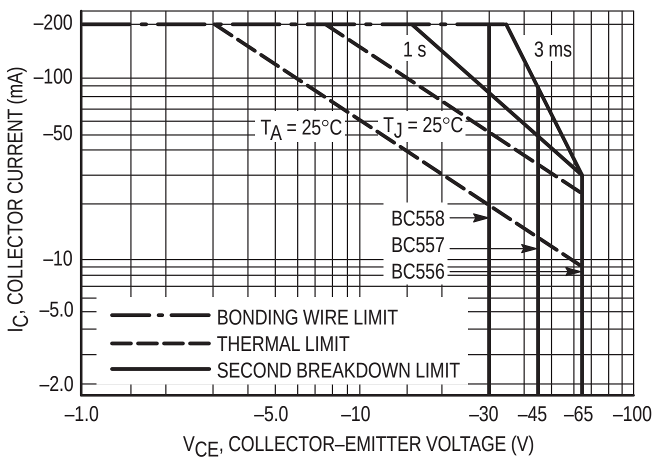


Figure 14. Active Region Safe Operating Area

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 in 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.

PNP Silicon Epitaxial Transistor

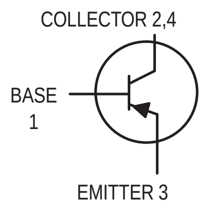
BCP53T1

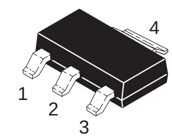
Motorola Preferred Device

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(1) 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

Characteristic	Symbol	Max	Unit
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 10	°C Sec

1. 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.

REV 1

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 (I_C = –5.0 mAdc, V_{CE} = –2.0 Vdc) (I_C = –150 mAdc, V_{CE} = –2.0 Vdc) (I_C = –500 mAdc, V_{CE} = –2.0 Vdc)	h_{FE}	 25 40 25	 — — —	 — 250 —	—
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

TYPICAL ELECTRICAL CHARACTERISTICS

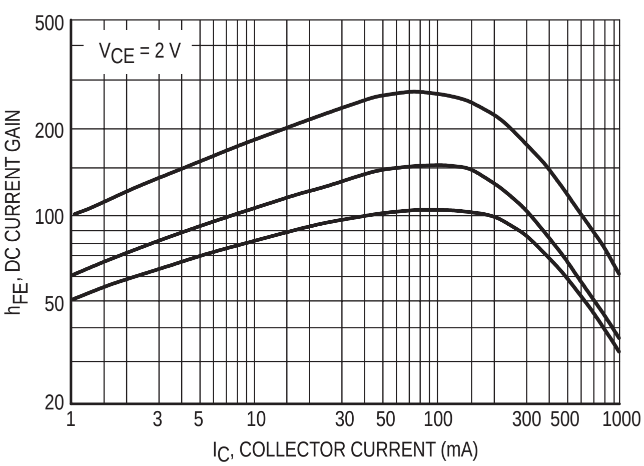


Figure 1. DC Current Gain

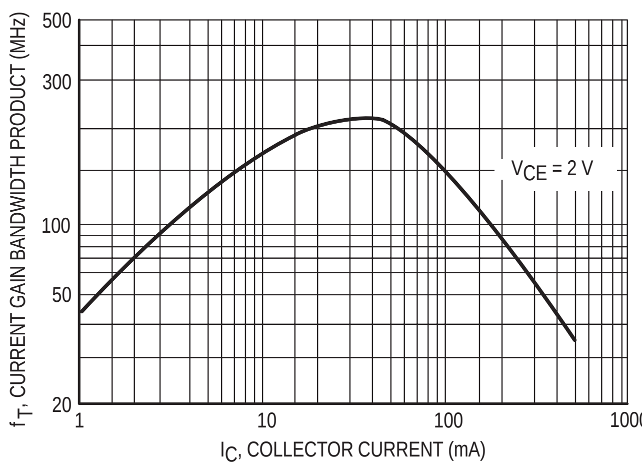


Figure 2. Current Gain Bandwidth Product

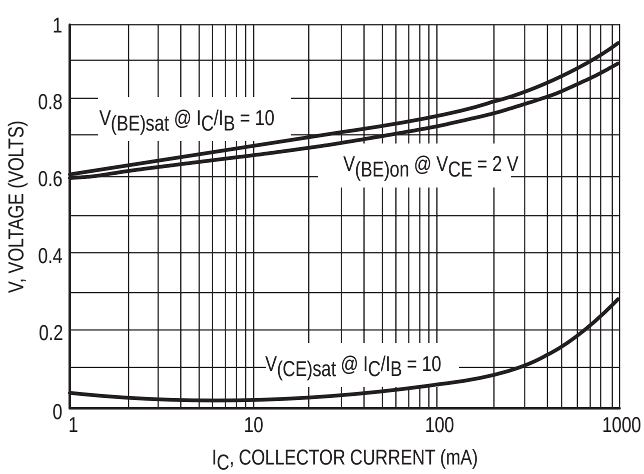


Figure 3. Saturation and "ON" Voltages

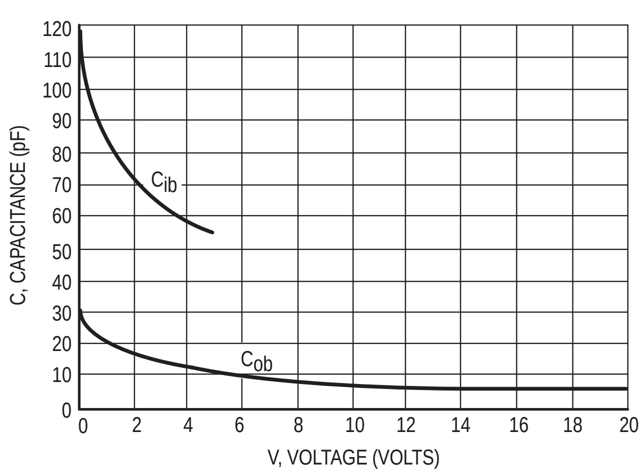


Figure 4. Capacitances

NPN Silicon Epitaxial Transistor

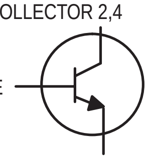
BCP56T1 SERIES

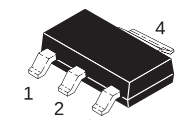
Motorola Preferred Device

**MEDIUM POWER
NPN SILICON
HIGH CURRENT
TRANSISTOR
SURFACE MOUNT**

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





**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(1) 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

Characteristic	Symbol	Max	Unit
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 10	°C Sec

1. 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.

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

REV 1

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 (2)						
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

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

TYPICAL ELECTRICAL CHARACTERISTICS

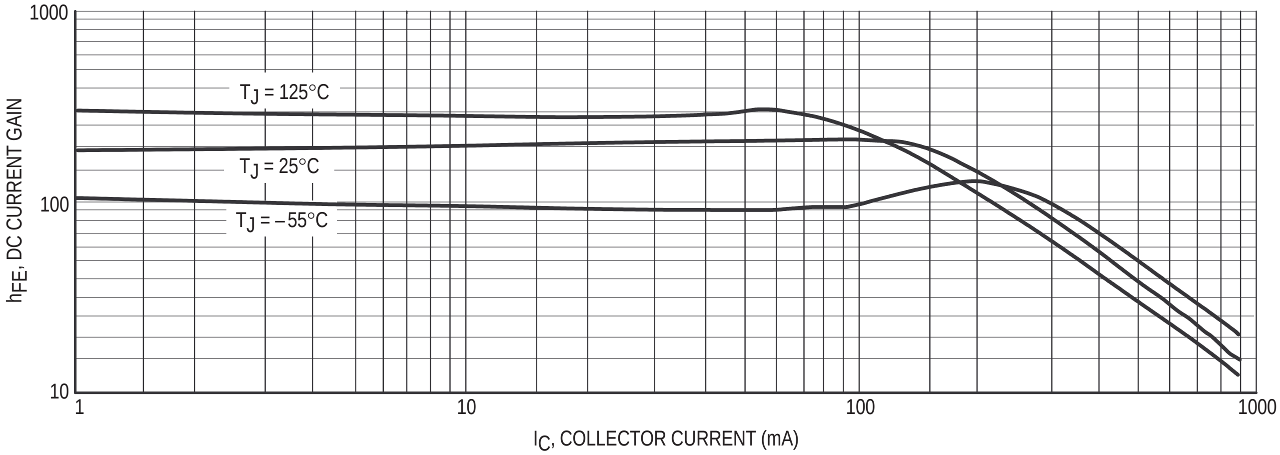


Figure 1. DC Current Gain

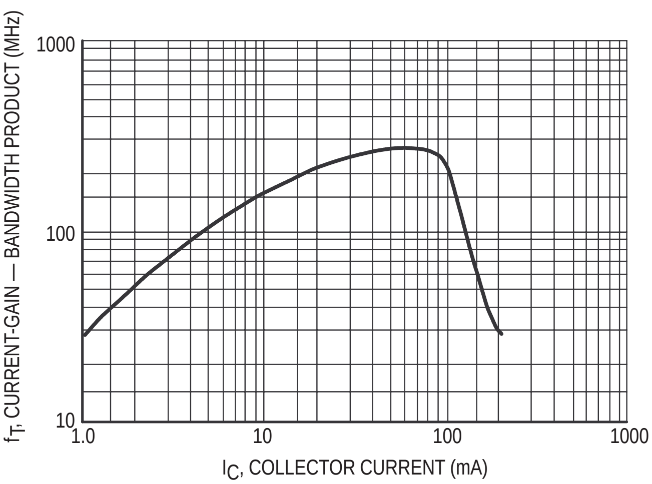


Figure 2. Current-Gain — Bandwidth Product

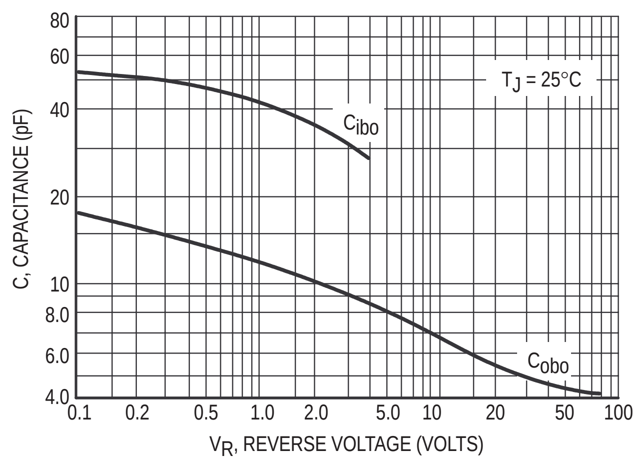


Figure 3. Capacitance

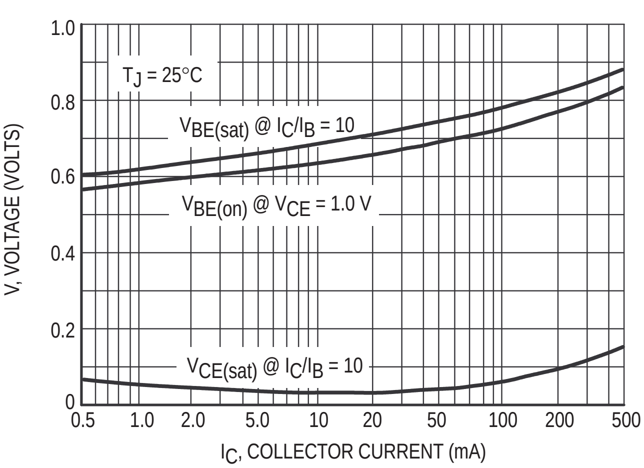


Figure 4. “On” Voltages

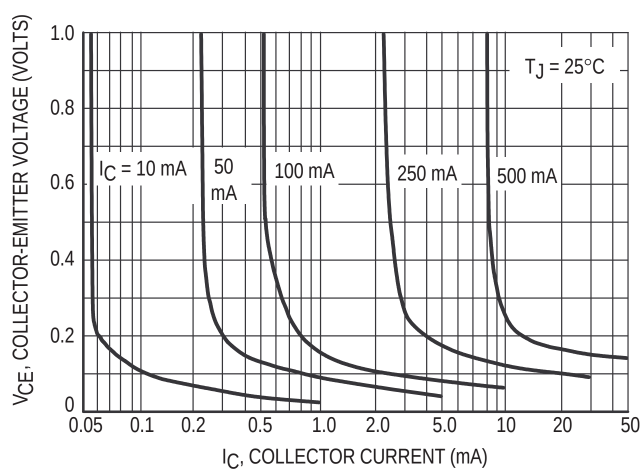


Figure 5. Collector Saturation Region

BCP68T1

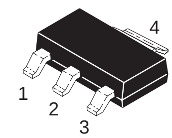
Motorola Preferred Device

NPN Silicon Epitaxial Transistor

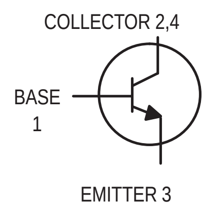
This NPN Silicon Epitaxial Transistor is designed for use in low voltage, high current applications. The device is housed in the SOT-223 package, which is designed for medium power surface mount applications.

- 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

**MEDIUM POWER
NPN SILICON
HIGH CURRENT
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}	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(1) 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

Characteristic	Symbol	Max	Unit
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 10	°C Sec

1. 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.

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

REV 1

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 (2)					
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

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

TYPICAL ELECTRICAL CHARACTERISTICS

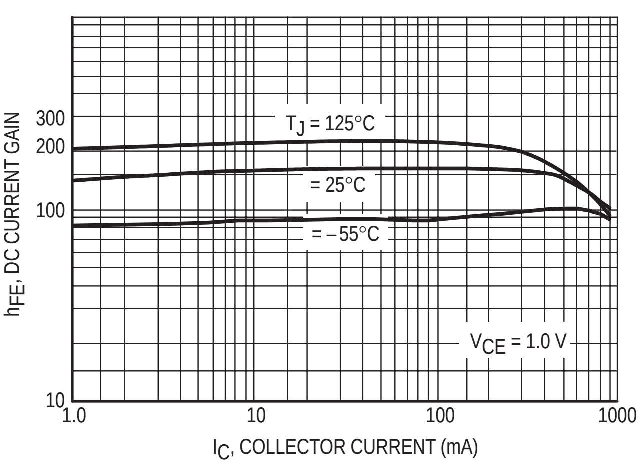


Figure 1. DC Current Gain

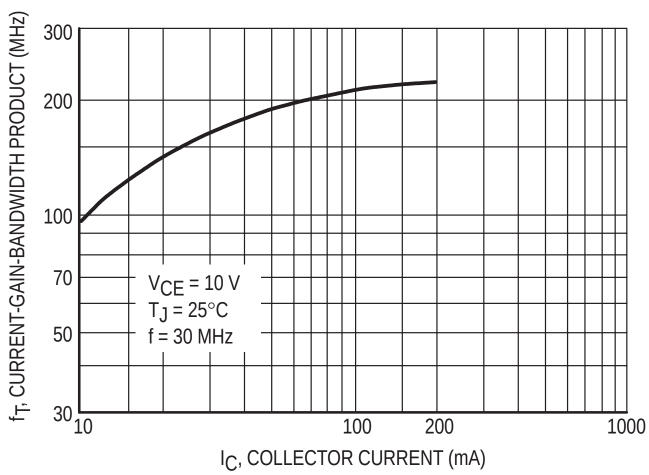


Figure 2. Current-Gain-Bandwidth Product

TYPICAL ELECTRICAL CHARACTERISTICS

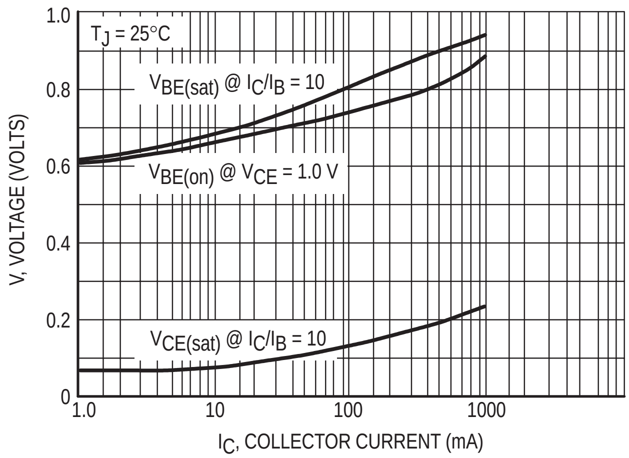


Figure 3. “On” Voltage

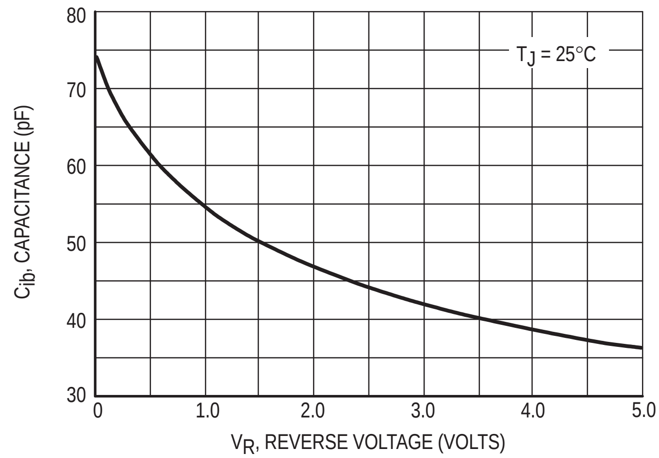


Figure 4. Capacitance

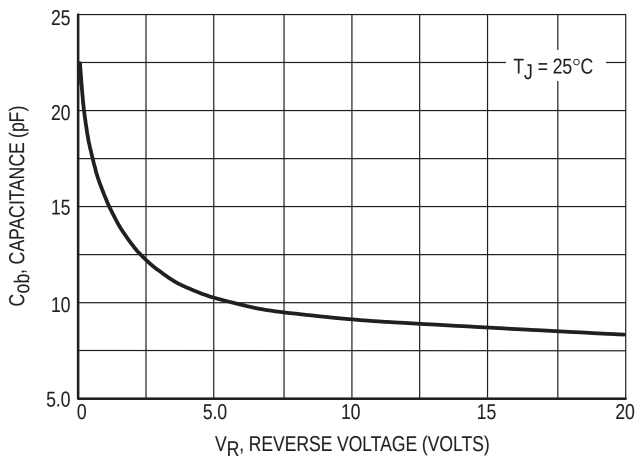


Figure 5. Capacitance

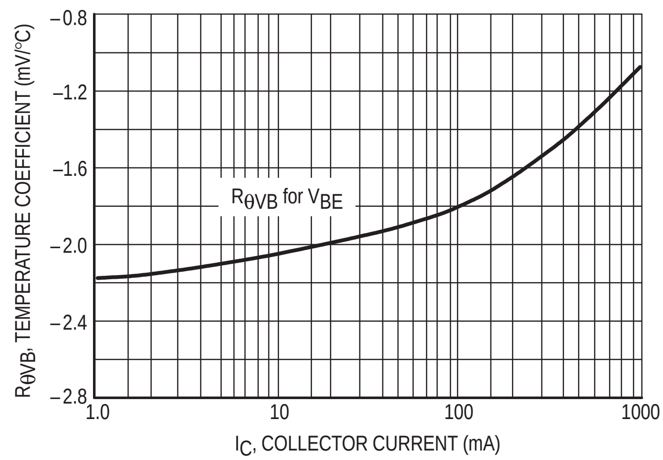


Figure 6. Base-Emitter Temperature Coefficient

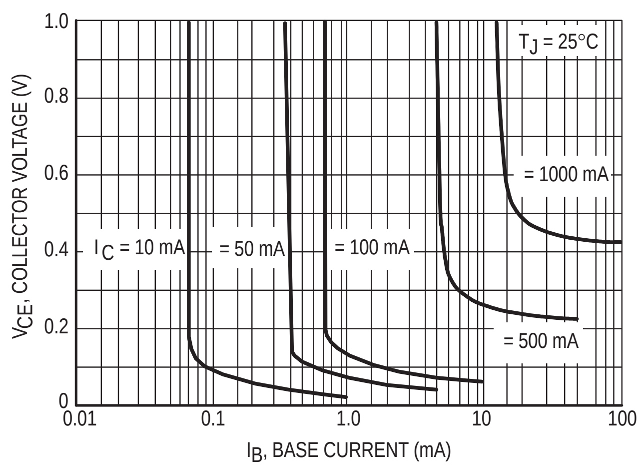


Figure 7. Saturation Region

PNP Silicon Epitaxial Transistor

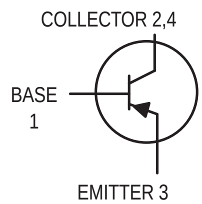
BCP69T1

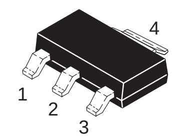
Motorola Preferred Device

**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(1) 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

Characteristic	Symbol	Max	Unit
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 10	°C Sec

1. 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.

REV 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					
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

TYPICAL ELECTRICAL CHARACTERISTICS

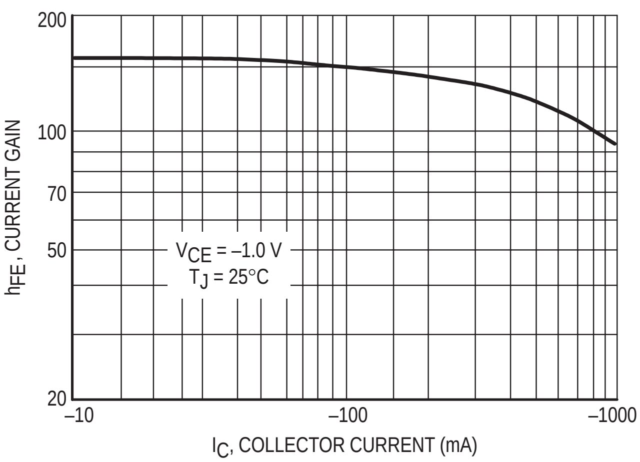


Figure 1. DC Current Gain

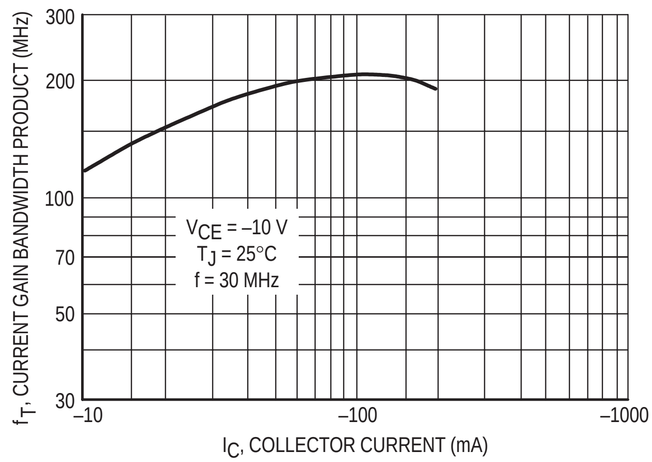


Figure 2. Current Gain Bandwidth Product

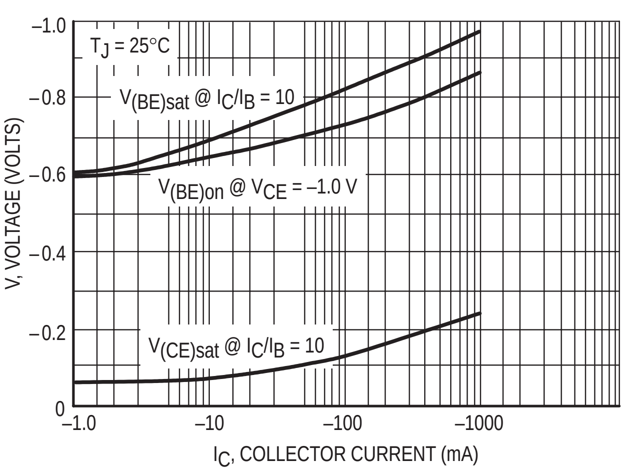


Figure 3. Saturation and “ON” Voltages

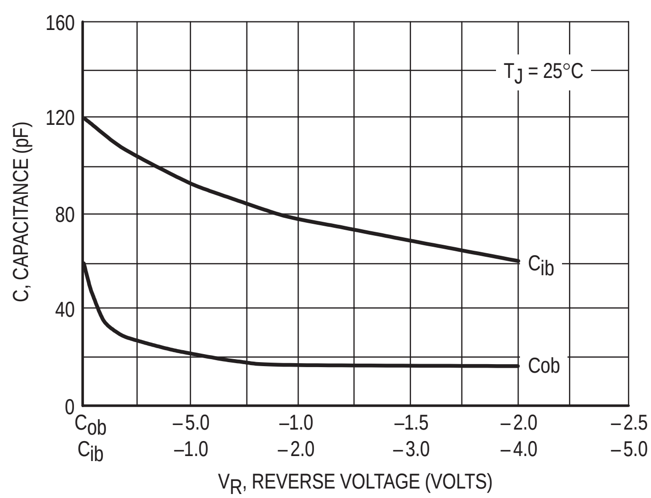
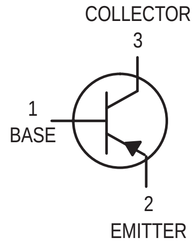
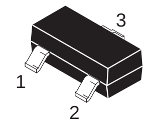


Figure 4. Capacitances

General Purpose Transistors
PNP Silicon

BCW29LT1
BCW30LT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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 (1) 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, (2) 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

DEVICE MARKING

BCW29LT1 = C1; BCW30LT1 = C2

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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = –2.0 mAdc, V_{CE} = –5.0 Vdc)	BCW29	h_{FE}	120	260	—
	BCW30		215	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

TYPICAL NOISE CHARACTERISTICS

($V_{CE} = -5.0$ Vdc, $T_A = 25°C$)

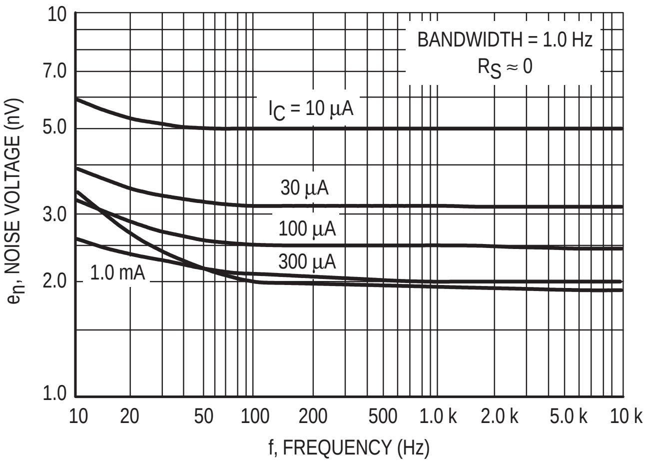


Figure 1. Noise Voltage

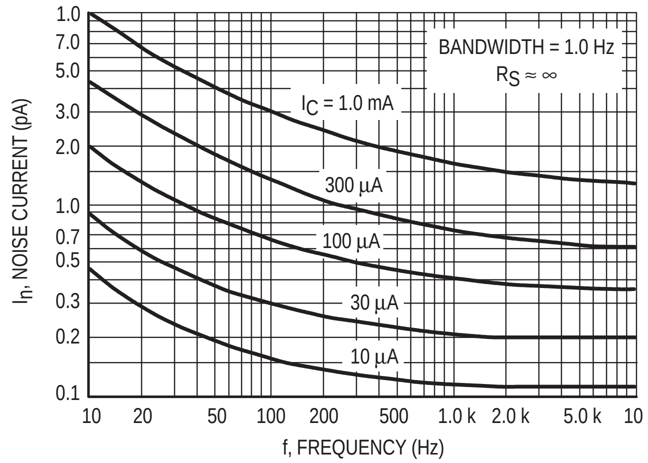


Figure 2. Noise Current

NOISE FIGURE CONTOURS

($V_{CE} = -5.0$ Vdc, $T_A = 25°C$)

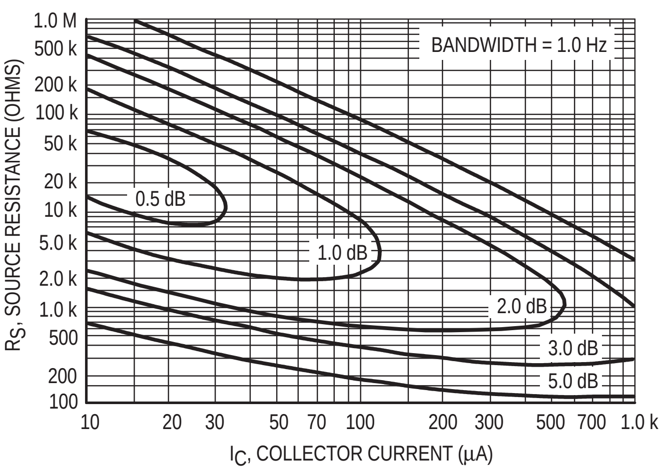


Figure 3. Narrow Band, 100 Hz

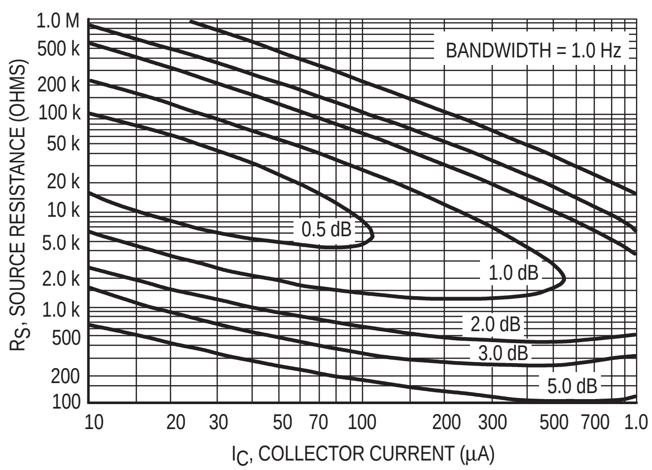


Figure 4. Narrow Band, 1.0 kHz

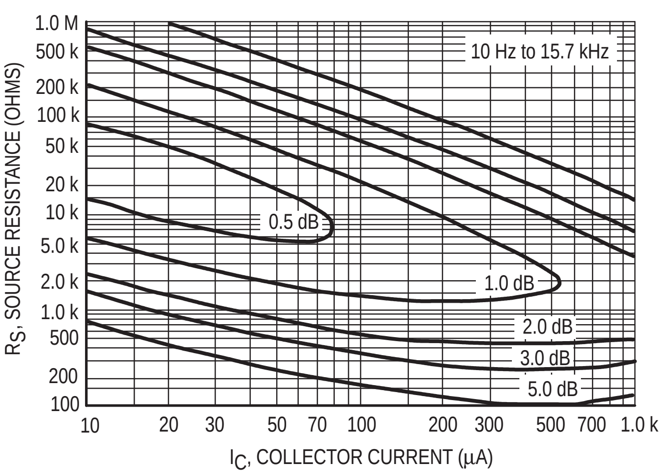


Figure 5. Wideband

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

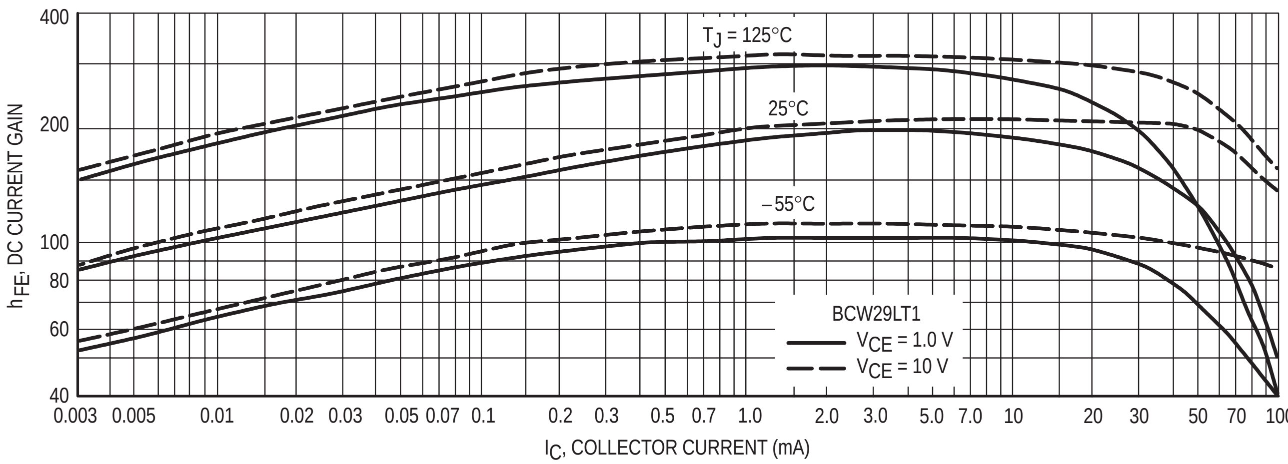


Figure 6. DC Current Gain

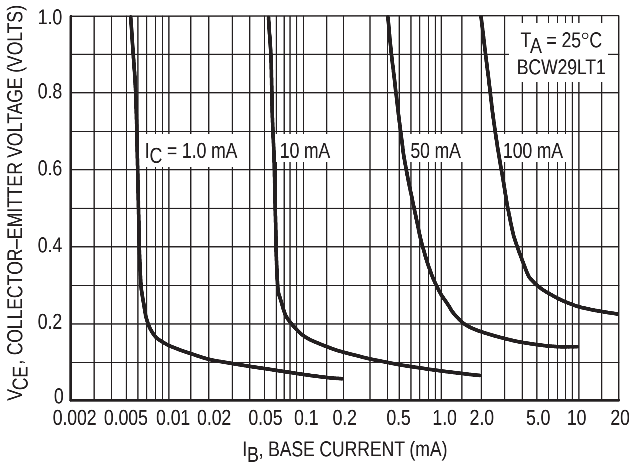


Figure 7. Collector Saturation Region

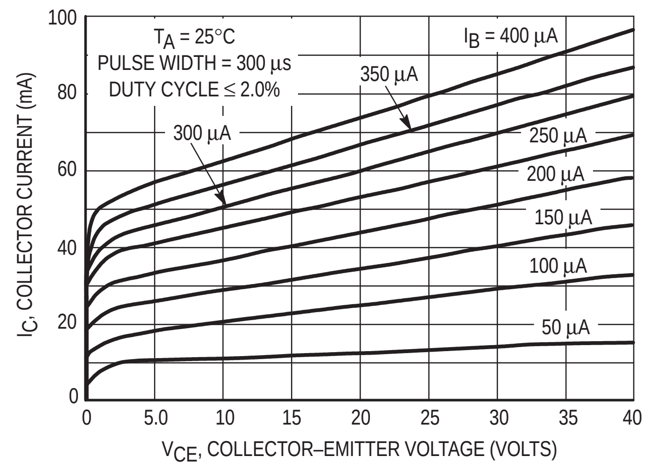


Figure 8. Collector Characteristics

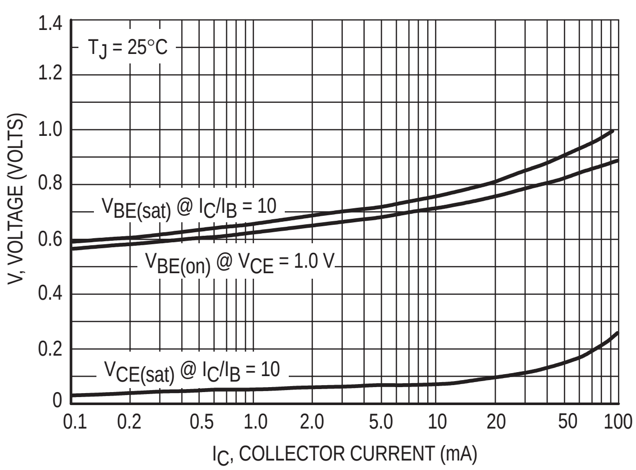


Figure 9. "On" Voltages

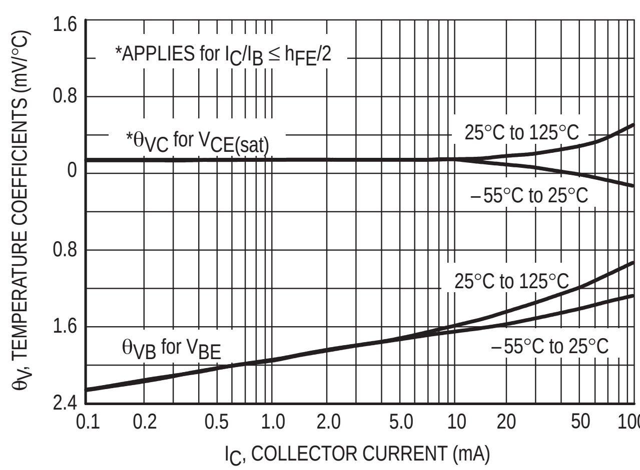


Figure 10. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

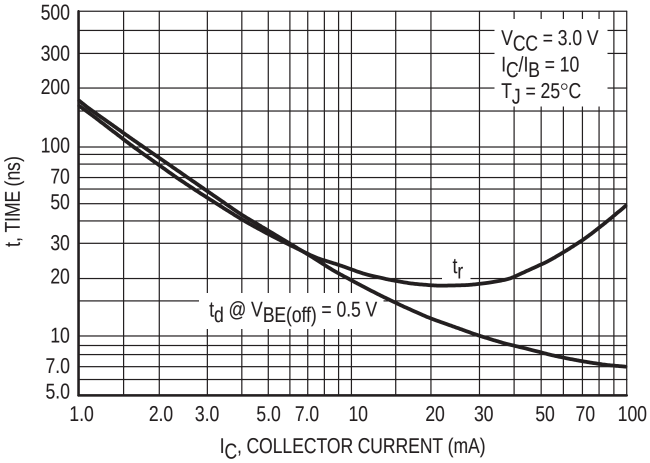


Figure 11. Turn–On Time

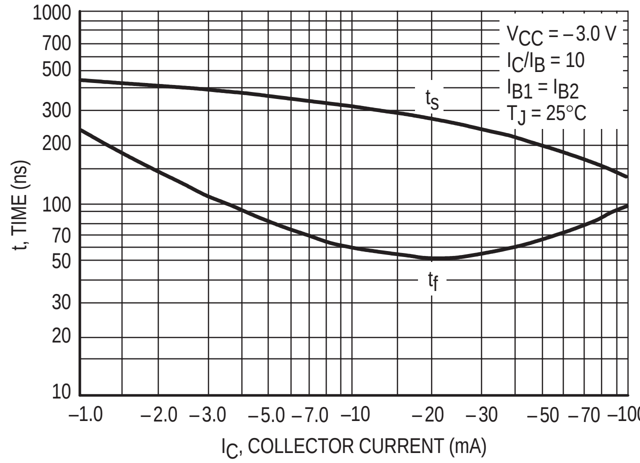


Figure 12. Turn–Off Time

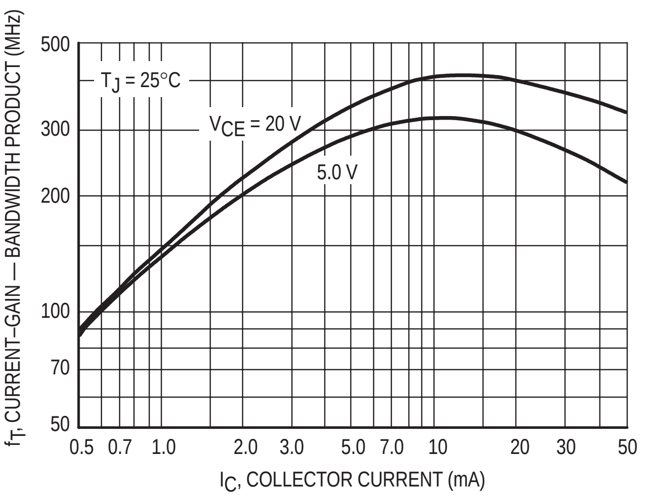


Figure 13. Current–Gain — Bandwidth Product

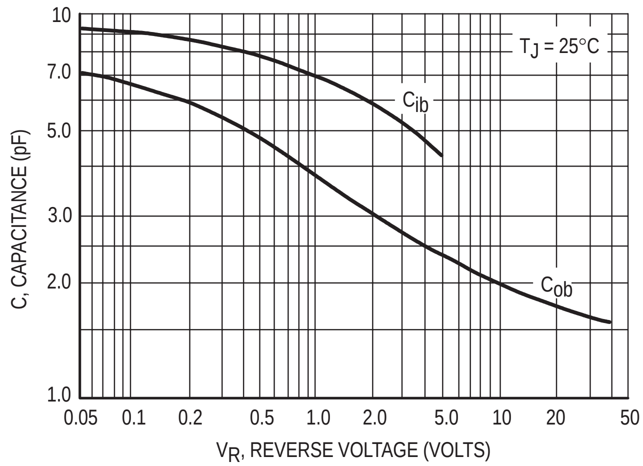


Figure 14. Capacitance

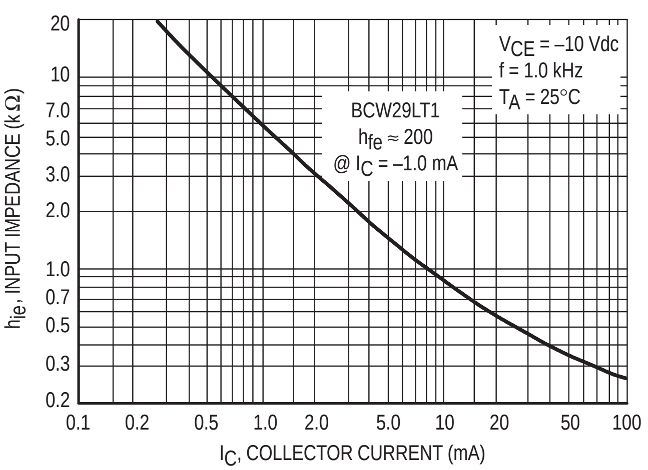


Figure 15. Input Impedance

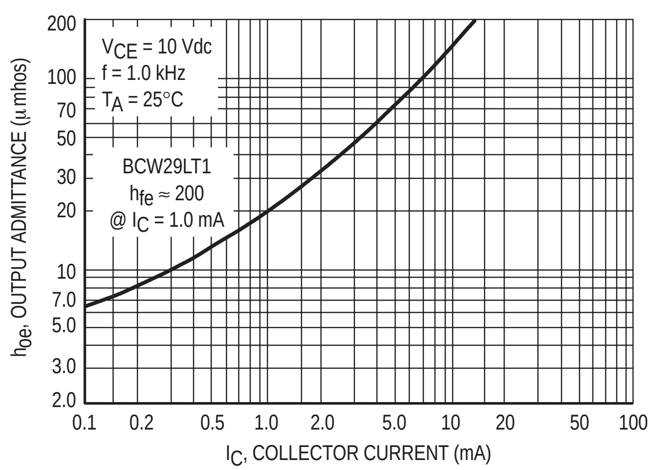


Figure 16. Output Admittance

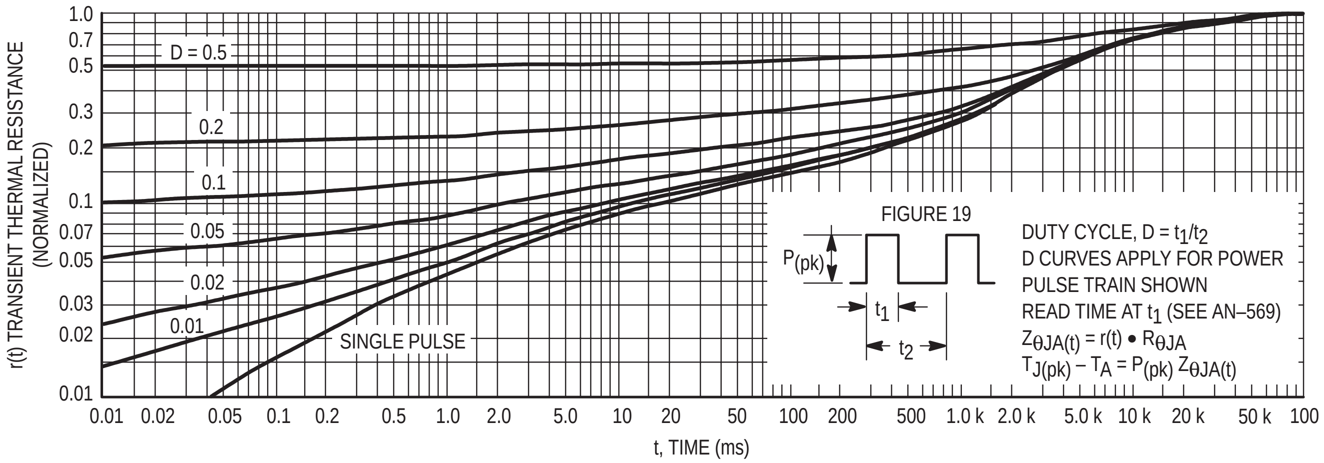


Figure 17. Thermal Response

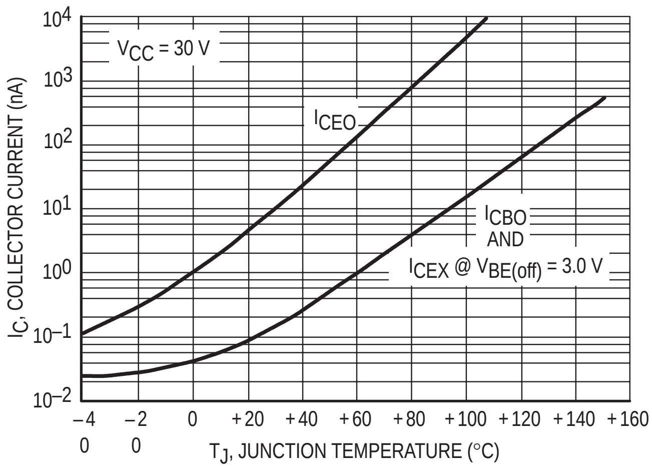


Figure 18. Typical Collector Leakage Current

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 17 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 17 by the steady state value $R_{\theta JA}$.

Example:

The BCW29LT1 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 17 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

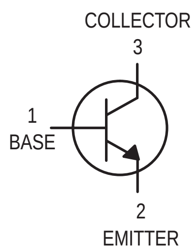
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C$.

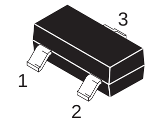
For more information, see AN–569.

General Purpose Transistor

NPN Silicon

BCW33LT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

BCW33LT1 = D3

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

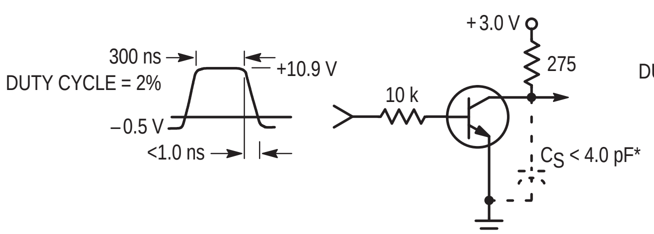
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	32	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μAdc, I_B = 0)	$V_{(BR)CBO}$	32	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 32 Vdc, I_E = 0) (V_{CB} = 32 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 100 10	 nAdc μAdc

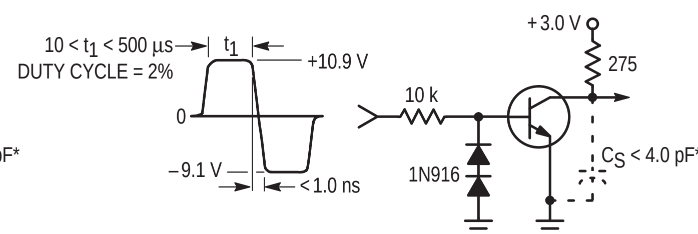
1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	hFE	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 (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Noise Figure (V_{CE} = 5.0 Vdc, I_C = 0.2 mAdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	10	dB

EQUIVALENT SWITCHING TIME TEST CIRCUITS





*Total shunt capacitance of test jig and connectors

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

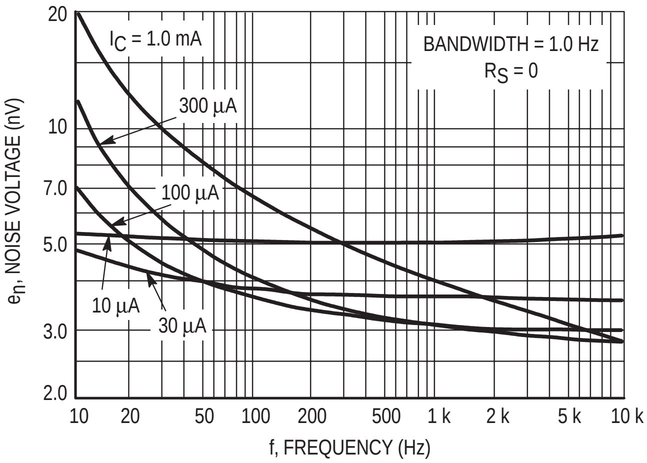


Figure 3. Noise Voltage

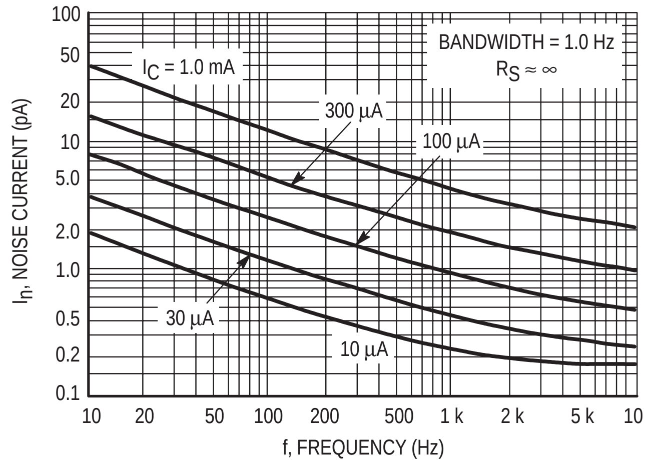


Figure 4. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

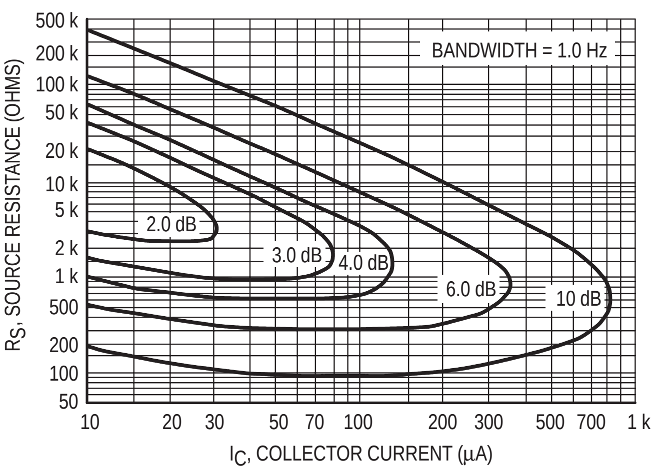


Figure 5. Narrow Band, 100 Hz

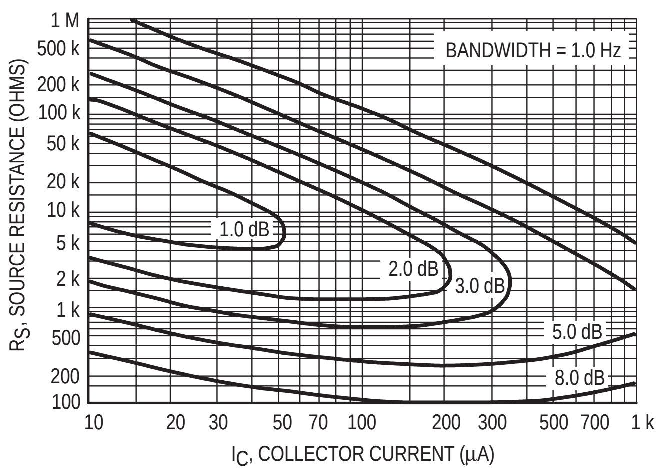


Figure 6. Narrow Band, 1.0 kHz

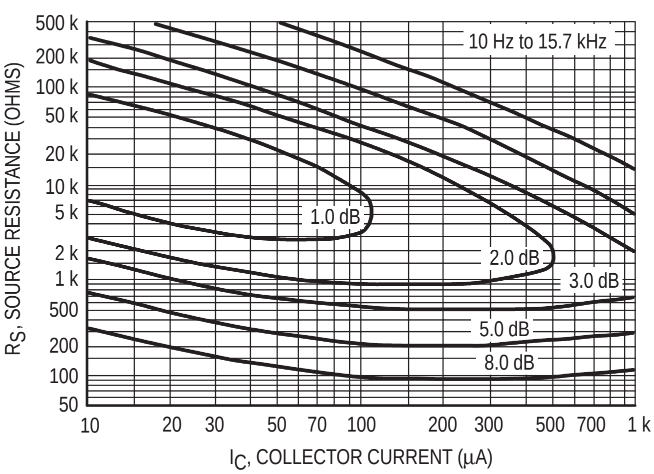


Figure 7. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

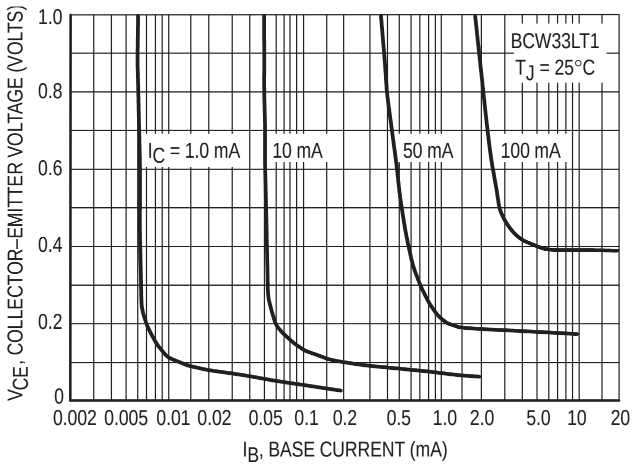


Figure 8. Collector Saturation Region

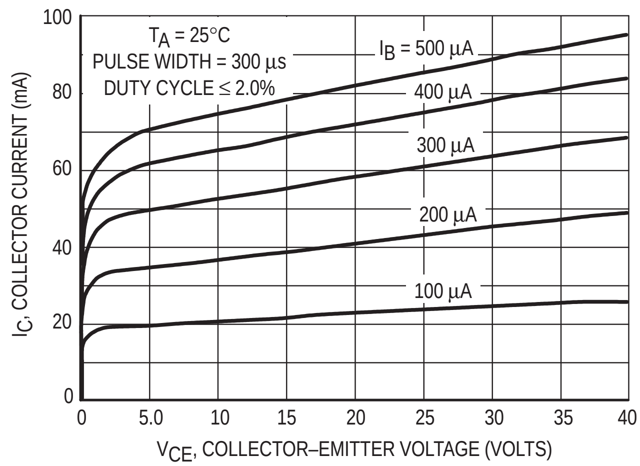


Figure 9. Collector Characteristics

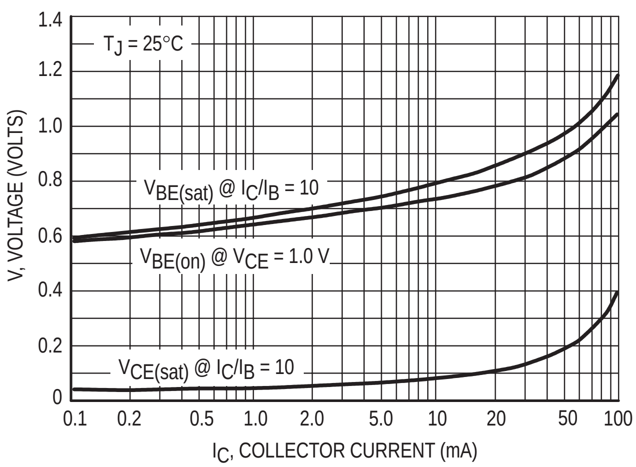


Figure 10. “On” Voltages

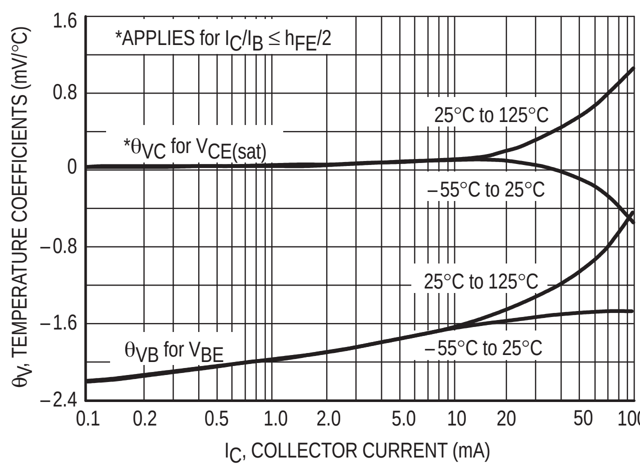


Figure 11. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

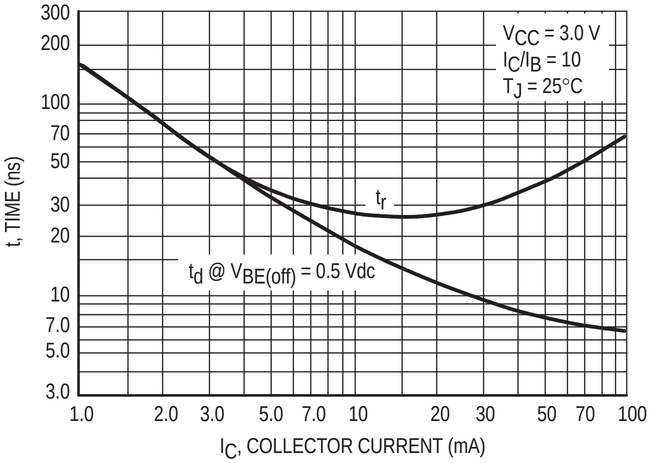


Figure 12. Turn–On Time

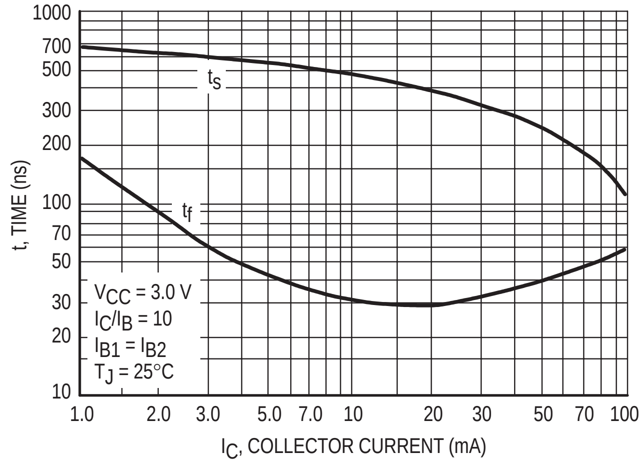


Figure 13. Turn–Off Time

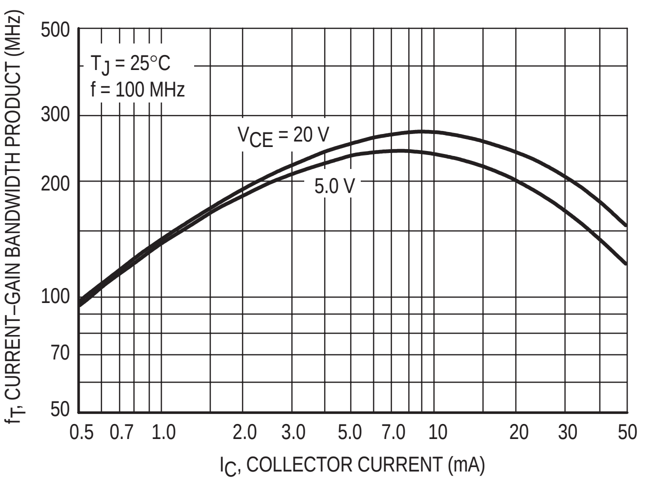


Figure 14. Current–Gain — Bandwidth Product

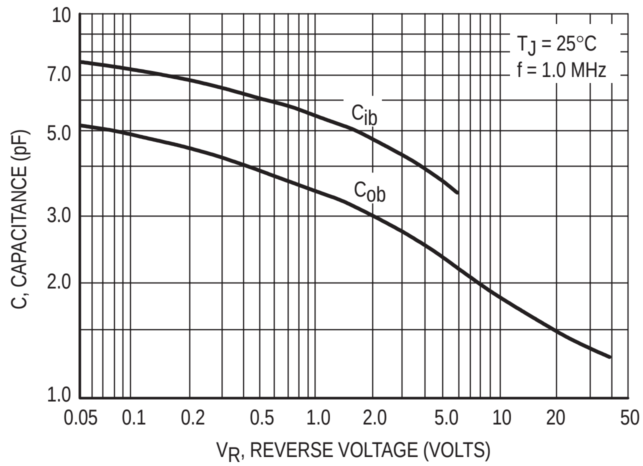


Figure 15. Capacitance

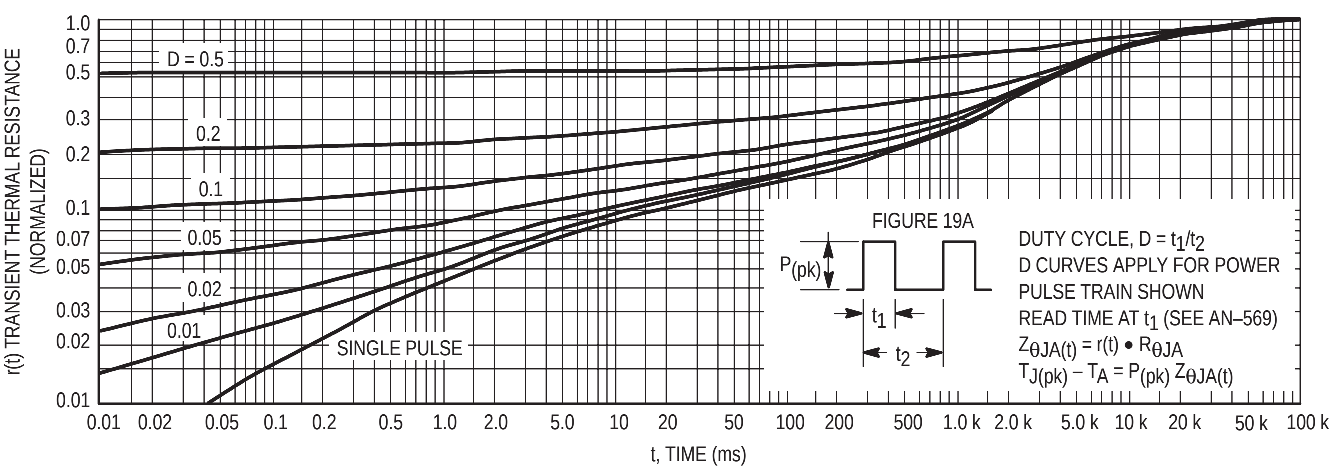


Figure 16. Thermal Response

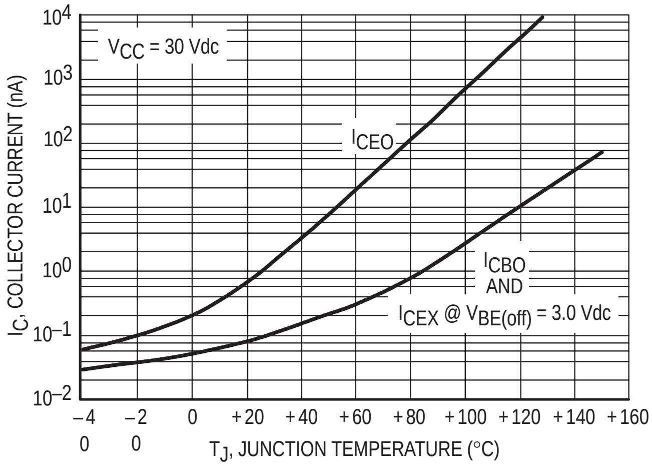


Figure 16A.

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 16A. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 16 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 16 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 16 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

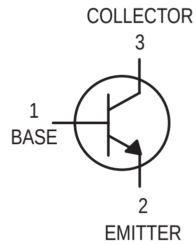
The peak rise in junction temperature is therefore

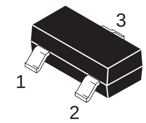
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C.$

For more information, see AN–569.

General Purpose Transistors
NPN Silicon

BCW60ALT1
BCW60BLT1
BCW60DLT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

BCW60ALT1 = AA, BCW60BLT1 = AB, BCW60DLT1 = AD

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

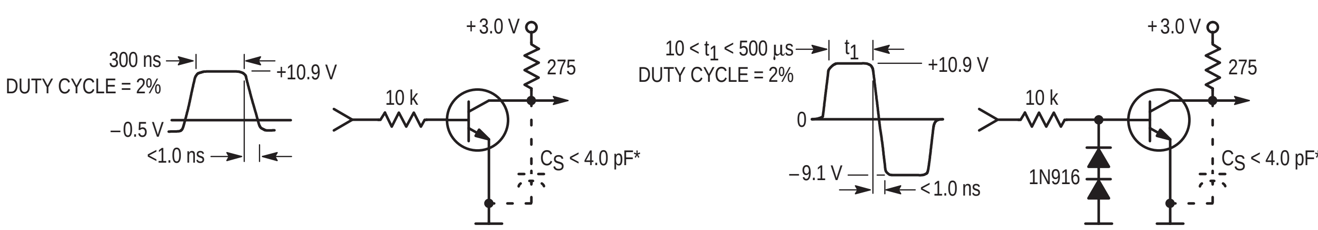
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)	$V_{(BR)CEO}$	32	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)	I_{CES}	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	 —	 20	nAdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	BCW60A		20	—	
	BCW60B		30	—	
	BCW60D		100	—	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCW60A		120	220	
	BCW60B		175	310	
	BCW60D		380	630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCW60A		60	—	
	BCW60B		70	—	
	BCW60D		100	—	
AC Current Gain		h_{fe}			—
(V_{CE} = 5.0 Vdc, I_C = 2.0 mAdc, f = 1.0 kHz)	BCW60A		125	250	
	BCW60B		175	350	
	BCW60D		350	700	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)			—	0.55	
(I_C = 10 mAdc, I_B = 0.25 mAdc)			—	0.35	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)			0.7	1.05	
(I_C = 50 mAdc, I_B = 0.25 mAdc)			0.6	0.85	
Base–Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)			0.6	0.75	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)			125	—	
Output Capacitance		C_{obo}			pF
(V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)			—	4.5	
Noise Figure		NF			dB
(V_{CE} = 5.0 Vdc, I_C = 0.2 mAdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)			—	6.0	
SWITCHING CHARACTERISTICS					
Turn–On Time		t_{on}			ns
(I_C = 10 mAdc, I_{B1} = 1.0 mAdc)			—	150	
Turn–Off Time		t_{off}			ns
(I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)			—	800	

EQUIVALENT SWITCHING TIME TEST CIRCUITS



*Total shunt capacitance of test jig and connectors

Figure 1. Turn–On Time **Figure 2. Turn–Off Time**

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

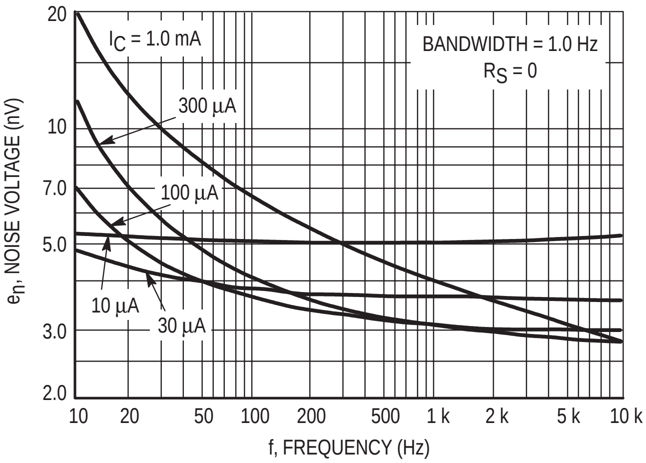


Figure 3. Noise Voltage

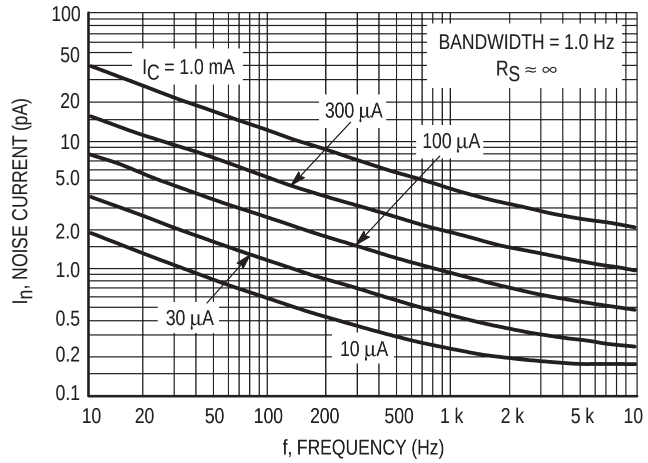


Figure 4. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

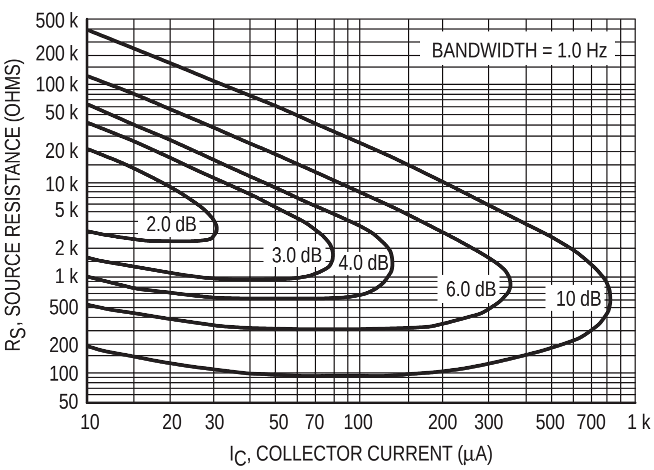


Figure 5. Narrow Band, 100 Hz

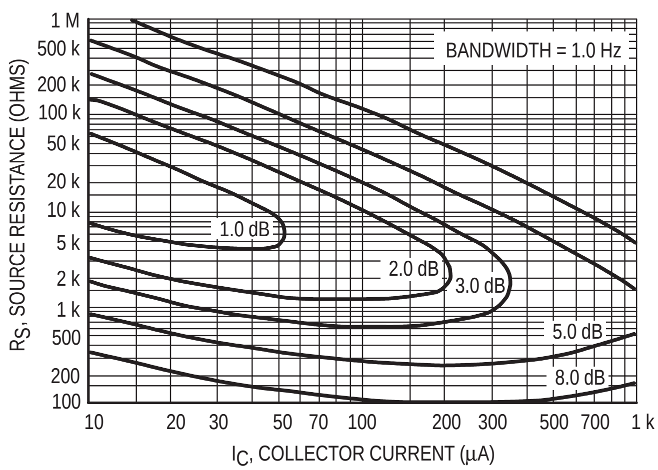


Figure 6. Narrow Band, 1.0 kHz

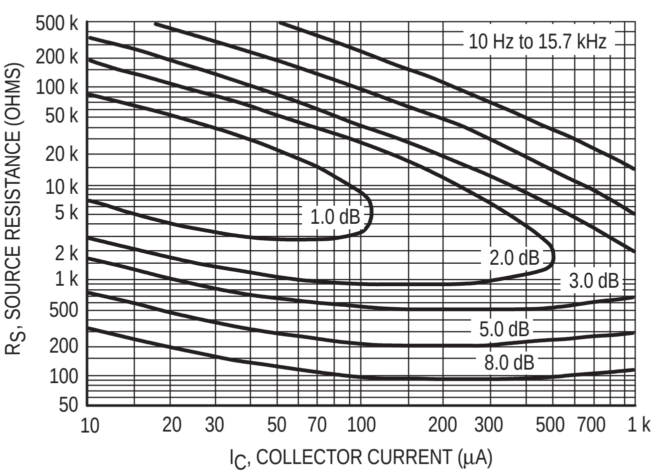


Figure 7. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

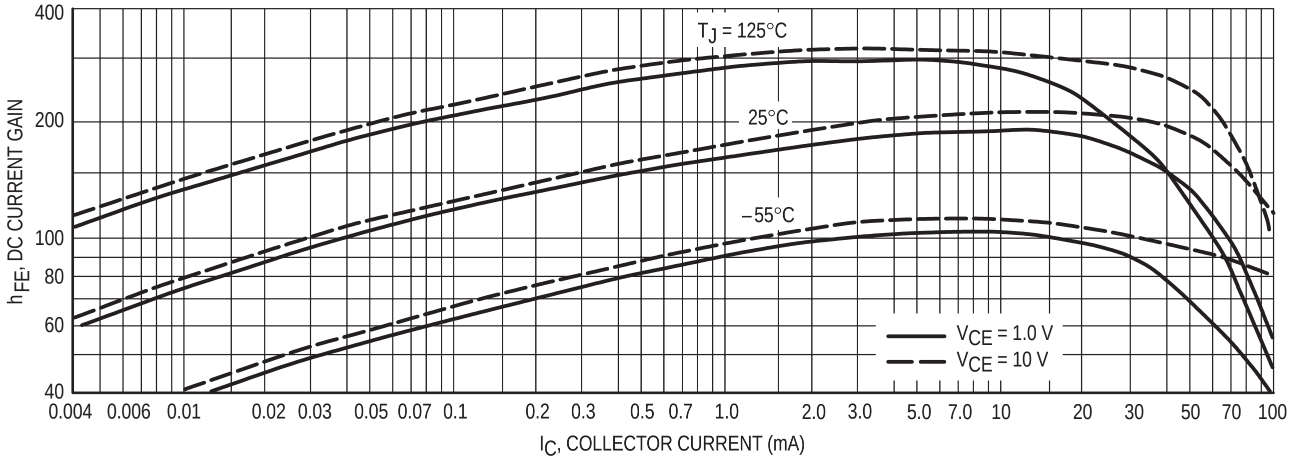


Figure 8. DC Current Gain

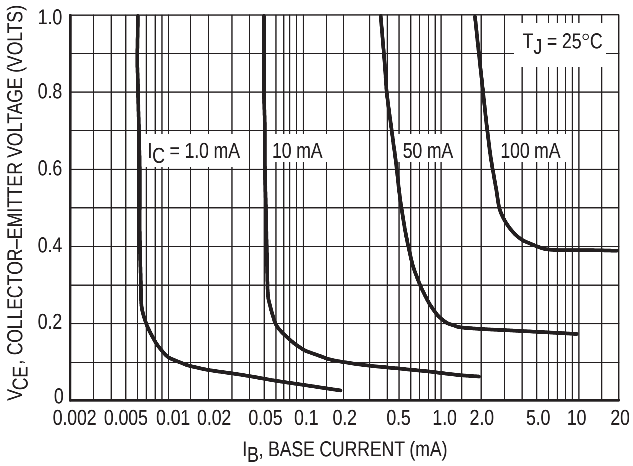


Figure 9. Collector Saturation Region

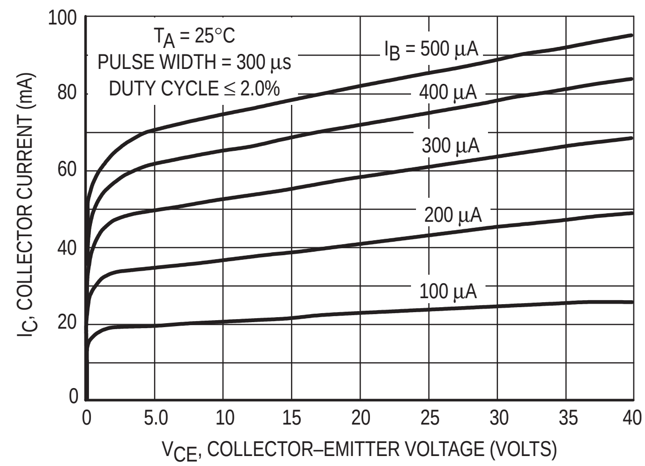


Figure 10. Collector Characteristics

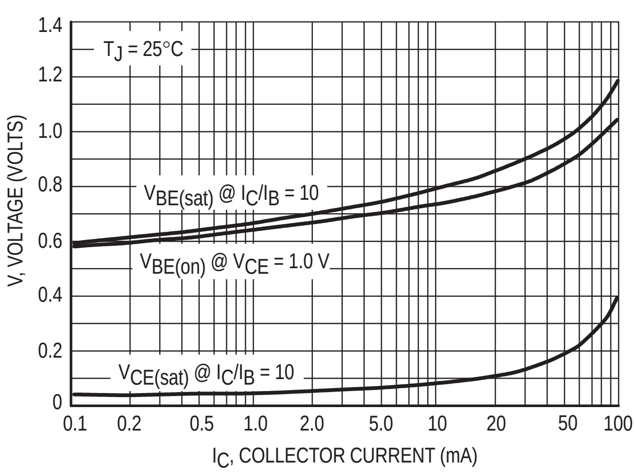


Figure 11. "On" Voltages

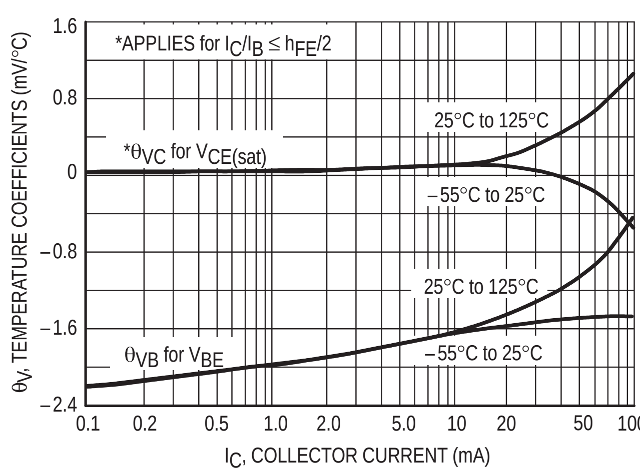


Figure 12. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

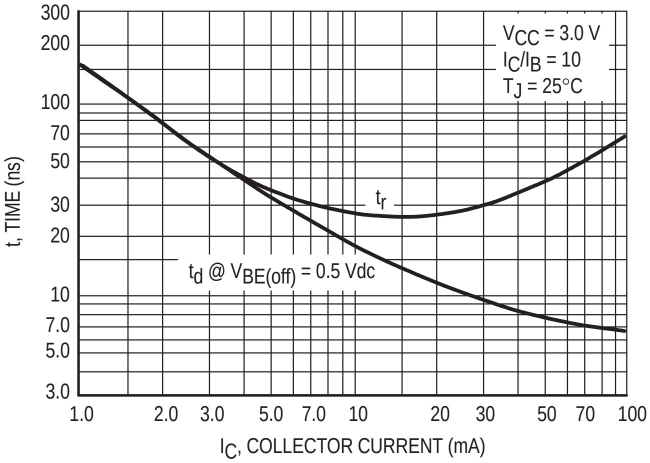


Figure 13. Turn–On Time

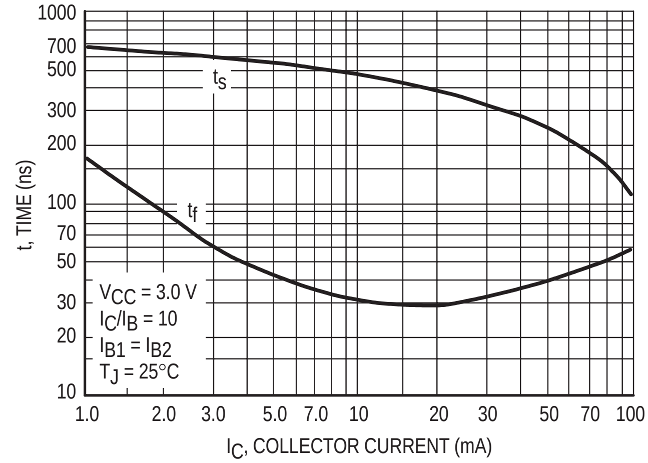


Figure 14. Turn–Off Time

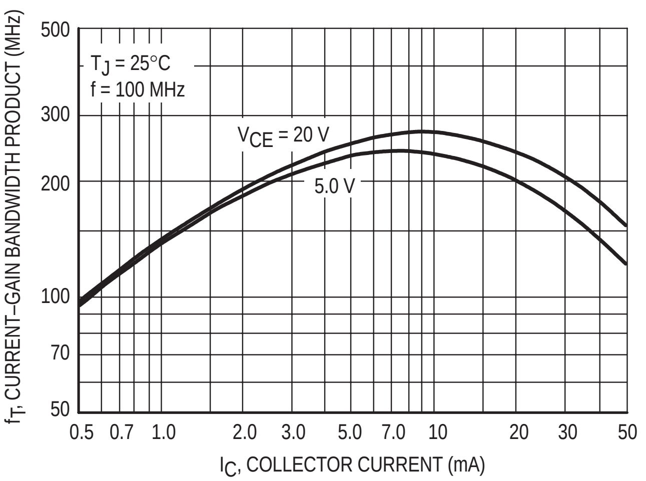


Figure 15. Current–Gain — Bandwidth Product

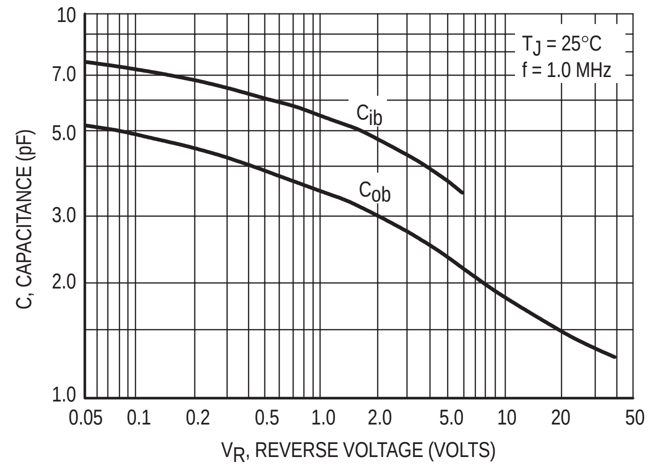


Figure 16. Capacitance

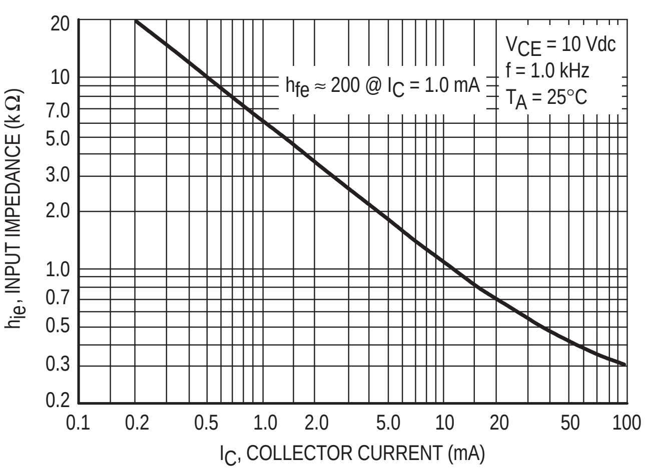


Figure 17. Input Impedance

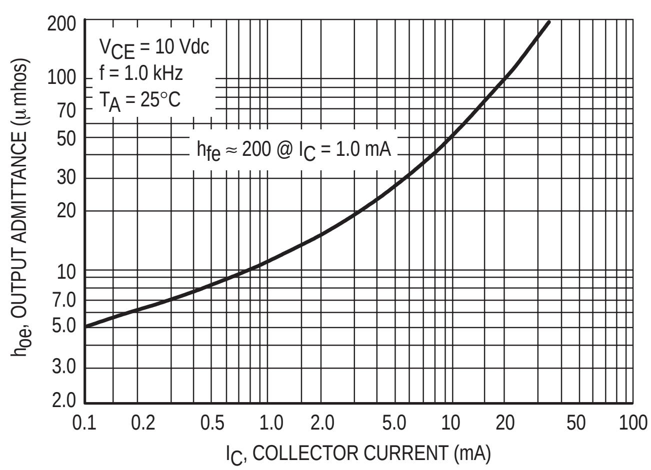


Figure 18. Output Admittance

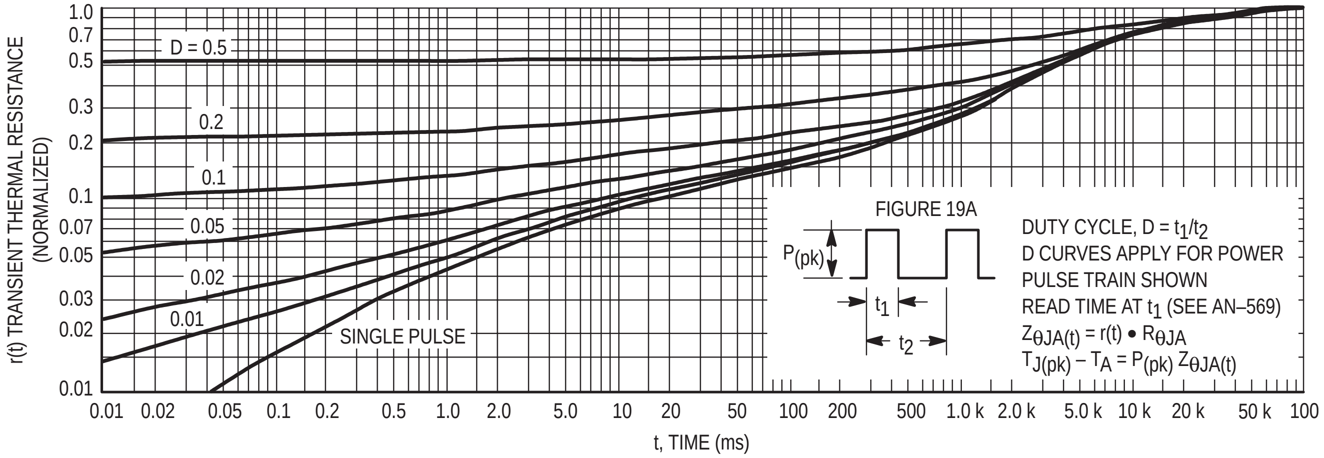


Figure 19. Thermal Response

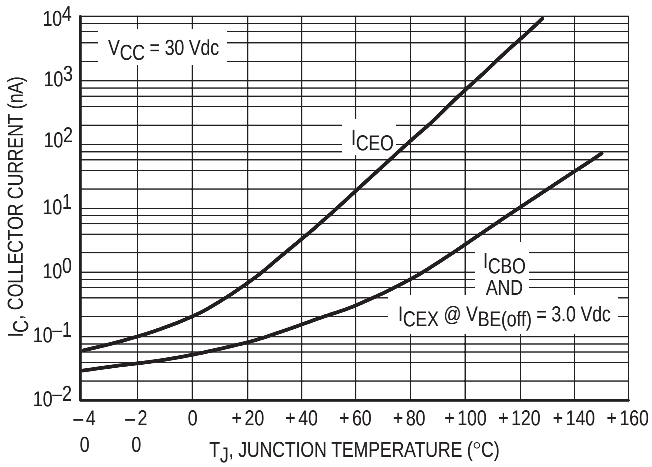


Figure 19A.

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.

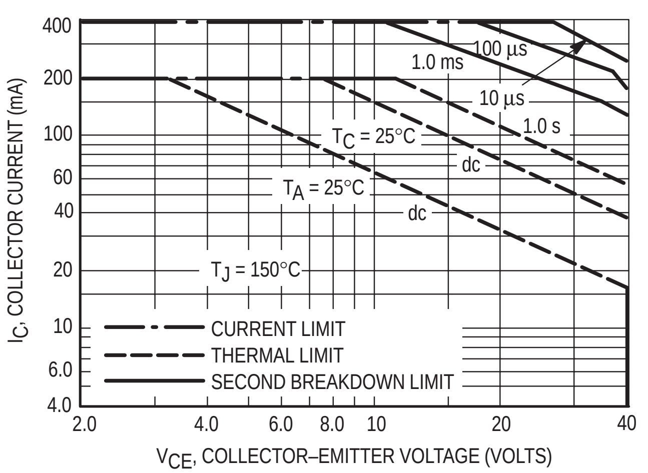


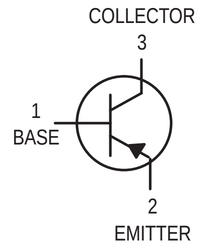
Figure 20.

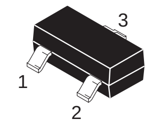
The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

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 $T_{J(pk)} \le 150°C$. $T_{J(pk)}$ 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.

General Purpose Transistors
PNP Silicon

BCW61BLT1
BCW61CLT1
BCW61DLT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = –10 µAdc, V_{CE} = –5.0 Vdc)	BCW61B		30	—	
	BCW61C		40	—	
	BCW61D		100	—	
(I_C = –2.0 mAdc, V_{CE} = –5.0 Vdc)	BCW61B		140	310	
	BCW61C		250	460	
	BCW61D		380	630	
(I_C = –50 mAdc, V_{CE} = –1.0 Vdc)	BCW61B		80	—	
	BCW61C		100	—	
	BCW61D		100	—	
AC Current Gain		h_{fe}			—
(V_{CE} = –5.0 Vdc, I_C = –2.0 mAdc, f = 1.0 kHz)	BCW61B		175	350	
	BCW61C		250	500	
	BCW61D		350	700	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = –50 mAdc, I_B = –1.25 mAdc)			—	–0.55	
(I_C = –10 mAdc, I_B = –0.25 mAdc)			—	–0.25	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = –50 mAdc, I_B = –1.25 mAdc)			–0.68	–1.05	
(I_C = –10 mAdc, I_B = –0.25 mAdc)			–0.6	–0.85	
Base–Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = –2.0 mAdc, V_{CE} = –5.0 Vdc)			–0.6	–0.75	
SMALL–SIGNAL CHARACTERISTICS					
Output Capacitance		C_{obo}			pF
(V_{CE} = –10 Vdc, I_C = 0, f = 1.0 MHz)			—	6.0	
Noise Figure		NF			dB
(V_{CE} = –5.0 Vdc, I_C = –0.2 mAdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)			—	6.0	
SWITCHING CHARACTERISTICS					
Turn–On Time		t_{on}			ns
(I_C = –10 mAdc, I_{B1} = –1.0 mAdc)			—	150	
Turn–Off Time		t_{off}			ns
(I_{B2} = –1.0 mAdc, V_{BB} = –3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)			—	800	

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

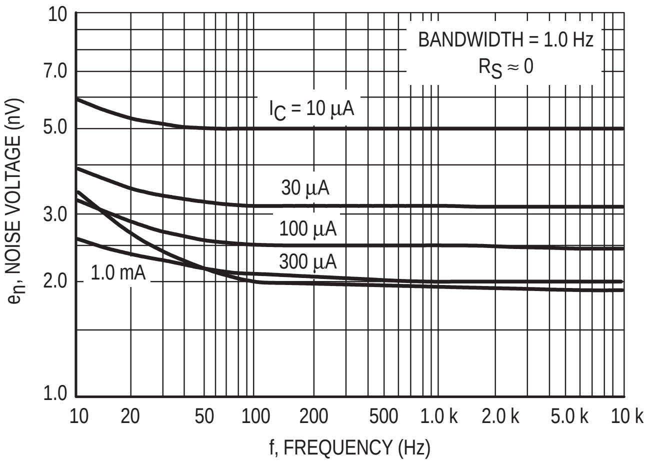


Figure 1. Noise Voltage

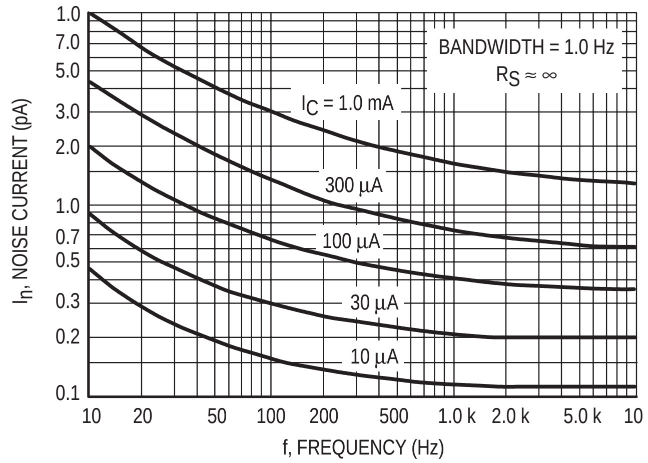


Figure 2. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

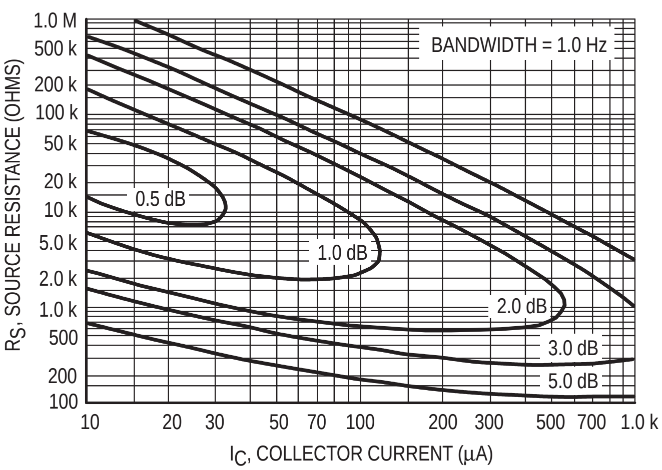


Figure 3. Narrow Band, 100 Hz

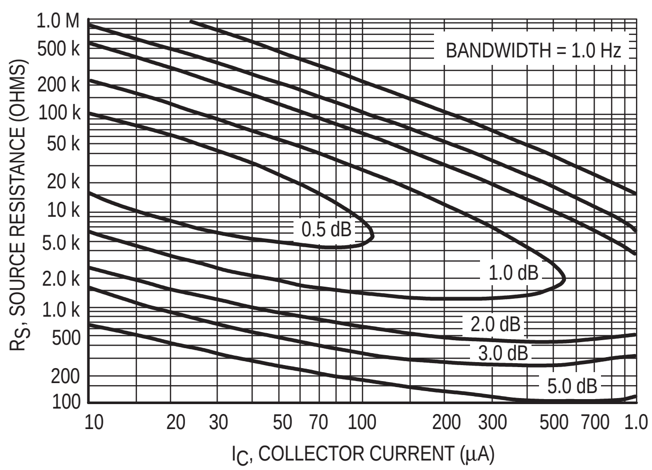


Figure 4. Narrow Band, 1.0 kHz

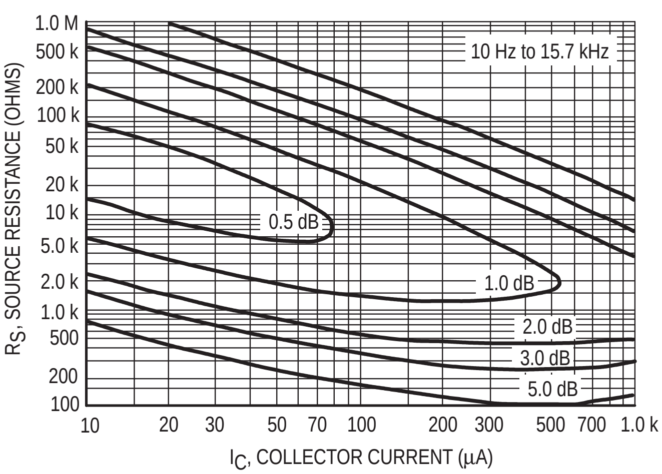


Figure 5. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

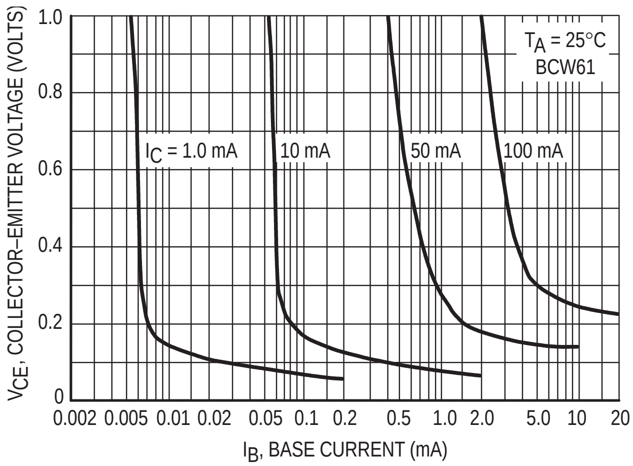


Figure 6. Collector Saturation Region

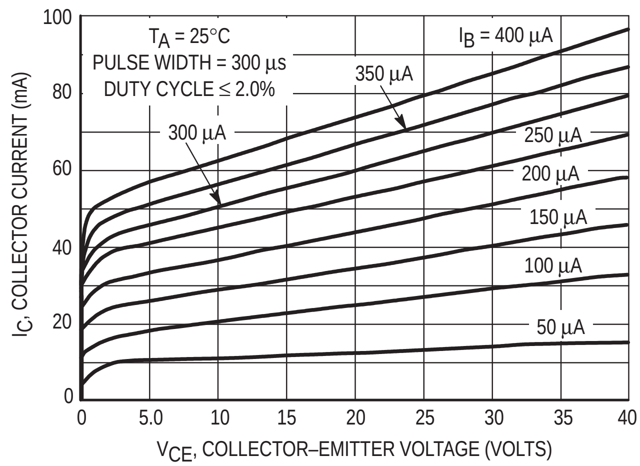


Figure 7. Collector Characteristics

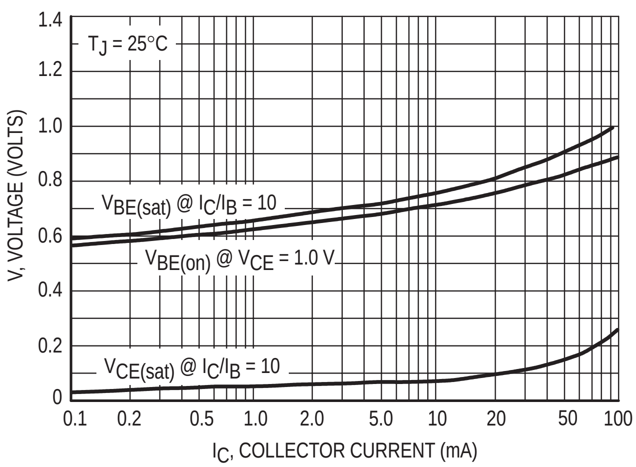


Figure 8. "On" Voltages

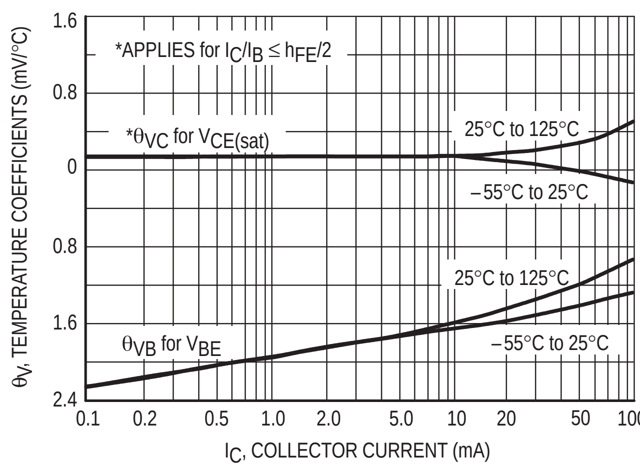


Figure 9. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

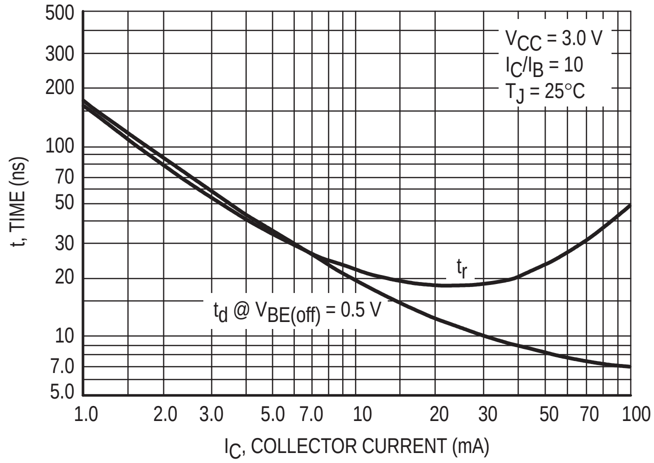


Figure 10. Turn–On Time

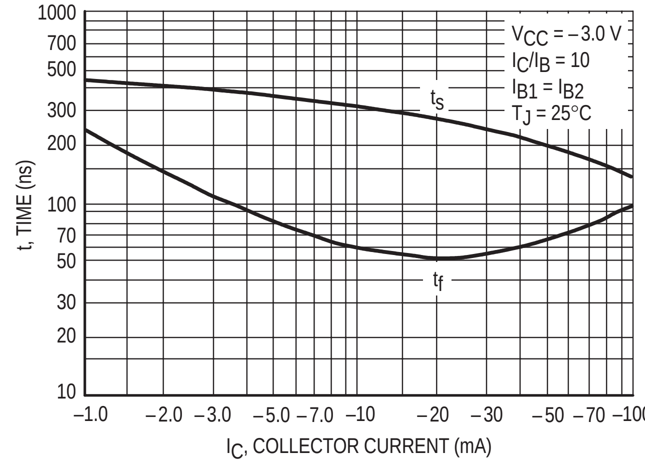


Figure 11. Turn–Off Time

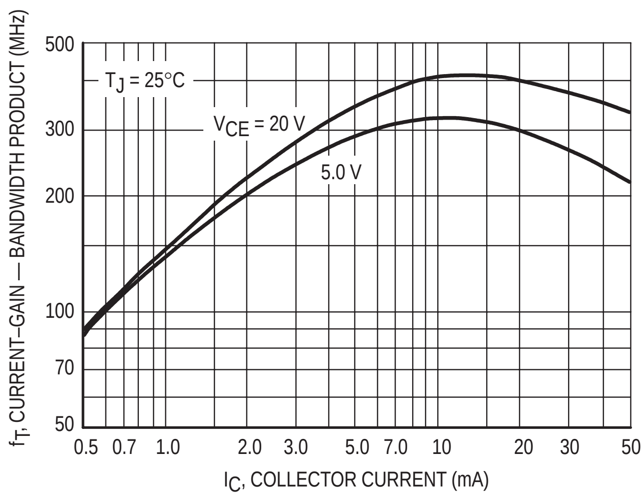


Figure 12. Current–Gain — Bandwidth Product

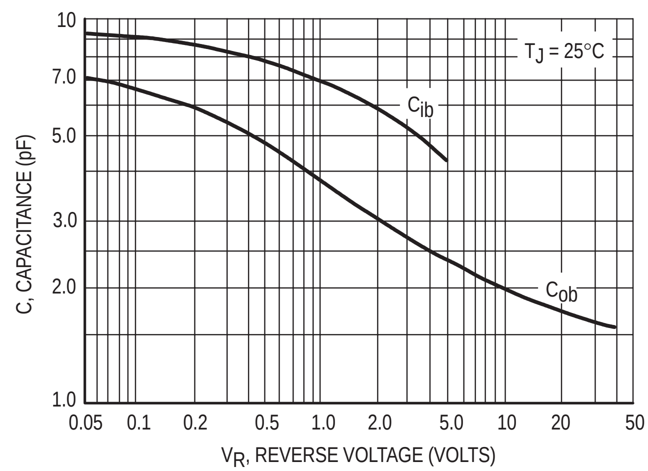


Figure 13. Capacitance

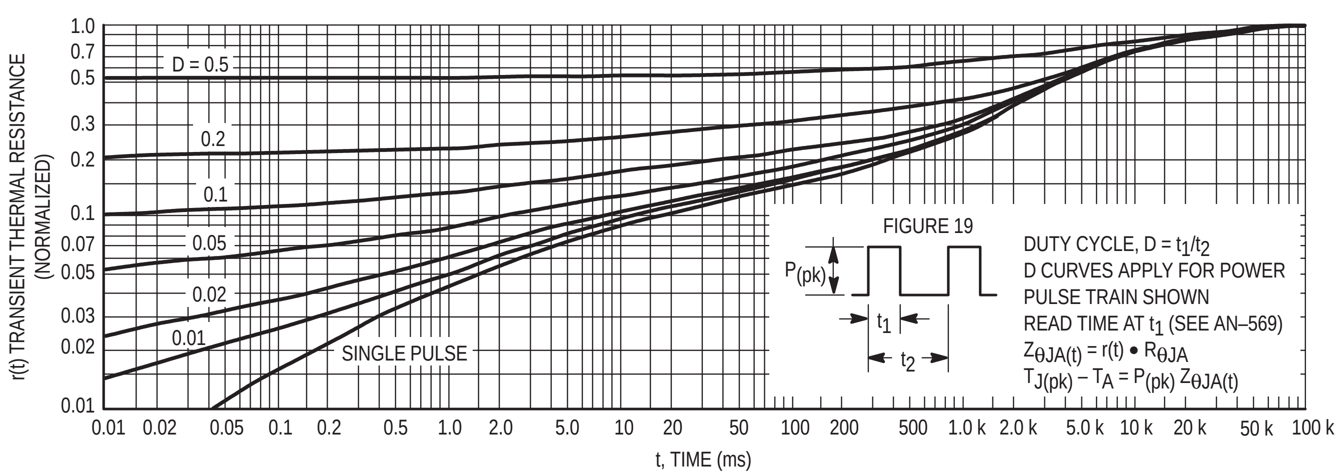


Figure 14. Thermal Response

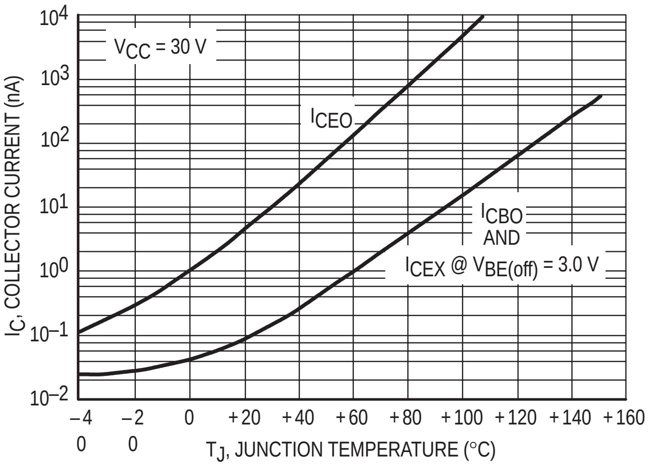


Figure 15. Typical Collector Leakage Current

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 15. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 14 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 14 by the steady state value $R_{\theta JA}$.

Example:

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

$$t_1 = 1.0 \text{ ms}, t_2 = 5.0 \text{ ms } (D = 0.2)$$

Using Figure 14 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

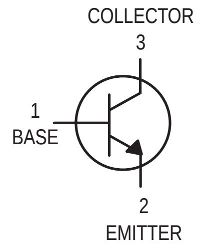
The peak rise in junction temperature is therefore

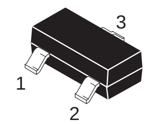
$$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C.$$

For more information, see AN–569.

General Purpose Transistor
NPN Silicon

BCW65ALT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

BCW65ALT1 = EA

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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

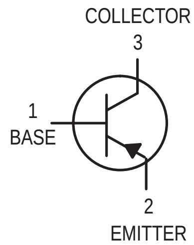
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

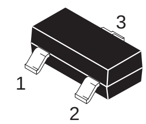
Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
(I_C = 100 µAdc, V_{CE} = 10 Vdc)		35	—	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		75	—	220	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		100	—	250	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		35	—	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.7	—	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.3	—	
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 (V_{CE} = 5.0 Vdc, I_C = 0.2 mAdc, 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

General Purpose Transistor

PNP Silicon

BCW68GLT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

BCW68GLT1 = DH

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board (1) 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, (2) 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

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

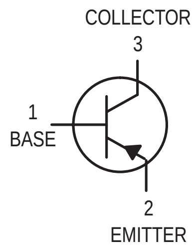
1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

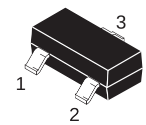
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
(I_C = –10 mAdc, V_{CE} = –1.0 Vdc)		120	—	400	
(I_C = –100 mAdc, V_{CE} = –1.0 Vdc)		160	—	—	
(I_C = –300 mAdc, V_{CE} = –1.0 Vdc)		60	—	—	
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

General Purpose Transistors
PNP Silicon

BCW69LT1
BCW70LT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

BCW69LT1 = H1; BCW70LT1 = H2

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board (1) 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, (2) 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

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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = –2.0 mAdc, V_{CE} = –5.0 Vdc)	BCW69	h_{FE}	120	260	—
	BCW70		215	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

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

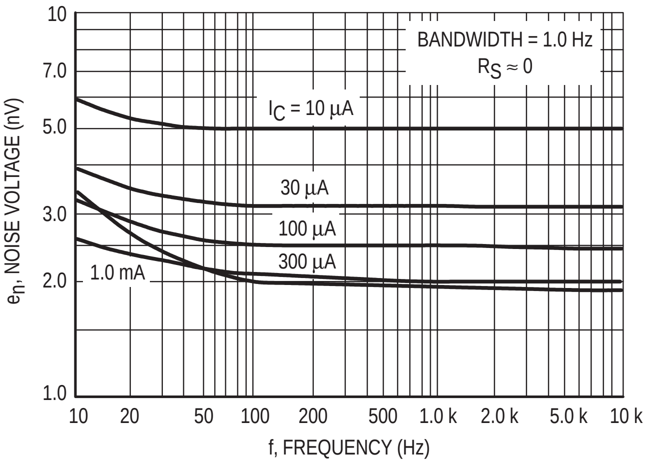


Figure 1. Noise Voltage

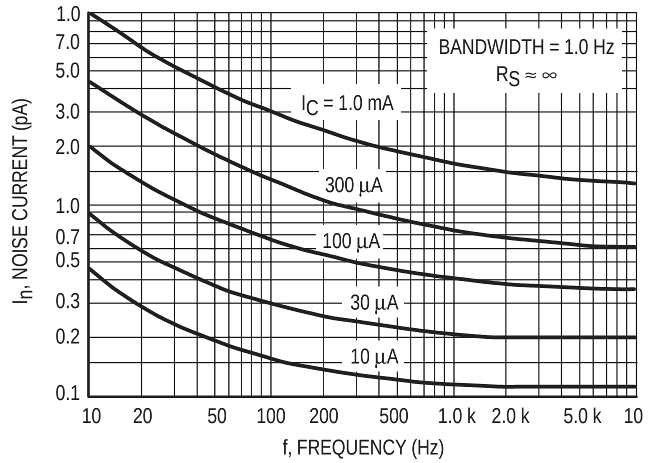


Figure 2. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

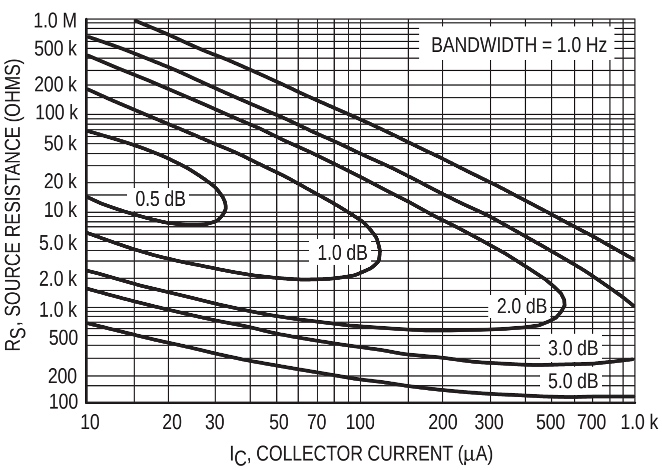


Figure 3. Narrow Band, 100 Hz

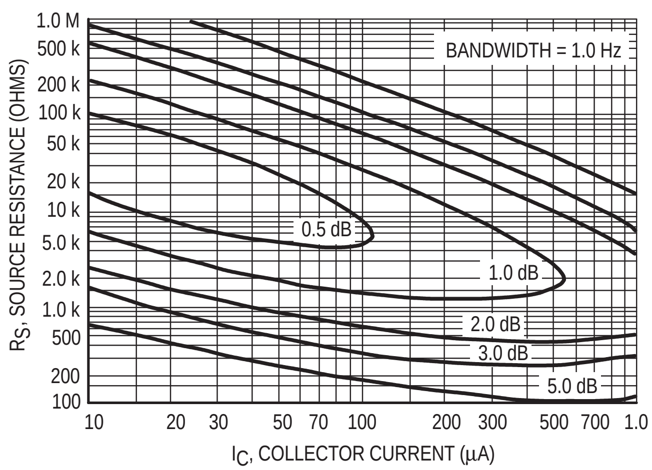


Figure 4. Narrow Band, 1.0 kHz

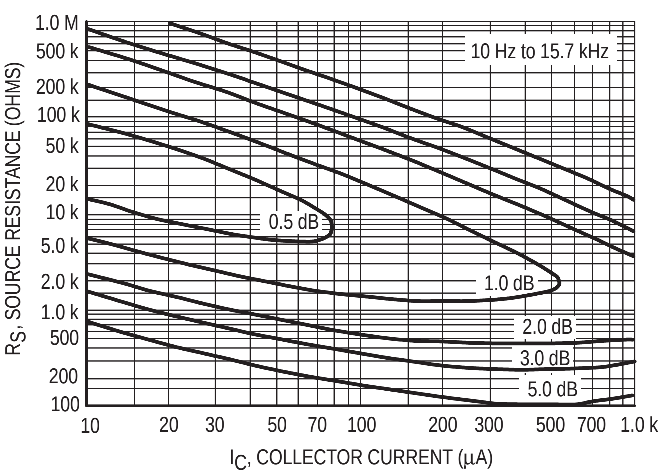


Figure 5. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

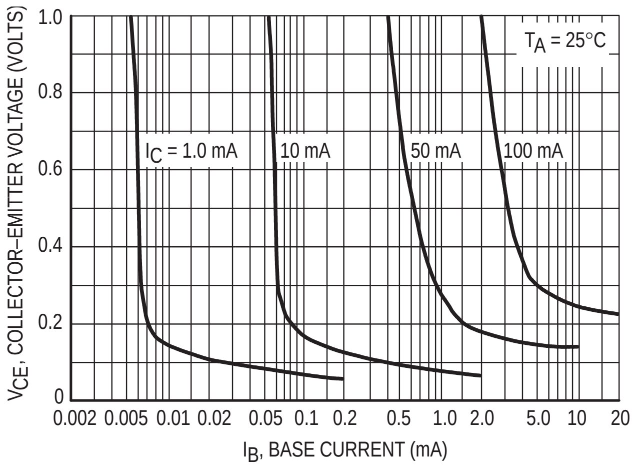


Figure 6. Collector Saturation Region

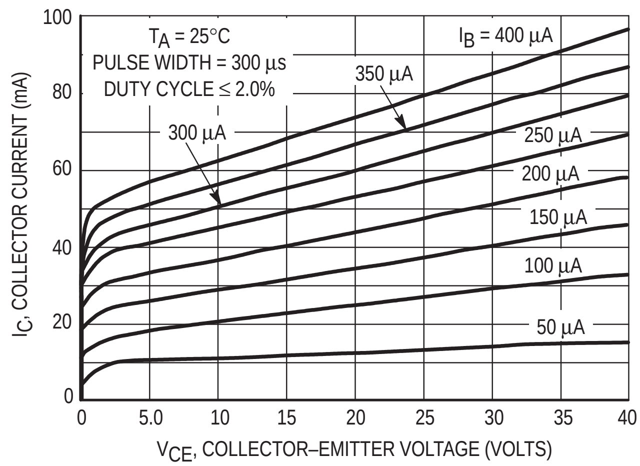


Figure 7. Collector Characteristics

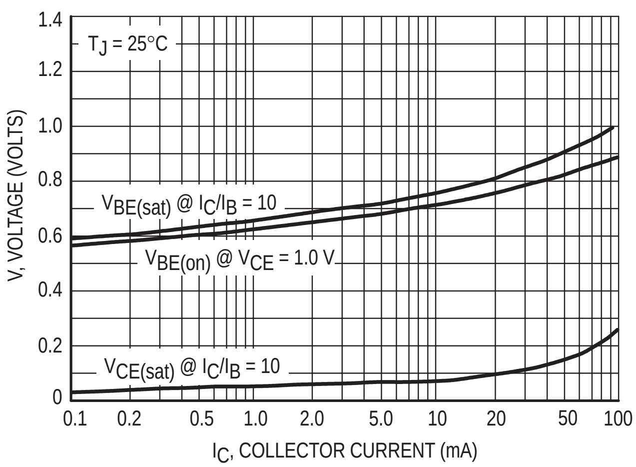


Figure 8. "On" Voltages

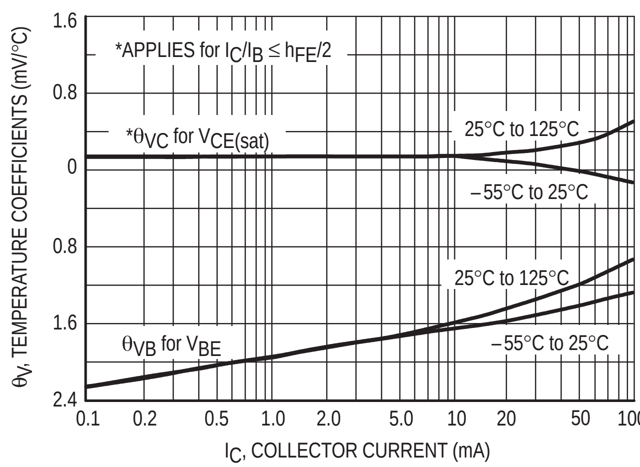


Figure 9. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

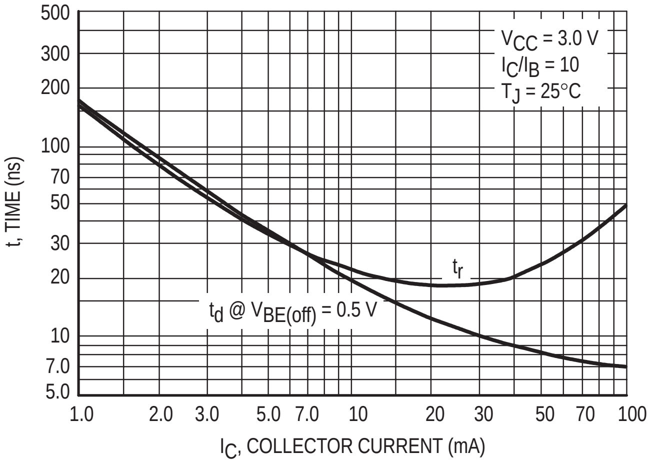


Figure 10. Turn–On Time

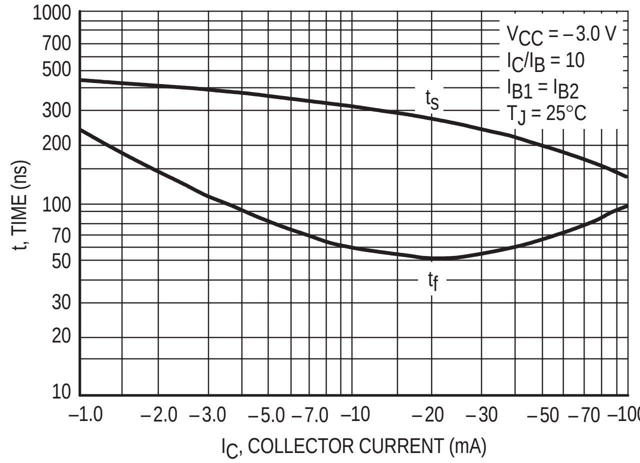


Figure 11. Turn–Off Time

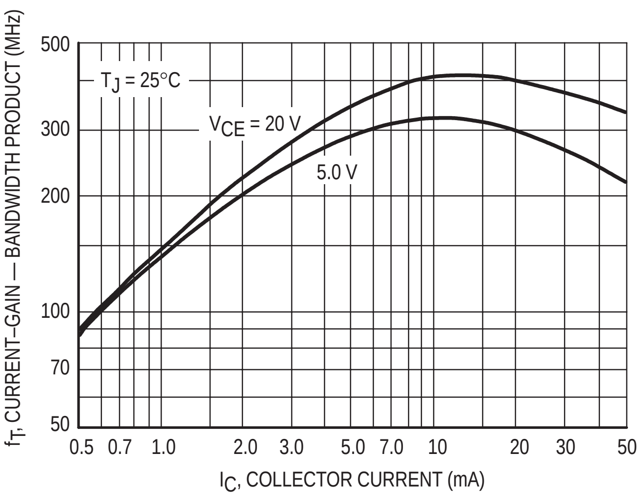


Figure 12. Current–Gain — Bandwidth Product

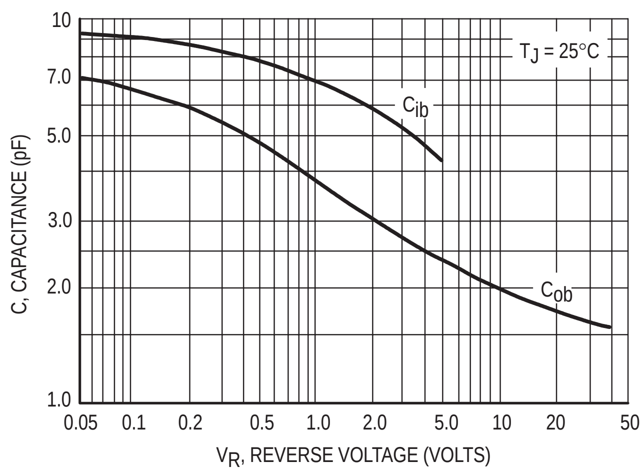


Figure 13. Capacitance

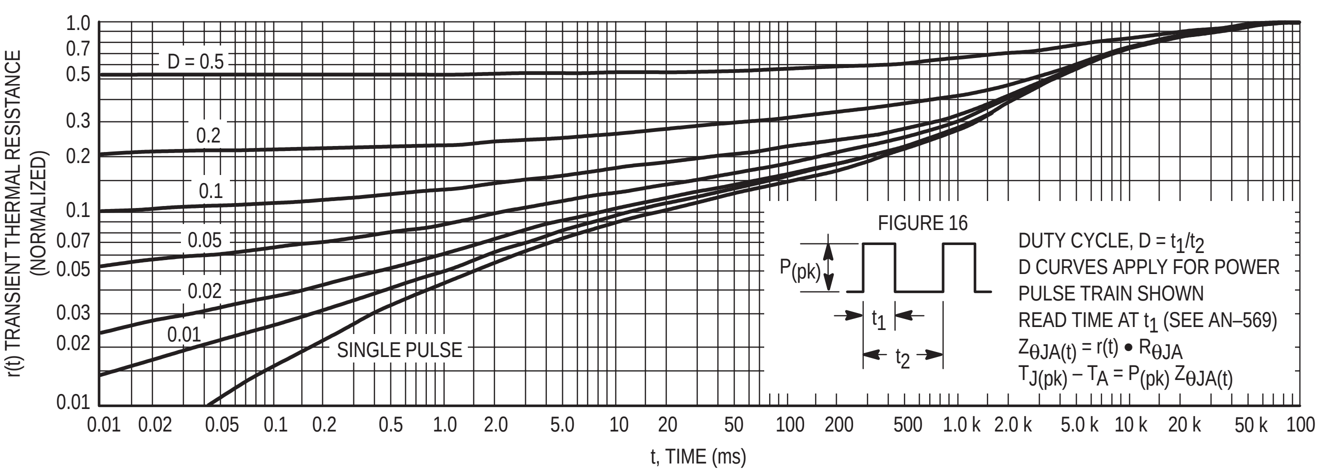


Figure 14. Thermal Response

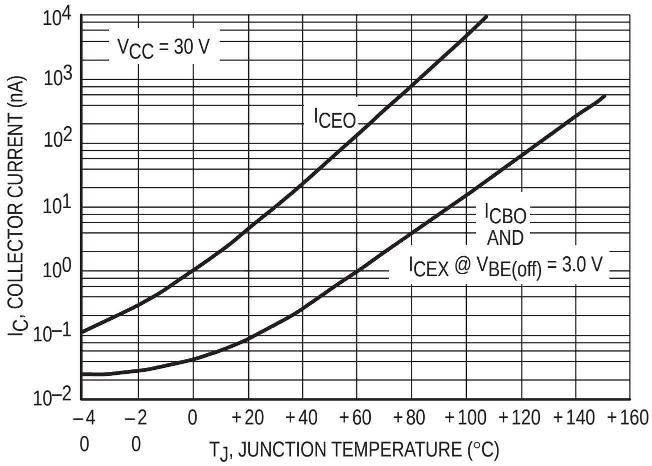


Figure 15. Typical Collector Leakage Current

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 16. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 14 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 14 by the steady state value $R_{\theta JA}$.

Example:

Dissipating 2.0 watts peak under the following conditions:

t_1 = 1.0 ms, t_2 = 5.0 ms (D = 0.2)

Using Figure 14 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

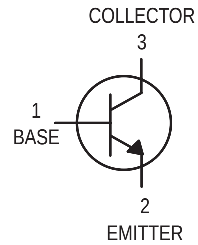
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C$.

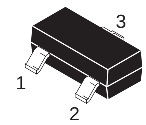
For more information, see AN–569.

General Purpose Transistor

NPN Silicon

BCW72LT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

BCW72LT1 = K2

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

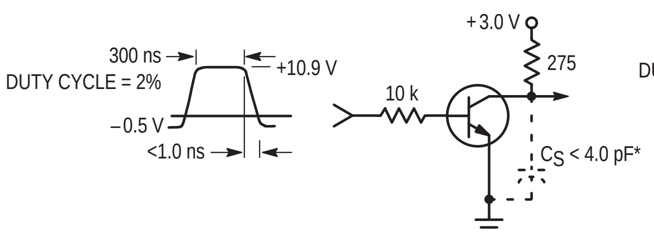
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 2.0 mAdc, V_{EB} = 0)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 2.0 mAdc, V_{EB} = 0)	$V_{(BR)CES}$	45	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	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

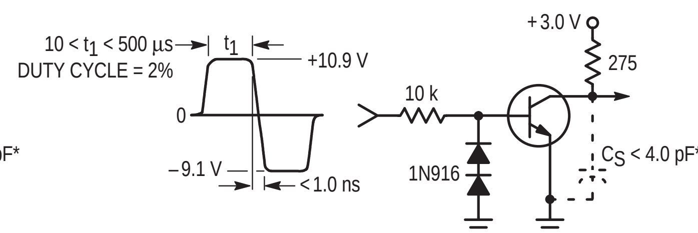
1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic	Symbol	Min	Typ	Max	Unit
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)	$V_{CE(sat)}$	—	—	0.25	Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)		—	0.21	—	
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

EQUIVALENT SWITCHING TIME TEST CIRCUITS





*Total shunt capacitance of test jig and connectors

Figure 1. Turn–On Time **Figure 2. Turn–Off Time**

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

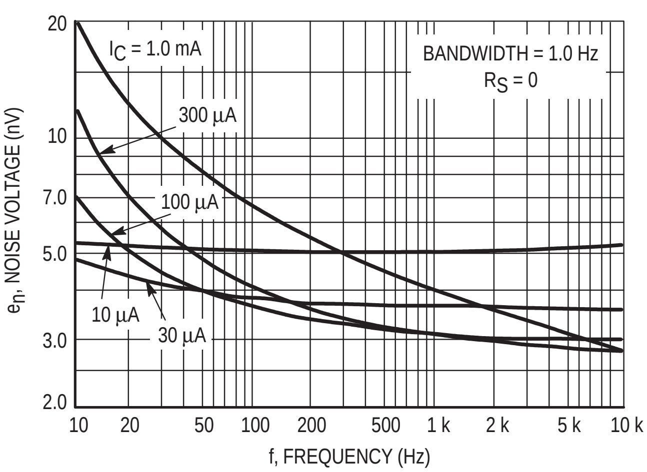


Figure 3. Noise Voltage

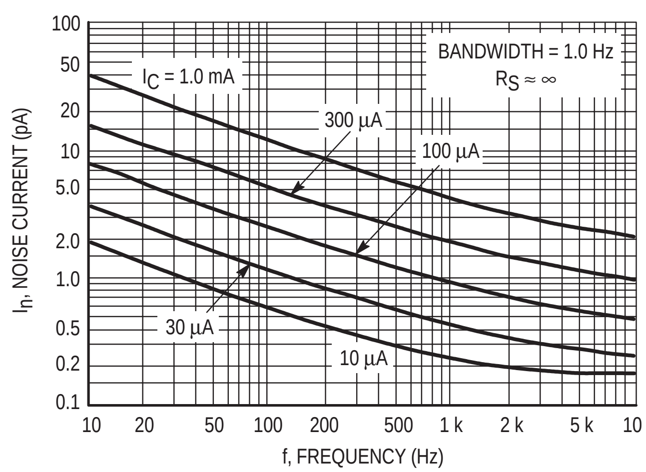


Figure 4. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

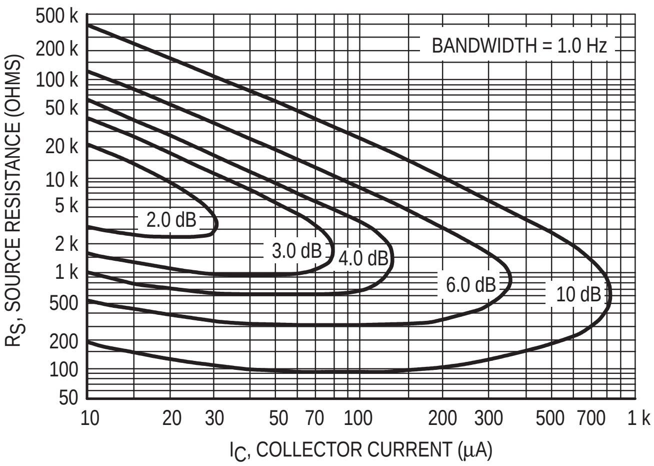


Figure 5. Narrow Band, 100 Hz

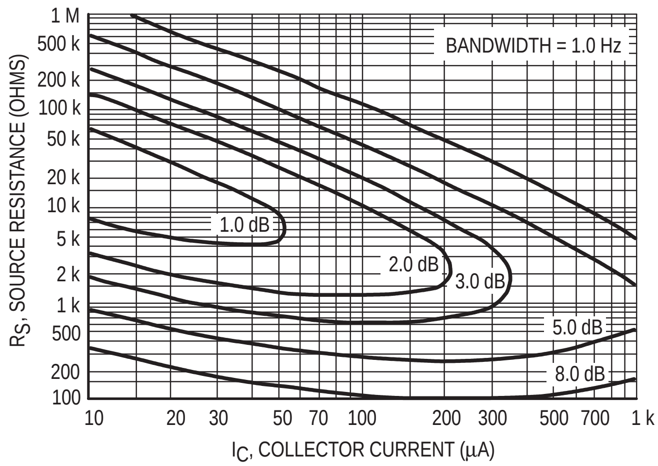


Figure 6. Narrow Band, 1.0 kHz

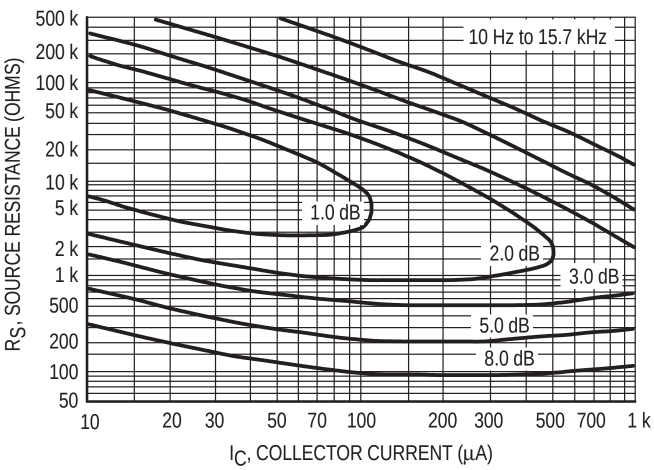


Figure 7. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

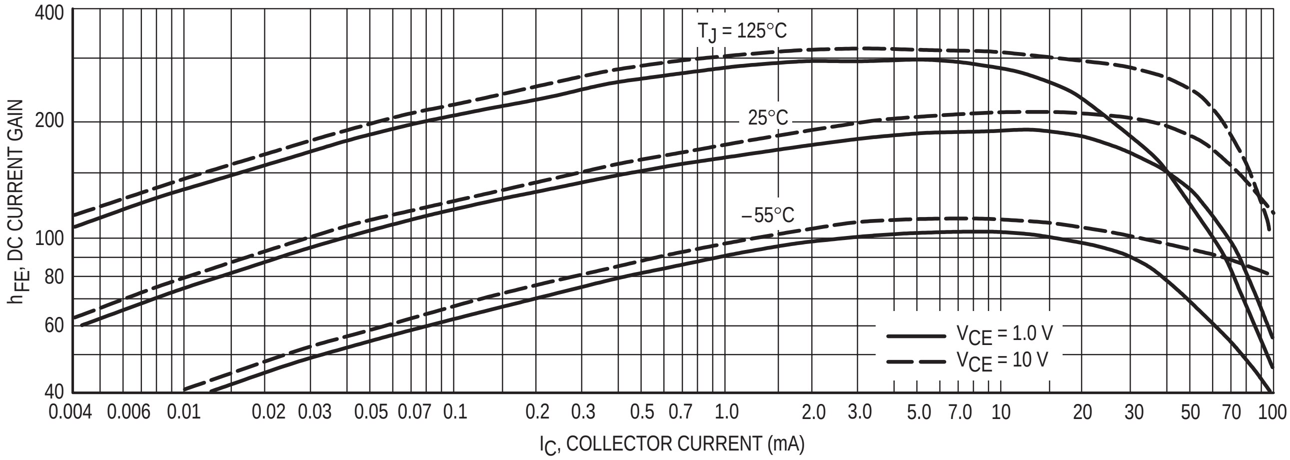


Figure 8. DC Current Gain

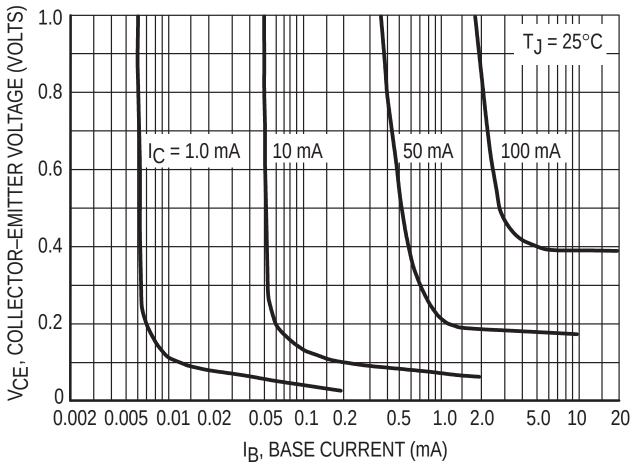


Figure 9. Collector Saturation Region

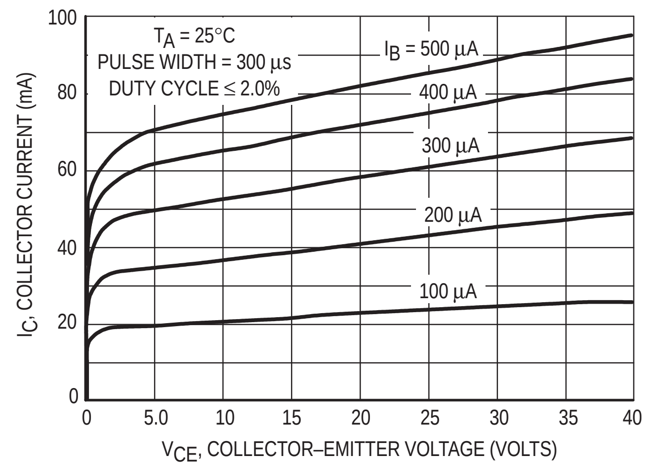


Figure 10. Collector Characteristics

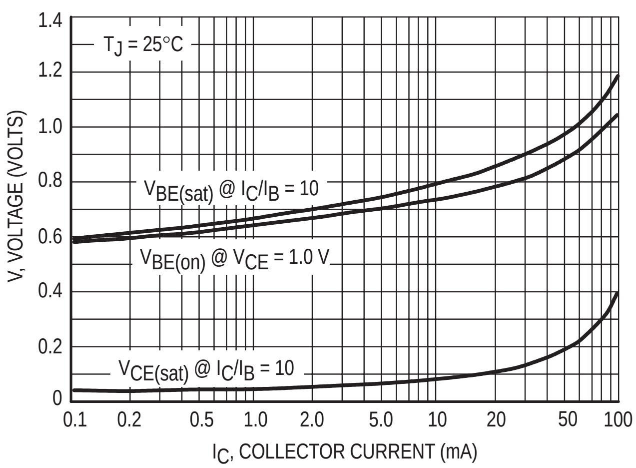


Figure 11. “On” Voltages

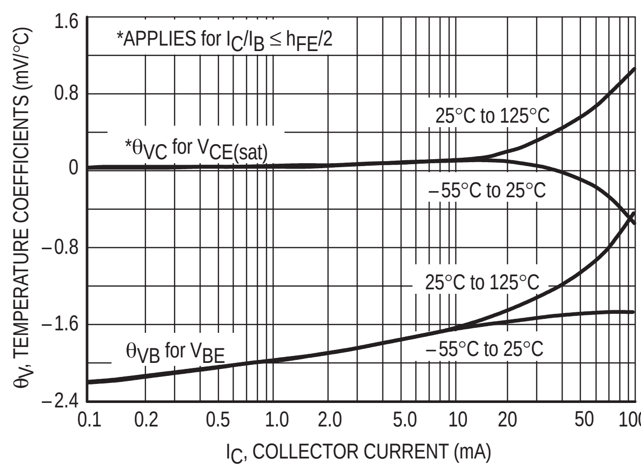


Figure 12. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

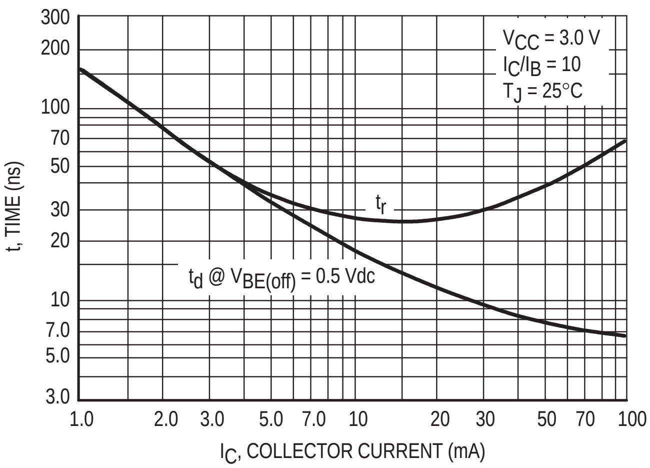


Figure 13. Turn–On Time

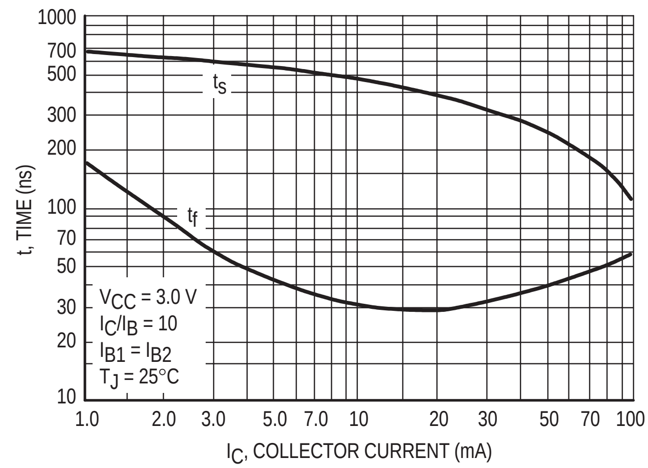


Figure 14. Turn–Off Time

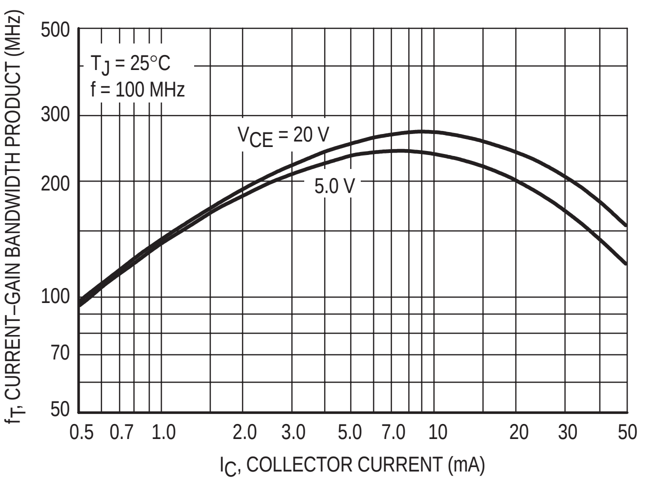


Figure 15. Current–Gain — Bandwidth Product

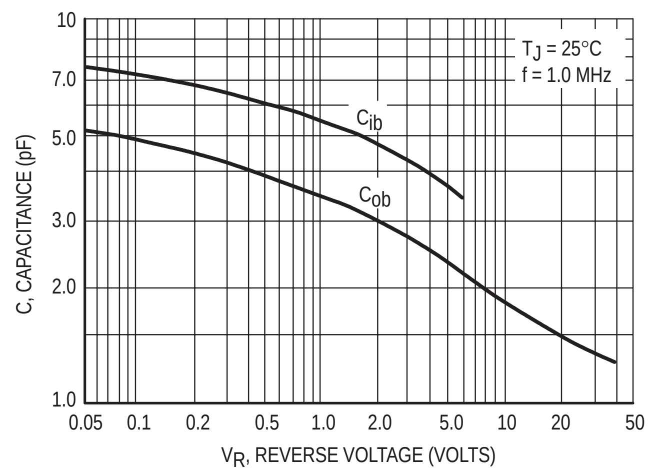


Figure 16. Capacitance

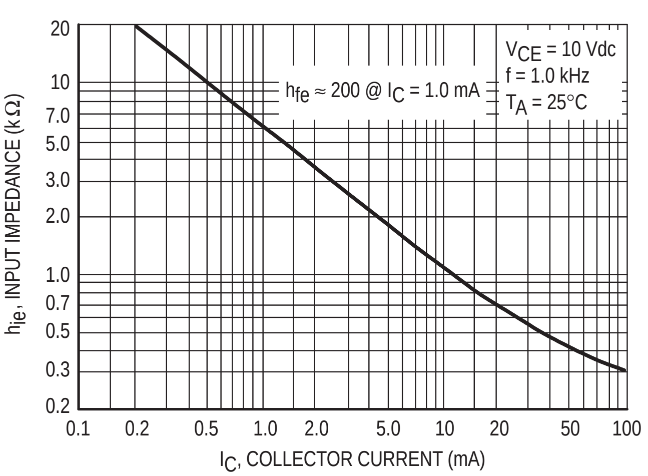


Figure 17. Input Impedance

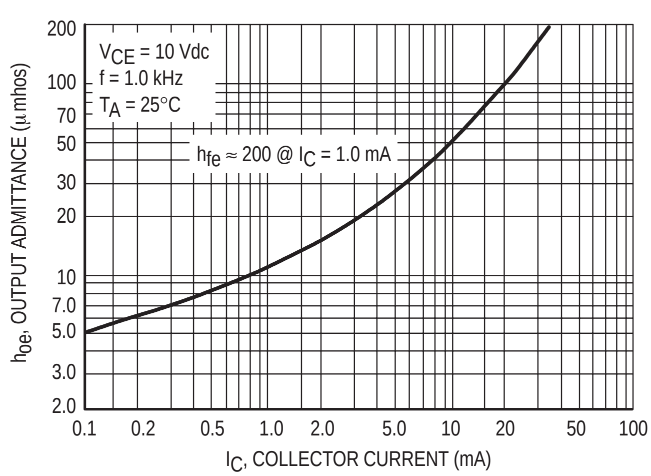


Figure 18. Output Admittance

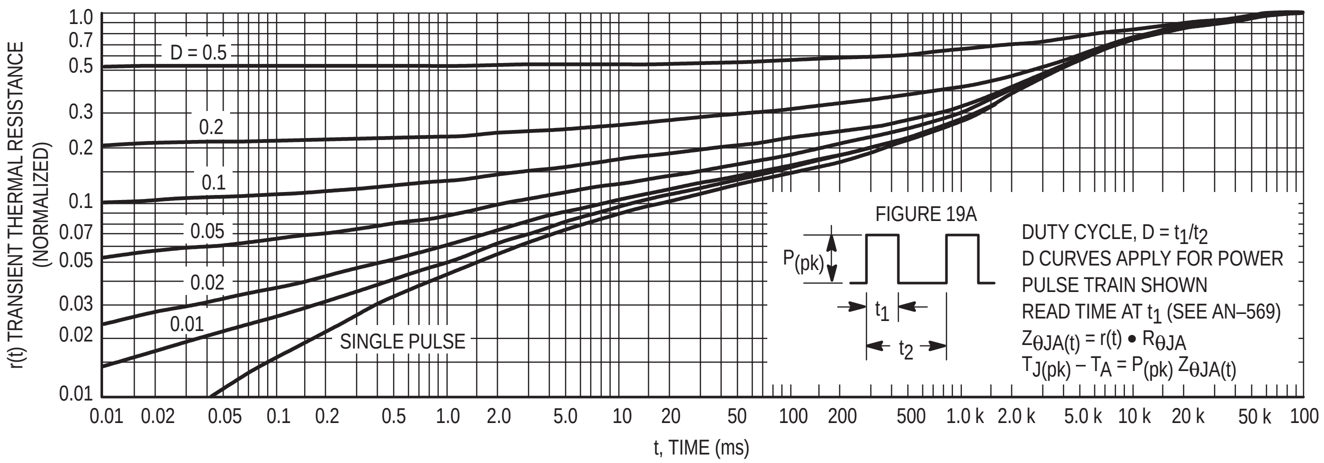


Figure 19. Thermal Response

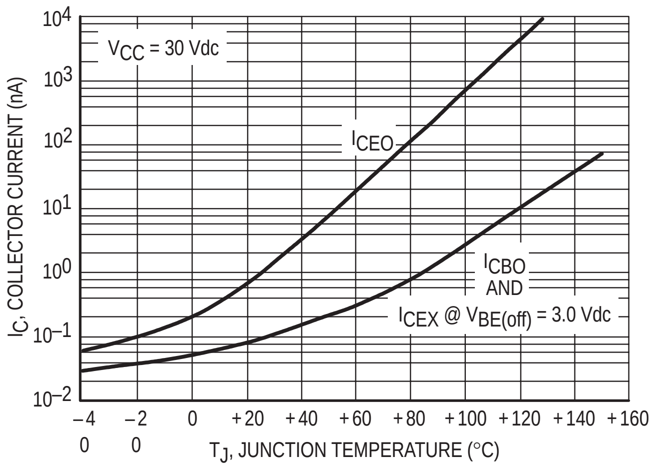


Figure 19A.

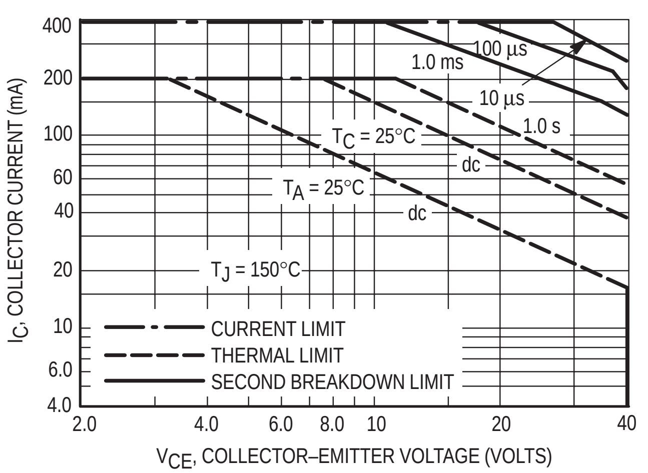


Figure 20.

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

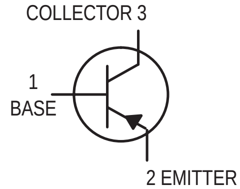
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C.$

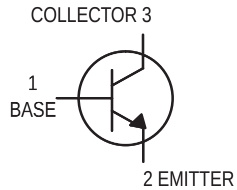
For more information, see AN–569.

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 $T_{J(pk)} \le 150°C$. $T_{J(pk)}$ 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.

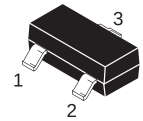
General Purpose Transistors





PNP
BCX17LT1
BCX18LT1
NPN
BCX19LT1
BCX20LT1

Voltage and current are negative for PNP transistors



CASE 318 – 08, STYLE 6
SOT– 23 (TO – 236AB)

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		BCX17LT1 BCX19LT1	BCX18LT1 BCX20LT1	
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

DEVICE MARKING

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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board (1) 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, (2) 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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

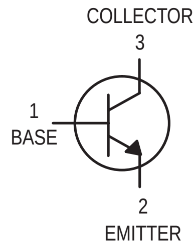
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

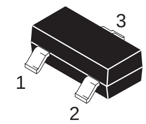
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BCX17, 19 BCX18, 20	$V_{(BR)CEO}$	45 25	— —	— —	Vdc
Collector–Emitter Breakdown Voltage (I_C = 10 μAdc, I_C = 0)	BCX17, 19 BCX18, 20	$V_{(BR)CES}$	50 30	— —	— —	Vdc
Collector 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

General Purpose Transistors

NPN Silicon

BCX70GLT1
BCX70JLT1
BCX70KLT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

BCX70GLT1 = AG; BCX70JLT1 = AJ; BCX70KLT1 = AK

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

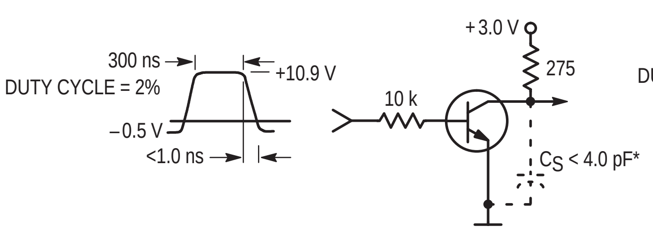
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E= 0)	$V_{(BR)CEO}$	45	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)	I_{CES}	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	20	nAdc

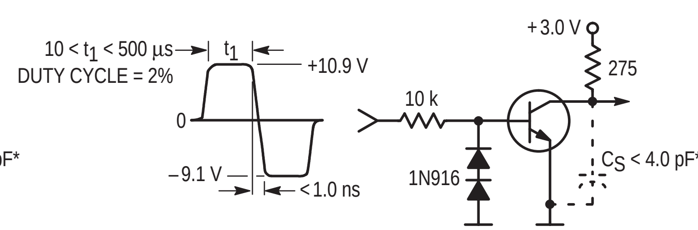
1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	BCX70G		—	—	
	BCX70J		40	—	
	BCX70K		100	—	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCX70G		120	220	
	BCX70J		250	460	
	BCX70K		380	630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCX70G		60	—	
	BCX70J		90	—	
	BCX70K		100	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)			—	0.55	
(I_C = 10 mAdc, I_B = 0.25 mAdc)			—	0.35	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)			0.7	1.05	
(I_C = 50 mAdc, I_B = 0.25 mAdc)			0.6	0.85	
Base–Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.55	0.75	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_C = 0, f = 1.0 MHz)		C_{obo}	—	4.5	pF
Small–Signal Current Gain		h_{fe}			—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BCX70G		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 = 990Ω)		t_{off}	—	800	ns

EQUIVALENT SWITCHING TIME TEST CIRCUITS





*Total shunt capacitance of test jig and connectors

Figure 1. Turn–On Time **Figure 2. Turn–Off Time**

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

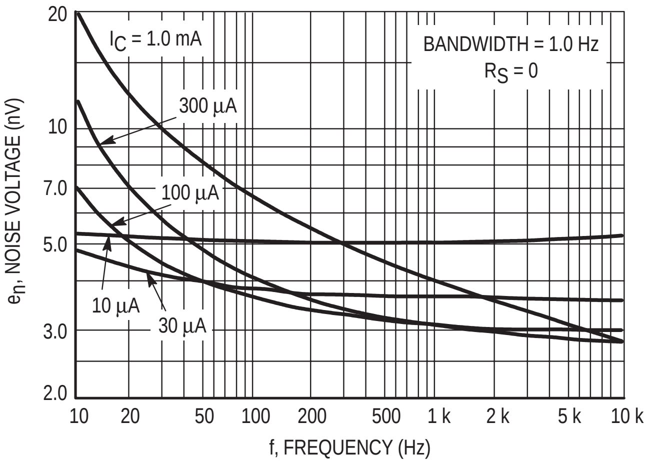


Figure 3. Noise Voltage

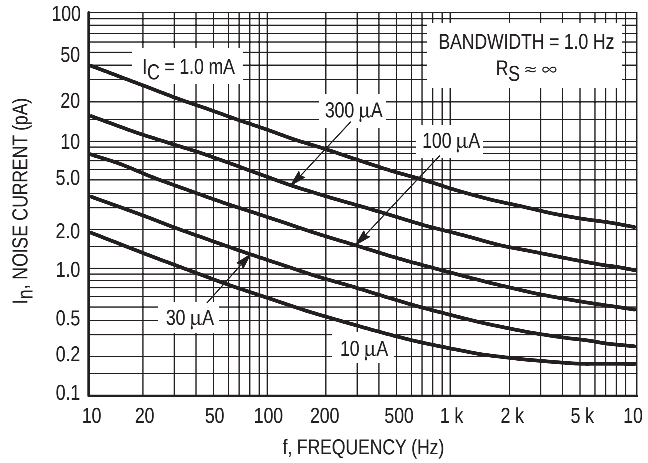


Figure 4. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

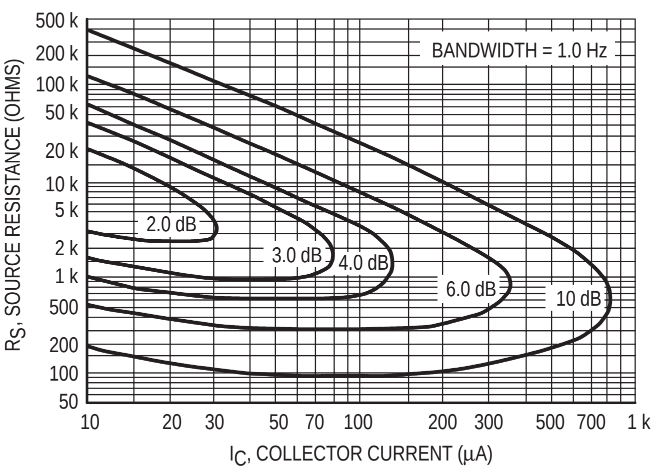


Figure 5. Narrow Band, 100 Hz

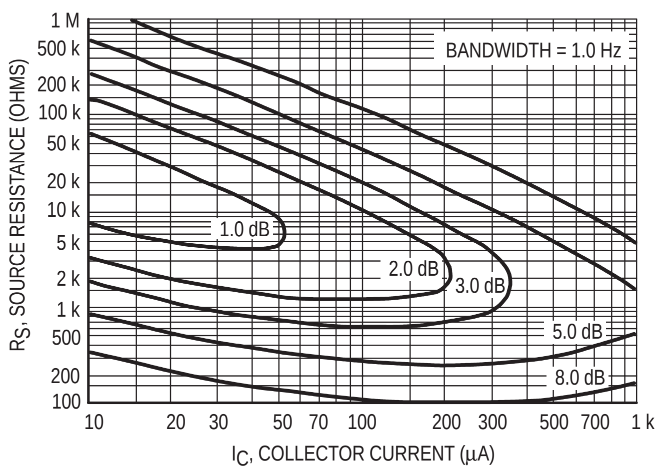


Figure 6. Narrow Band, 1.0 kHz

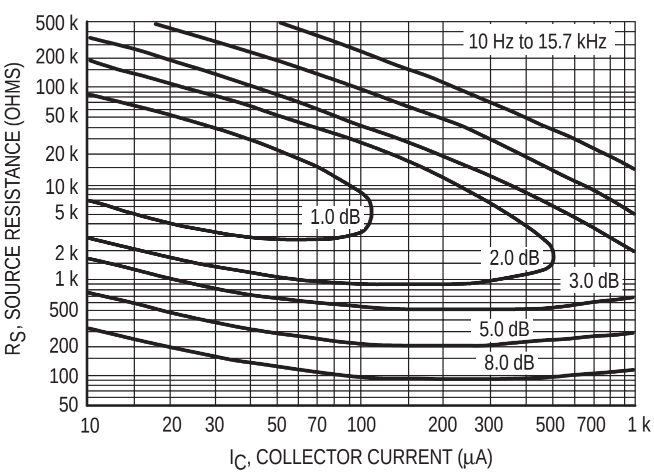


Figure 7. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

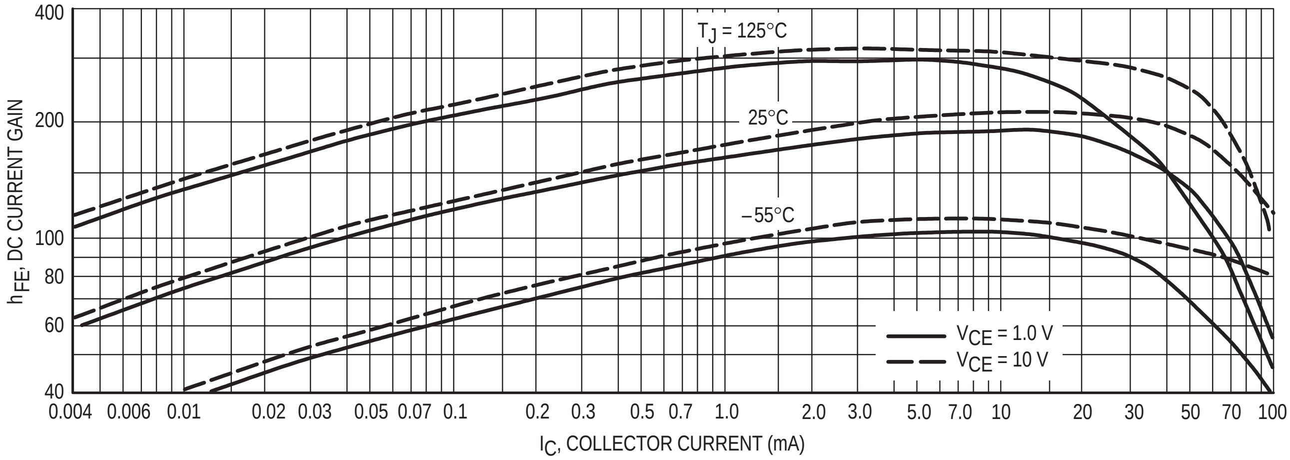


Figure 8. DC Current Gain

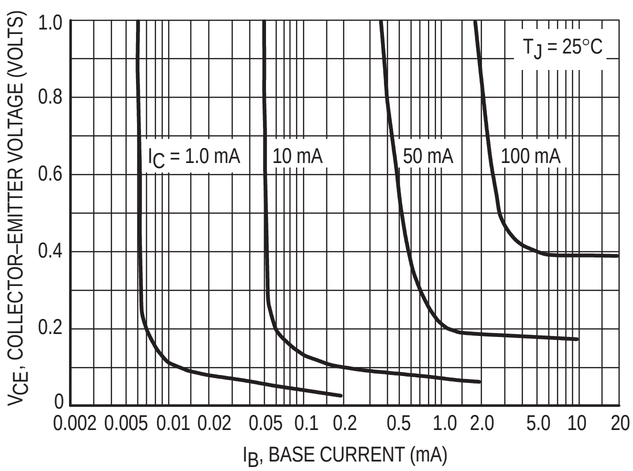


Figure 9. Collector Saturation Region

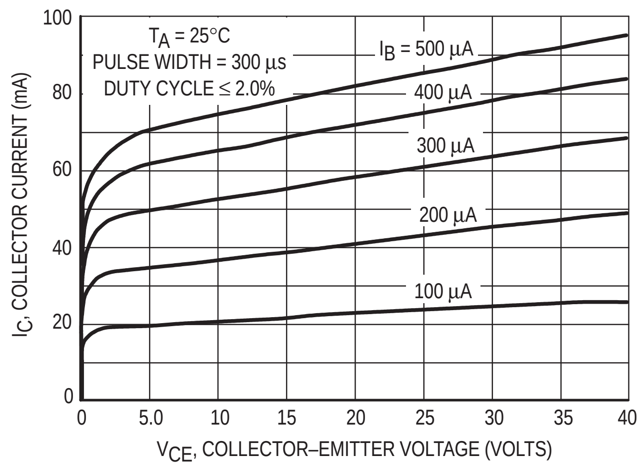


Figure 10. Collector Characteristics

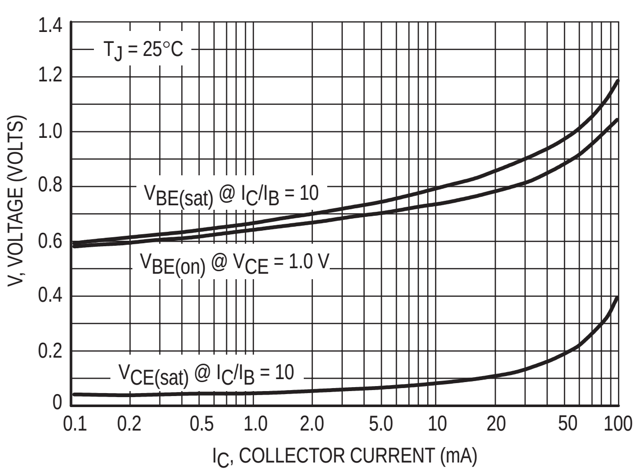


Figure 11. "On" Voltages

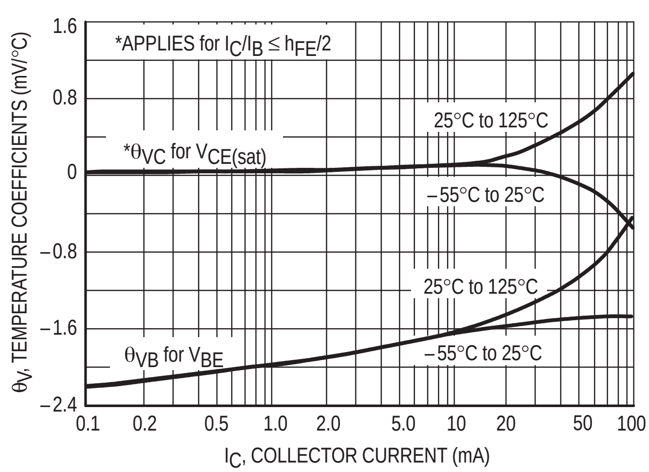


Figure 12. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

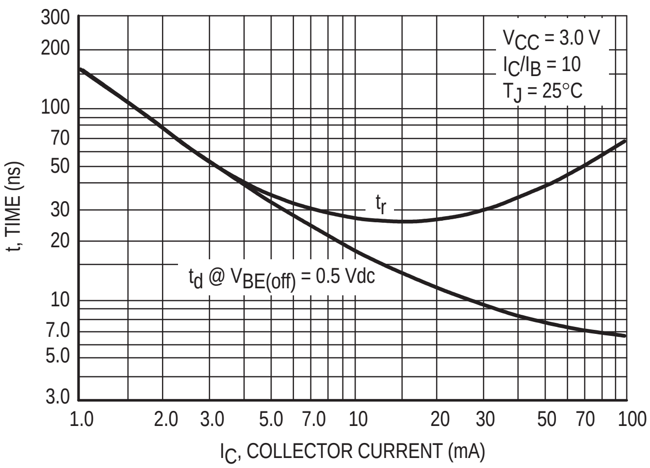


Figure 13. Turn–On Time

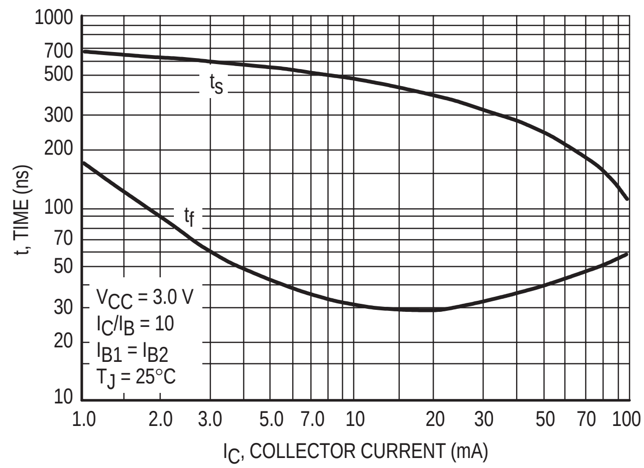


Figure 14. Turn–Off Time

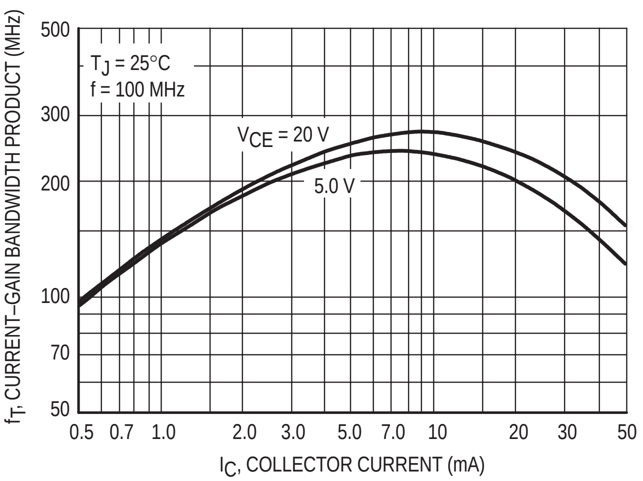


Figure 15. Current–Gain — Bandwidth Product

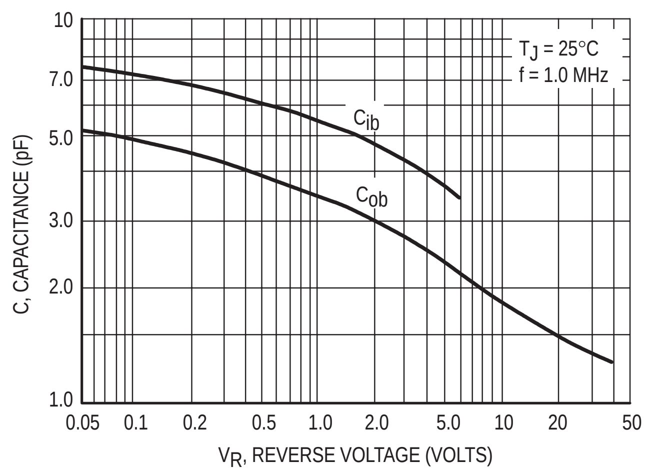


Figure 16. Capacitance

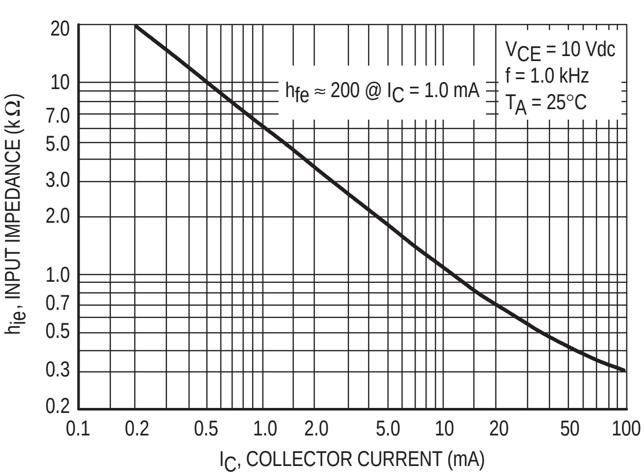


Figure 17. Input Impedance

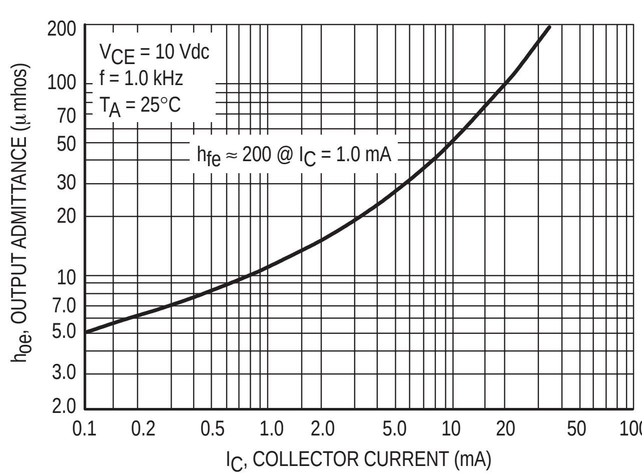


Figure 18. Output Admittance

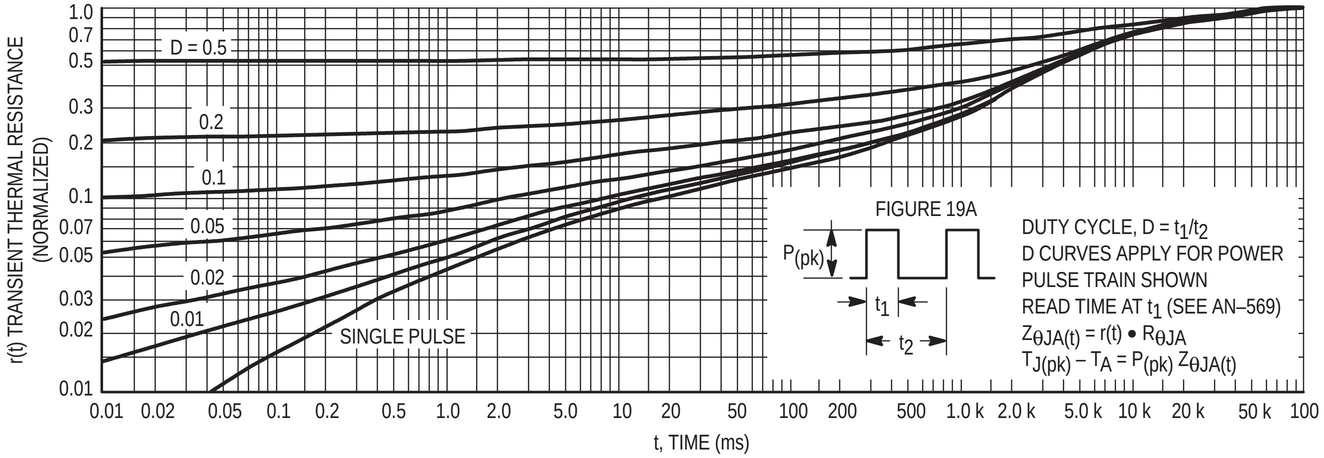


Figure 19. Thermal Response

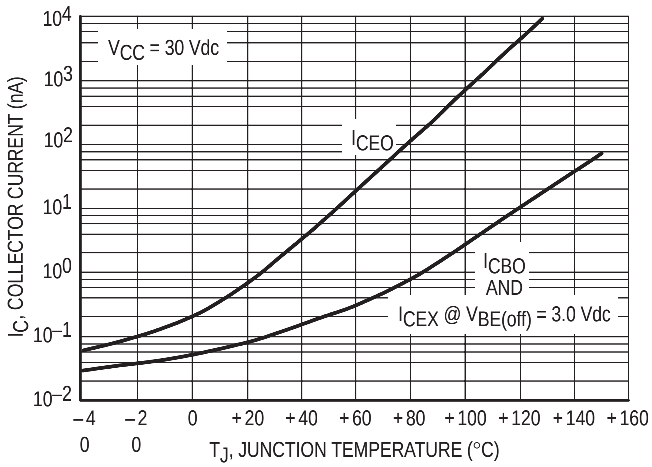


Figure 19A.

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.

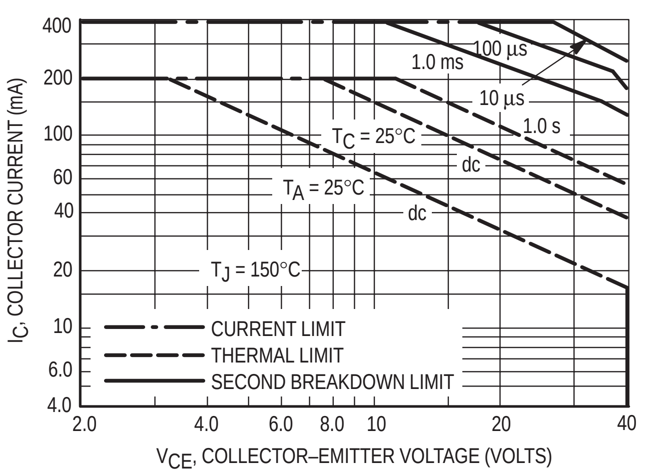


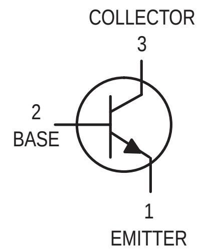
Figure 20.

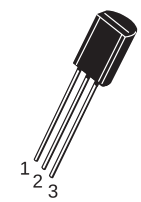
The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

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 $T_{J(pk)} \le 150°C$. $T_{J(pk)}$ 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.

One Watt Amplifier Transistor
NPN Silicon

BDB01C





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	80	Vdc
Collector–Base Voltage	V_{CES}	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	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)	$V_{(BR)CEO}$	80	—	Vdc
Collector Cutoff Current (V_{CB} = 80 V, I_E = 0)	I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (I_C = 0, V_{EB} = 5.0 V)	I_{EBO}	—	100	nAdc

REV 1

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

Characteristic	Symbol	Min	Max	Unit
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[1] (I_C = 1000 mA, I_B = 100 mA)	$V_{CE(sat)}$	—	0.7	Vdc
Collector–Emitter On Voltage[1] (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

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

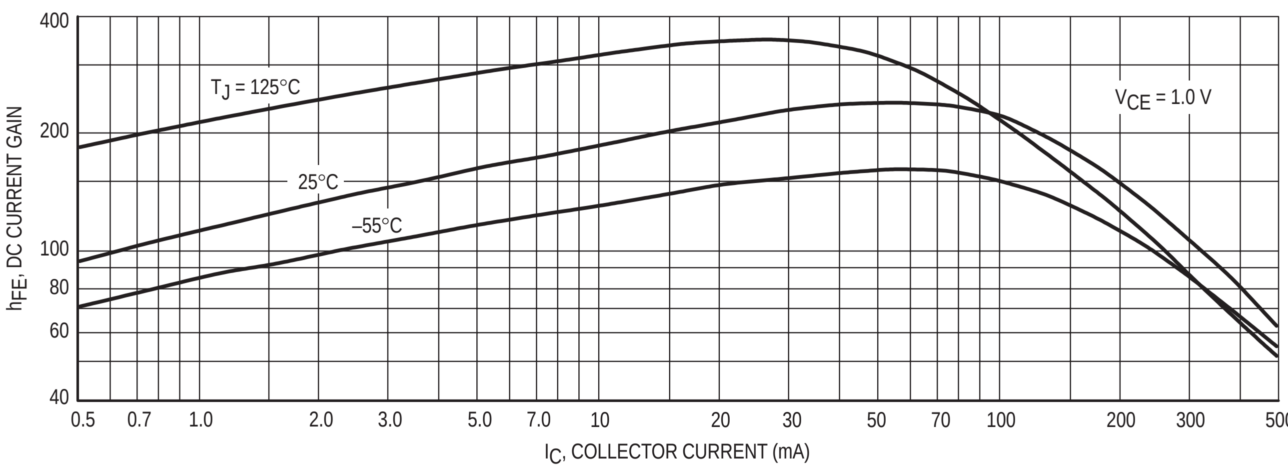


Figure 1. DC Current Gain

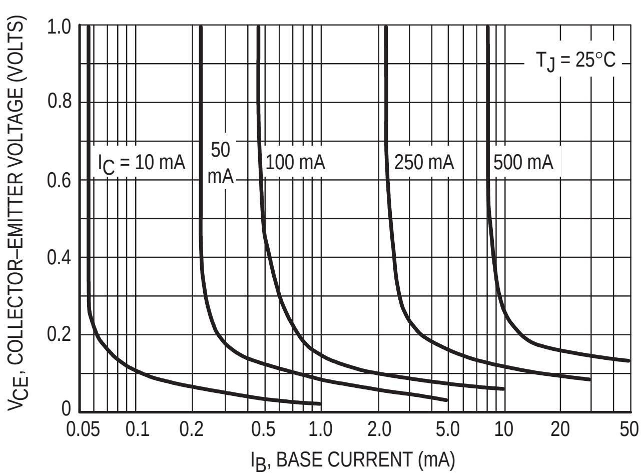


Figure 2. Collector Saturation Region

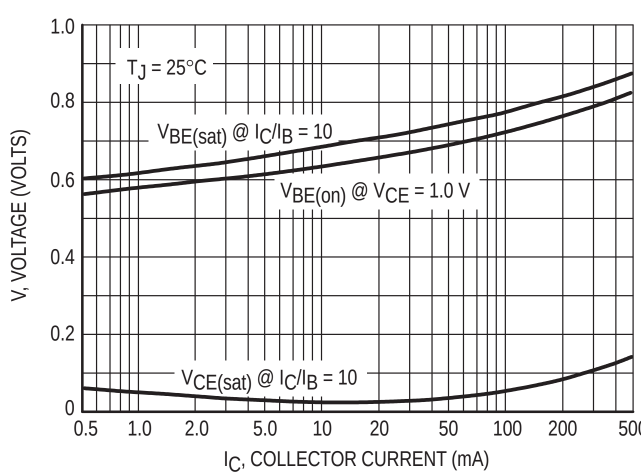


Figure 3. On Voltages

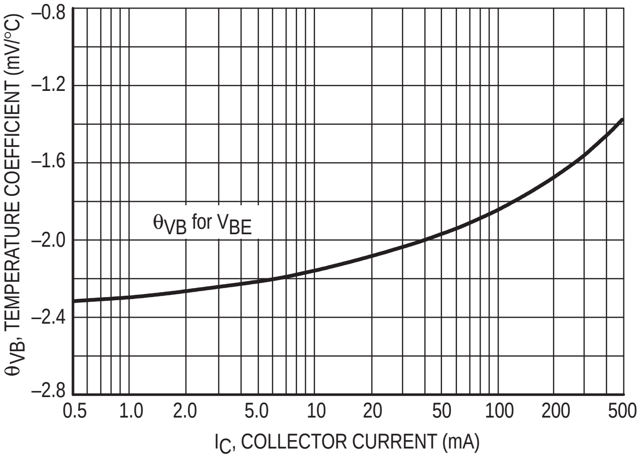


Figure 4. Base–Emitter Temperature Coefficient

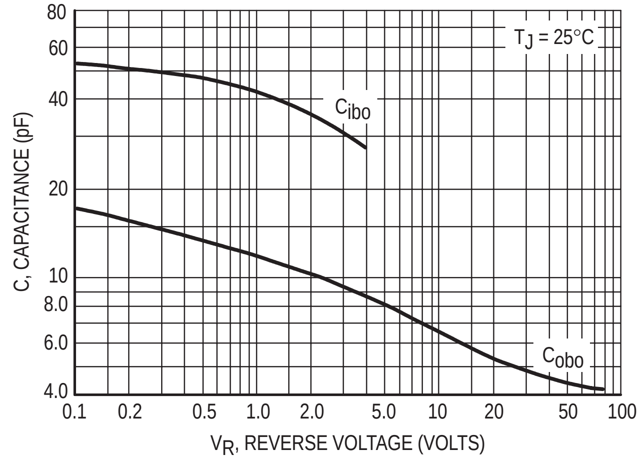


Figure 5. Capacitance

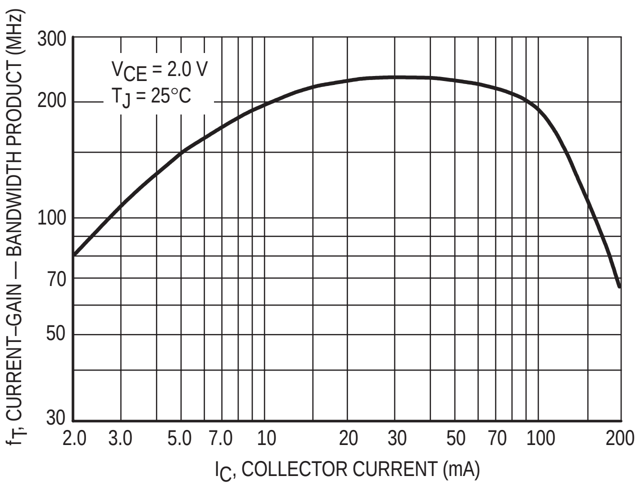


Figure 6. Current–Gain — Bandwidth Product

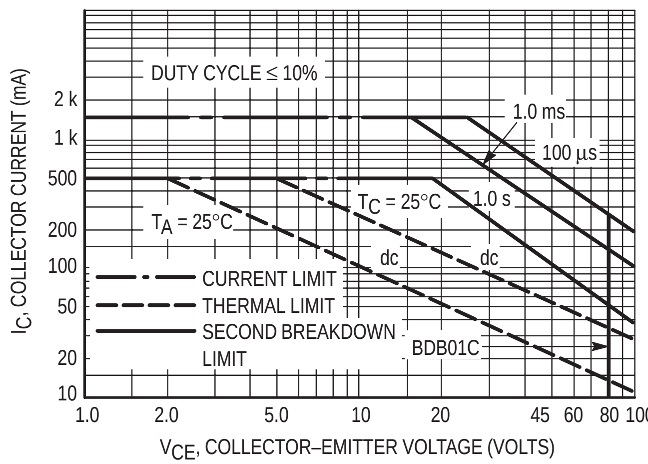
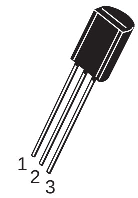


Figure 7. Active Region–Safe Operating Area

One Watt Amplifier Transistors

PNP Silicon

BDB02C



CASE 29–05, STYLE 1
TO–92 (TO–226AE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	–80	Vdc
Collector–Base Voltage	V_{CES}	–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	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)	$V_{(BR)CEO}$	–80	—	Vdc
Collector Cutoff Current (V_{CB} = –80 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(1) (I_C = –1000 mA, I_B = –100 mA)	$V_{CE(sat)}$	—	–0.7	Vdc
Collector–Emitter On Voltage(1) (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

1. Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle 2.0%.

REV 1

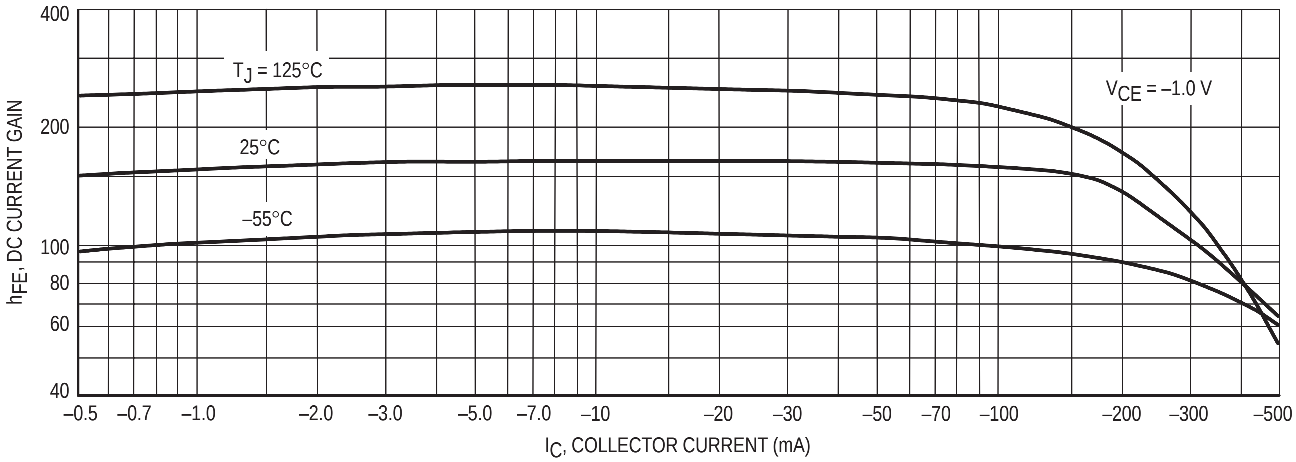


Figure 1. DC Current Gain

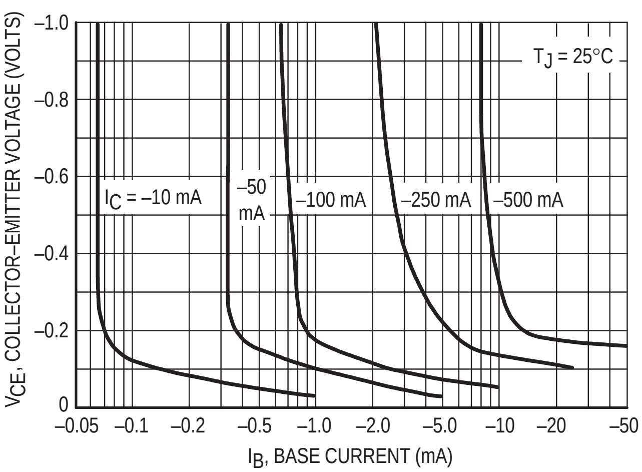


Figure 2. Collector Saturation Region

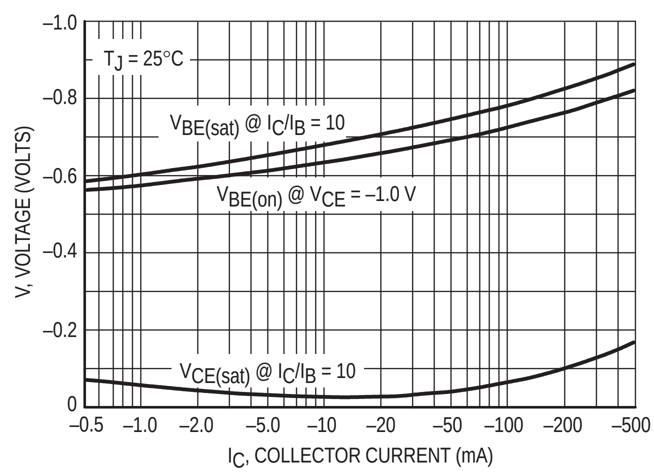


Figure 3. On Voltages

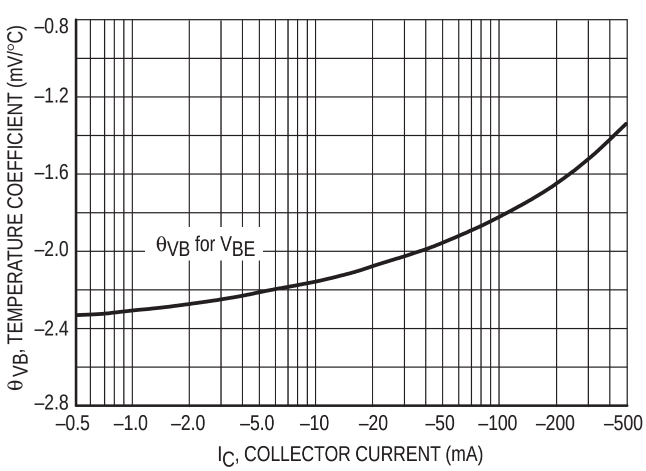


Figure 4. Base–Emitter Temperature Coefficient

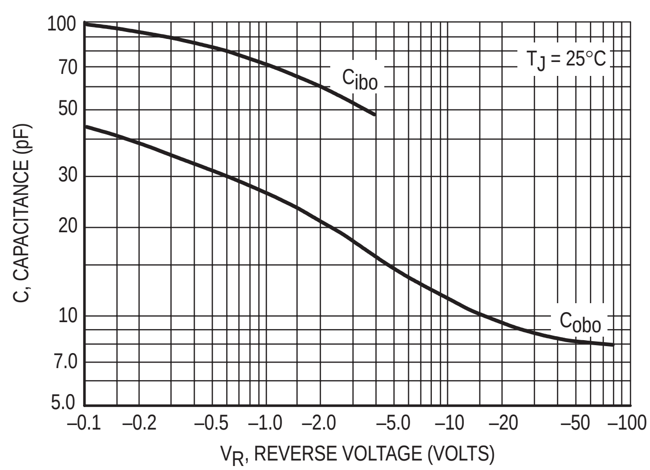


Figure 5. Capacitance

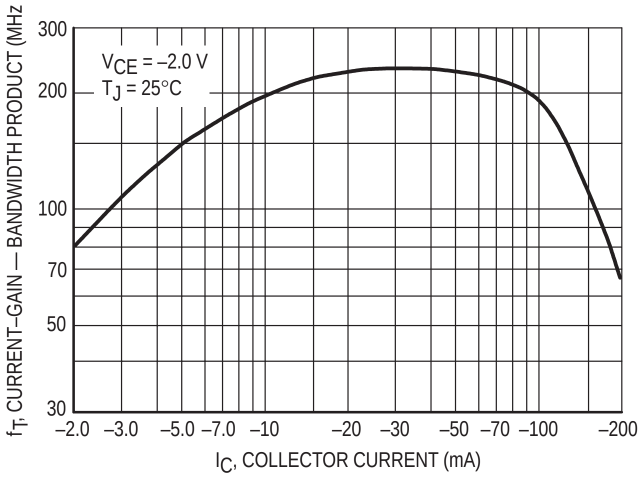


Figure 6. Current–Gain — Bandwidth Product

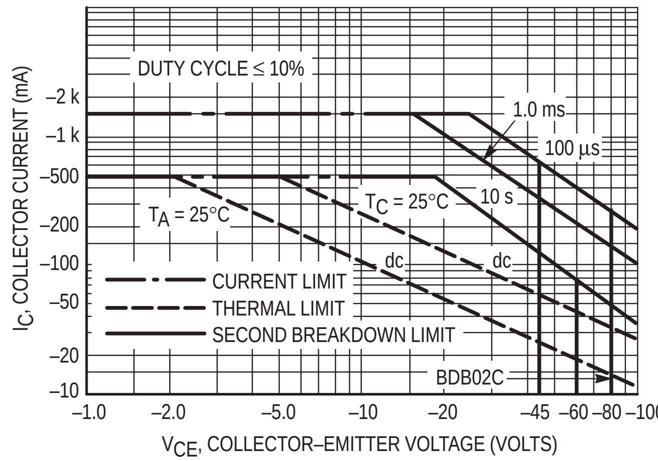
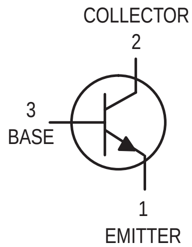
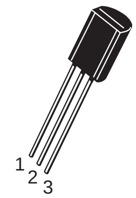


Figure 7. Active Region — Safe Operating Area

One Watt Amplifier Transistor
NPN Silicon

BDC01D





CASE 29–05, STYLE 14
TO–92 (TO–226AE)

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	Watts 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 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

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

Characteristic	Symbol	Min	Max	Unit
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(1) (I_C = 1000 mA, I_B = 100 mA)	$V_{CE(sat)}$	—	0.7	Vdc
Collector–Emitter On Voltage(1) (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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle 2.0%.

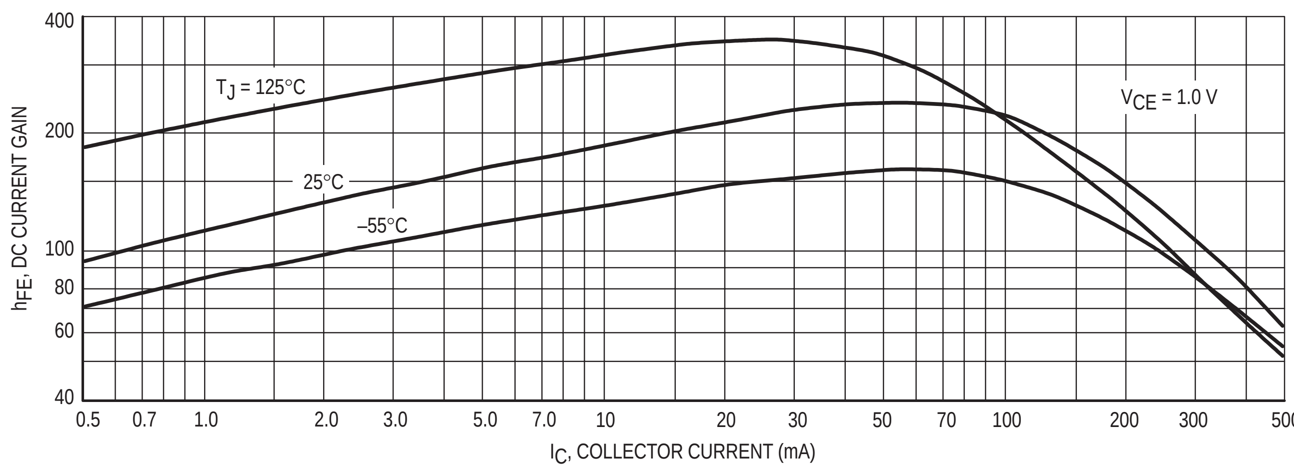


Figure 1. DC Current Gain

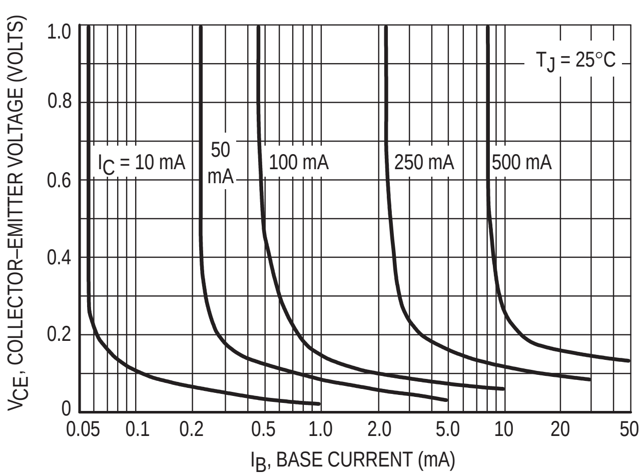


Figure 2. Collector Saturation Region

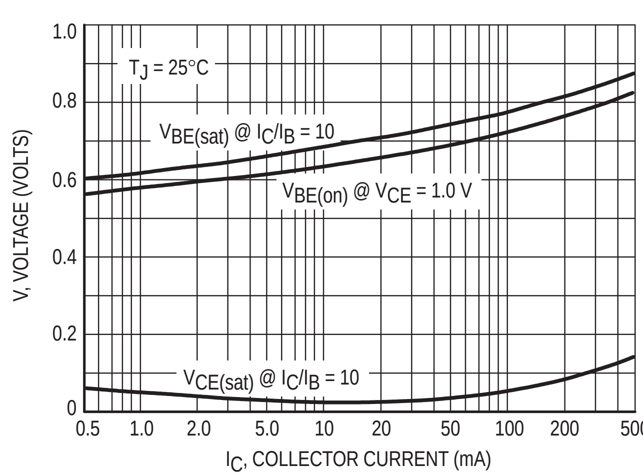


Figure 3. "On" Voltages

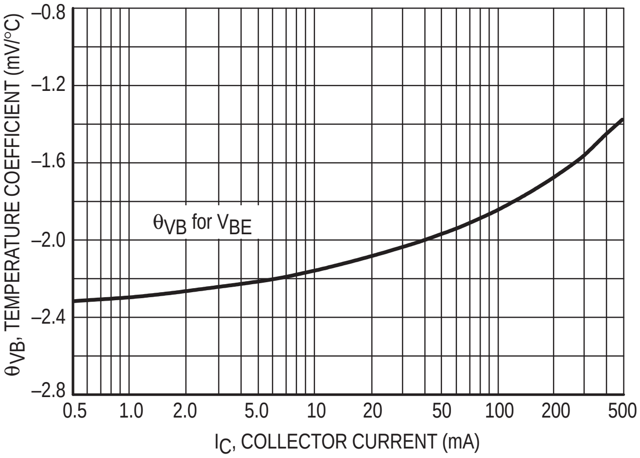


Figure 4. Base–Emitter Temperature Coefficient

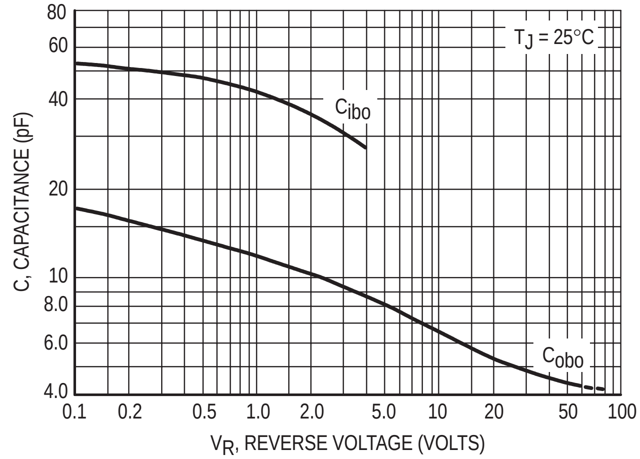


Figure 5. Capacitance

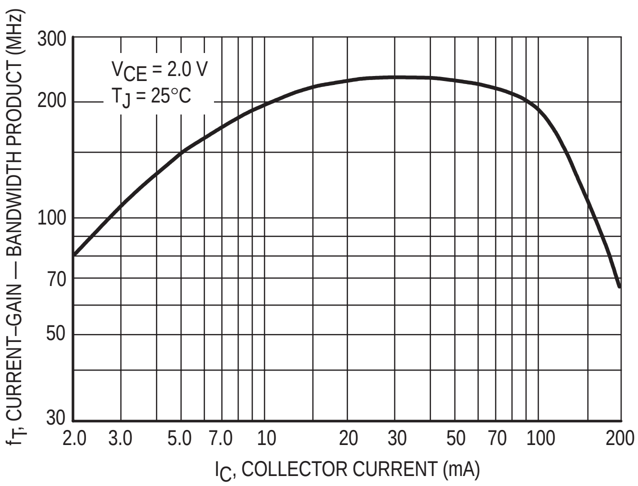


Figure 6. Current–Gain — Bandwidth Product

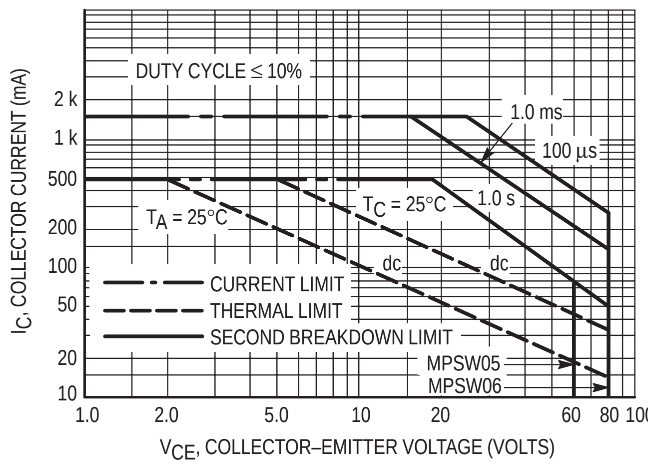
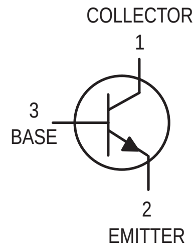
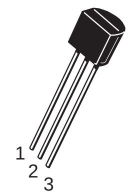


Figure 7. Active Region — Safe Operating Area

RF Transistor
NPN Silicon



BF199



CASE 29–04, STYLE 21
TO–92 (TO–226AA)

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	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)	$V_{(BR)CEO}$	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)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 7.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	85	—	—
Base–Emitter On Voltage (I_C = 7.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	770	900	mVdc
SMALL–SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product (I_C = 5.0 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 = 4.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 Ω, f = 35 MHz)	N_f	—	2.5	—	dB

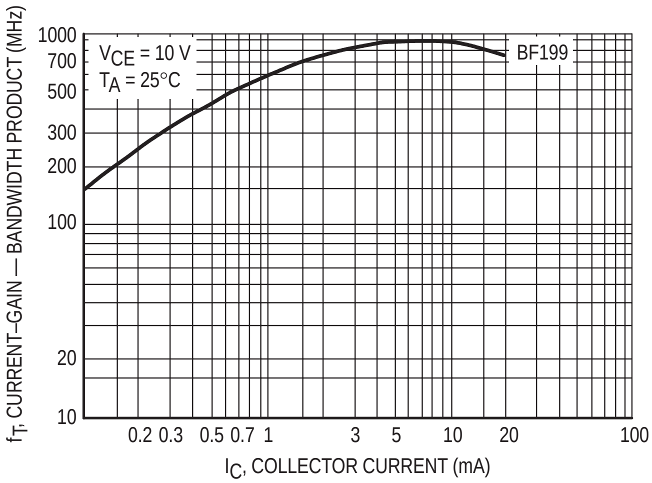


Figure 1. Current–Gain — Bandwidth Product

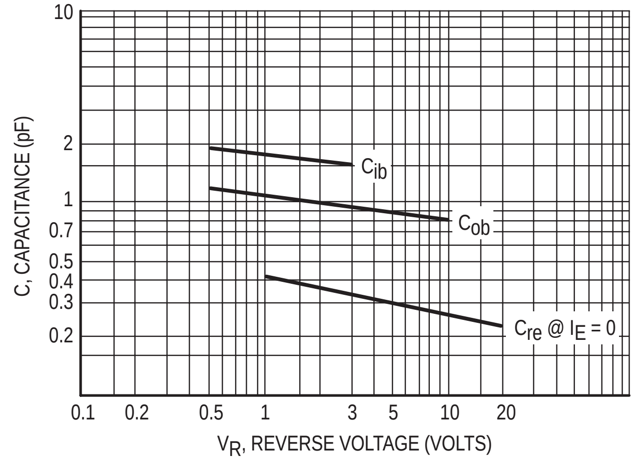


Figure 2. Capacitances

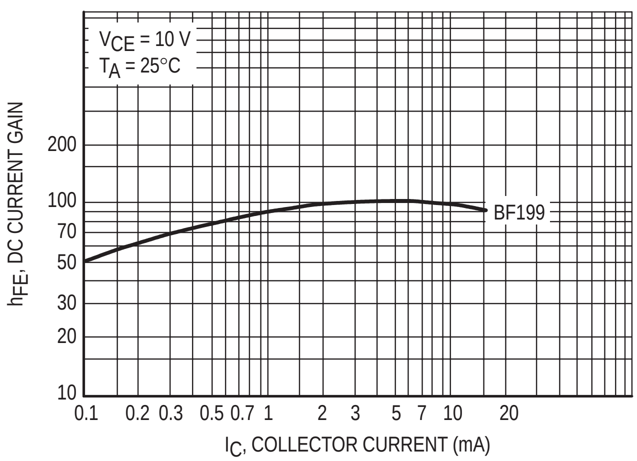


Figure 3. DC Current Gain

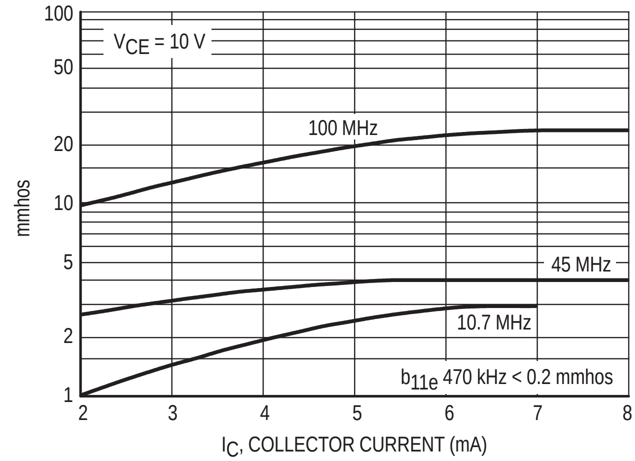


Figure 4. b11e

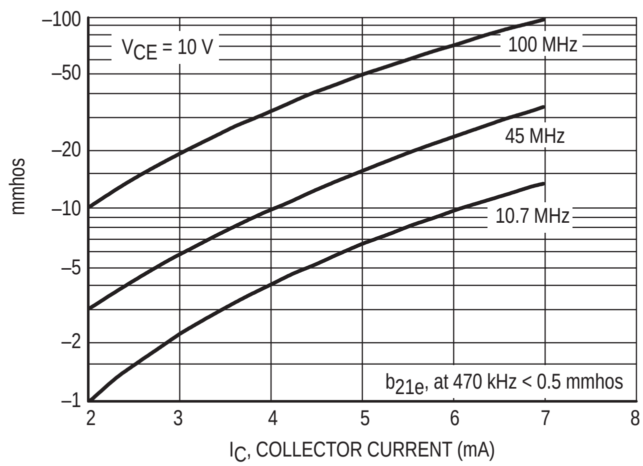


Figure 5. b21e

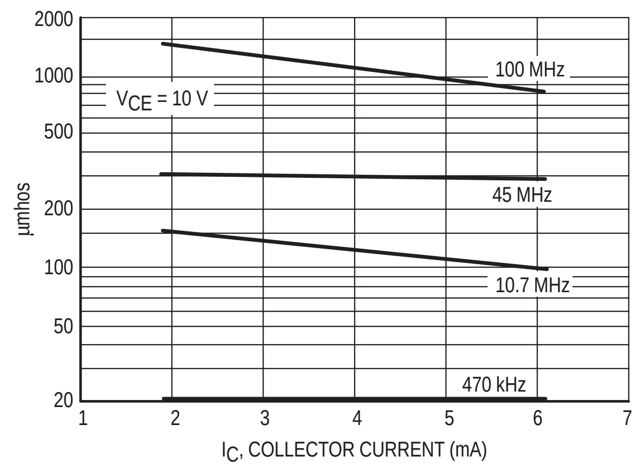


Figure 6. b22e (boe)

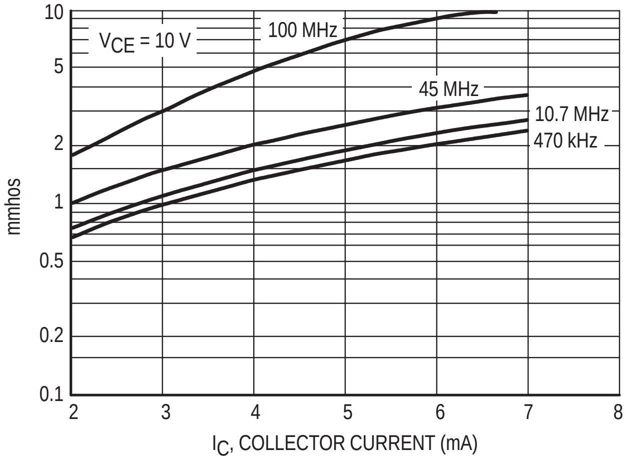


Figure 7. g11e (gie)

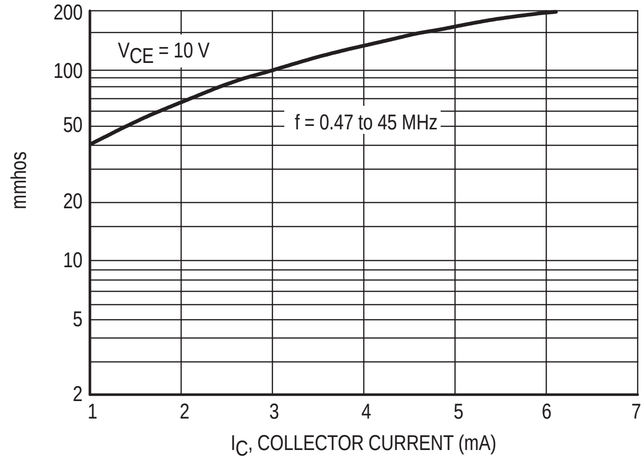


Figure 8. g21e (Yfe)

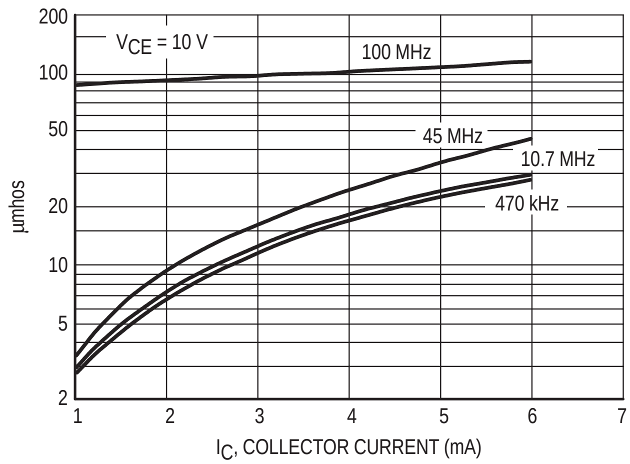
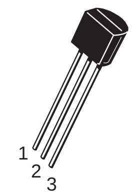


Figure 9. g22e (goe)

RF Transistor

NPN Silicon

BF224



CASE 29–04, STYLE 21
TO–92 (TO–226AA)

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	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)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 7.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	—	—
Base–Emitter On Voltage (I_C = 7.0 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 = 7.0 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 = 1.0 MHz)	C_{re}	—	0.28	—	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 Ω, f = 100 MHz) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 Ω, f = 200 MHz)	N_f	 — —	 2.5 3.5	 — —	dB

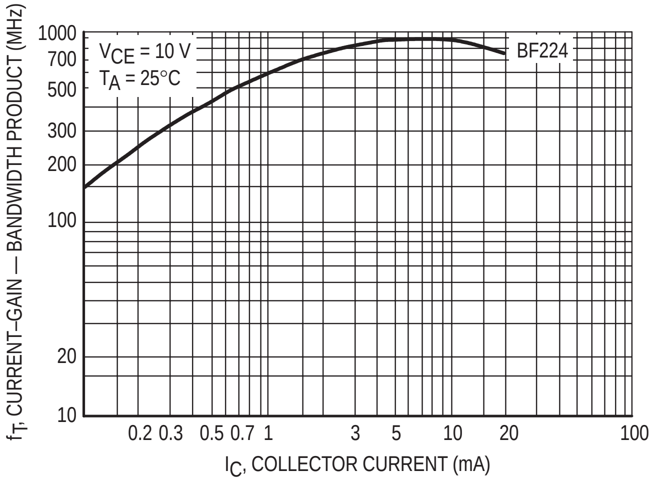


Figure 1. Current–Gain — Bandwidth Product

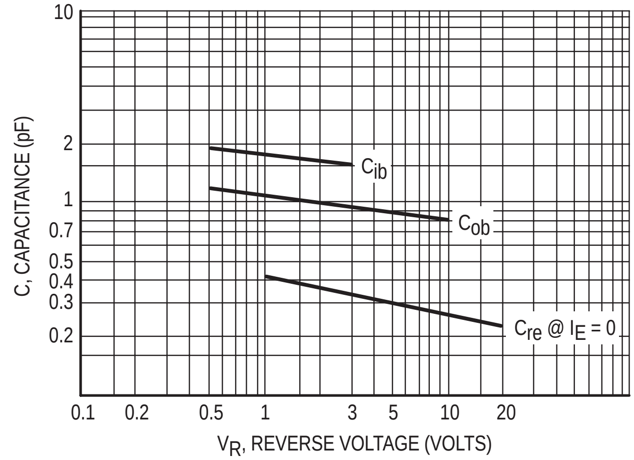


Figure 2. Capacitances

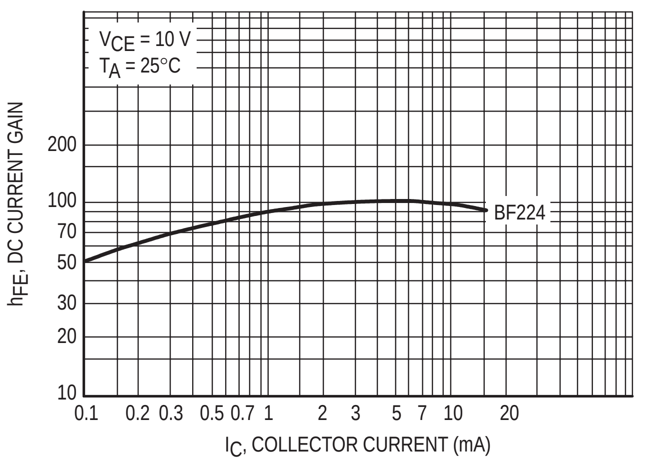


Figure 3. DC Current Gain

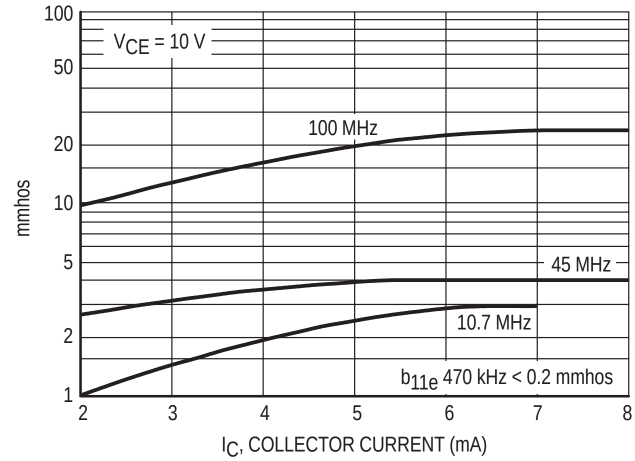


Figure 4. b11e

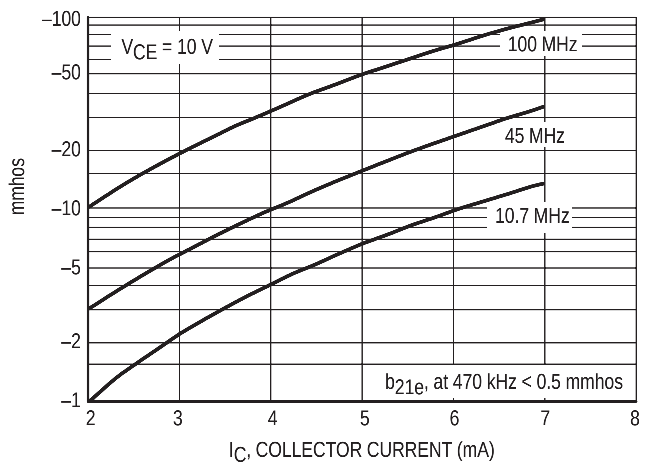


Figure 5. b21e

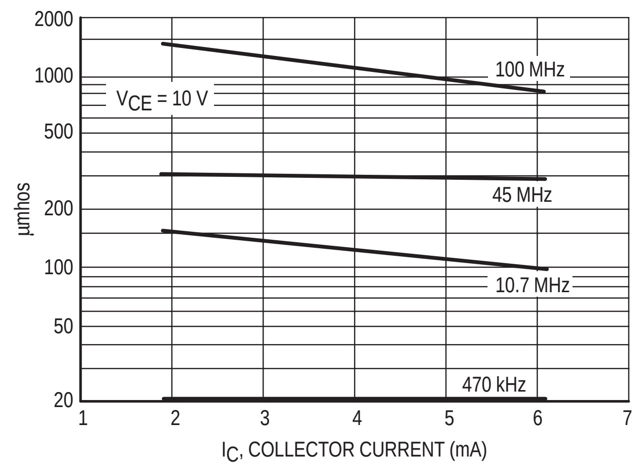


Figure 6. b22e (boe)

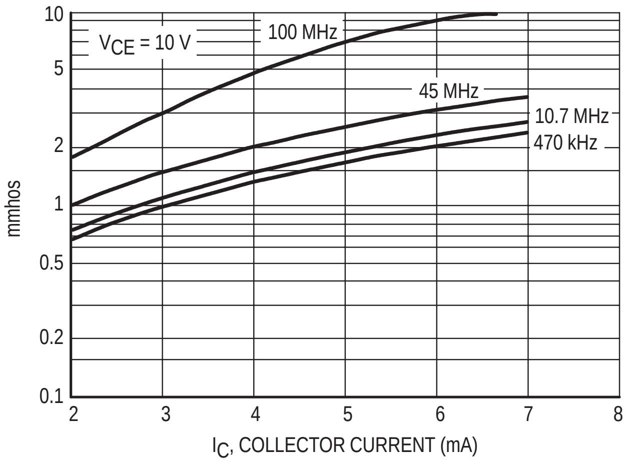


Figure 7. g11e (gie)

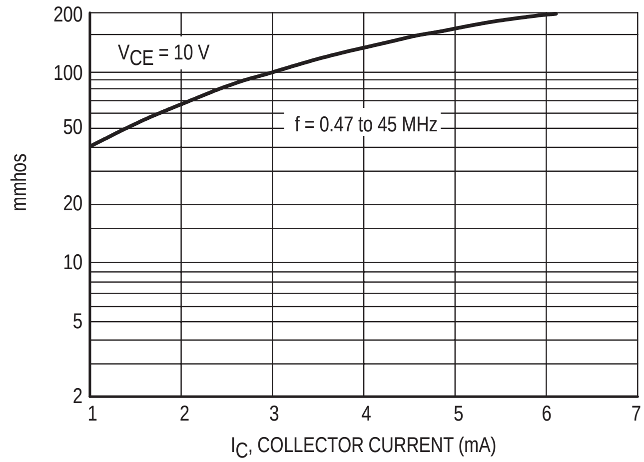


Figure 8. g21e (Yfe)

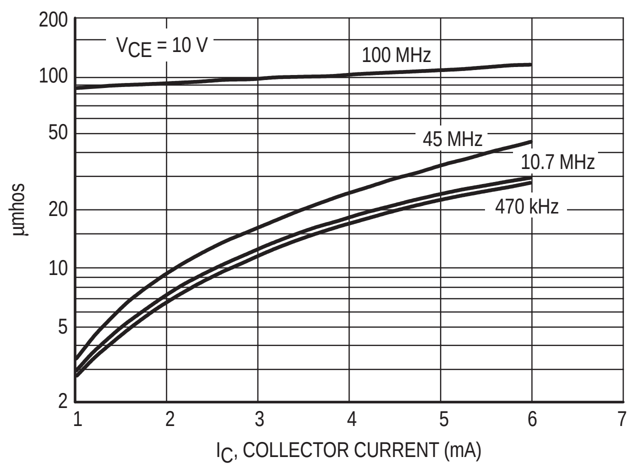
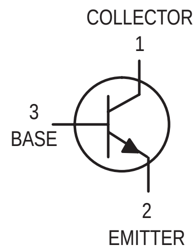
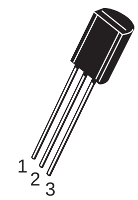


Figure 9. g22e (goe)

AM/FM Transistor
NPN Silicon

BF240





CASE 29–04, STYLE 21
TO–92 (TO–226AA)

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 = 1.0 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} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 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	0.7	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%.

REV 1

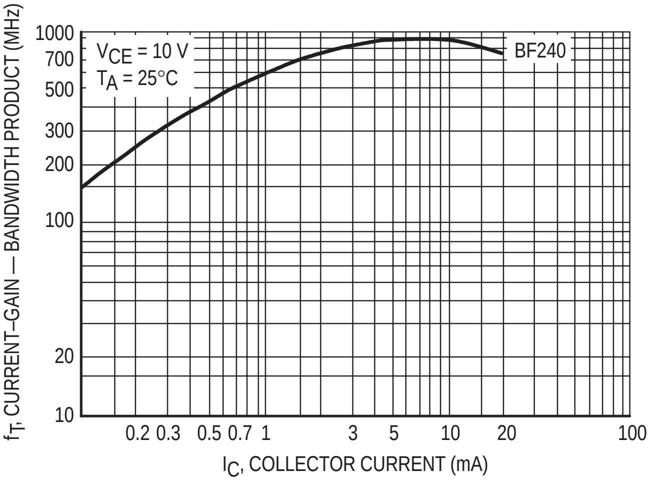


Figure 1. Current–Gain — Bandwidth Product

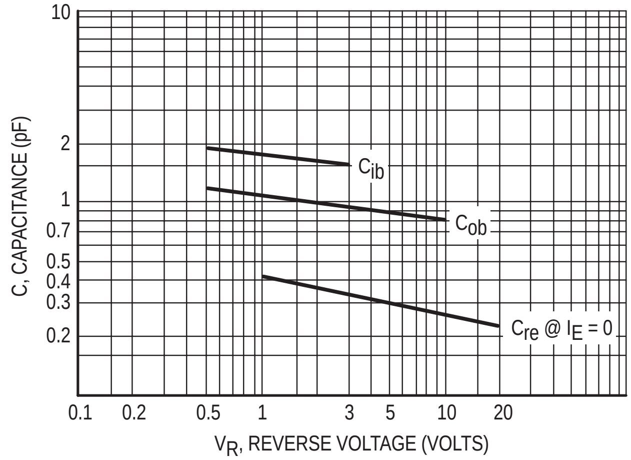


Figure 2. Capacitances

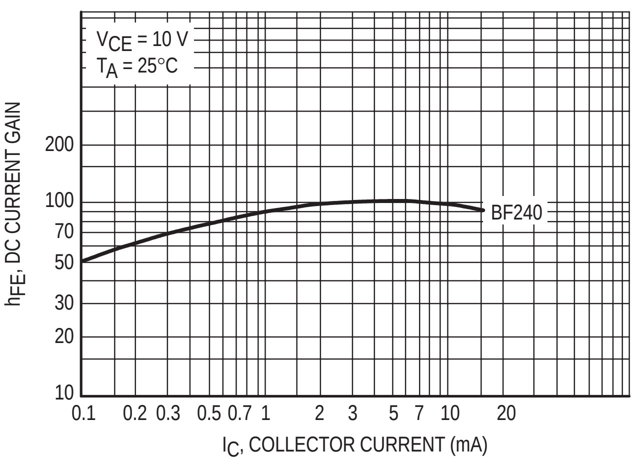


Figure 3. DC Current Gain

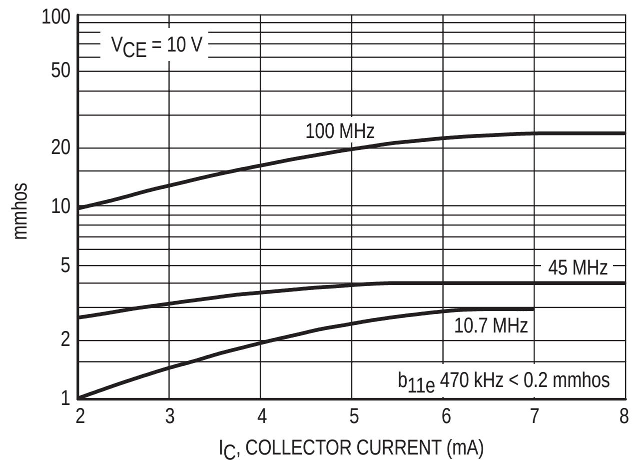


Figure 4. b11e

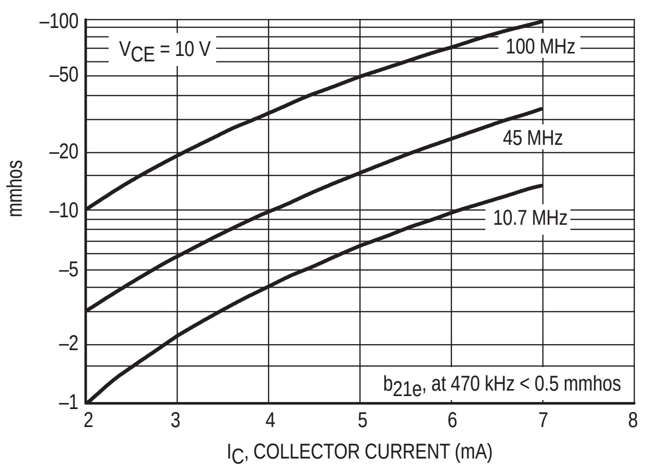


Figure 5. b21e

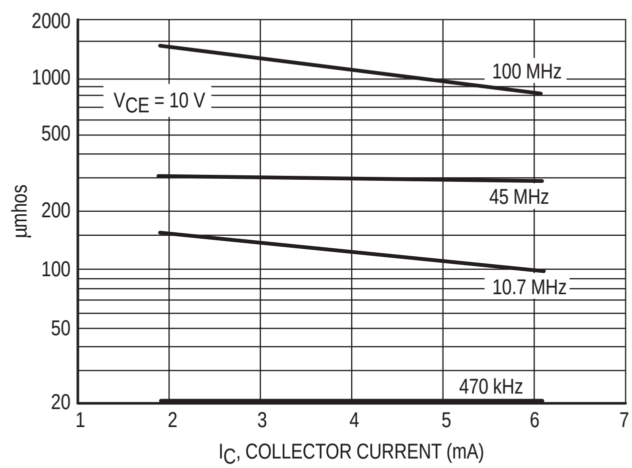


Figure 6. b22e (boe)

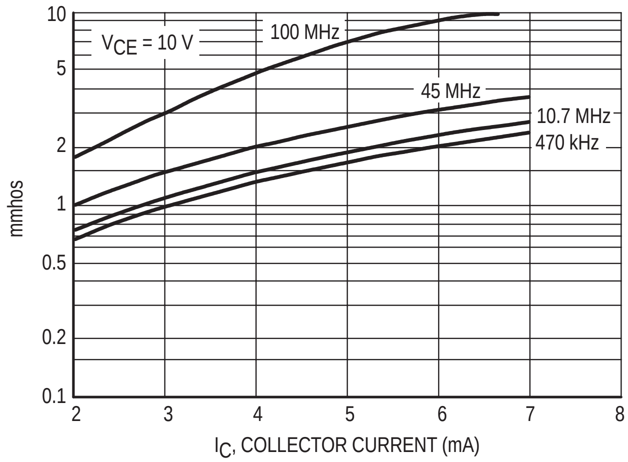


Figure 7. g11e (gie)

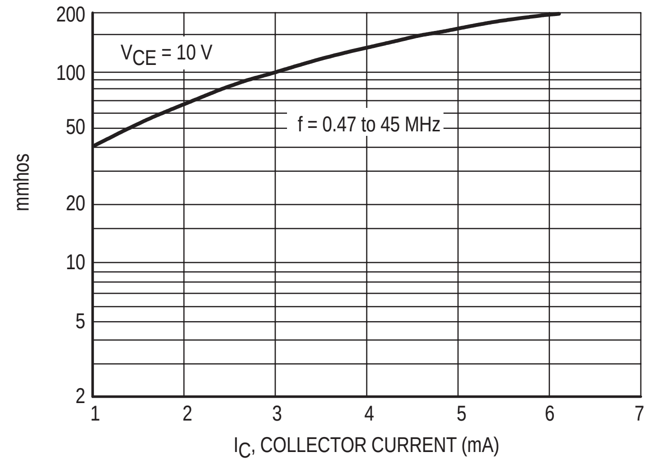


Figure 8. g21e (Yfe)

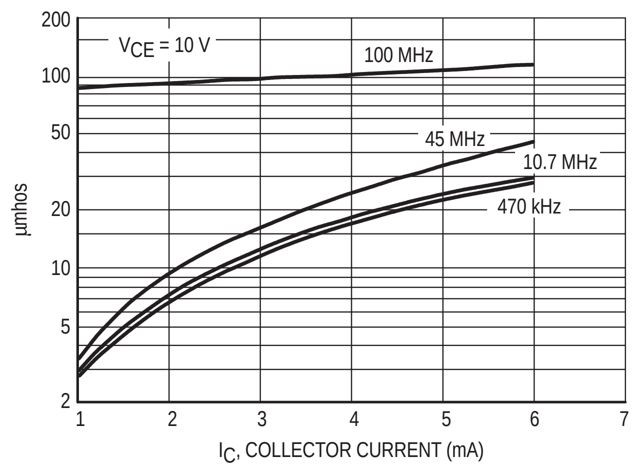
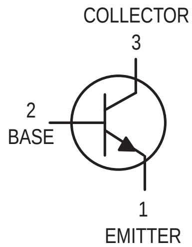
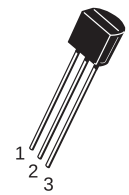


Figure 9. g22e (goe)

High Voltage Transistor
NPN Silicon



BF393



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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	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)	$V_{(BR)CEO}$	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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

(Replaces BF392/D)

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

Characteristic	Symbol	Min	Max	Unit
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	—	
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 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	—	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

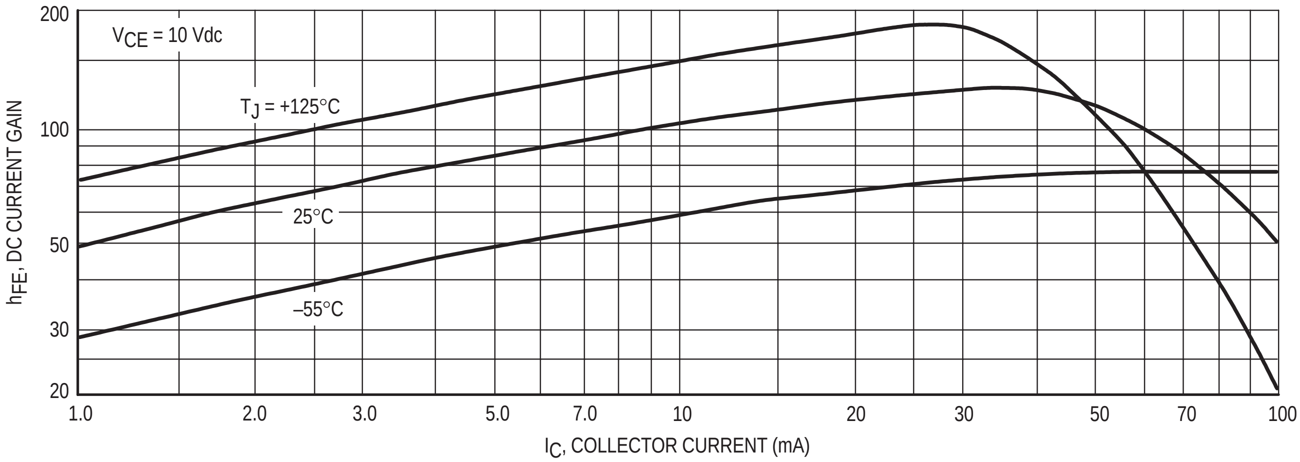


Figure 1. DC Current Gain

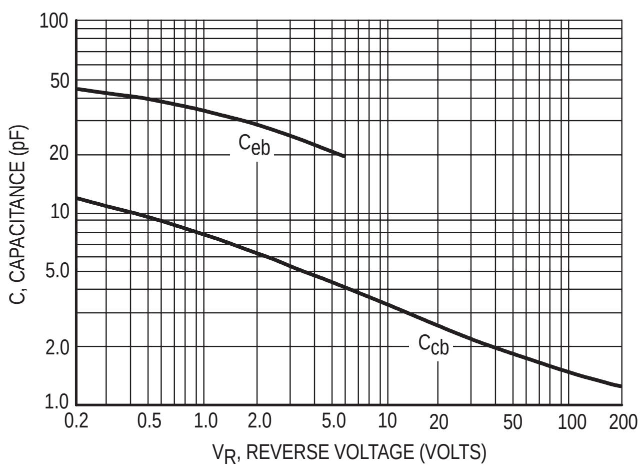


Figure 2. Capacitances

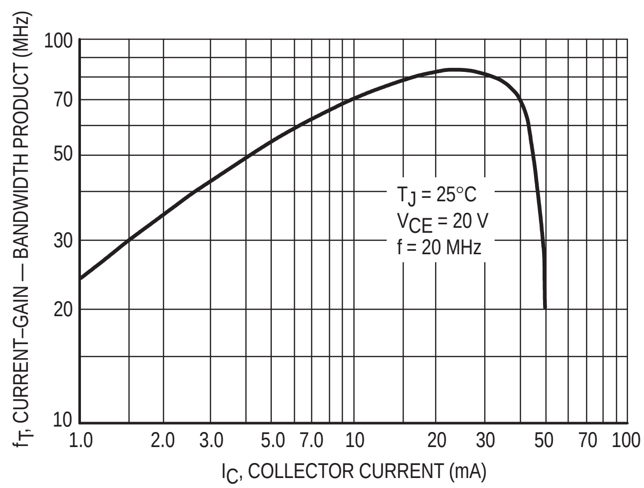


Figure 3. Current–Gain — Bandwidth Product

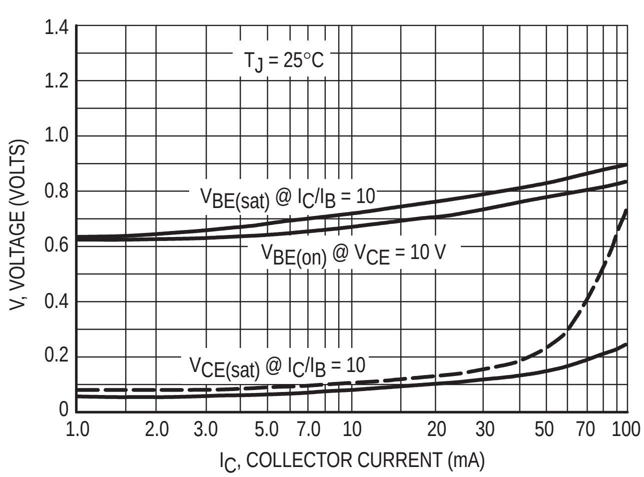


Figure 4. “On” Voltages

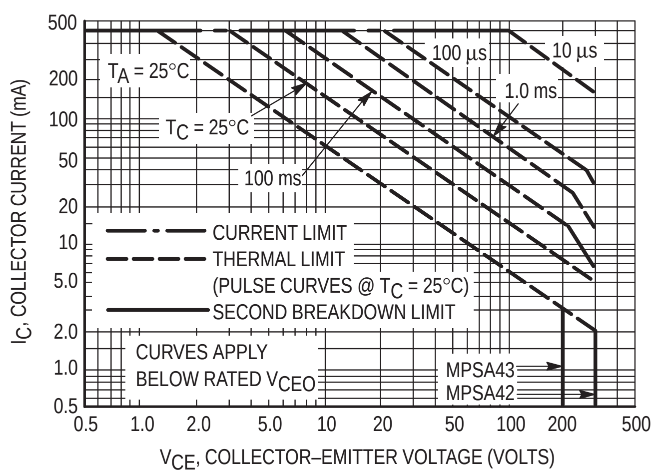
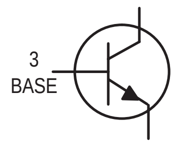
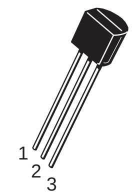


Figure 5. Maximum Forward Bias Safe Operating Area

High Voltage Transistors
NPN Silicon



BF420
BF422



CASE 29–04, STYLE 14
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BF420	BF422	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		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)	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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 25 mAdc, V_{CE} = 20 Vdc)	BF420		50	—	
	BF422		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 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	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

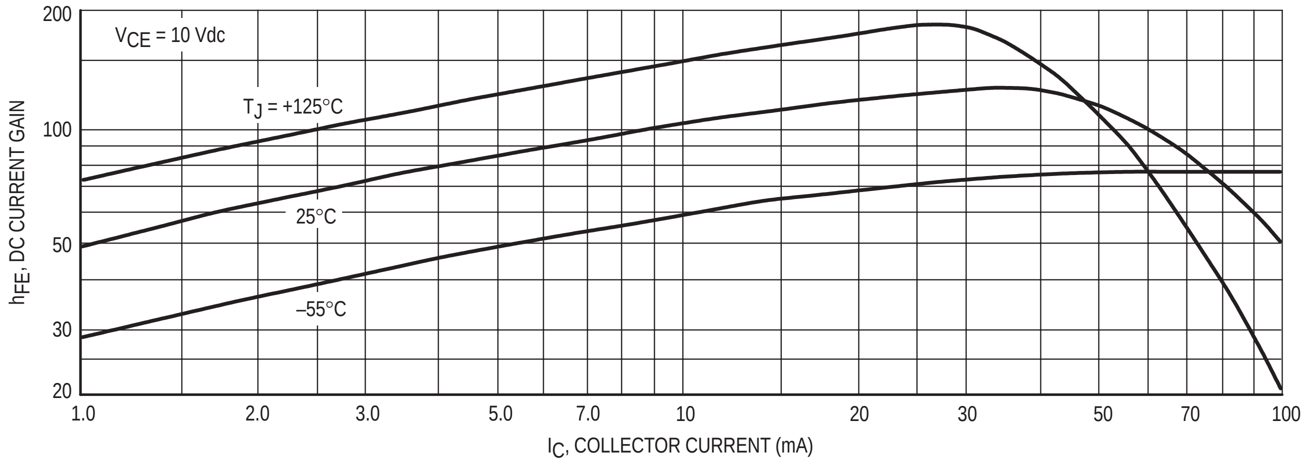


Figure 1. DC Current Gain

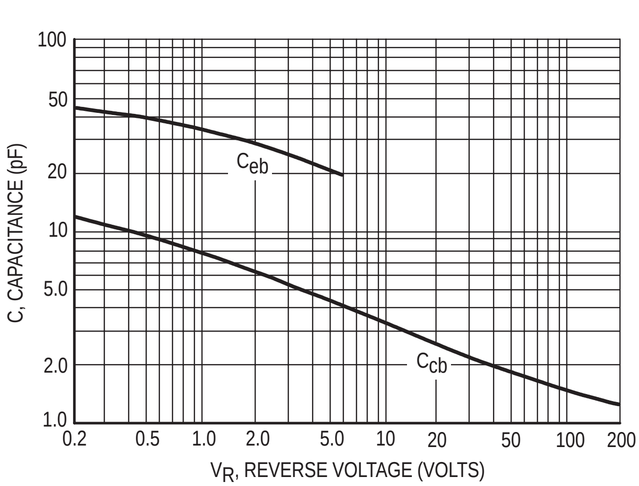


Figure 2. Capacitances

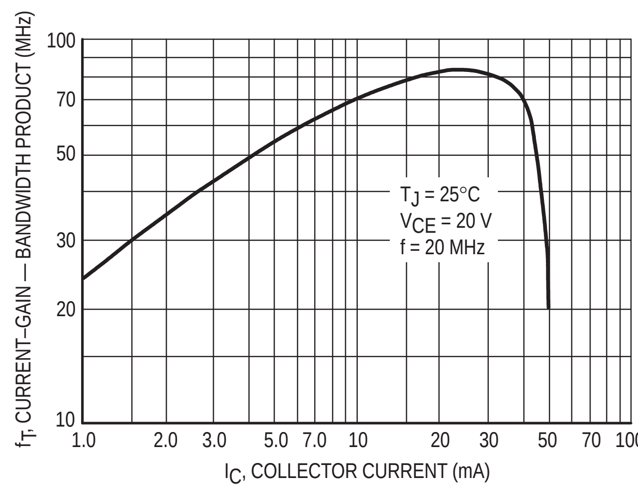


Figure 3. Current–Gain — Bandwidth Product

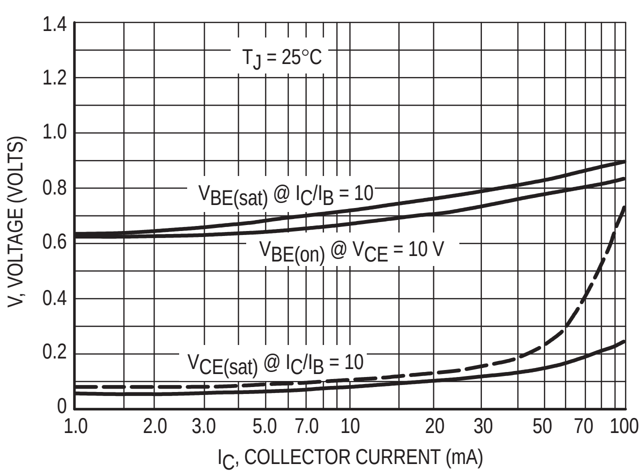


Figure 4. "On" Voltages

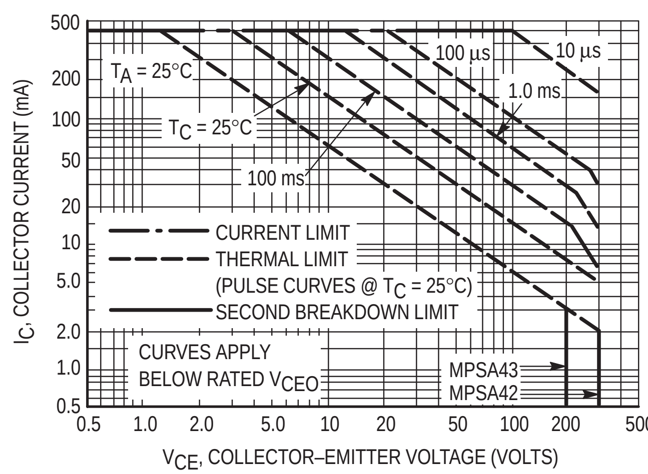
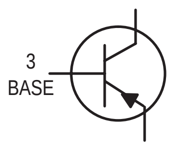


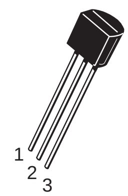
Figure 5. Maximum Forward Bias Safe Operating Area

High Voltage Transistors

PNP Silicon

BF421
BF423





CASE 29–04, STYLE 14
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BF421	BF423	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		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)	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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = –25 mA, V_{CE} = –20 Vdc)	BF421	h_{FE}	50	—	—
	BF423		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

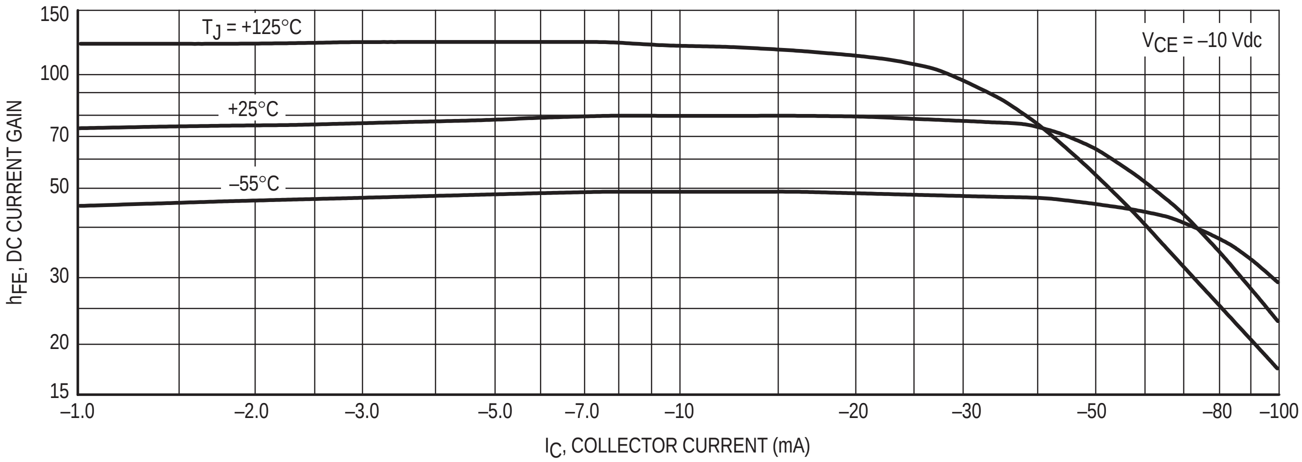


Figure 1. DC Current Gain

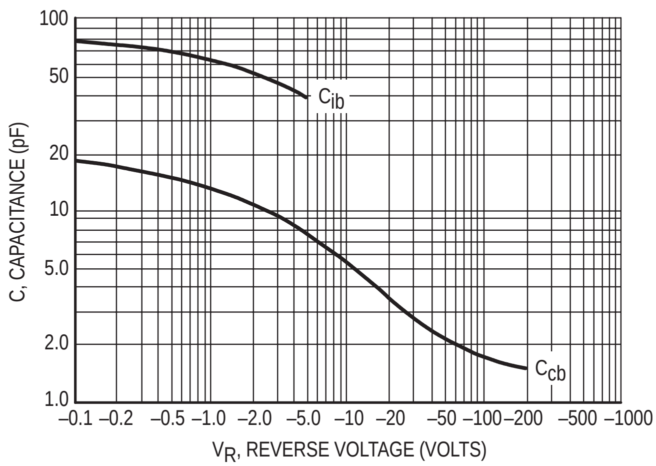


Figure 2. Capacitances

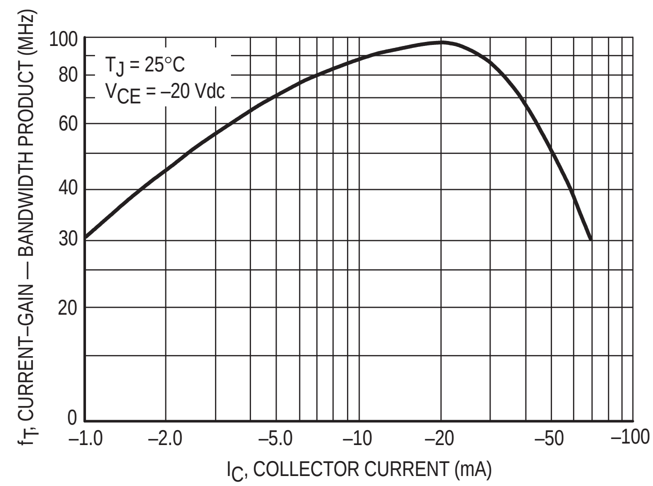


Figure 3. Current–Gain — Bandwidth Product

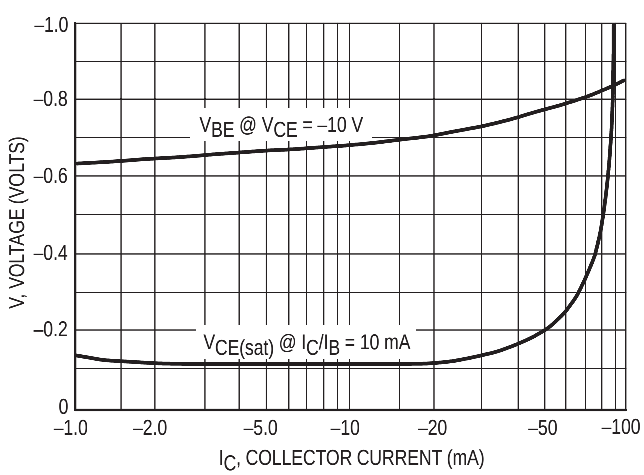


Figure 4. “On” Voltages

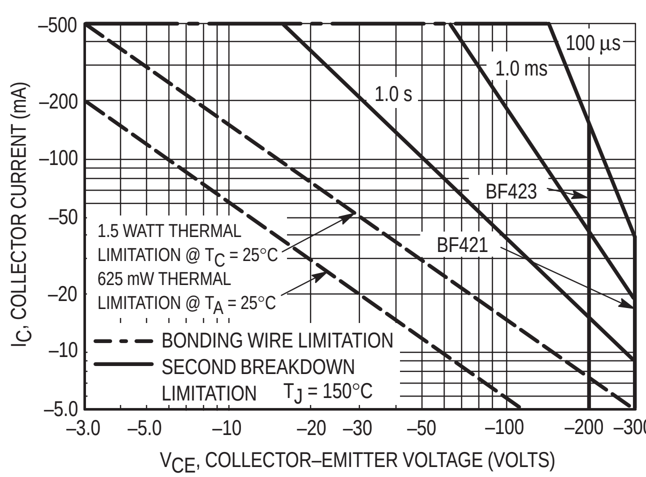
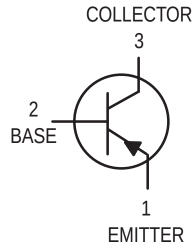
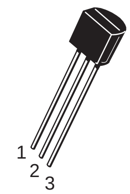


Figure 5. Active Region — Safe Operating Area

High Voltage Transistor
PNP Silicon

BF493S





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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	Watts 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)	$V_{(BR)CEO}$	–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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

Characteristic	Symbol	Min	Max	Unit
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

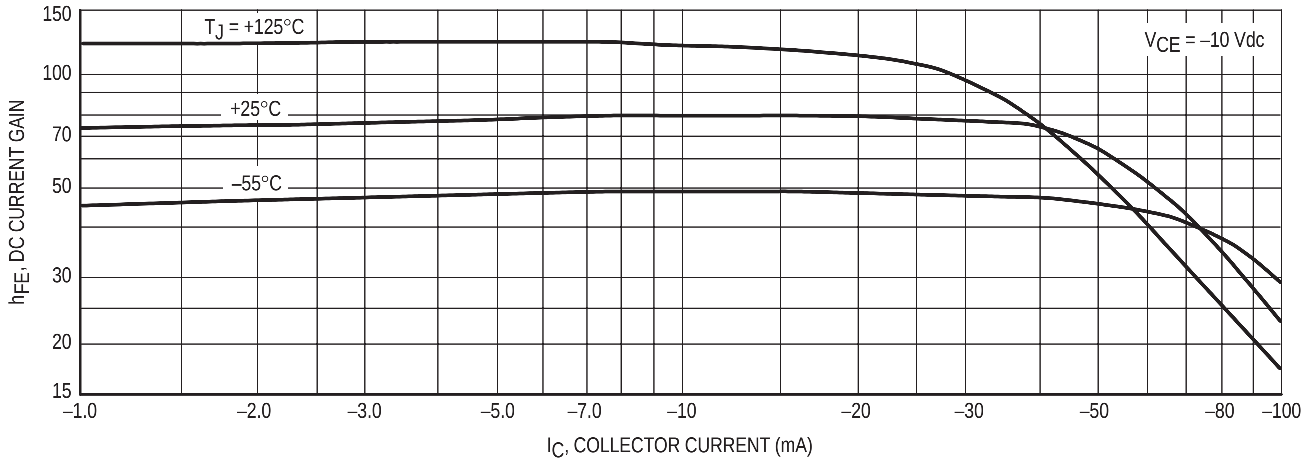


Figure 1. DC Current Gain

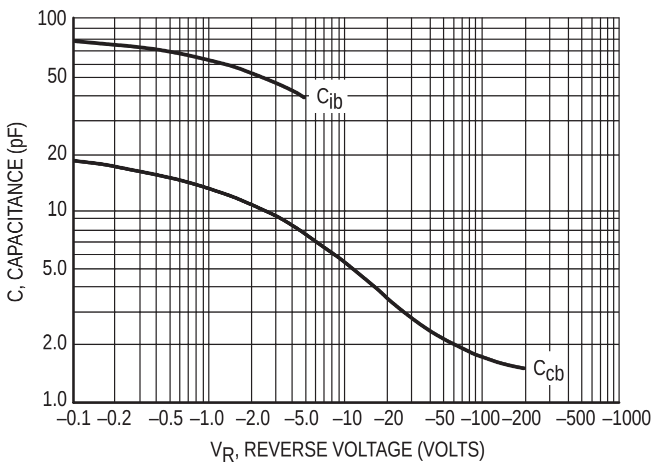


Figure 2. Capacitances

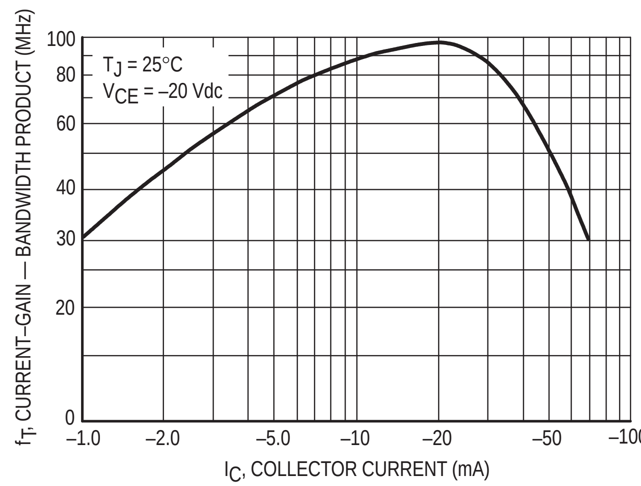


Figure 3. Current–Gain — Bandwidth Product

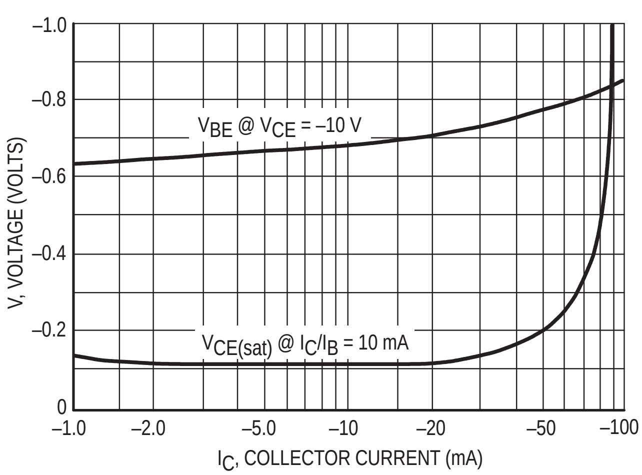


Figure 4. “On” Voltages

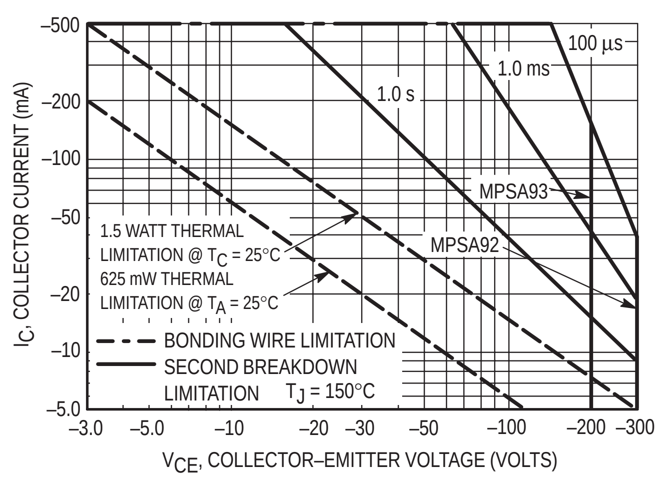
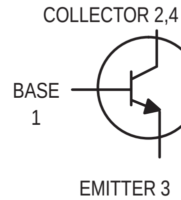


Figure 5. Active Region — Safe Operating Area

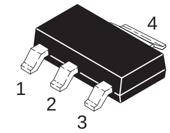
NPN Silicon Transistor



BF720T1

Motorola Preferred Device

NPN SILICON TRANSISTOR SURFACE MOUNT



CASE 318E-04, STYLE 1
SOT–223 (TO-261AA)

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

Characteristic	Symbol	Max	Unit
Thermal Resistance from Junction-to-Ambient(1)	$R_{\theta JA}$	83.3	°C/W

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

Characteristics	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

1. 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.

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

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

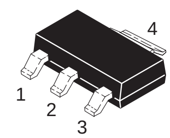
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain (I_C = 25 mAdc, V_{CE} = 20 Vdc)	h_{FE}	50	—	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	0.6	Vdc
DYNAMIC CHARACTERISTICS				
Current–Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 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

PNP Silicon Transistor

BF721T1

Motorola Preferred Device

PNP SILICON TRANSISTOR SURFACE MOUNT



CASE 318E-04, STYLE 1
SOT–223 (TO-261AA)

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(1)	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

Characteristic	Symbol	Max	Unit
Thermal Resistance from Junction to Ambient(1)	$R_{\theta JA}$	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 (V_{CE} = –250 Vdc, R_{BE} = 2.7 kΩ) (V_{CE} = –200 Vdc, R_{BE} = 2.7 kΩ, T_J = 150°C)	I_{CER}	 — —	 –50 –10	 nAdc μAdc

1. 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.

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

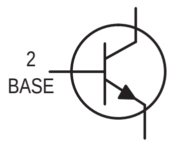
REV 3

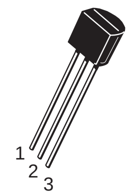
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Max	Unit
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

High Voltage Transistor
NPN Silicon

BF844





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)		45	—	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)		20	—	
Collector–Emitter Saturation Voltage(1)	$V_{CE(sat)}$			Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)		—	0.4	
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.5	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	0.75	
Base–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.75	Vdc
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

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

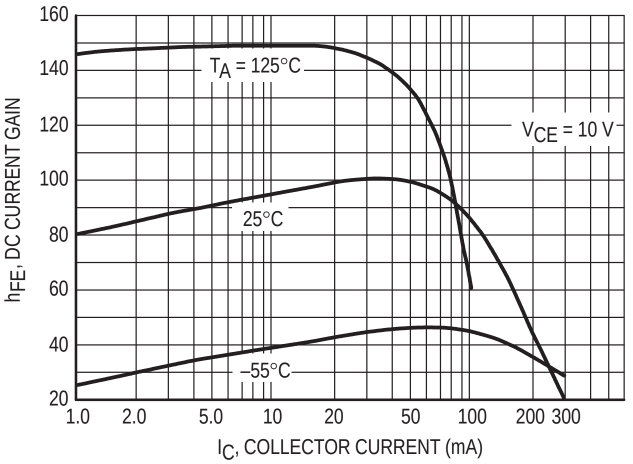


Figure 1. DC Current Gain

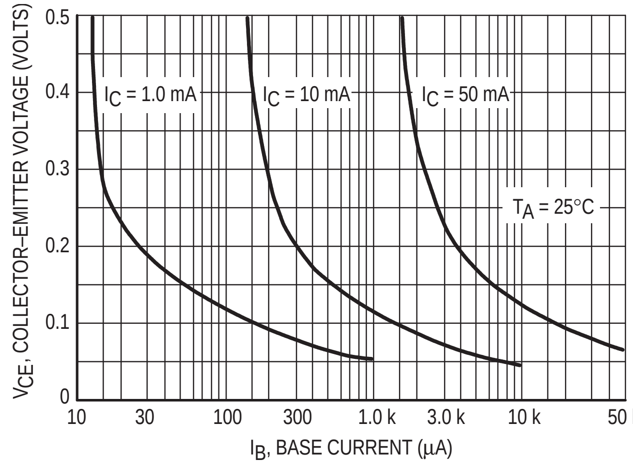


Figure 2. Collector Saturation Region

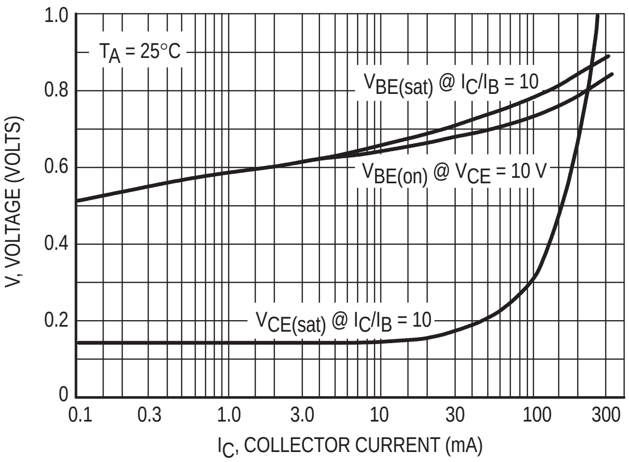


Figure 3. On Voltages

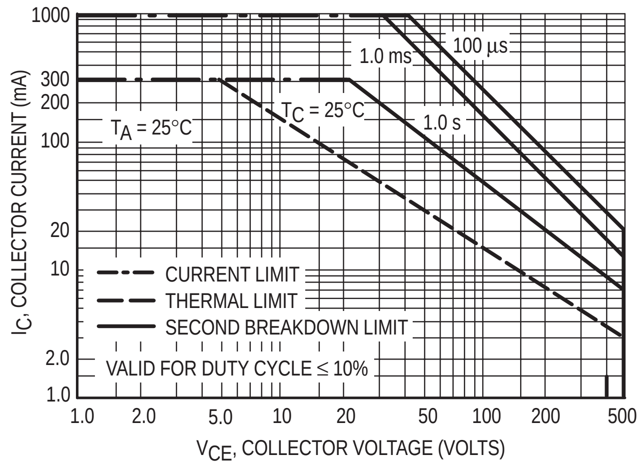


Figure 4. Active Region Safe Operating Area

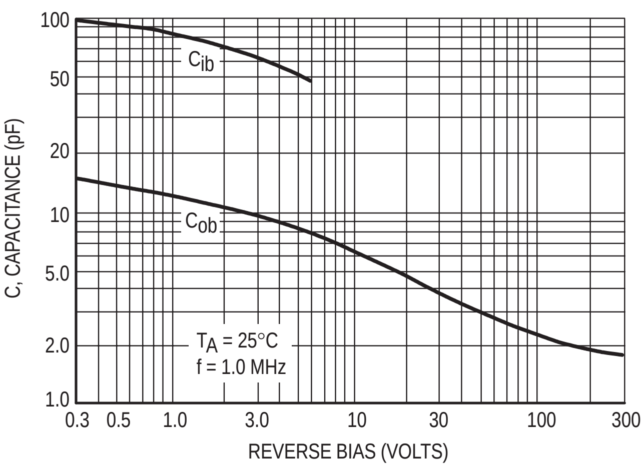


Figure 5. Capacitance

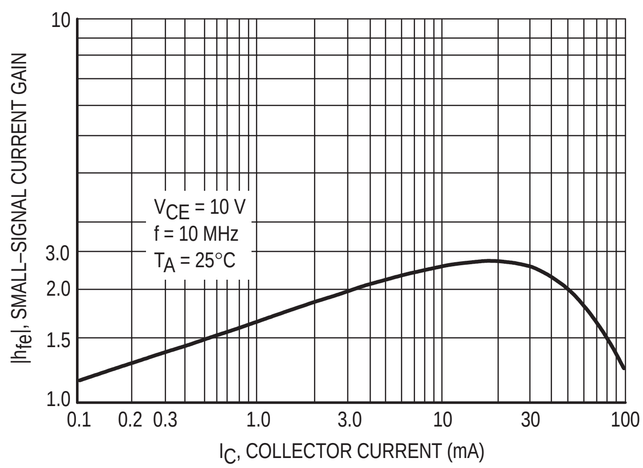
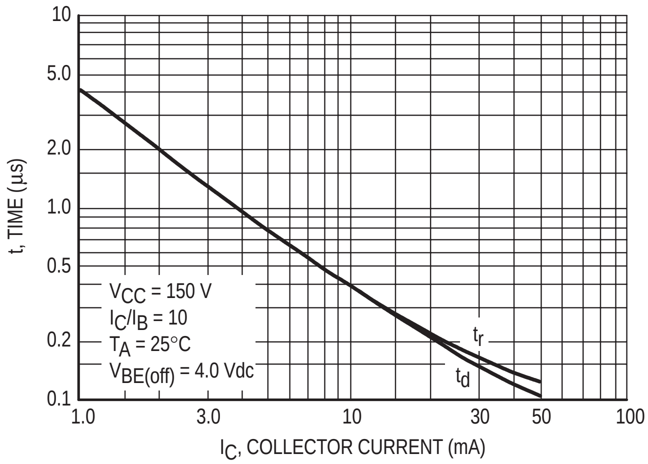


Figure 6. High Frequency Current Gain



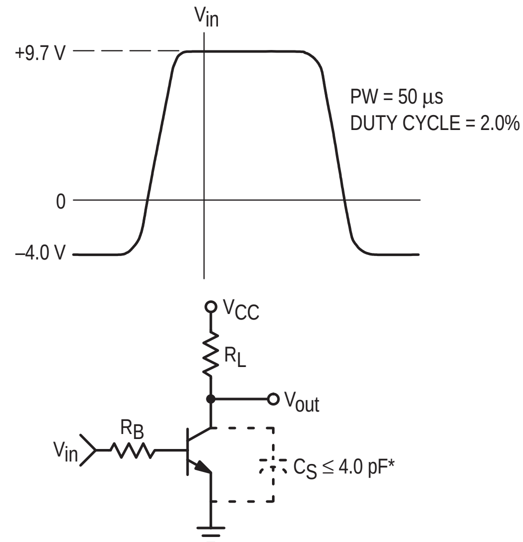
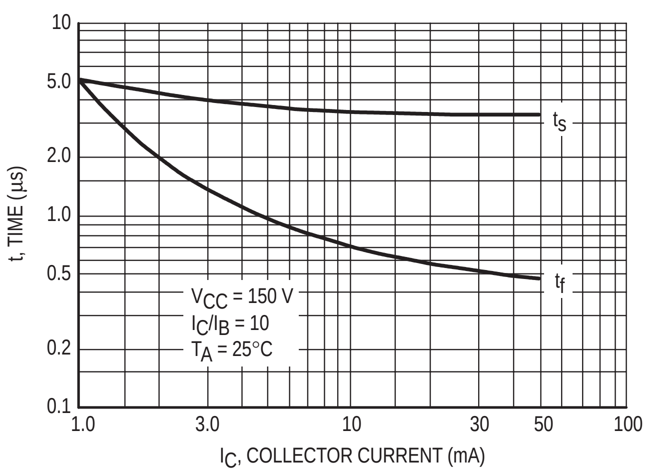


Figure 7. Turn–On Switching Times and Test Circuit



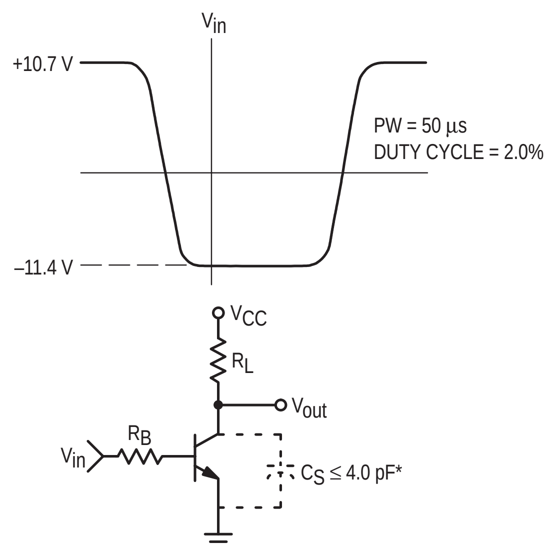
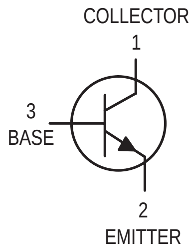


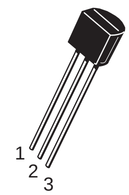
Figure 8. Turn–Off Switching Times and Test Circuit

* Total Shunt Capacitance or Test Jig and Connectors.

VHF Transistor
NPN Silicon

BF959





CASE 29–04, STYLE 21
TO–92 (TO–226AA)

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 = 5.0 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)	$V_{BE(sat)}$	—	—	1.0	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 = 4.0 mA, V_{CE} = 10 V, R_S = 50 Ω, f = 200 MHz)	N_f	—	3.0	—	dB

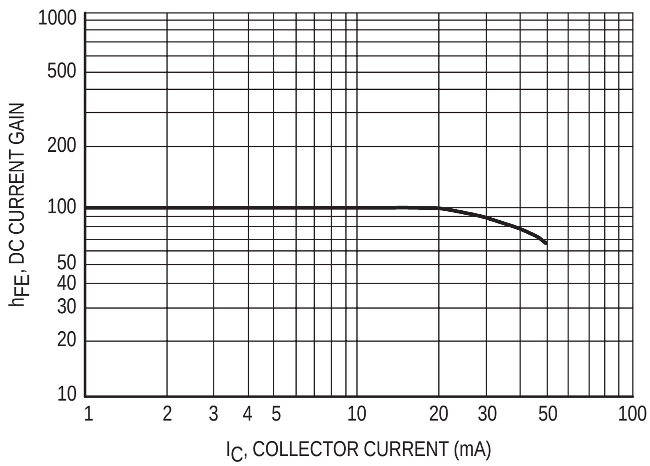


Figure 1. h_{FE} at 10 V

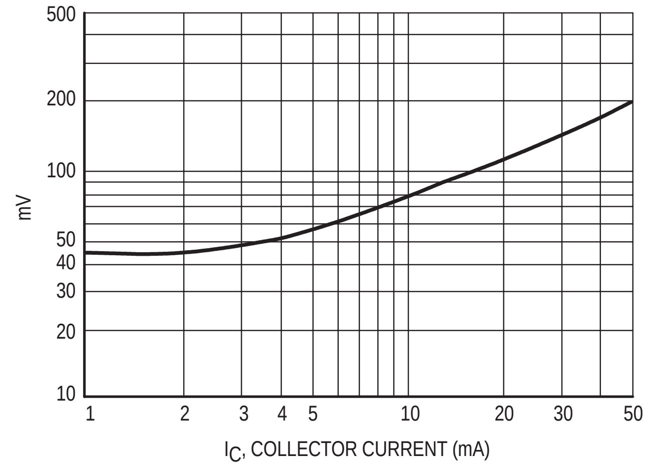


Figure 2. $V_{CE(sat)}$ at I_C/I_B = 10

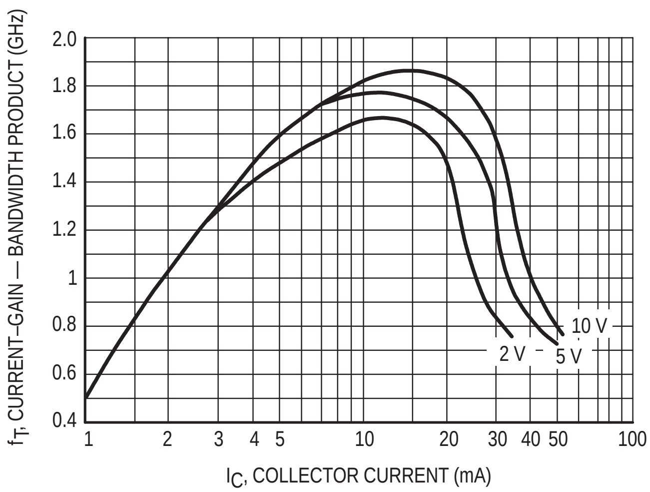


Figure 3. Current–Gain — Bandwidth Product

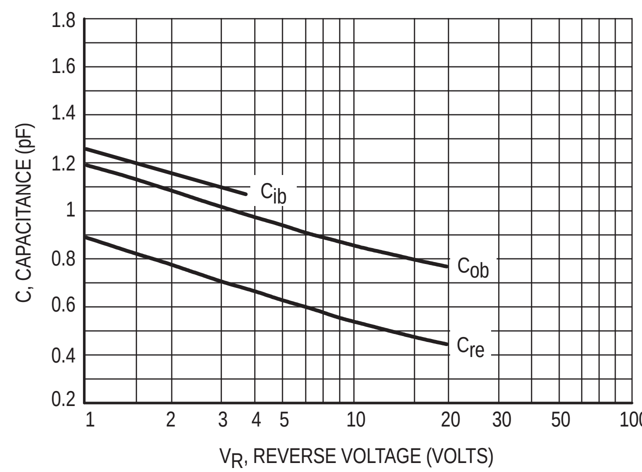


Figure 4. Capacitances

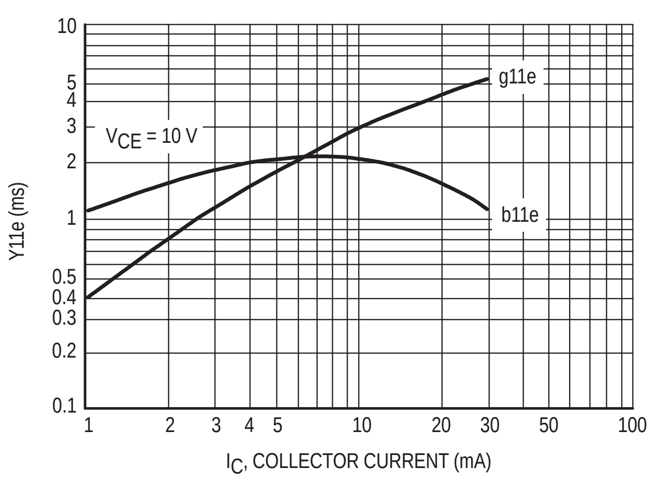


Figure 5. Input Impedance at 30 MHz

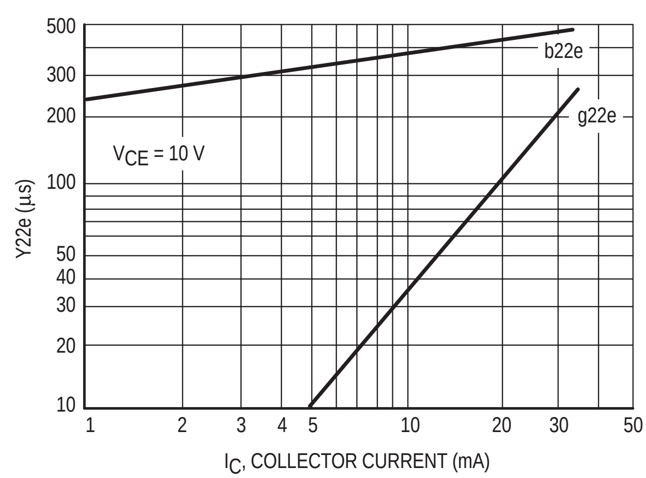


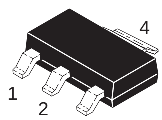
Figure 6. Output Impedance at 30 MHz

SOT-223 Package High Voltage Transistor
PNP Silicon

BSP16T1

Motorola Preferred Device

SOT–223 PACKAGE
PNP SILICON
HIGH VOLTAGE
TRANSISTOR
SURFACE MOUNT



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

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 Device Dissipation, T_A = 25°C (1)	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

Characteristic	Symbol	Max	Unit
Thermal Resistance, 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

1. 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.

REV 2

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

Characteristics	Symbol	Min	Max	Unit
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

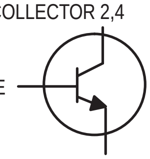
NPN Silicon Epitaxial Transistor

BSP19AT1

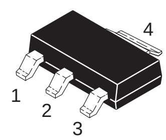
Motorola Preferred Device

This family of NPN Silicon Epitaxial transistors is designed for use as a general purpose amplifier and in switching applications. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- High Voltage: $V_{(BR)CEO}$ of 250 and 350 Volts.
- 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
  T1 Configuration – 7 inch/1000 unit reel
  T3 Configuration – 13 inch/4000 unit reel
- PNP Complement is BSP16T1



**SOT–223 PACKAGE
NPN SILICON
HIGH VOLTAGE
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 (Open Base)	V_{CEO}	350	Vdc
Collector-Base Voltage (Open Emitter)	V_{CBO}	400	Vdc
Emitter-Base Voltage (Open Collector)	V_{EBO}	5.0	Vdc
Collector Current (DC)	I_C	1000	mAdc
Total Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	0.8 6.4	Watts mW/°C
Storage Temperature Range	T_{stg}	–65 to 150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

SP19A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance from Junction-to-Ambient	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 10	°C Sec

1. Device mounted on a FR-4 glass epoxy printed circuit board using minimum recommended footprint.

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

REV 2

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

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 400 Vdc, I_E = 0)	I_{CBO}	—	20	nAdc
Emitter-Base Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	µAdc
ON CHARACTERISTICS (2)				
DC Current Gain (I_C = 20 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	—	—
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)	f_T	70	—	MHz
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)	$V_{BE(sat)}$	—	1.3	Vdc

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

NPN Small-Signal Darlington Transistor

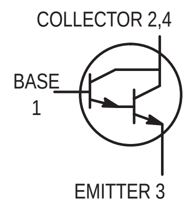
BSP52T1

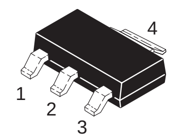
Motorola Preferred Device

**MEDIUM POWER
NPN SILICON
DARLINGTON
TRANSISTOR
SURFACE MOUNT**

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





**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}	5.0	Vdc
Collector Current	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C(1) 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

AS3

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
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 10	°C Sec

1. Device mounted on a FR-4 glass epoxy printed circuit board using minimum recommended footprint.

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

REV 1

ELECTRICAL CHARACTERISTICS (continued) (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 (2)				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 1000 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)	$V_{BE(on)}$	—	1.9	Vdc

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

PNP Small-Signal Darlington Transistor

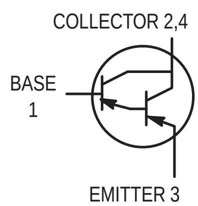
BSP62T1

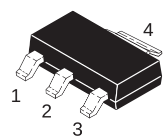
Motorola Preferred Device

**MEDIUM POWER
PNP SILICON
DARLINGTON
TRANSISTOR
SURFACE MOUNT**

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





**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}	5.0	Vdc
Collector Current	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C(1) 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

Characteristic	Symbol	Max	Unit
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 10	°C Sec

1. 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.

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

REV 2

ELECTRICAL CHARACTERISTICS (continued) (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 (2)				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 1000 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)	$V_{BE(on)}$	—	1.9	Vdc

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

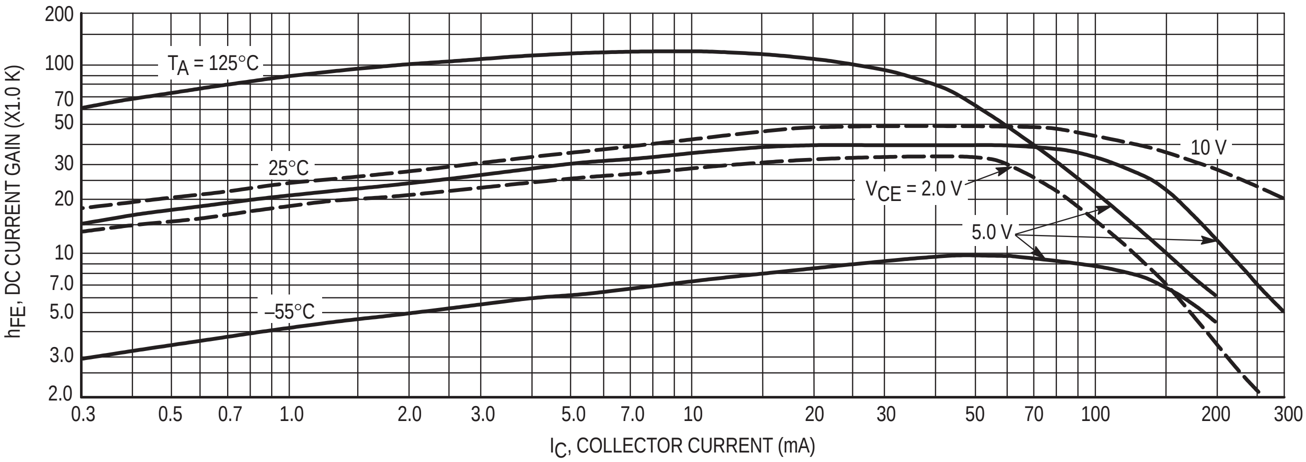


Figure 1. DC Current Gain

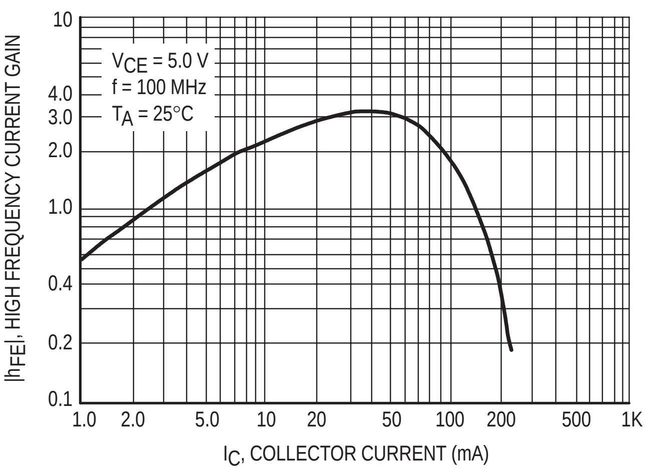


Figure 2. High Frequency Current Gain

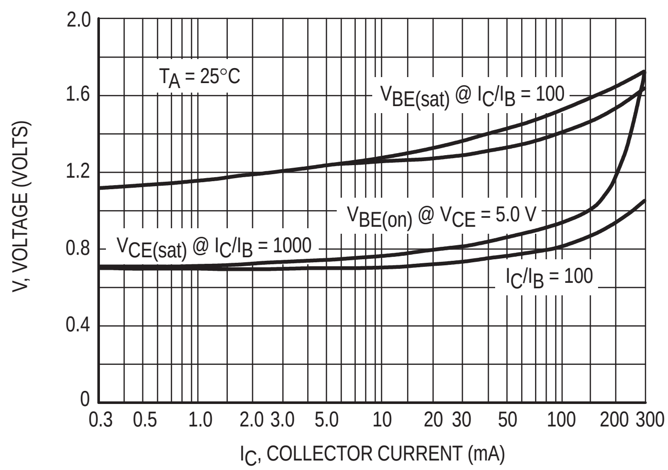


Figure 3. “On” Voltage

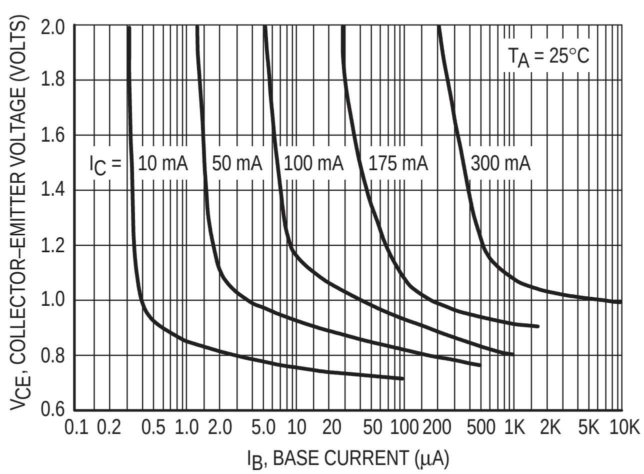
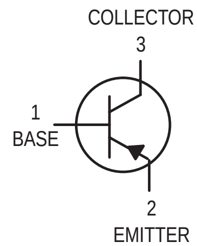
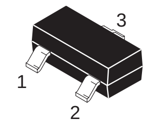


Figure 4. Collector Saturation Region

High Voltage Transistor
PNP Silicon



BSS63LT1



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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 CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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,(2) 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

DEVICE MARKING

BSS63LT1 = T1

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

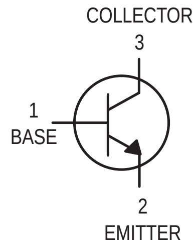
1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

REV 1

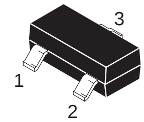
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Typ	Max	Unit
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	—	—	20	pF

Driver Transistor
NPN Silicon



BSS64LT1



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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,(2) 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

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 mAdc)	$V_{(BR)CEO}$	80	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μAdc)	$V_{(BR)CBO}$	120	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 100 μAdc)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 90 Vdc) (T_A = 150°C)	I_{CBO}	— —	0.1 500	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc)	I_{EBO}	—	200	nAdc

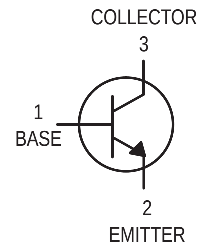
1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

REV 1

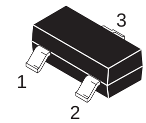
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = 1.0 Vdc, I_C = 10 mAdc)	H_{FE}	20	—	—
Collector–Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 400 μAdc)	$V_{CE(sat)}$	—	0.15	Vdc
(I_C = 50 mAdc, I_B = 15 mAdc)		—	0.2	
Forward Base–Emitter Voltage	$V_{BE(sat)}$	—	—	—
SMALL–SIGNAL CHARACTERISTICS				
Current–Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{ob}	—	20	pF

Switching Transistor
NPN Silicon



BSV52LT1



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	H_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		25	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		40	120	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		25	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			mVdc
(I_C = 10 mAdc, I_B = 300 μAdc)		—	300	
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	250	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	400	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$			mVdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		700	850	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	1200	
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

DTA114YE

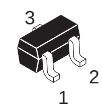
Preliminary Data Sheet

Bias Resistor Transistor

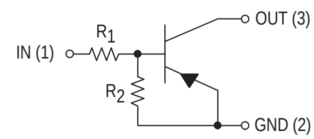
PNP Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

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. These digital transistors are designed to replace a single device and its external resistor bias network. The BRT eliminates these individual components by integrating them into a single device. The DTA114YE is housed in the SOT–416/SC–90 package which is ideal for low–power surface mount applications where board space is at a premium.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Available in 8 mm, 7 inch/3000 Unit Tape and Reel.



CASE 463–01, STYLE 1
SOT–416/SC–90



R_1 = 10 kΩ
R_2 = 47 kΩ

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

Rating	Symbol	Value	Unit
Output Voltage	V_O	–50	Vdc
Input Voltage	V_I	–40	Vdc
Output Current	I_O	–100	mAdc

DEVICE MARKING

DTA114YE = 59

THERMAL CHARACTERISTICS

Power Dissipation @ T_A = 25°C(1)	P_D	125	mW
Operating and Storage Temperature Range	T_J, T_{stg}	–55 to +150	°C
Junction Temperature	T_J	150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Off Voltage (V_O = –5.0 Vdc, I_O = –100 µAdc)	$V_{I(off)}$	—	—	–0.3	Vdc
Input On Voltage (V_O = –0.3 Vdc, I_O = –1.0 mAdc)	$V_{I(on)}$	–1.4	—	—	Vdc
Output On Voltage (I_O = –5.0 mAdc, I_I = –0.25 mAdc)	$V_{O(on)}$	—	—	–0.3	Vdc
Input Current (V_I = –5.0 Vdc)	I_I	—	—	–0.88	mAdc
Output Cutoff Current (V_O = –50 Vdc)	$I_{O(off)}$	—	—	–500	nAdc
DC Current Gain (V_O = –5.0 Vdc, I_O = –5.0 mAdc)	G_I	68	—	—	—
Input Resistance	R_1	7.0	10	13	kOhms
Resistance Ratio	R_1/R_2	0.17	0.21	0.25	

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.

This document contains information on a product under development. Motorola reserves the right to change or discontinue this product without notice.

REV 1

TYPICAL ELECTRICAL CHARACTERISTICS

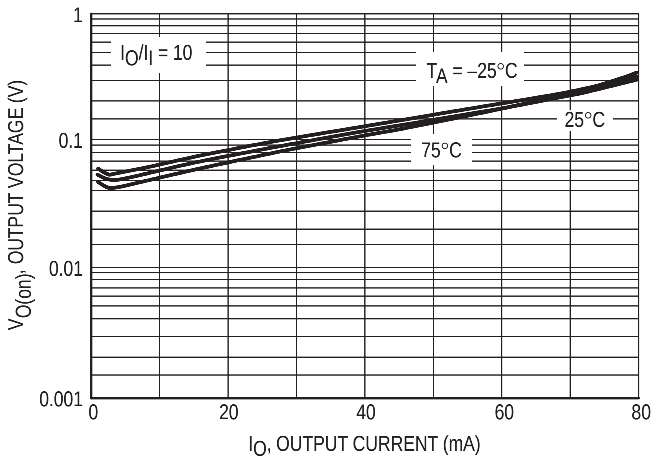


Figure 1. $V_{O(on)}$ versus I_O

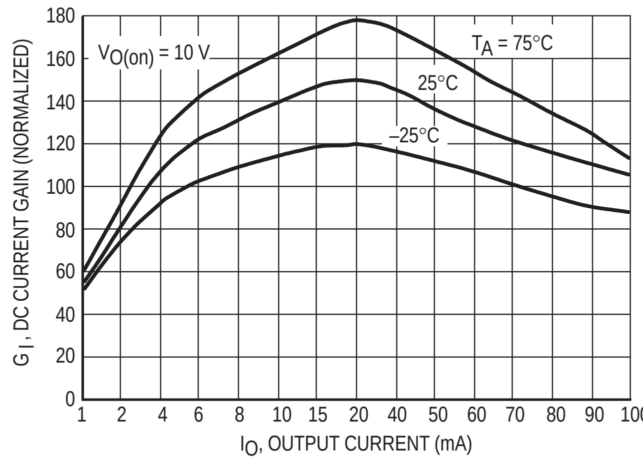


Figure 2. G_I, DC Current Gain

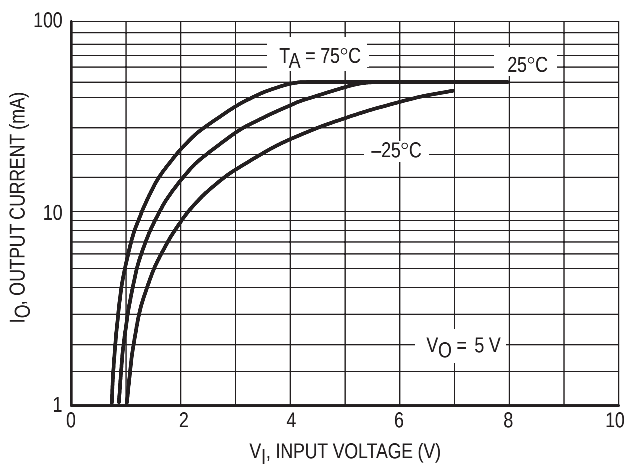


Figure 3. Output Current versus Input Voltage

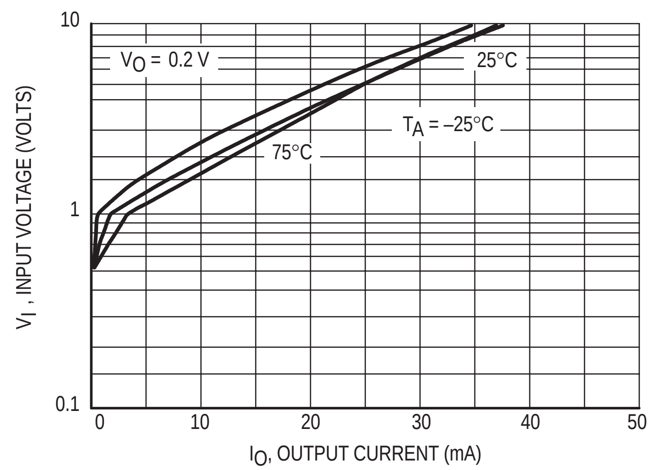


Figure 4. Input Voltage versus Output Current

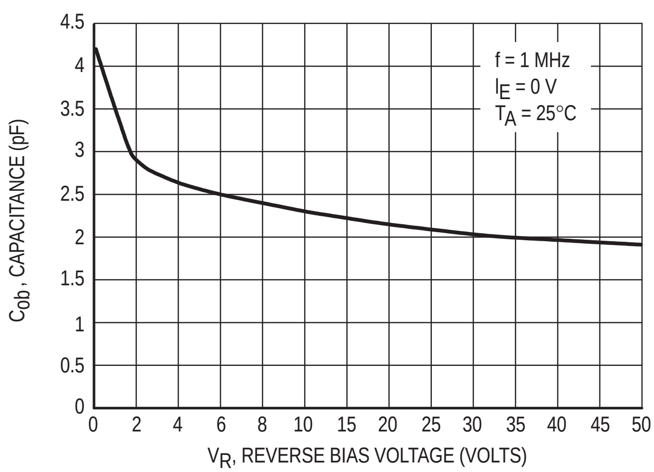


Figure 5. Output Capacitance

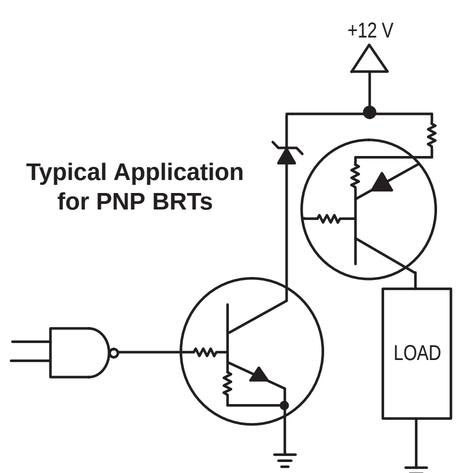


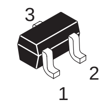
Figure 6. Inexpensive, Unregulated Current Source

Preliminary Data Sheet

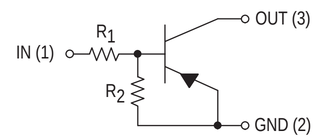
Bias Resistor Transistor

PNP Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

DTA143EE



CASE 463–01, STYLE 1
SOT–416/SC–90



R_1 = 4.7 kΩ
R_2 = 4.7 kΩ

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. These digital transistors are designed to replace a single device and its external resistor bias network. The BRT eliminates these individual components by integrating them into a single device. The DTA143EE is housed in the SOT–416/SC–90 package which is ideal for low–power surface mount applications where board space is at a premium.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Available in 8 mm, 7 inch/3000 Unit Tape and Reel.

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

Rating	Symbol	Value	Unit
Output Voltage	V_O	–50	Vdc
Input Voltage	V_I	–30	Vdc
Output Current	I_O	–100	mAdc

DEVICE MARKING

DTA143EE = 43

THERMAL CHARACTERISTICS

Power Dissipation @ T_A = 25°C(1)	P_D	125	mW
Operating and Storage Temperature Range	T_J, T_{stg}	–55 to +150	°C
Junction Temperature	T_J	150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Off Voltage (V_O = –5.0 Vdc, I_O = –100 µAdc)	$V_{I(off)}$	—	—	–0.5	Vdc
Input On Voltage (V_O = –0.3 Vdc, I_O = –20 mAdc)	$V_{I(on)}$	–3.0	—	—	Vdc
Output On Voltage (I_O = –10 mAdc, I_I = –0.5 mAdc)	$V_{O(on)}$	—	—	–0.3	Vdc
Input Current (V_I = –5.0 Vdc)	I_I	—	—	–1.8	mAdc
Output Cutoff Current (V_O = –50 Vdc)	$I_{O(off)}$	—	—	–500	nAdc
DC Current Gain (V_O = –5.0 Vdc, I_O = –10 mAdc)	G_I	20	—	—	—
Input Resistance	R_1	3.3	4.7	6.1	kOhms
Resistance Ratio	R_1/R_2	0.8	1.0	1.2	

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.
* Typical electrical characteristic curves are not available at this time.

This document contains information on a product under development. Motorola reserves the right to change or discontinue this product without notice.

DTC114TE

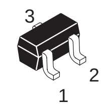
Preliminary Data Sheet

Bias Resistor Transistor

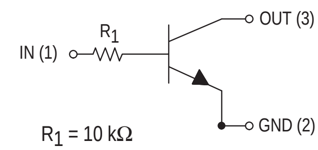
NPN Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

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. These digital transistors are designed to replace a single device and its external resistor bias network. The BRT eliminates these individual components by integrating them into a single device. The DTC114TE is housed in the SOT–416/SC–90 package which is ideal for low power surface mount applications where board space is at a premium.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Available in 8 mm, 7 inch/3000 Unit Tape and Reel.



CASE 463–01, STYLE 1
SOT–416/SC–90



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

DEVICE MARKING

DTC114TE = 94

THERMAL CHARACTERISTICS

Power Dissipation @ T_A = 25°C(1)	P_D	125	mW
Operating and Storage Temperature Range	T_J, T_{stg}	–55 to +150	°C
Junction Temperature	T_J	150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector–Base Breakdown Voltage (I_C = 50 μAdc)	$V_{(BR)CBO}$	50	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc)	$V_{(BR)CEO}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 50 μAdc)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector–Base Cutoff Current (V_{CB} = 50 Vdc)	I_{CBO}	—	—	500	nAdc
Emitter–Base Cutoff Current (V_{EB} = 4.0 Vdc)	I_{EBO}	—	—	500	nAdc
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5 Vdc)	h_{FE}	100	300	600	—
Collector–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.3	Vdc
Input Resistance	R_1	7.0	10	13	kOhms

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.
* Typical electrical characteristic curves are not available at this time.

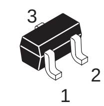
This document contains information on a product under development. Motorola reserves the right to change or discontinue this product without notice.

DTC114YE

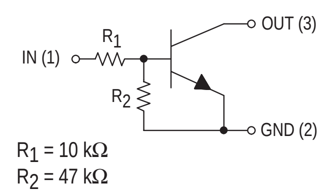
Preliminary Data Sheet

Bias Resistor Transistor

NPN Silicon Surface Mount Transistor with Monolithic Bias Resistor Network



CASE 463–01, STYLE 1
SOT–416/SC–90



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. These digital transistors are designed to replace a single device and its external resistor bias network. The BRT eliminates these individual components by integrating them into a single device. The DTC114YE is housed in the SOT–416/SC–90 package which is ideal for low power surface mount applications where board space is at a premium.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Available in 8 mm, 7 inch/3000 Unit Tape and Reel.

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

Rating	Symbol	Value	Unit
Output Voltage	V_O	50	Vdc
Input Voltage	V_I	40	Vdc
Output Current	I_O	100	mAdc

DEVICE MARKING

DTC114YE = 69

THERMAL CHARACTERISTICS

Power Dissipation @ T_A = 25°C(1)	P_D	125	mW
Operating and Storage Temperature Range	T_J, T_{stg}	–55 to +150	°C
Junction Temperature	T_J	150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Off Voltage (V_O = 5.0 Vdc, I_O = 100 μAdc)	$V_{I(off)}$	—	—	0.3	Vdc
Input On Voltage (V_O = 0.3 Vdc, I_O = 1.0 mAdc)	$V_{I(on)}$	1.4	—	—	Vdc
Output On Voltage (I_O = 5.0 mAdc, I_I = 0.25 mAdc)	$V_{O(on)}$	—	—	0.3	Vdc
Input Current (V_I = 5.0 Vdc)	I_I	—	—	0.88	mAdc
Output Cutoff Current (V_O = 50 Vdc)	$I_{O(off)}$	—	—	500	nAdc
DC Current Gain (V_O = 5.0 Vdc, I_O = 5.0 mAdc)	G_I	68	—	—	—
Input Resistance	R_1	7.0	10	13	kOhms
Resistance Ratio	R_1/R_2	0.17	0.21	0.25	

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.

This document contains information on a product under development. Motorola reserves the right to change or discontinue this product without notice.

REV 1

TYPICAL ELECTRICAL CHARACTERISTICS

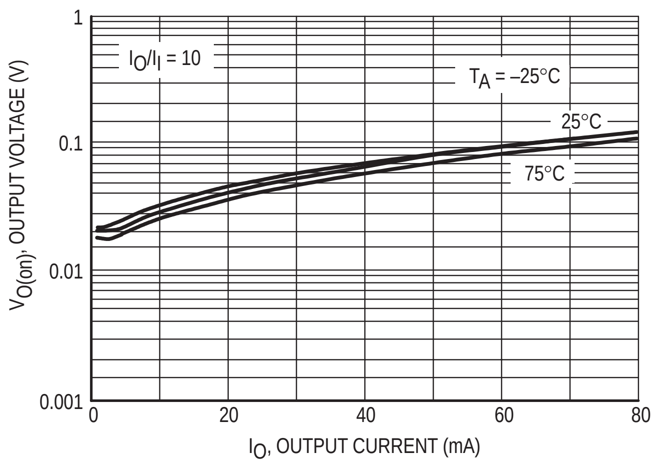


Figure 1. $V_{O(on)}$ versus I_O

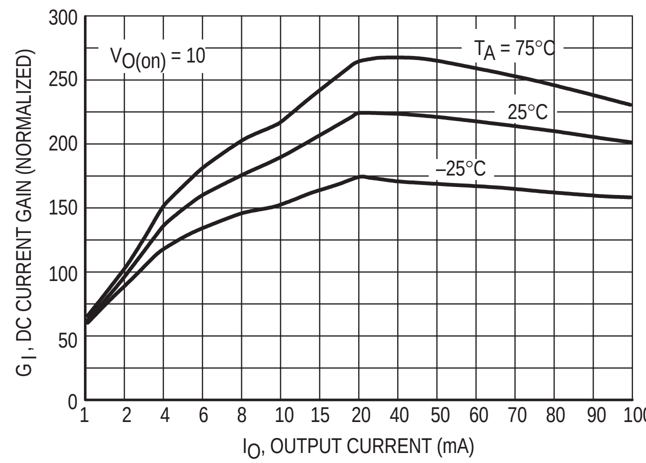


Figure 2. G_I, DC Current Gain

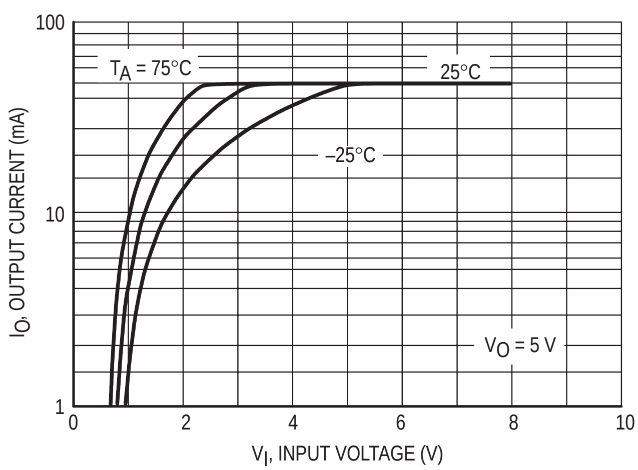


Figure 3. Output Current versus Input Voltage

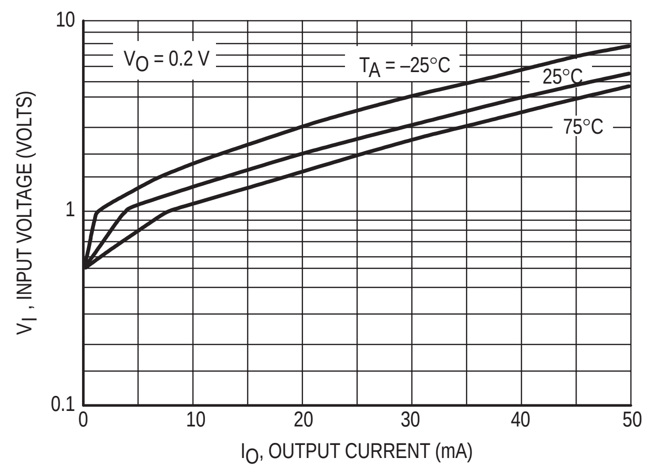


Figure 4. Input Voltage versus Output Current

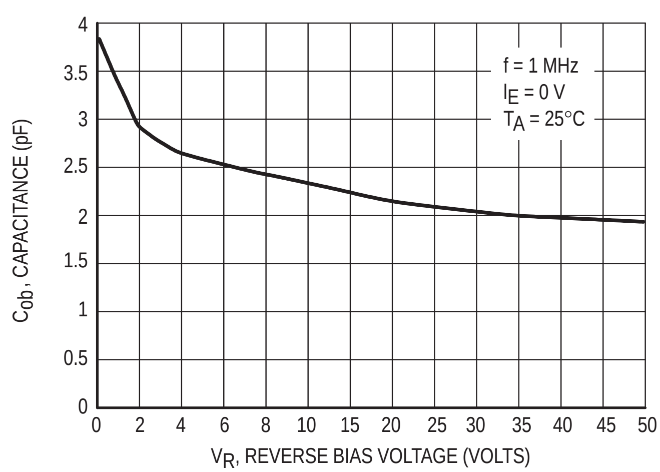


Figure 5. Output Capacitance

TYPICAL APPLICATIONS FOR NPN BRTs

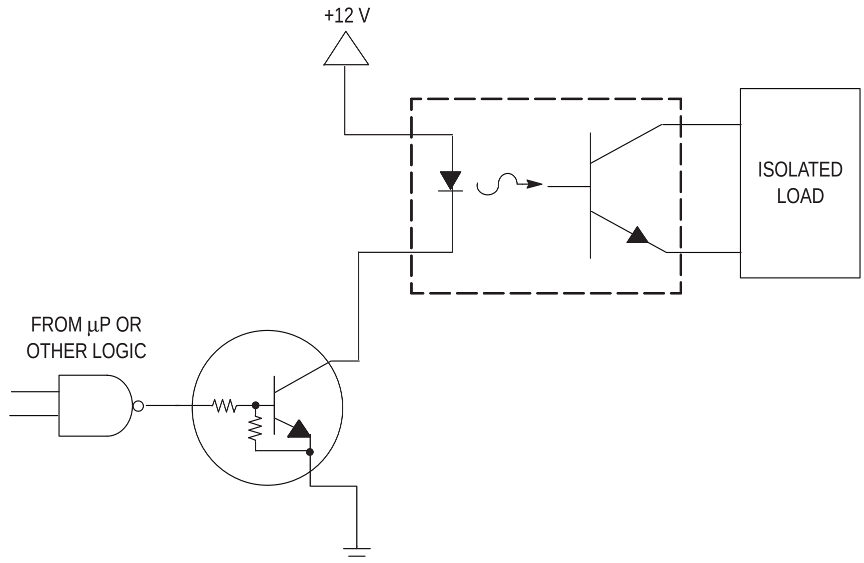


Figure 6. Level Shifter: Connects 12 or 24 Volt Circuits to Logic

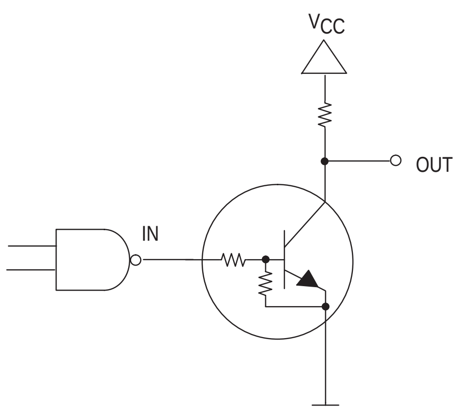


Figure 7. Open Collector Inverter: Inverts the Input Signal

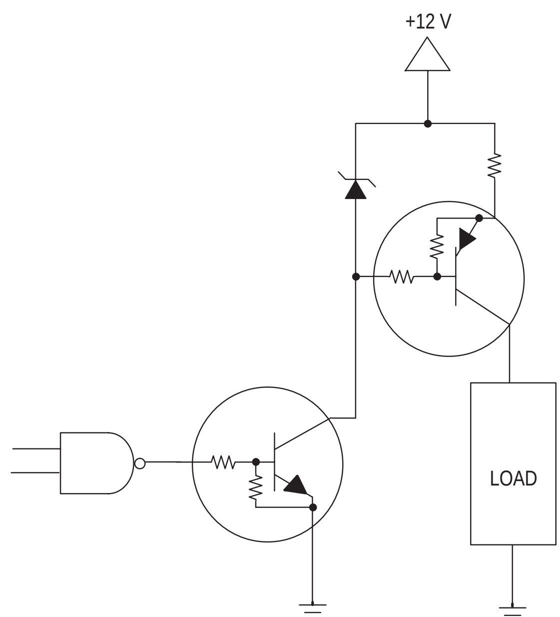


Figure 8. Inexpensive, Unregulated Current Source

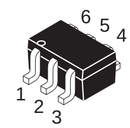
MBT3904DW1T1
MBT3906DW1T1
MBT3946DW1T1

Dual General Purpose Transistors

The MBT3904DW1T1, MBT3906DW1T1, and MBT3946DW1T1 devices are spin–offs of our popular SOT–23/SOT–323 three–leaded devices. They are designed for general purpose amplifier applications and are housed in the SOT–363 six–leaded surface mount package. By putting two discrete devices in one package, these devices are ideal for low–power surface mount applications where board space is at a premium.

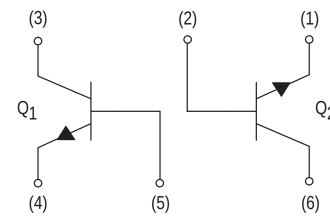
- h_{FE}, 100–300
- Low $V_{CE(sat)}$, ≤ 0.4 V
- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Available in 8 mm, 7–inch/3,000 Unit Tape and Reel

MBT3904DW1T1
MBT3906DW1T1
MBT3946DW1T1

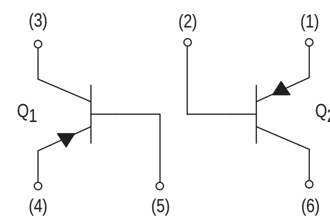


CASE 419B–01, STYLE 1

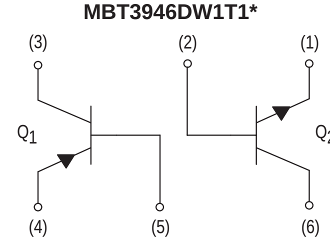
MBT3904DW1T1



MBT3906DW1T1



MBT3946DW1T1*



*Q1 same as MBT3906DW1T1
Q2 same as MBT3904DW1T1

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector–Emitter Voltage	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	V_{CEO}	40 –40	Vdc
Collector–Base Voltage	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	V_{CBO}	60 –40	Vdc
Emitter–Base Voltage	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	V_{EBO}	6.0 –5.0	Vdc
Collector Current — Continuous	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	I_C	200 –200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Package Dissipation(1) T_A = 25°C	P_D	150	mW
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	833	°C/W
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

1. Device mounted on FR4 glass epoxy printed circuit board using the minimum recommended footprint.

DEVICE MARKING

MBT3904DW1T1 = MA	MBT3946DW1T1 = 46
MBT3906DW1T1 = A2	

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(2)		$V_{(BR)CEO}$			Vdc
(I_C = 1.0 mAdc, I_B = 0)	MBT3904DW1T1 (NPN)		40	—	
(I_C = –1.0 mAdc, I_B = 0)	MBT3906DW1T1 (PNP)		–40	—	
Collector–Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 10 μAdc, I_E = 0)	MBT3904DW1T1 (NPN)		60	—	
(I_C = –10 μAdc, I_E = 0)	MBT3906DW1T1 (PNP)		–40	—	
Emitter–Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)	MBT3904DW1T1 (NPN)		6.0	—	
(I_E = –10 μAdc, I_C = 0)	MBT3906DW1T1 (PNP)		–5.0	—	
Base Cutoff Current		I_{BL}			nAdc
(V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)	MBT3904DW1T1 (NPN)		—	50	
(V_{CE} = –30 Vdc, V_{EB} = –3.0 Vdc)	MBT3906DW1T1 (PNP)		—	–50	
Collector Cutoff Current		I_{CEX}			nAdc
(V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)	MBT3904DW1T1 (NPN)		—	50	
(V_{CE} = –30 Vdc, V_{EB} = –3.0 Vdc)	MBT3906DW1T1 (PNP)		—	–50	
ON CHARACTERISTICS (2)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MBT3904DW1T1 (NPN)		40	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)			70	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			60	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			30	—	
(I_C = –0.1 mAdc, V_{CE} = –1.0 Vdc)	MBT3906DW1T1 (PNP)		60	—	
(I_C = –1.0 mAdc, V_{CE} = –1.0 Vdc)			80	—	
(I_C = –10 mAdc, V_{CE} = –1.0 Vdc)			100	300	
(I_C = –50 mAdc, V_{CE} = –1.0 Vdc)			60	—	
(I_C = –100 mAdc, V_{CE} = –1.0 Vdc)			30	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MBT3904DW1T1 (NPN)		—	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.3	
(I_C = –10 mAdc, I_B = –1.0 mAdc)	MBT3906DW1T1 (PNP)		—	–0.25	
(I_C = –50 mAdc, I_B = –5.0 mAdc)			—	–0.4	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MBT3904DW1T1 (NPN)		0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.95	
(I_C = –10 mAdc, I_B = –1.0 mAdc)	MBT3906DW1T1 (PNP)		–0.65	–0.85	
(I_C = –50 mAdc, I_B = –5.0 mAdc)			—	–0.95	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MBT3904DW1T1 (NPN)		300	—	
(I_C = –10 mAdc, V_{CE} = –20 Vdc, f = 100 MHz)	MBT3906DW1T1 (PNP)		250	—	
Output Capacitance		C_{obo}			pF
(V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	MBT3904DW1T1 (NPN)		—	4.0	
(V_{CB} = –5.0 Vdc, I_E = 0, f = 1.0 MHz)	MBT3906DW1T1 (PNP)		—	4.5	
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MBT3904DW1T1 (NPN)		—	8.0	
(V_{EB} = –0.5 Vdc, I_C = 0, f = 1.0 MHz)	MBT3906DW1T1 (PNP)		—	10.0	

2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

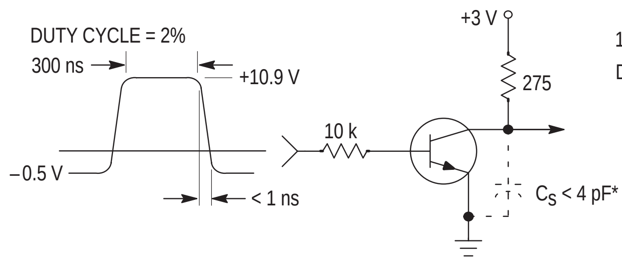
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

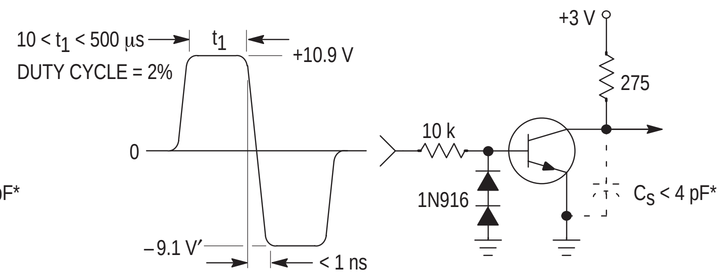
Characteristic		Symbol	Min	Max	Unit
Input Impedance		h_{ie}			k Ω
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	MBT3904DW1T1 (NPN)		1.0	10	
(V_{CE} = –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	MBT3906DW1T1 (PNP)		2.0	12	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	MBT3904DW1T1 (NPN)		0.5	8.0	
(V_{CE} = –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	MBT3906DW1T1 (PNP)		0.1	10	
Small–Signal Current Gain		h_{fe}			—
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	MBT3904DW1T1 (NPN)		100	400	
(V_{CE} = –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	MBT3906DW1T1 (PNP)		100	400	
Output Admittance		h_{oe}			μmhos
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	MBT3904DW1T1 (NPN)		1.0	40	
(V_{CE} = –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	MBT3906DW1T1 (PNP)		3.0	60	
Noise Figure		NF			dB
(V_{CE} = 5.0 Vdc, I_C = 100 μAdc, R_S = 1.0 k Ω, f = 1.0 kHz)	MBT3904DW1T1 (NPN)		—	5.0	
(V_{CE} = –5.0 Vdc, I_C = –100 μAdc, R_S = 1.0 k Ω, f = 1.0 kHz)	MBT3906DW1T1 (PNP)		—	4.0	

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Device	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = –0.5 Vdc)	MBT3904DW1T1 (NPN)	t_d	—	35	ns
	(V_{CC} = –3.0 Vdc, V_{BE} = 0.5 Vdc)	MBT3906DW1T1 (PNP)		—	35	
Rise Time	(I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	MBT3904DW1T1 (NPN)	t_r	—	35	
	(I_C = –10 mAdc, I_{B1} = –1.0 mAdc)	MBT3906DW1T1 (PNP)		—	35	
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc)	MBT3904DW1T1 (NPN)	t_s	—	200	ns
	(V_{CC} = –3.0 Vdc, I_C = –10 mAdc)	MBT3906DW1T1 (PNP)		—	225	
Fall Time	(I_{B1} = I_{B2} = 1.0 mAdc)	MBT3904DW1T1 (NPN)	t_f	—	50	
	(I_{B1} = I_{B2} = –1.0 mAdc)	MBT3906DW1T1 (PNP)		—	75	

MBT3904DW1T1 (NPN)





* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

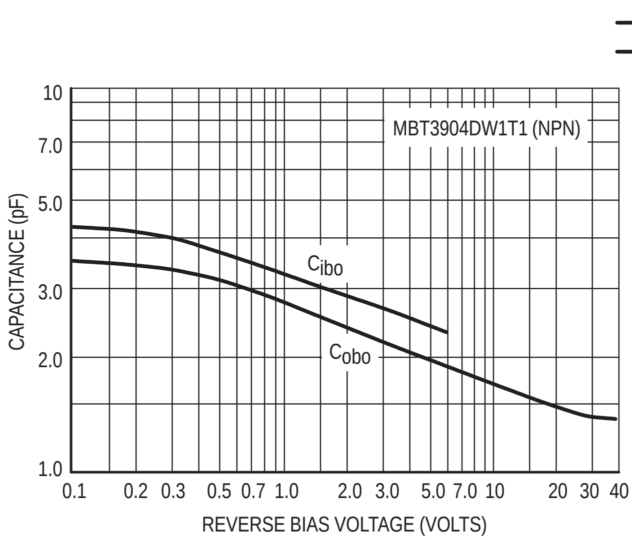


Figure 3. Capacitance

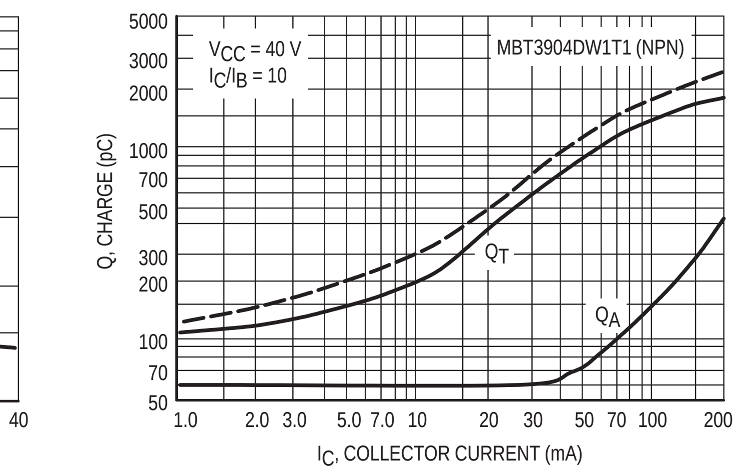


Figure 4. Charge Data

MBT3904DW1T1 (NPN)

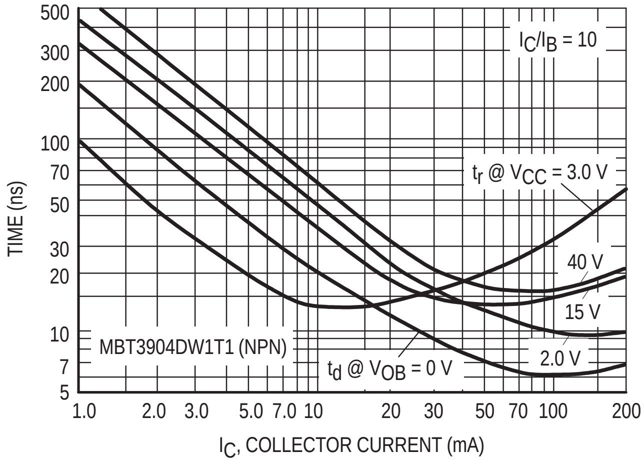


Figure 5. Turn–On Time

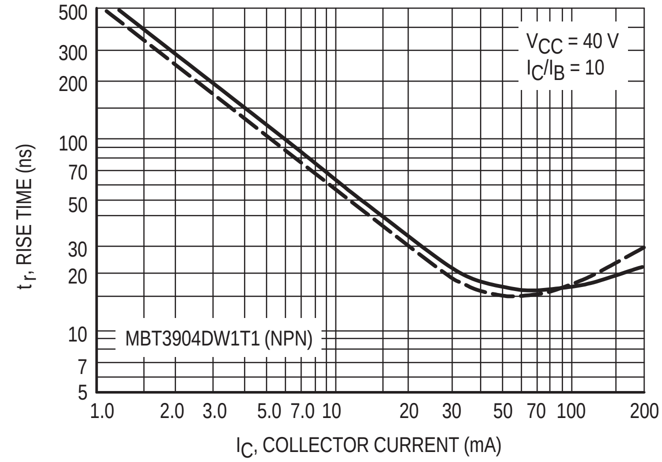


Figure 6. Rise Time

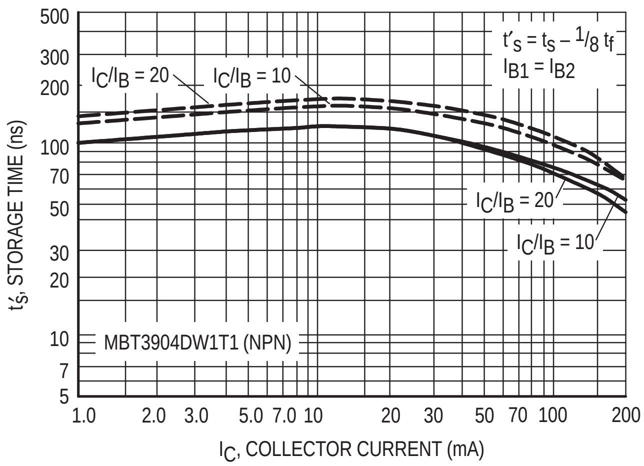


Figure 7. Storage Time

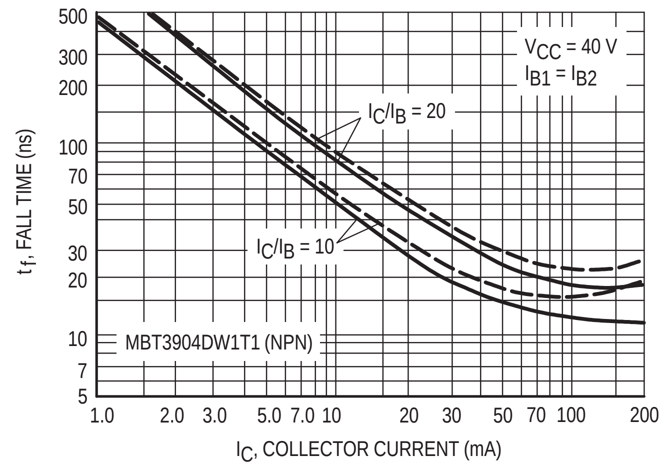


Figure 8. Fall Time

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

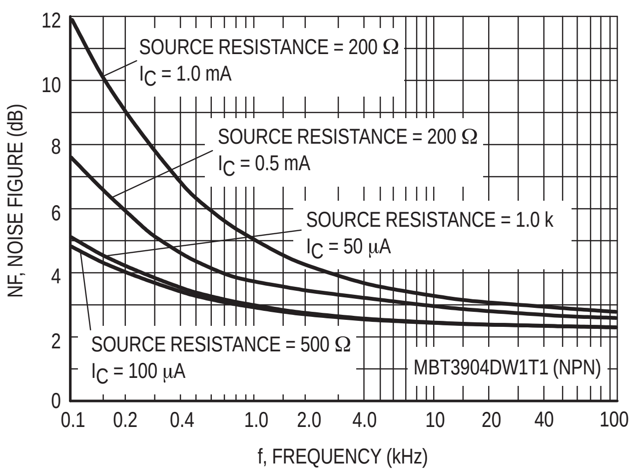


Figure 9. Noise Figure

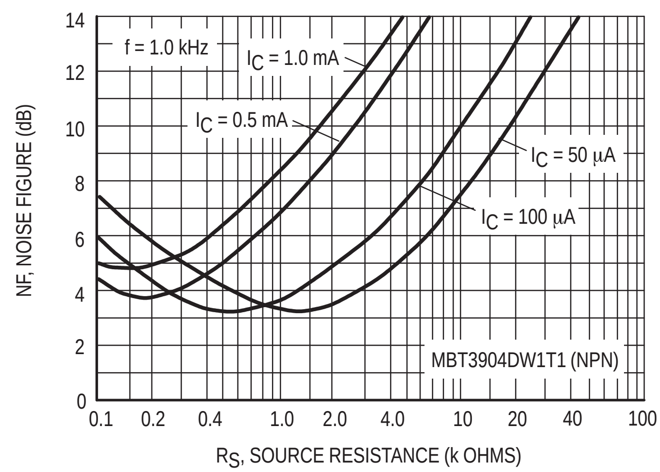


Figure 10. Noise Figure

MBT3904DW1T1 (NPN)

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

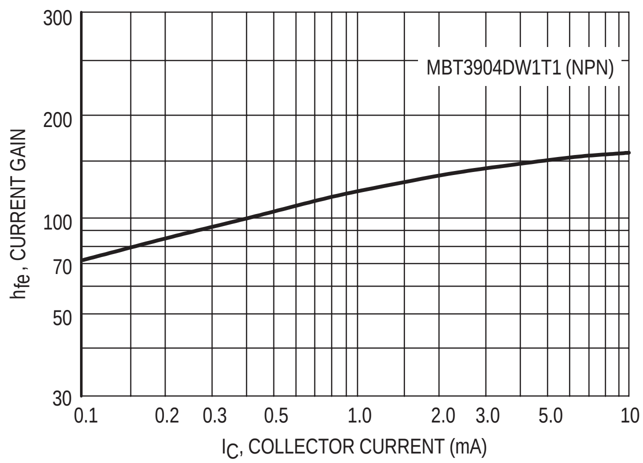


Figure 11. Current Gain

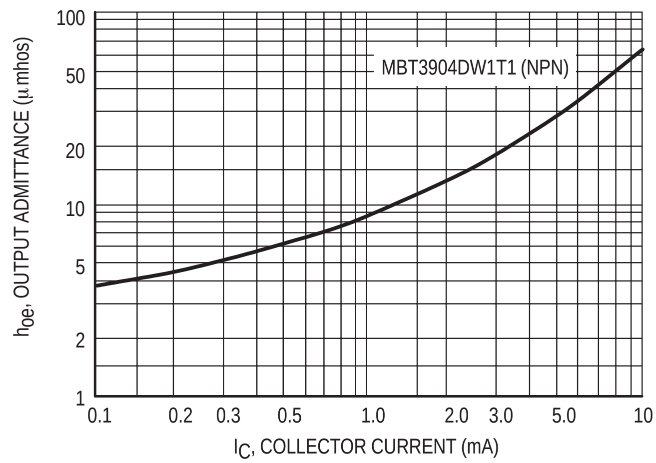


Figure 12. Output Admittance

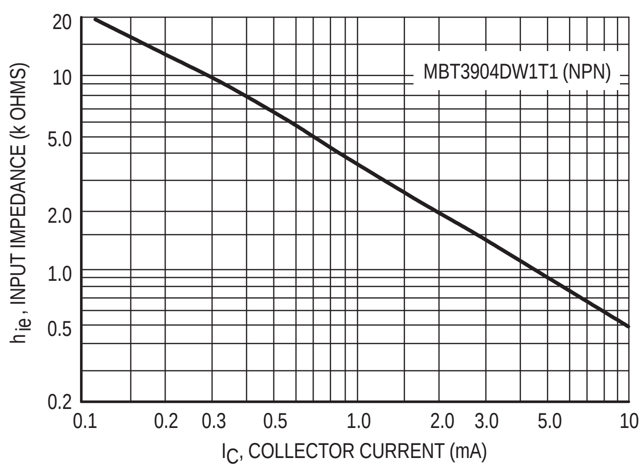


Figure 13. Input Impedance

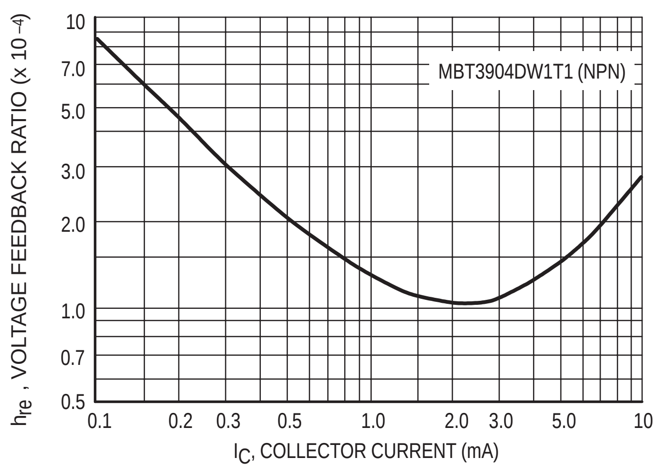


Figure 14. Voltage Feedback Ratio

MBT3904DW1T1 (NPN)

TYPICAL STATIC CHARACTERISTICS

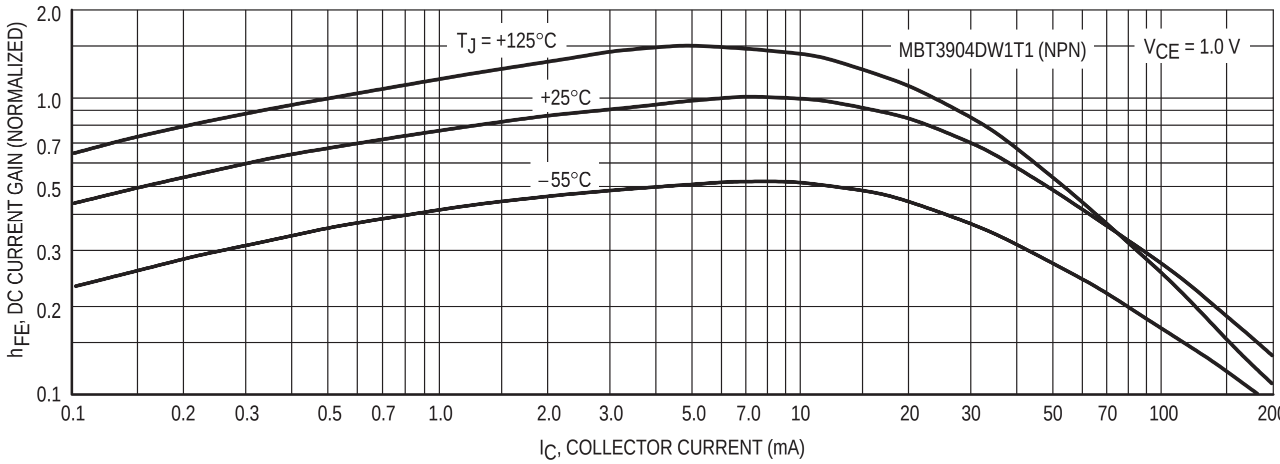


Figure 15. DC Current Gain

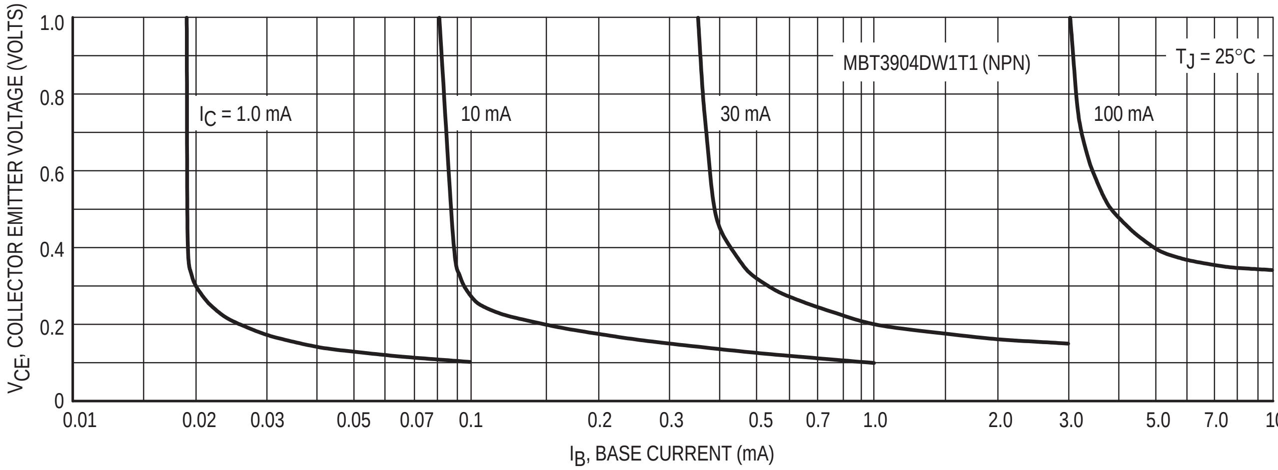


Figure 16. Collector Saturation Region

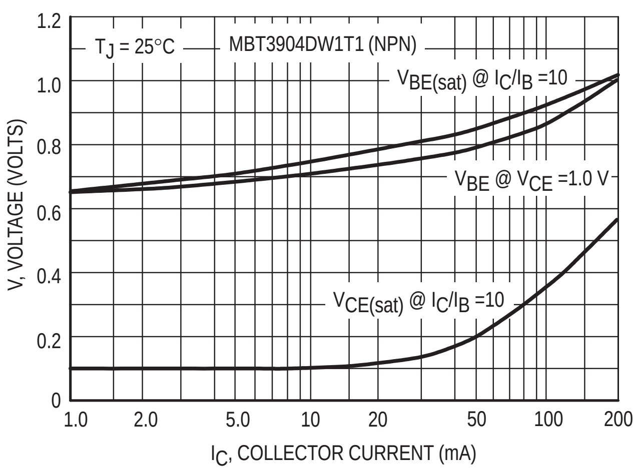


Figure 17. “ON” Voltages

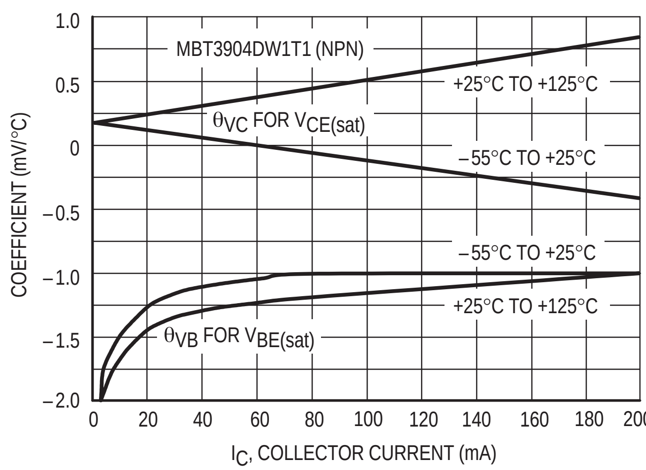
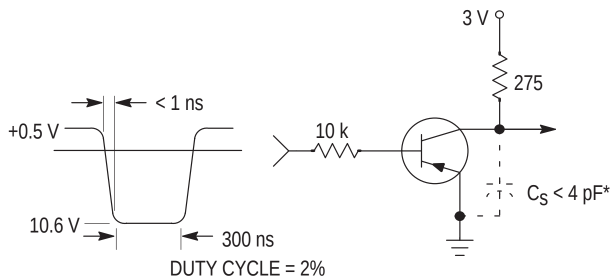
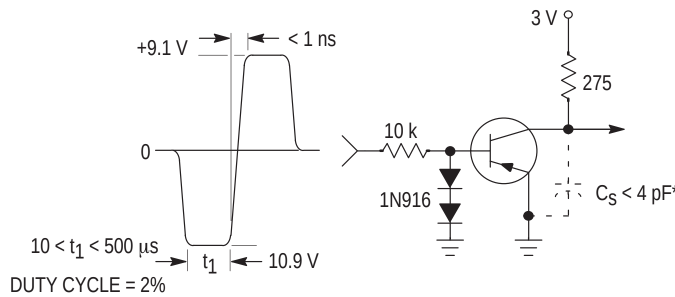


Figure 18. Temperature Coefficients

MBT3906DW1T1 (PNP)





* Total shunt capacitance of test jig and connectors

Figure 19. Delay and Rise Time Equivalent Test Circuit

Figure 20. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

T_J = 25°C
T_J = 125°C

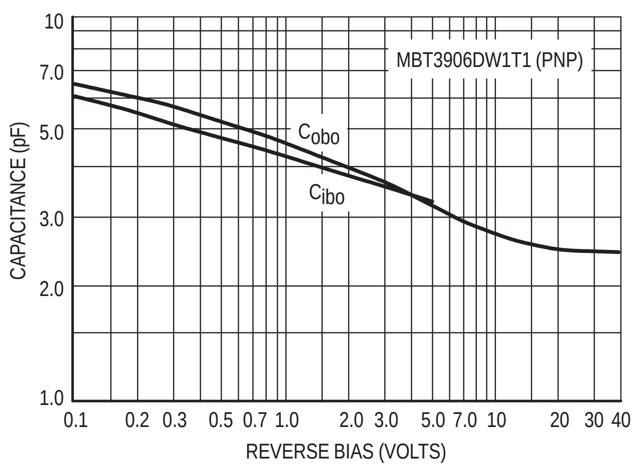


Figure 21. Capacitance

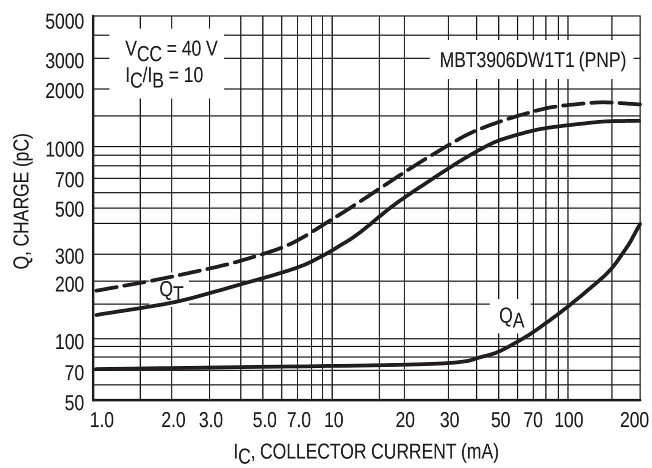


Figure 22. Charge Data

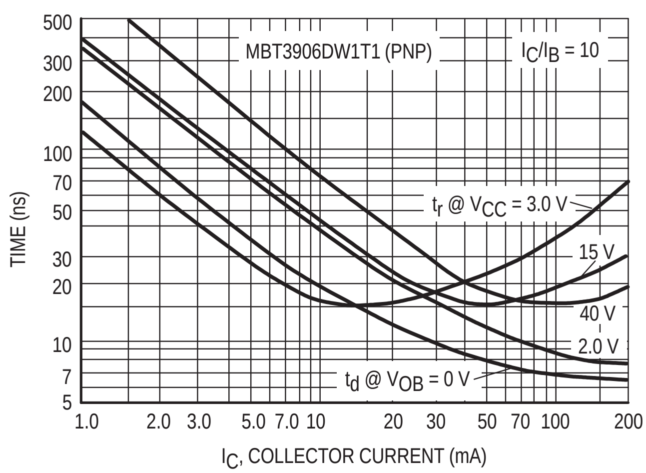


Figure 23. Turn–On Time

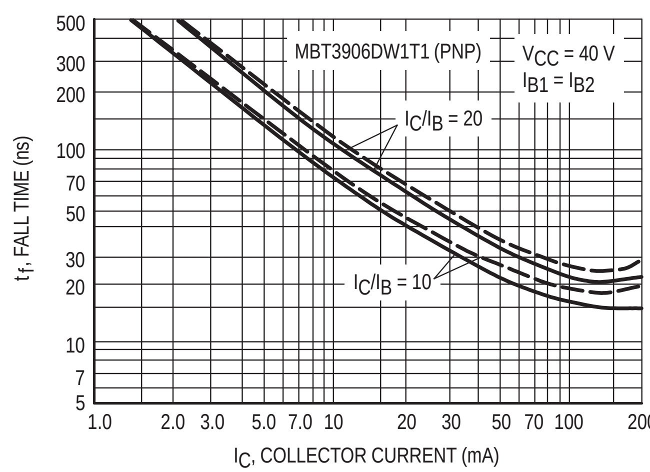


Figure 24. Fall Time

MBT3906DW1T1 (PNP)

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

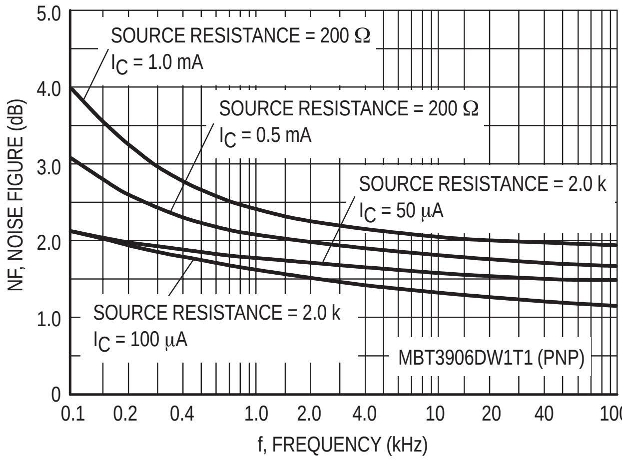


Figure 25.

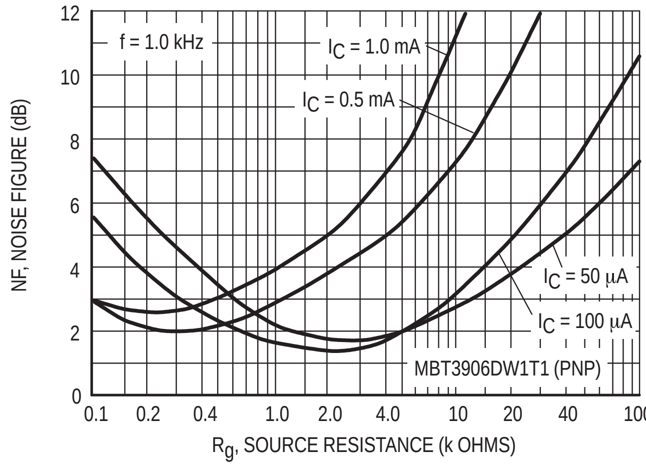


Figure 26.

h PARAMETERS

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

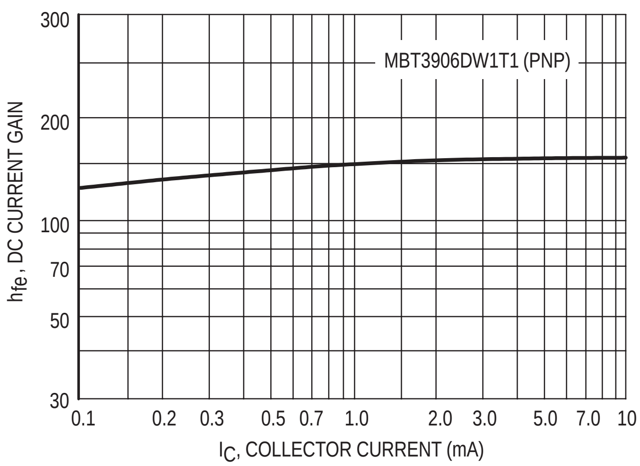


Figure 27. Current Gain

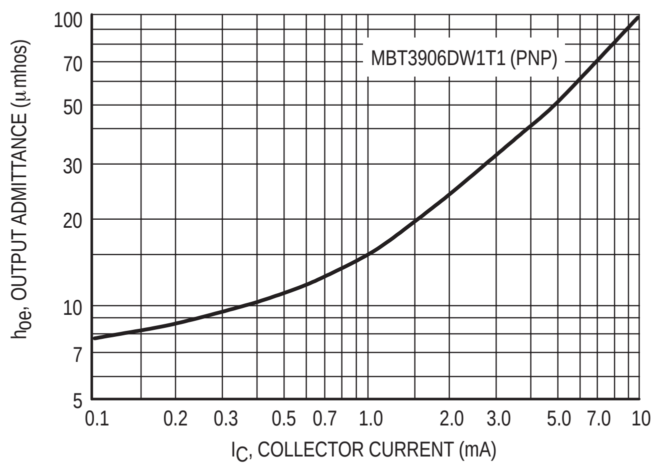


Figure 28. Output Admittance

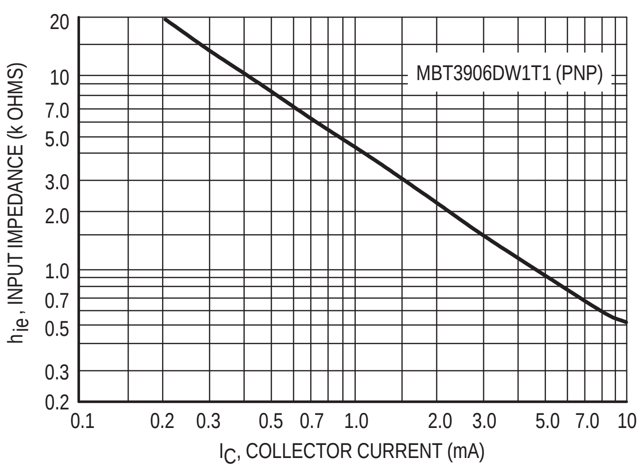


Figure 29. Input Impedance

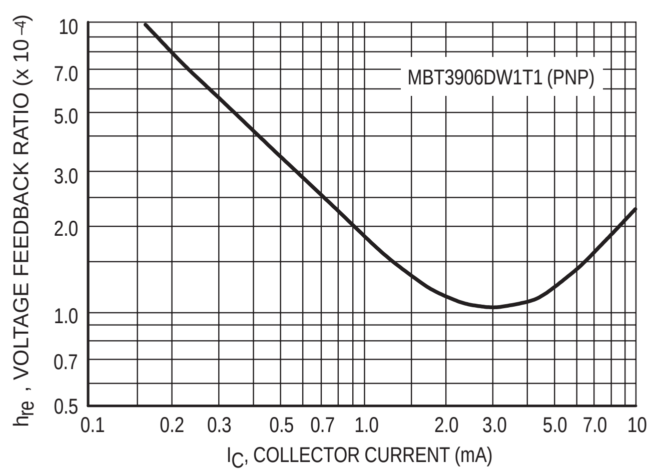


Figure 30. Voltage Feedback Ratio

MBT3906DW1T1 (PNP)

TYPICAL STATIC CHARACTERISTICS

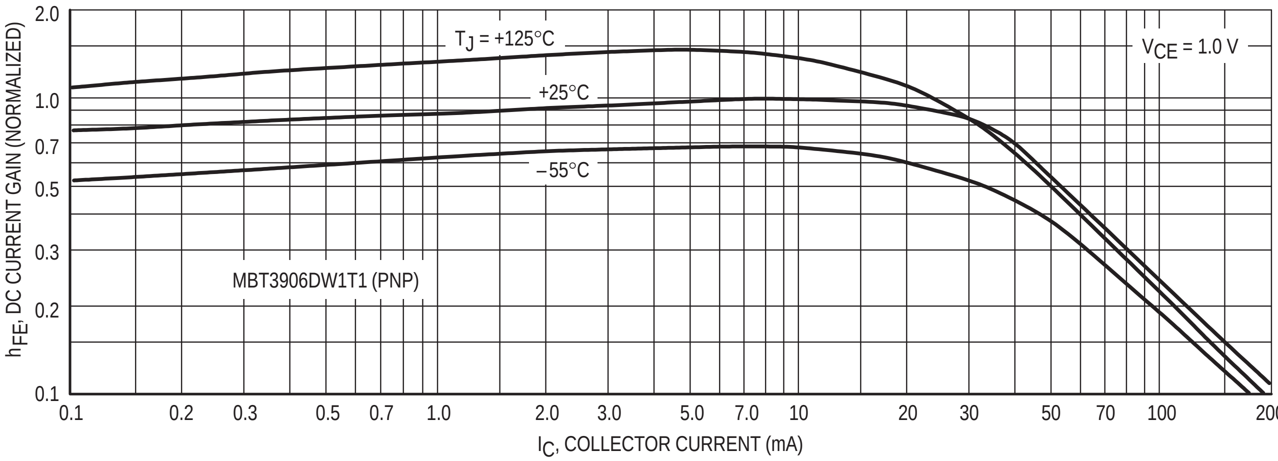


Figure 31. DC Current Gain

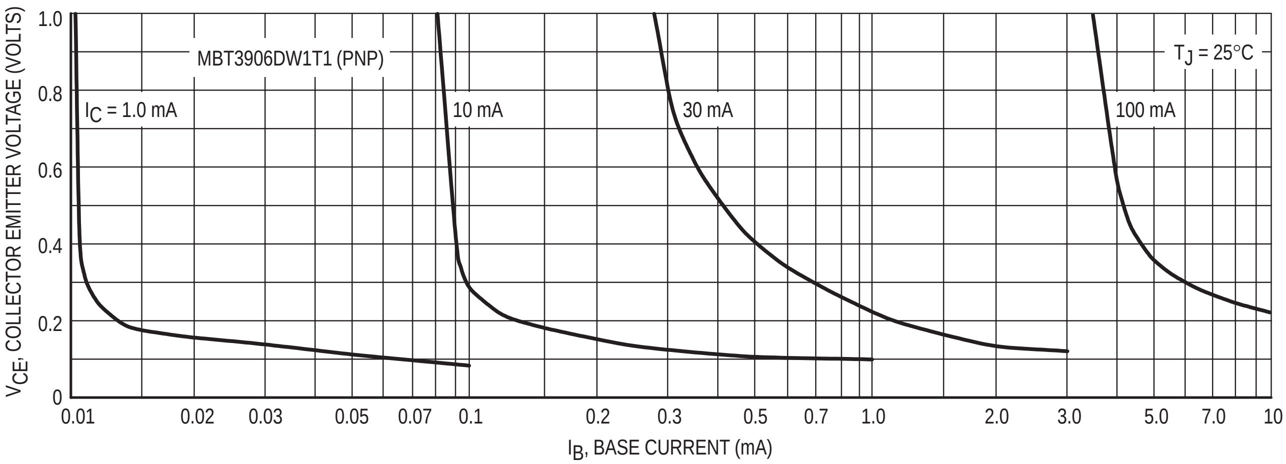


Figure 32. Collector Saturation Region

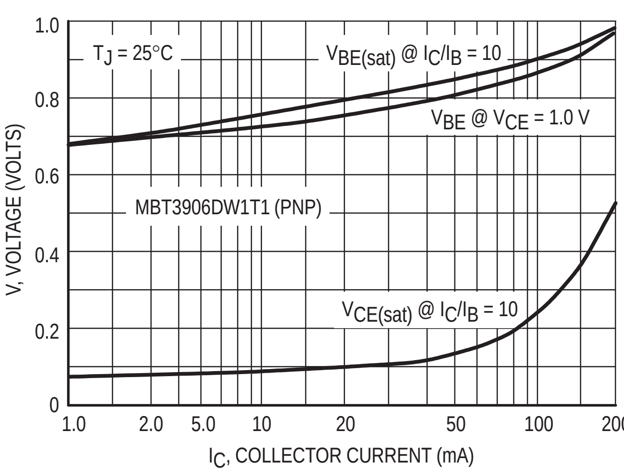


Figure 33. "ON" Voltages

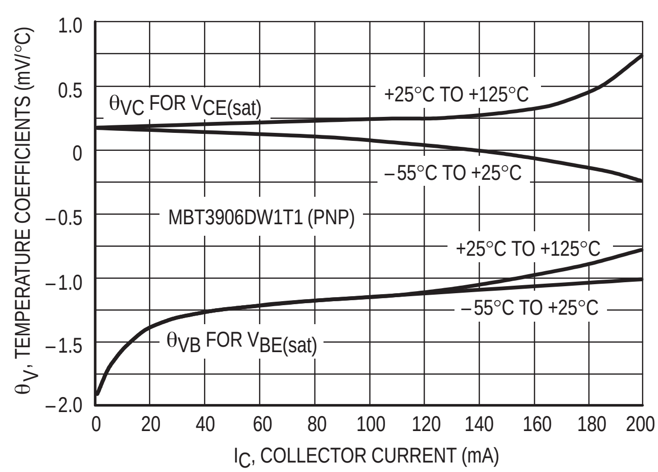
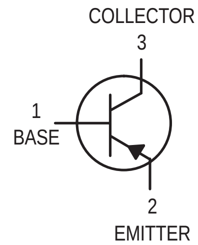


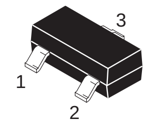
Figure 34. Temperature Coefficients

Chopper Transistor
PNP Silicon



MMBT404ALT1

Motorola Preferred Device



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBT404ALT1 = 2N

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.

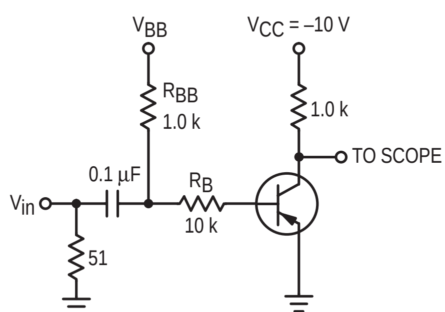
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

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

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
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 –0.2	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



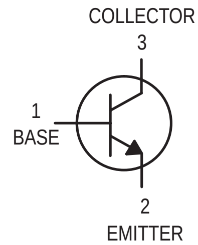
	V_{in} (Volts)	V_{BB} (Volts)
t_{on}, t_d, t_r	–12	+1.4
t_{off}, t_s and t_f	+20.6	–11.6

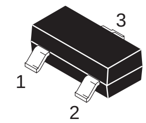
Voltages and resistor values shown are for I_C = 10 mA, I_C/I_B = 10 and I_{B1} = I_{B2}

Figure 1. Switching Time Test Circuit

VHF/UHF Transistor
NPN Silicon

MMBT918LT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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,(1) 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,(2) 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

DEVICE MARKING

MMBT918LT1 = M3B

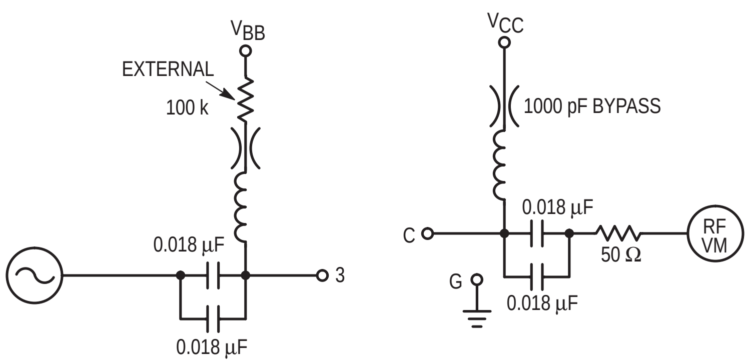
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

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

Characteristic	Symbol	Min	Max	Unit
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	C_{obo}			pF
(V_{CB} = 0 Vdc, I_E = 0, f = 1.0 MHz)		—	3.0	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		—	1.7	
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



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

Figure 1. NF, G_{pe} Measurement Circuit 20–200

Low Saturation Voltage PNP Silicon Driver Transistors

MMBT1010LT1
MSD1010T1

Motorola Preferred Devices

PNP GENERAL PURPOSE DRIVER TRANSISTORS SURFACE MOUNT

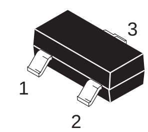
Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

This PNP Silicon Epitaxial Planar Transistor is designed to conserve energy in general purpose driver applications. This device is housed in the SOT-23 and SC–59 packages which are designed for low power surface mount applications.

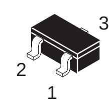
- Low $V_{CE(sat)}$, < 0.1 V at 50 mA

Applications

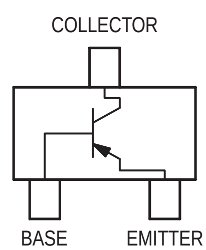
- LCD Backlight Driver
- Annunciator Driver
- General Output Device Driver



CASE 318–08, STYLE 6
SOT-23



CASE 318D–04, STYLE 1
SC-59



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	45	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	15	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

DEVICE MARKING

MMBT1010LT1 = GLP
MSD1010T1 = GLP

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation T_A = 25°C Derate above 25°C	P_D(1)	250 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ +150	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 10 mA, I_B = 0	15	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 µA, I_E = 0	5.0	—	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}(2)	V_{CE} = 5 V, I_C = 100 mA	300	600	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$(2)	I_C = 10 mA, I_B = 1.0 mA I_C = 50 mA, I_B = 5.0 mA I_C = 100 mA, I_B = 10 mA	— —	0.1 0.1 0.19	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$(2)	I_C = 100 mA, I_B = 10 mA	—	1.1	Vdc

(1) Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.
(2) Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

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

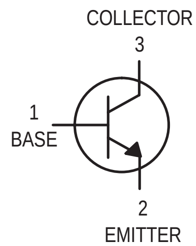
REV 2

Preliminary Information

General Purpose Transistor

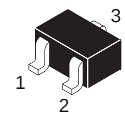
NPN Silicon

These transistors are designed for general purpose amplifier applications. They are housed in the SOT–323/SC–70 package which is designed for low power surface mount applications.



MMBT2222AWT1

Motorola Preferred Device



CASE 419–02, STYLE 3
SOT–323/SC–70

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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board T_A = 25°C	P_D	150	mW
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	833	°C/W
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

DEVICE MARKING

MMBT2222AWT1 = 1P

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)	$V_{(BR)CBO}$	75	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 60 Vdc, V_{EB} = 3.0 Vdc)	I_{BL}	—	20	nAdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{EB} = 3.0 Vdc)	I_{CEX}	—	10	nAdc

1. Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%.

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS(1)					
DC Current Gain (1)		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)			75	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)			100	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)			40	—	
Collector–Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.0	
Base–Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	2.0	
SMALL–SIGNAL 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_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
Input Impedance (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)		h_{ie}	0.25	1.25	k ohms
Voltage Feedback Ratio (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)		h_{re}	—	4.0	X 10^{-4}
Small–Signal Current Gain (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)		h_{fe}	75	375	—
Output Admittance (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)		h_{oe}	25	200	μmhos
Noise Figure (V_{CE} = 10 Vdc, I_C = 100 μAdc, R_S = 1.0 k ohms, f = 1.0 kHz)		NF	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = –0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	10	ns
Rise Time		t_r	—	25	
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	

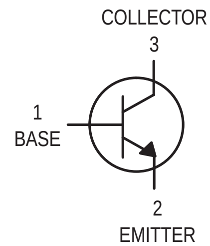
1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

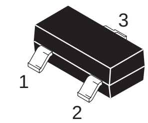
General Purpose Transistors

NPN Silicon

MMBT2222LT1
MMBT2222ALT1*

***Motorola Preferred Device**





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	2222	2222A	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(1) 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,(2) 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

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} = 60 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}	—	100	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MMBT2222A	I_{BL}	—	20	nAdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

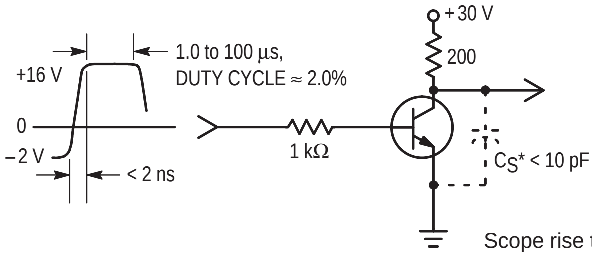
Preferred devices are Motorola recommended choices for future use and best overall value.

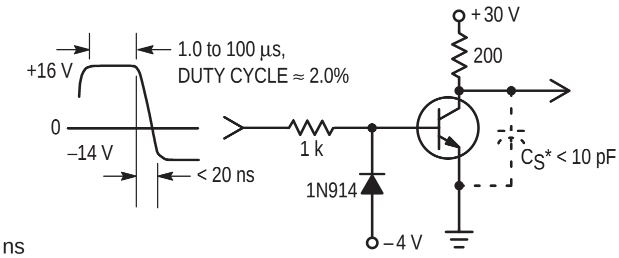
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Max	Unit
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)			75	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = –55°C)	MMBT2222A only		35	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc) (3)			100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (3)			50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc) (3)	MMBT2222		30	—	
	MMBT2222A		40	—	
Collector–Emitter Saturation Voltage (3)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MMBT2222		—	0.4	
	MMBT2222A		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	MMBT2222		—	1.6	
	MMBT2222A		—	1.0	
Base–Emitter Saturation Voltage (3)		$V_{BE(sat)}$			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 (4)		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	
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	

3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
4. f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS





Scope rise time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

Figure 1. Turn–On Time **Figure 2. Turn–Off Time**

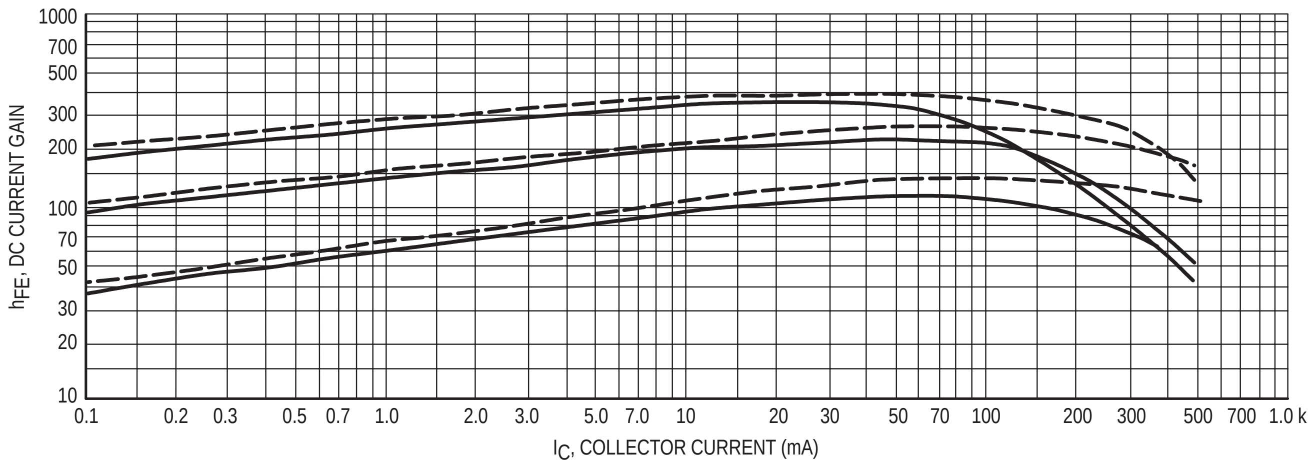


Figure 3. DC Current Gain

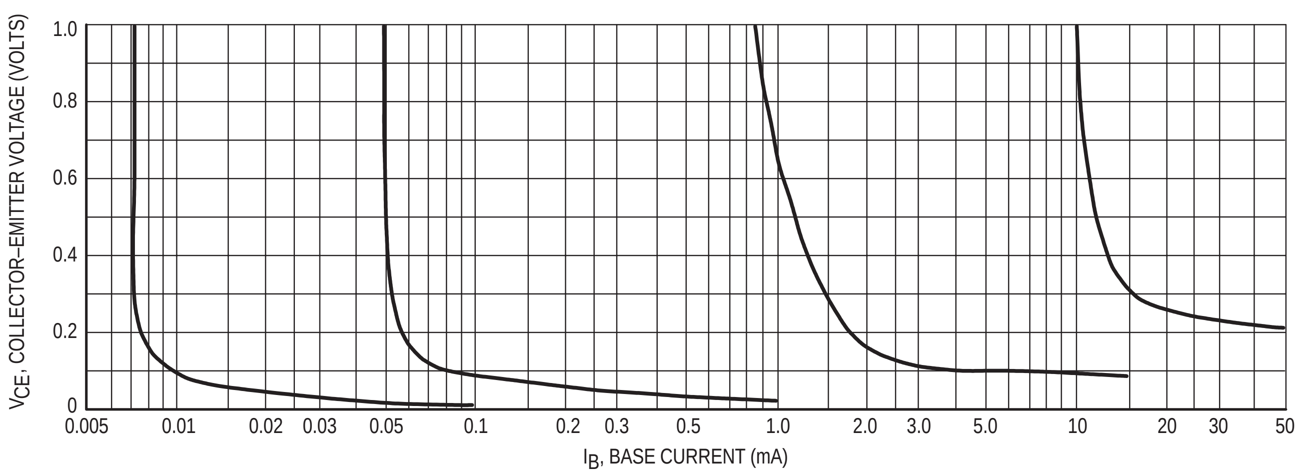


Figure 4. Collector Saturation Region

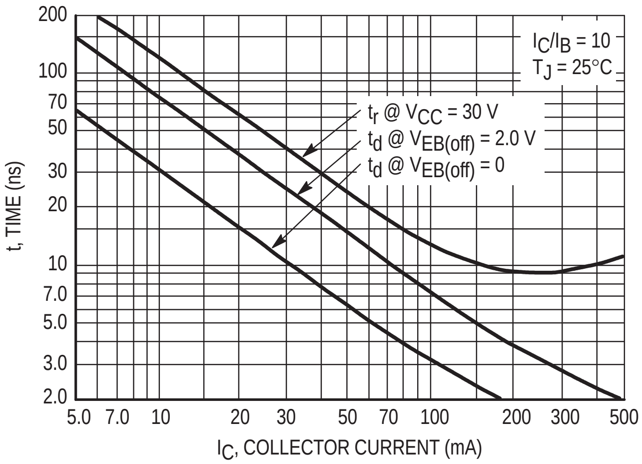


Figure 5. Turn–On Time

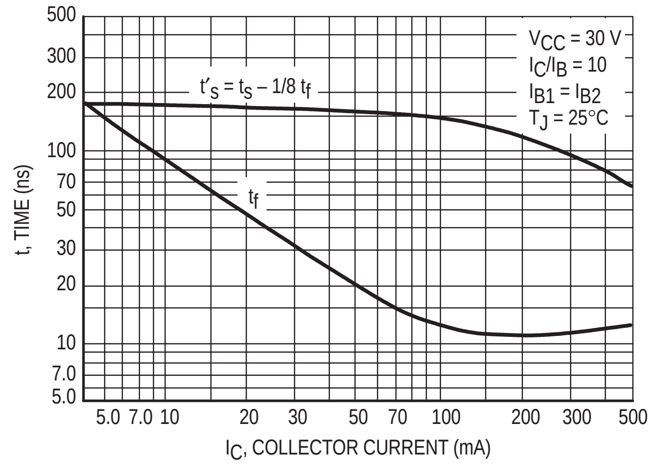


Figure 6. Turn–Off Time

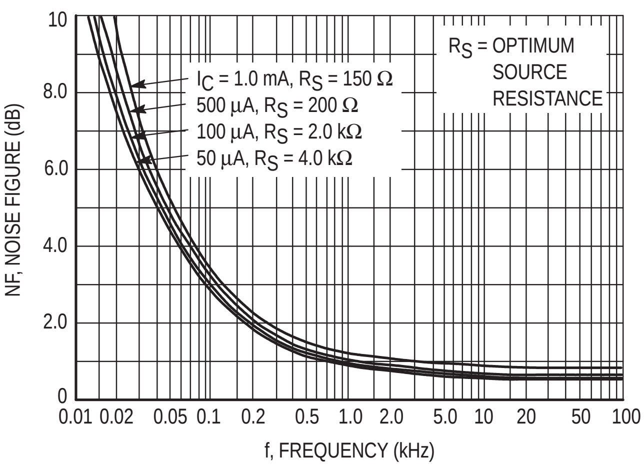


Figure 7. Frequency Effects

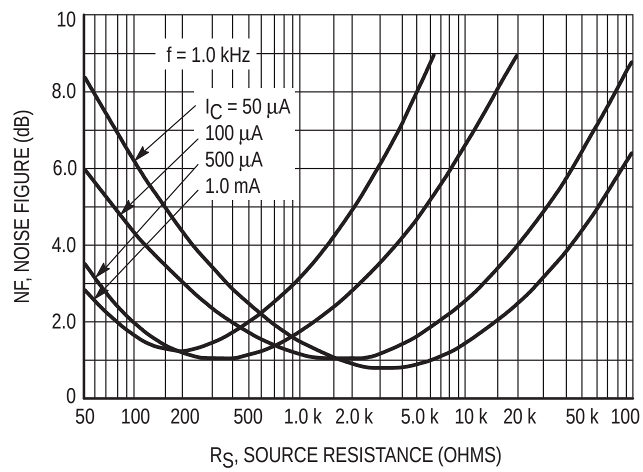


Figure 8. Source Resistance Effects

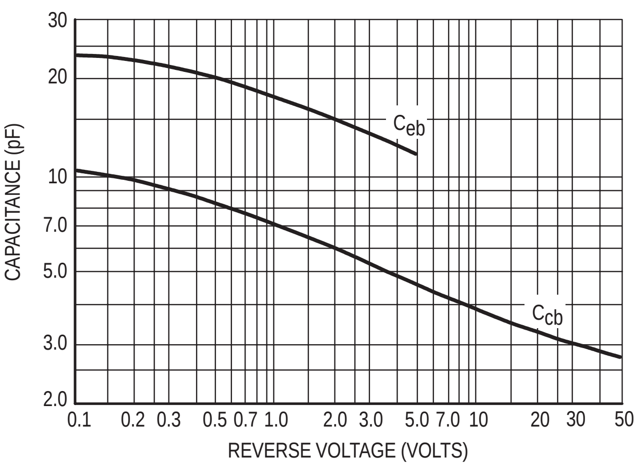


Figure 9. Capacitances

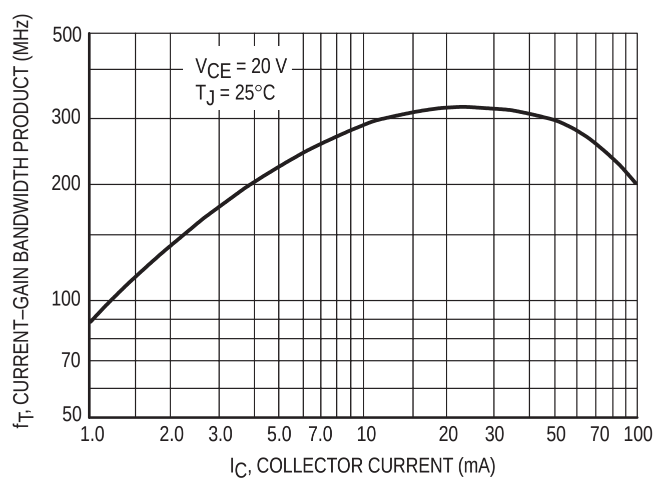


Figure 10. Current–Gain Bandwidth Product

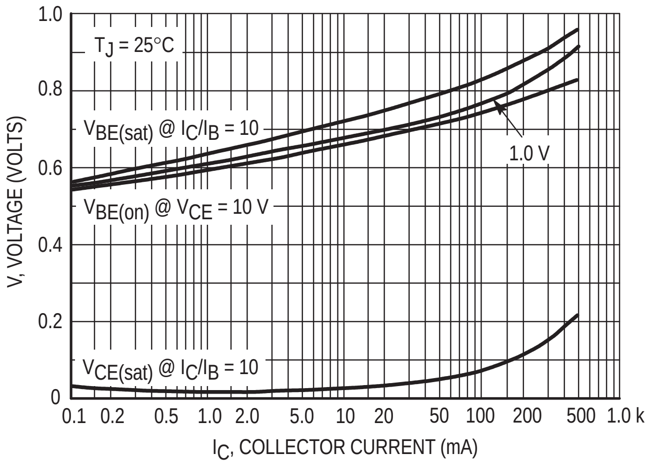


Figure 11. "On" Voltages

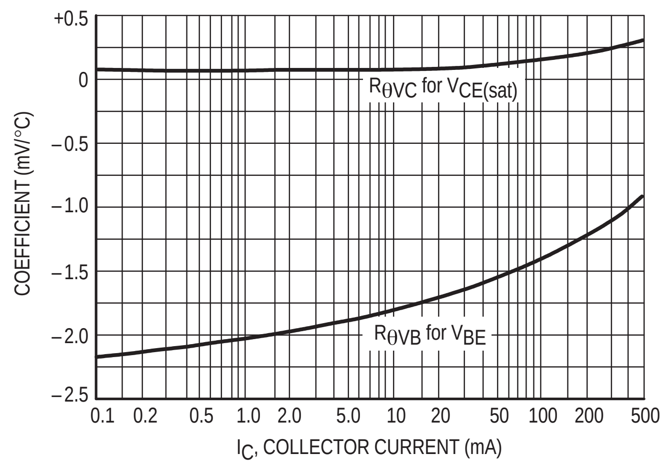
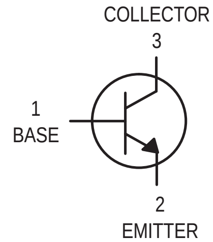


Figure 12. Temperature Coefficients

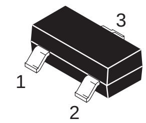
Switching Transistors

NPN Silicon



MMBT2369LT1
MMBT2369ALT1*

***Motorola Preferred Device**



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

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 (3) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	40	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	— —	0.4 30	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0) MMBT2369A	I_{CES}	—	—	0.4	μAdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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 (3)		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 (3)		$V_{CE(sat)}$				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 (3)		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MMBT2369A		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	
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

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

SWITCHING TIME EQUIVALENT TEST CIRCUITS FOR 2N2369, 2N3227

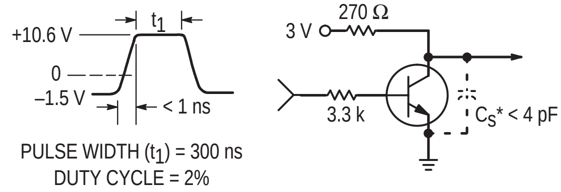


Figure 1. t_{on} Circuit — 10 mA

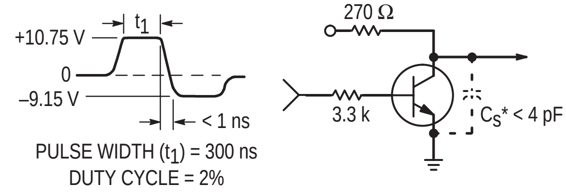


Figure 3. t_{off} Circuit — 10 mA

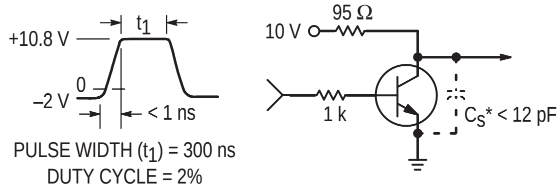


Figure 2. t_{on} Circuit — 100 mA

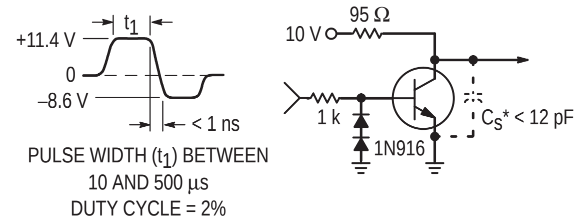


Figure 4. t_{off} Circuit — 100 mA

* Total shunt capacitance of test jig and connectors.

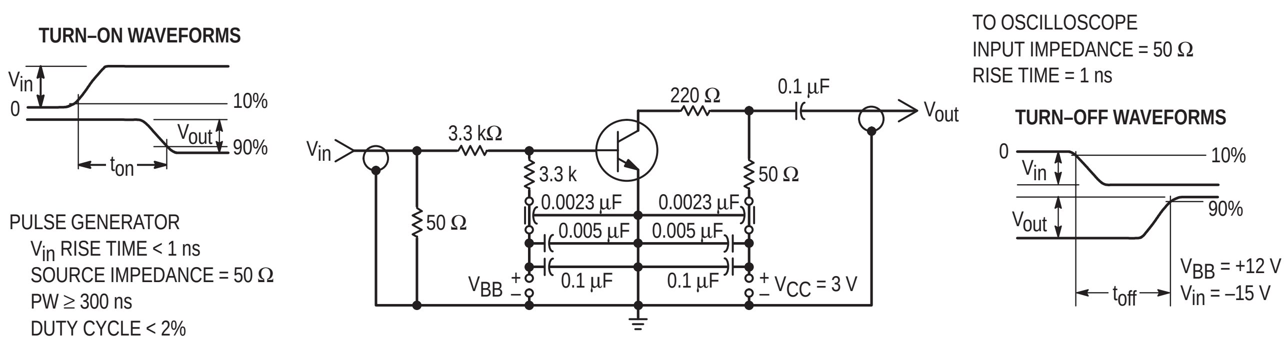


Figure 5. Turn–On and Turn–Off Time Test Circuit

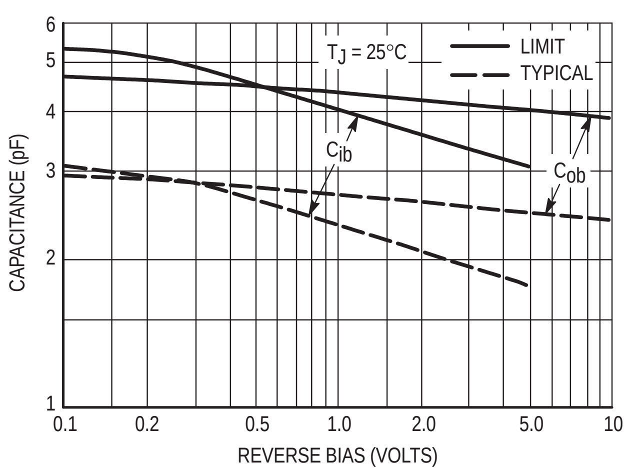


Figure 6. Junction Capacitance Variations

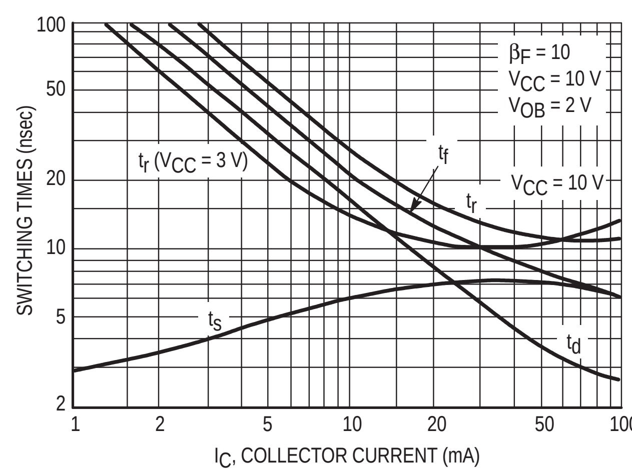


Figure 7. Typical Switching Times

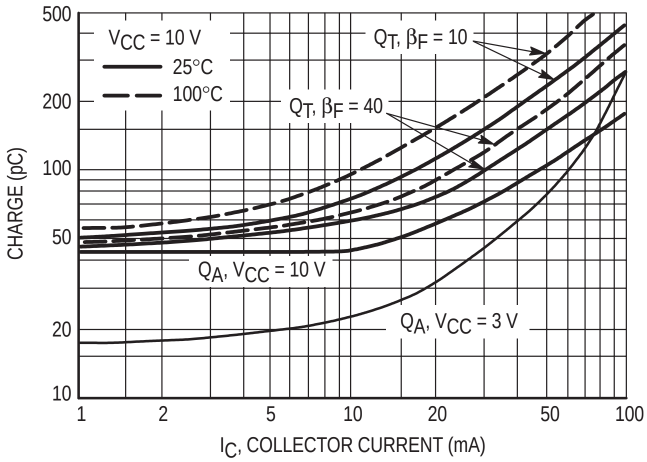


Figure 8. Maximum Charge Data

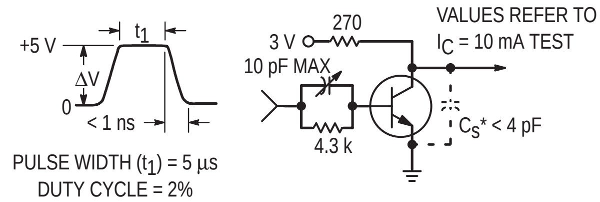


Figure 9. Q_T Test Circuit

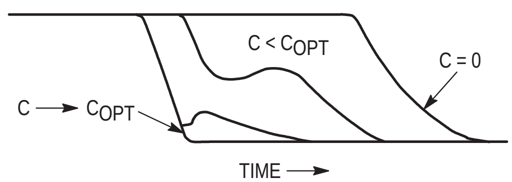


Figure 10. Turn–Off Waveform

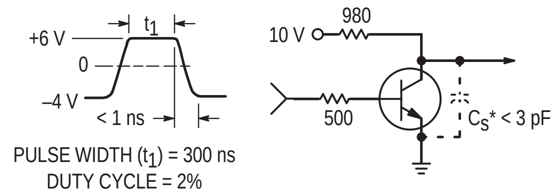


Figure 11. Storage Time Equivalent Test Circuit

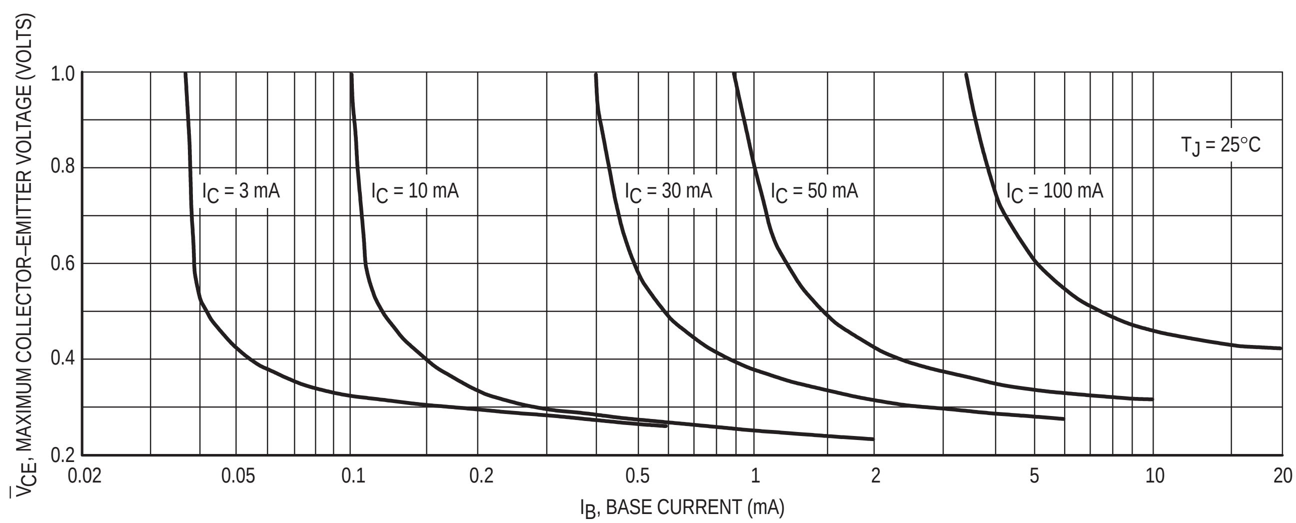


Figure 12. Maximum Collector Saturation Voltage Characteristics

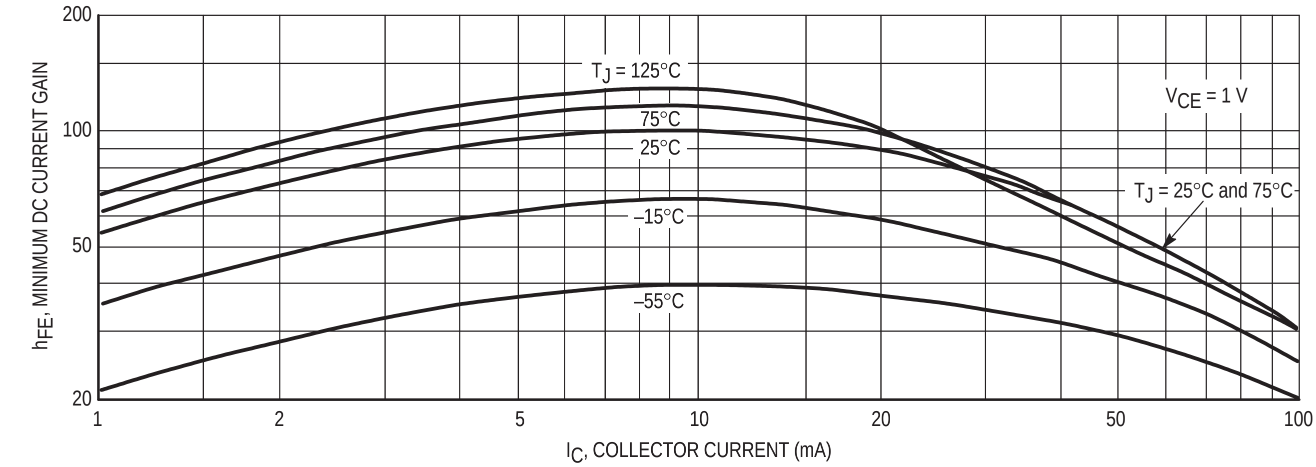


Figure 13. Minimum Current Gain Characteristics

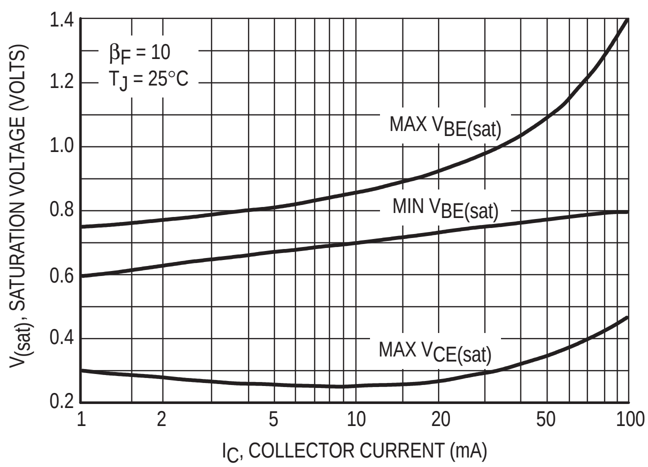


Figure 14. Saturation Voltage Limits

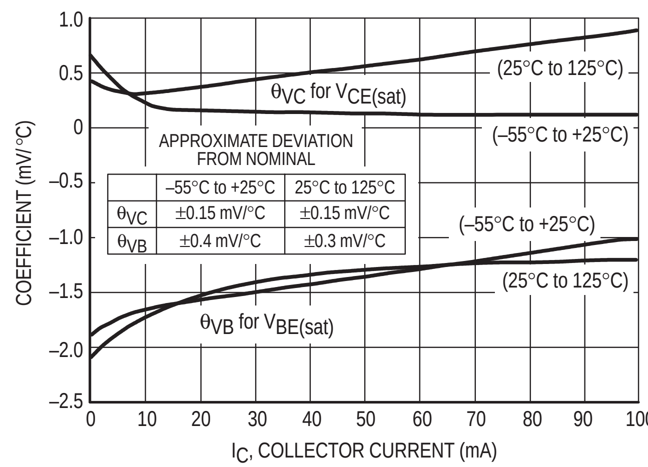
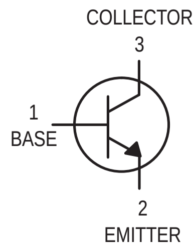
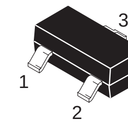


Figure 15. Typical Temperature Coefficients

Low Noise Transistor
NPN Silicon

MMBT2484LT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

MMBT2484LT1 = 1U

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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic	Symbol	Min	Max	Unit
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 mAdc)	$V_{BE(on)}$	—	0.95	Vdc
SMALL–SIGNAL CHARACTERISTICS				
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
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

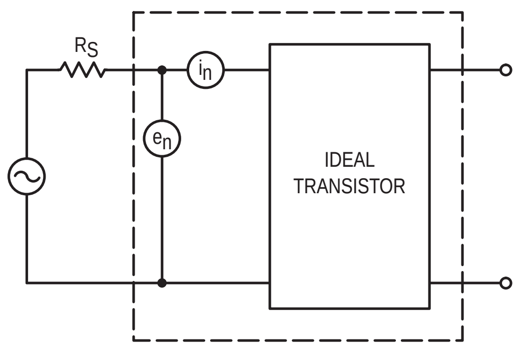


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

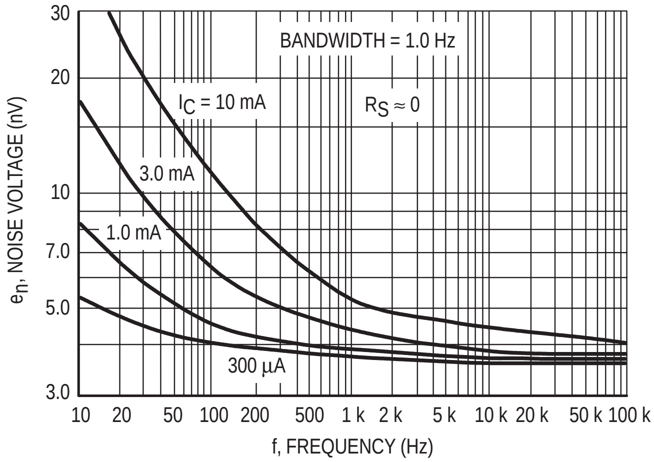


Figure 2. Effects of Frequency

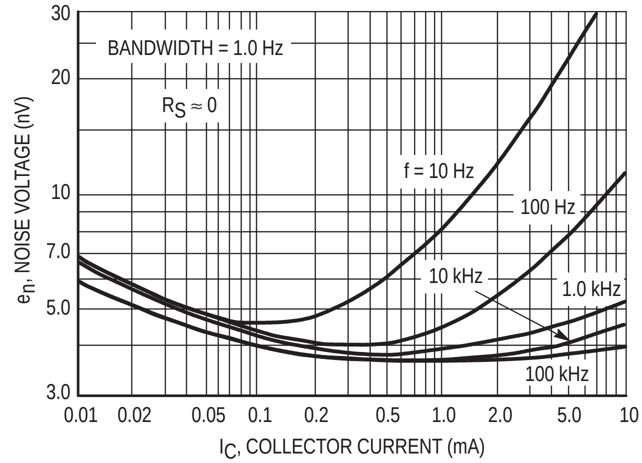


Figure 3. Effects of Collector Current

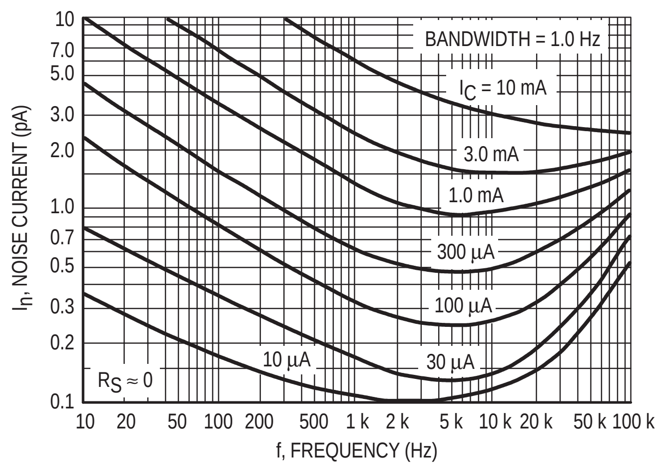


Figure 4. Noise Current

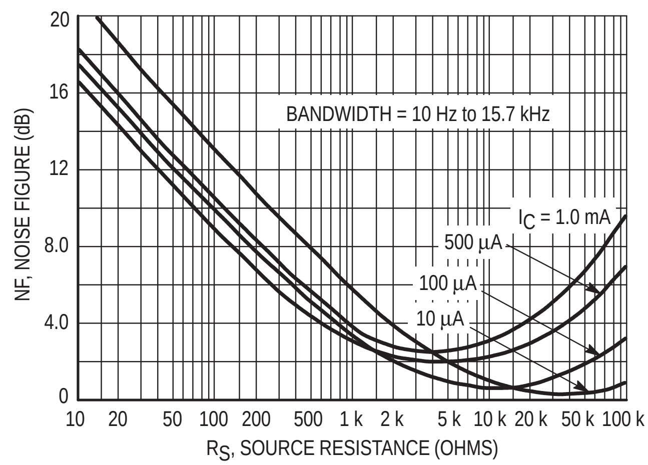


Figure 5. Wideband Noise Figure

100 Hz NOISE DATA

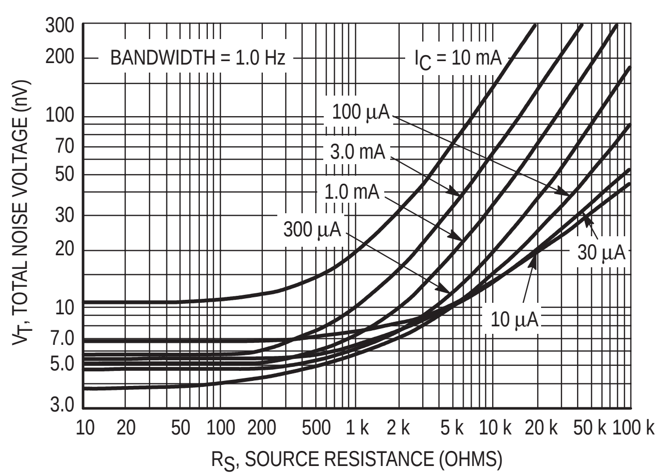


Figure 6. Total Noise Voltage

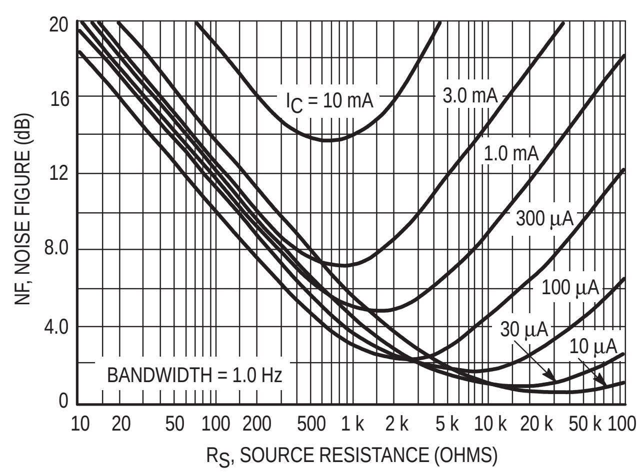


Figure 7. Noise Figure

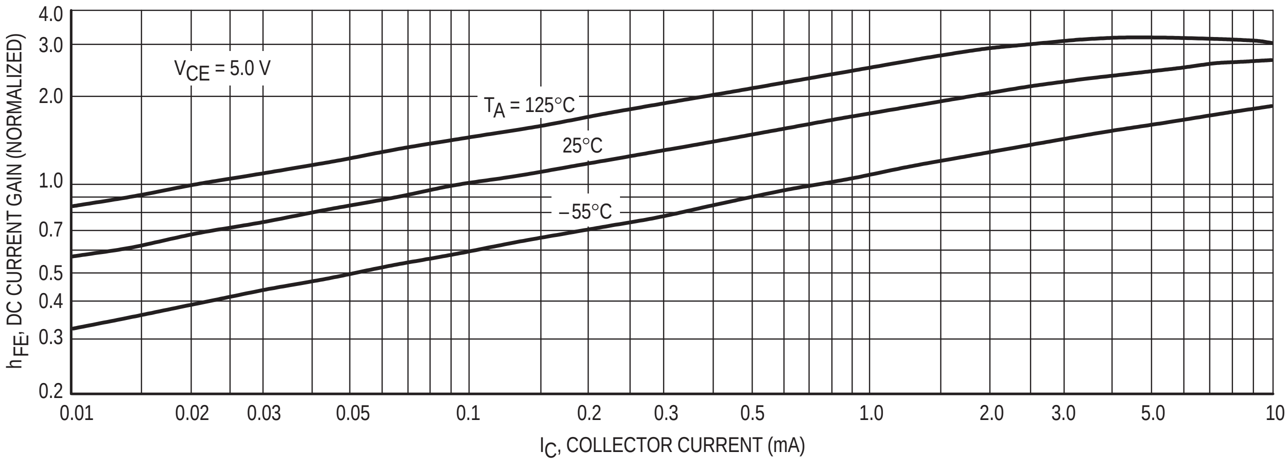


Figure 8. DC Current Gain

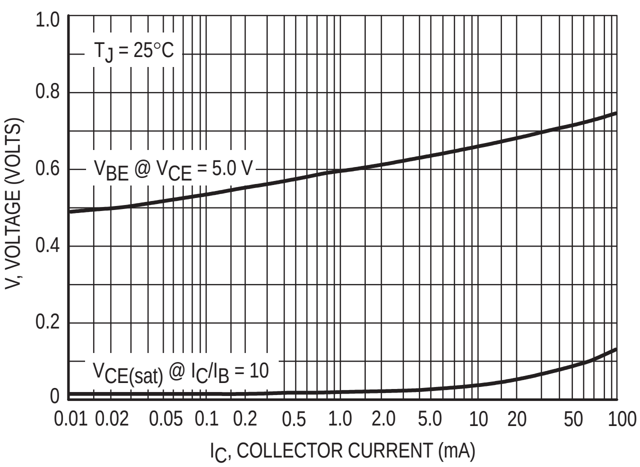


Figure 9. “On” Voltages

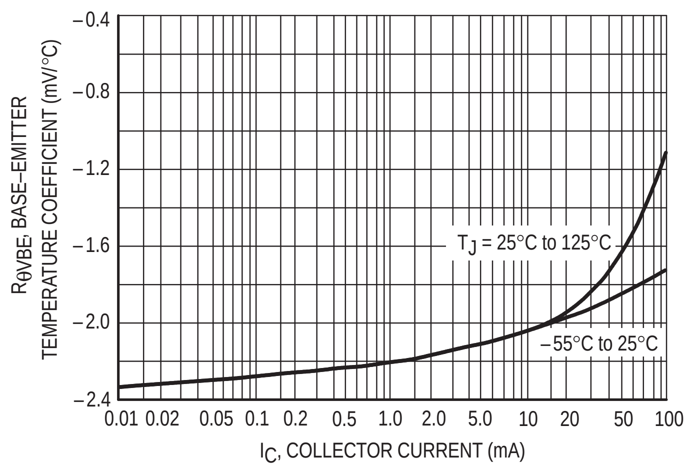


Figure 10. Temperature Coefficients

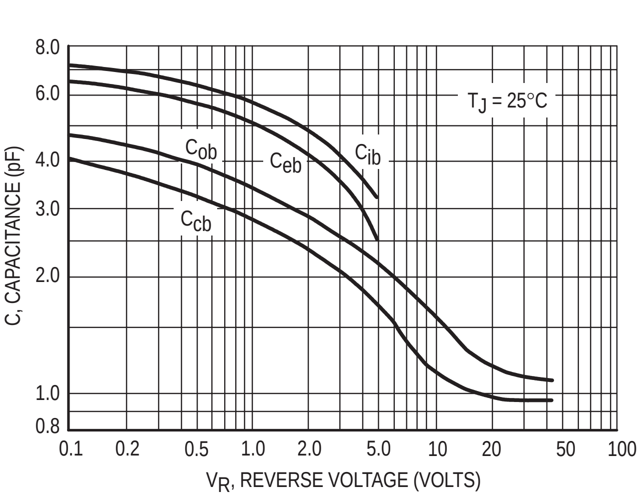


Figure 11. Capacitance

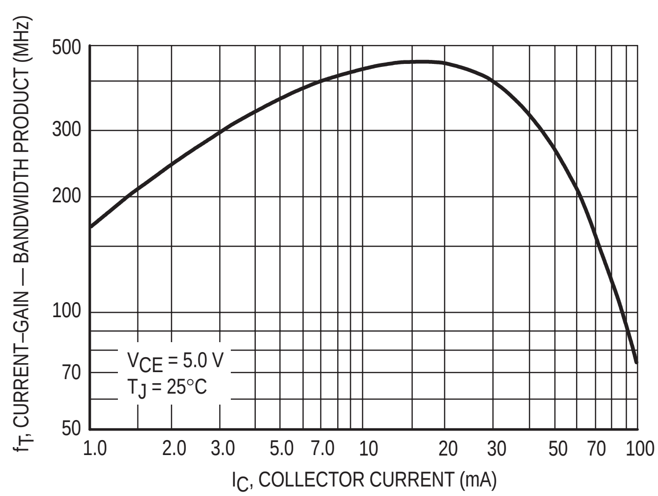


Figure 12. Current–Gain — Bandwidth Product

Preliminary Information

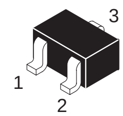
General Purpose Transistor

PNP Silicon

These transistors are designed for general purpose amplifier applications. They are housed in the SOT–323/SC–70 package which is designed for low power surface mount applications.

MMBT2907AWT1

Motorola Preferred Device



CASE 419–02, STYLE 3
SOT–323/SC–70

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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) $T_A = 25°C$	P_D	150	mW
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	833	°C/W
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

DEVICE MARKING

MMBT2907AWT1 = 2F

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)	$V_{(BR)CEO}$	–60	—	Vdc
Collector–Base Breakdown Voltage (I_C = –10 mAdc, I_E = 0)	$V_{(BR)CBO}$	–60	—	Vdc
Emitter–Base Breakdown Voltage (I_E = –10 μAdc, I_C = 0)	$V_{(BR)EBO}$	–5.0	—	Vdc
Base Cutoff Current (V_{CE} = –30 Vdc, $V_{EB(off)}$ = –0.5 Vdc)	I_{BL}	—	–50	nAdc
Collector Cutoff Current (V_{CE} = –30 Vdc, $V_{EB(off)}$ = –0.5 Vdc)	I_{CEX}	—	–50	nAdc

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

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

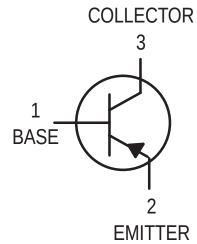
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS(1)					
DC Current Gain (1) (I_C = –0.1 mAdc, V_{CE} = –10 Vdc) (I_C = –1.0 mAdc, V_{CE} = –10 Vdc) (I_C = –10 mAdc, V_{CE} = –10 Vdc) (I_C = –150 mAdc, V_{CE} = –10 Vdc) (I_C = –500 mAdc, V_{CE} = –10 Vdc)		H_{FE}	 75 100 100 100 50	 — — — — —	—
Collector–Emitter Saturation Voltage(1) (I_C = –150 mAdc, I_B = –15 mAdc) (I_C = –500 mAdc, I_B = –50 mAdc)		$V_{CE(sat)}$	 — —	 –0.4 –1.6	Vdc
Base–Emitter Saturation Voltage(1) (I_C = –150 mAdc, I_B = –15 mAdc) (I_C = –500 mAdc, I_B = –50 mAdc)		$V_{BE(sat)}$	 — —	 –1.3 –2.6	Vdc
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product (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	
Rise Time		t_r	—	40	
Storage Time	(V_{CC} = –6.0 Vdc, I_C = –150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	80	
Fall Time		t_f	—	30	
Turn–Off Time		t_{off}	—	100	

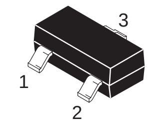
1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

General Purpose Transistors
PNP Silicon

MMBT2907LT1
MMBT2907ALT1*

*Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	2907	2907A	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(1) 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,(2) 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

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(3) (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, $V_{BE(off)}$ = –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 = 125°C)	 MMBT2907 MMBT2907A MMBT2907 MMBT2907A	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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = –0.1 mAdc, V_{CE} = –10 Vdc)	MMBT2907		35	—	
	MMBT2907A		75	—	
(I_C = –1.0 mAdc, V_{CE} = –10 Vdc)	MMBT2907		50	—	
	MMBT2907A		100	—	
(I_C = –10 mAdc, V_{CE} = –10 Vdc)	MMBT2907		75	—	
	MMBT2907A		100	—	
(I_C = –150 mAdc, V_{CE} = –10 Vdc) (3)	MMBT2907		—	—	
	MMBT2907A		100	300	
(I_C = –500 mAdc, V_{CE} = –10 Vdc) (3)	MMBT2907		30	—	
	MMBT2907A		50	—	
Collector–Emitter Saturation Voltage (3)		$V_{CE(sat)}$			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 (3)		$V_{BE(sat)}$			Vdc
(I_C = –150 mAdc, I_B = –15 mAdc)			—	–1.3	
(I_C = –500 mAdc, I_B = –50 mAdc)			—	–2.6	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product (3),(4) (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	
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	

3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
4. f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

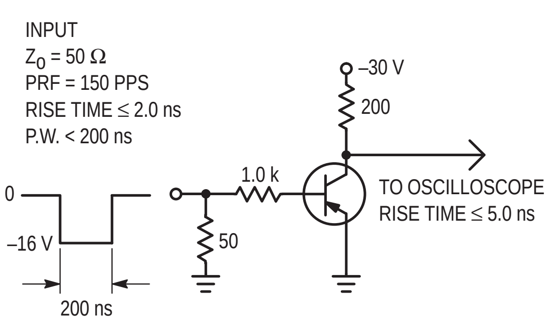


Figure 1. Delay and Rise Time Test Circuit

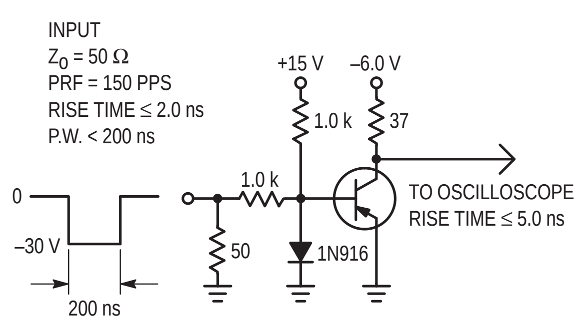


Figure 2. Storage and Fall Time Test Circuit

TYPICAL CHARACTERISTICS

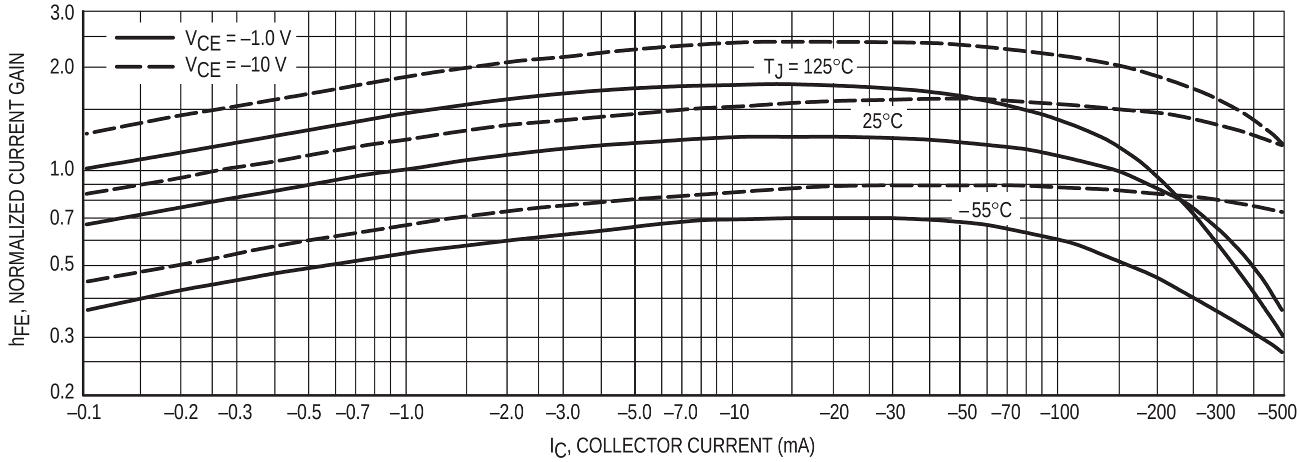


Figure 3. DC Current Gain

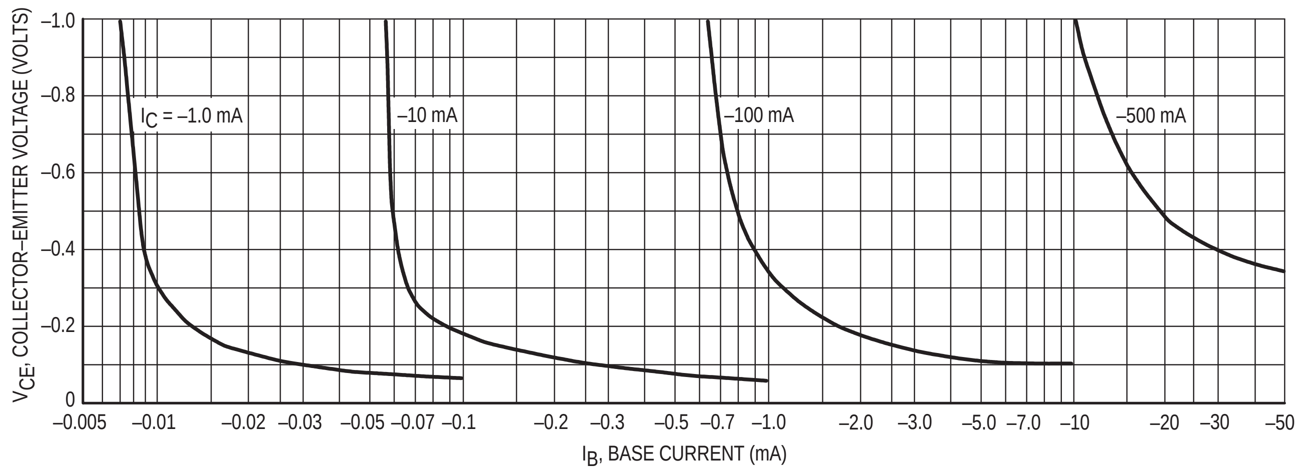


Figure 4. Collector Saturation Region

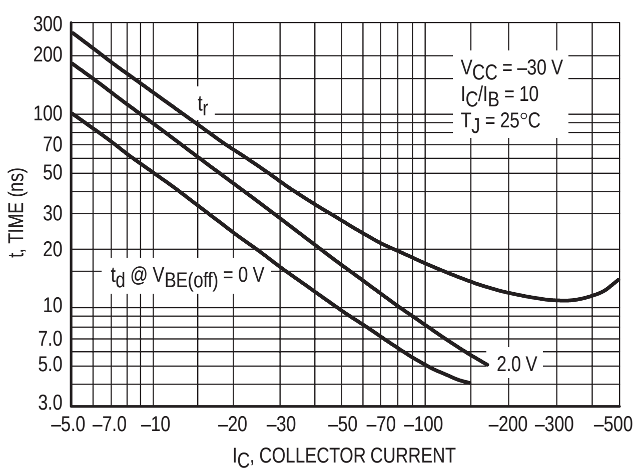


Figure 5. Turn–On Time

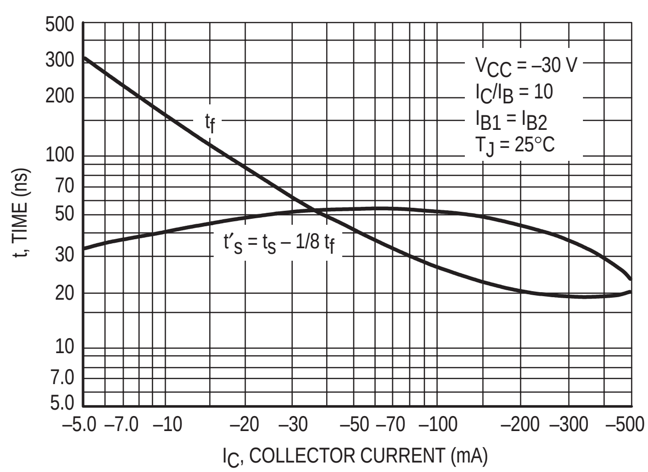


Figure 6. Turn–Off Time

TYPICAL SMALL–SIGNAL CHARACTERISTICS
NOISE FIGURE
V_{CE} = 10 Vdc, T_A = 25°C

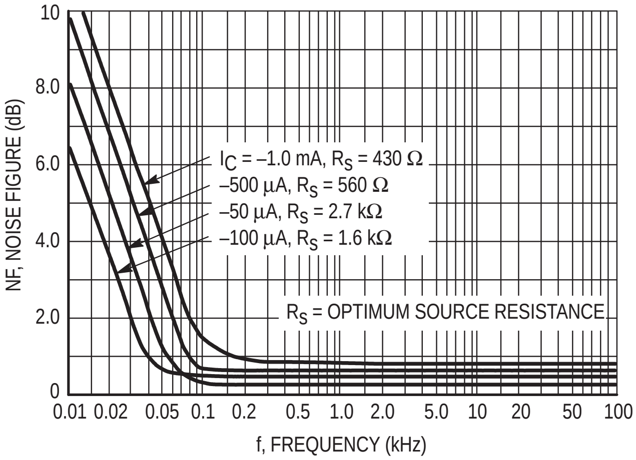


Figure 7. Frequency Effects

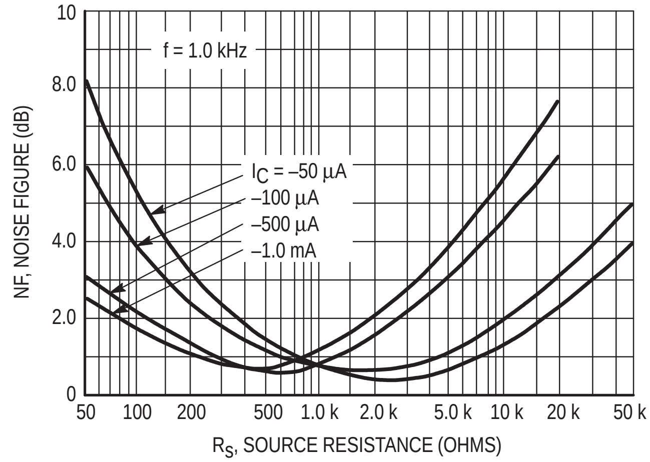


Figure 8. Source Resistance Effects

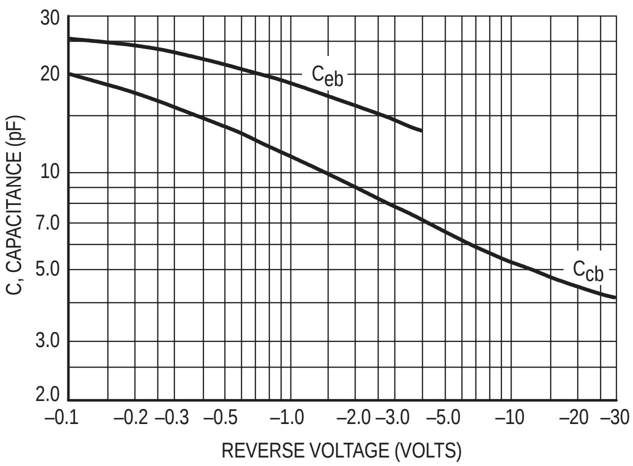


Figure 9. Capacitances

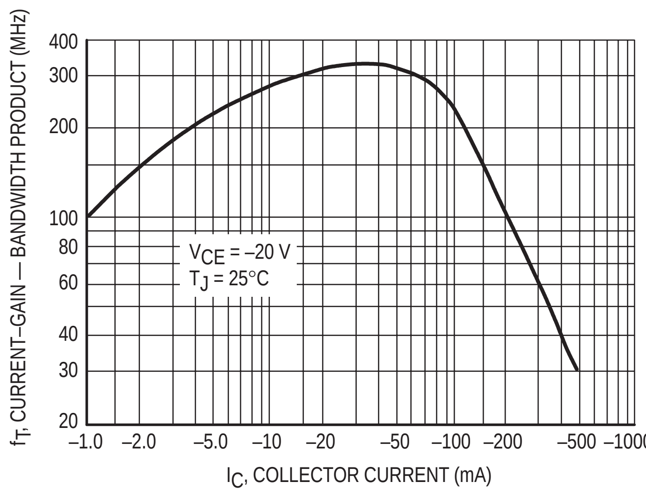


Figure 10. Current–Gain — Bandwidth Product

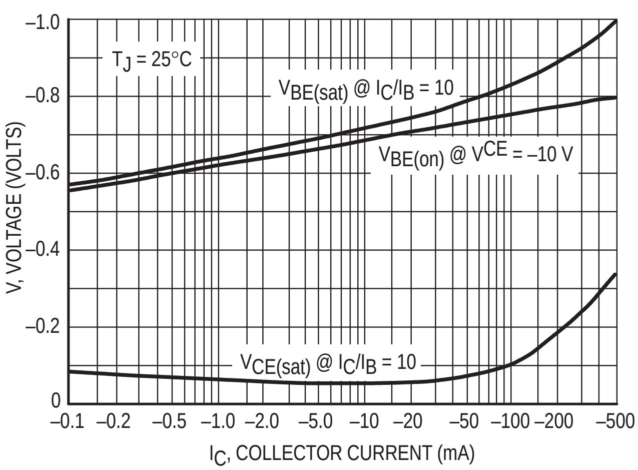


Figure 11. "On" Voltage

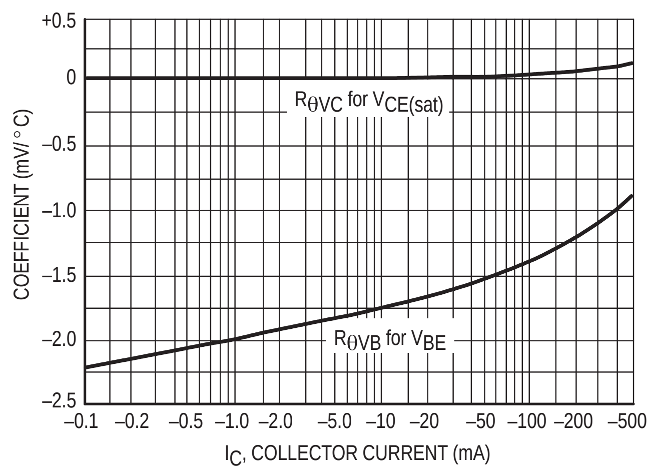
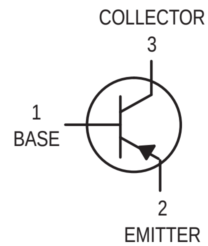


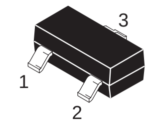
Figure 12. Temperature Coefficients

Switching Transistor
PNP Silicon



MMBT3640LT1

Motorola Preferred Device



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	–12	Vdc
Collector–Base Voltage	V_{CBO}	–12	Vdc
Emitter–Base Voltage	V_{EBO}	–4.0	Vdc
Collector Current — Continuous	I_C	–80	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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,(2) 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

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 Cutoff Current (V_{CE} = –6.0 Vdc, V_{EB} = 0)	I_B	—	–10	nAdc

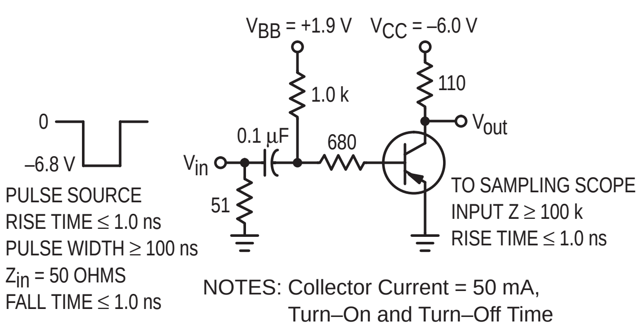
1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

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

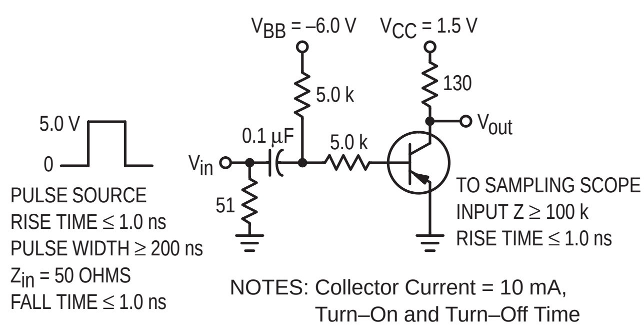
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS(3)				
DC Current Gain	h_{FE}			—
(I_C = –10 mAdc, V_{CE} = –0.3 Vdc)		30	120	
(I_C = –50 mAdc, V_{CE} = –1.0 Vdc)		20	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = –10 mAdc, I_B = –1.0 mAdc)		—	–0.2	
(I_C = –50 mAdc, I_B = –5.0 mAdc)		—	–0.6	
(I_C = –10 mAdc, I_B = –1.0 mAdc, T_A = 65°C)		—	–0.25	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = –10 mAdc, I_B = –0.5 mAdc)		–0.75	–0.95	
(I_C = –10 mAdc, I_B = –1.0 mAdc)		–0.8	–1.0	
(I_C = –50 mAdc, I_B = –5.0 mAdc)		—	–1.5	
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 (V_{CC} = –6.0 Vdc, I_C = –50 mAdc, $V_{EB(off)}$ = –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	t_{on}			ns
(V_{CC} = –6.0 Vdc, I_C = –50 mAdc, $V_{EB(off)}$ = –1.9 Vdc, I_{B1} = –5.0 mAdc)		—	25	
(V_{CC} = –1.5 Vdc, I_C = –10 mAdc, I_{B1} = –0.5 mAdc)		—	60	
Turn–Off Time	t_{off}			ns
(V_{CC} = –6.0 Vdc, I_C = –50 mAdc, $V_{EB(off)}$ = –1.9 Vdc, I_{B1} = I_{B2} = –5.0 mAdc)		—	35	
(V_{CC} = –1.5 Vdc, I_C = –10 mAdc, I_{B1} = I_{B2} = –0.5 mAdc)		—	75	

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



NOTES: Collector Current = 50 mA,
Turn–On and Turn–Off Time
Base Currents = 5.0 mA.

Figure 1.



NOTES: Collector Current = 10 mA,
Turn–On and Turn–Off Time
Base Currents = 0.5 mA.

Figure 2.

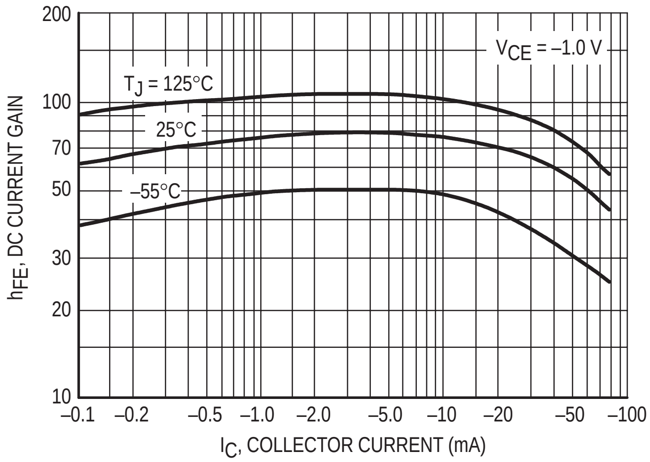


Figure 3. DC Current Gain

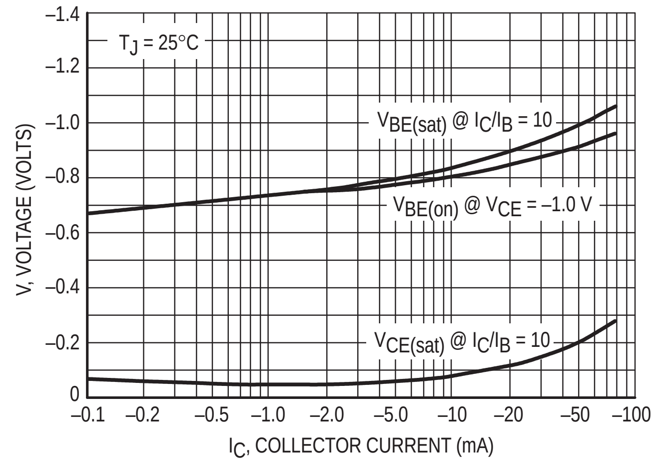


Figure 4. "On" Voltages

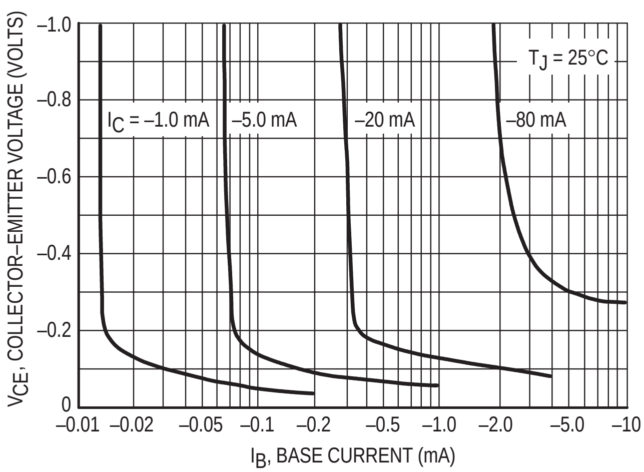


Figure 5. Collector Saturation Region

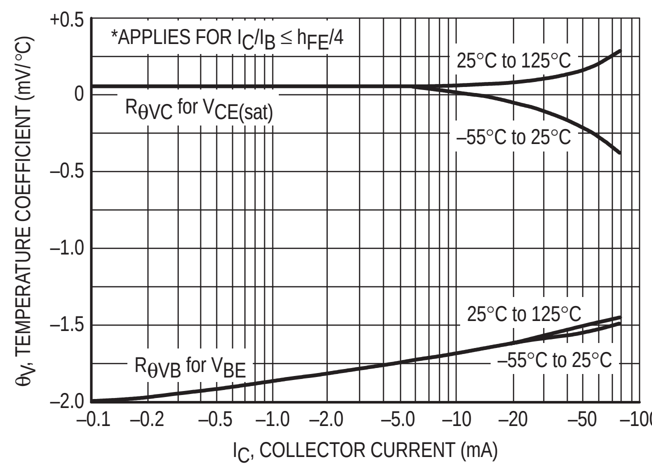


Figure 6. Temperature Coefficients

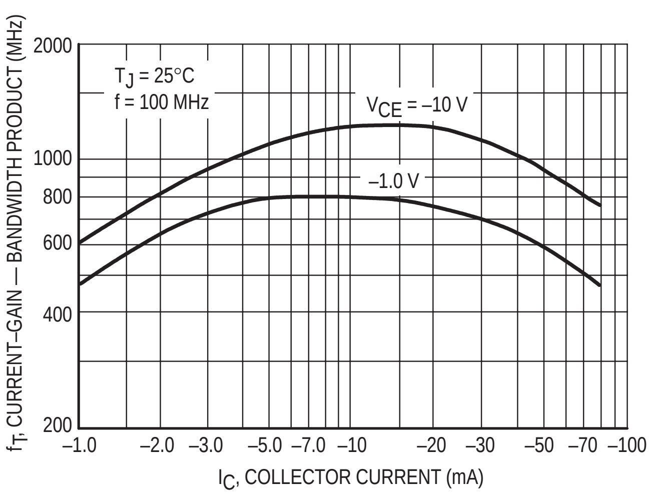


Figure 7. Current–Gain — Bandwidth Product

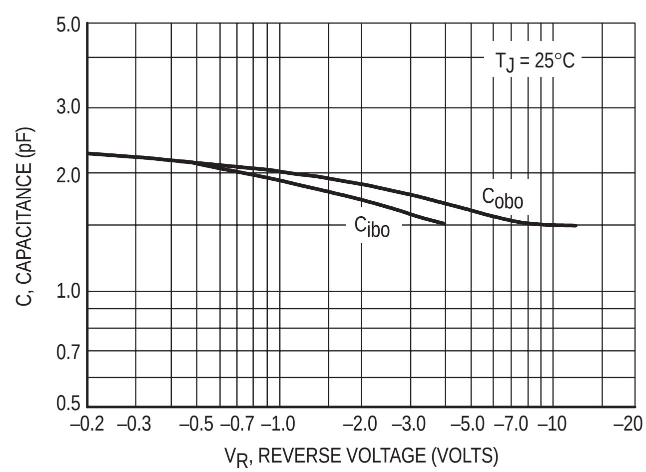


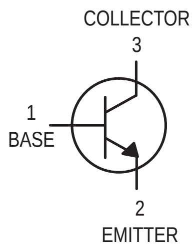
Figure 8. Capacitance

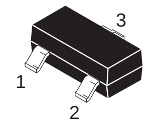
General Purpose Transistor

NPN Silicon

MMBT3904LT1

Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

MMBT3904LT1 = 1AM

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (3) (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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

REV 1

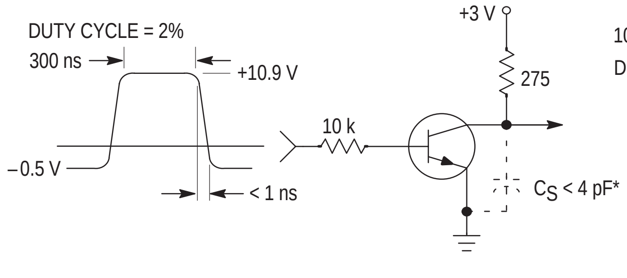
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

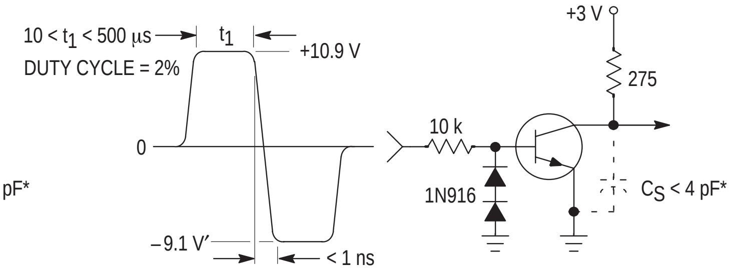
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS(3)				
DC Current Gain (1)	H_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		40	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		70	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		60	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		30	—	
Collector–Emitter Saturation Voltage (3)	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	0.3	
Base–Emitter Saturation Voltage (3)	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	0.95	
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 (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	h_{ie}	1.0	10	k ohms
Voltage Feedback Ratio (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	h_{re}	0.5	8.0	X 10^{-4}
Small–Signal Current Gain (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	h_{fe}	100	400	—
Output Admittance (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	h_{oe}	1.0	40	μmhos
Noise Figure (V_{CE} = 5.0 Vdc, I_C = 100 μAdc, R_S = 1.0 k ohms, 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 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	
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	

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





* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

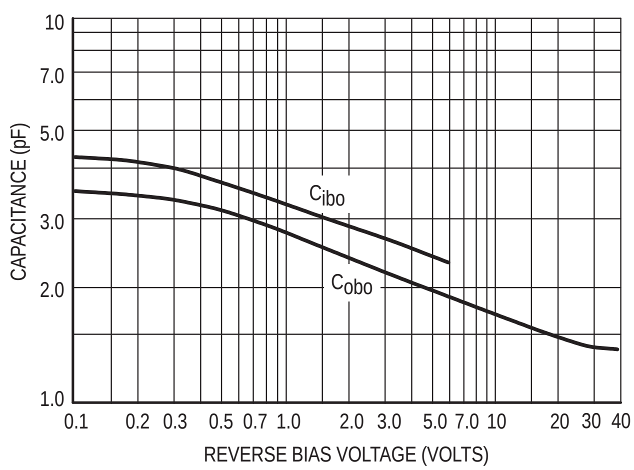


Figure 3. Capacitance

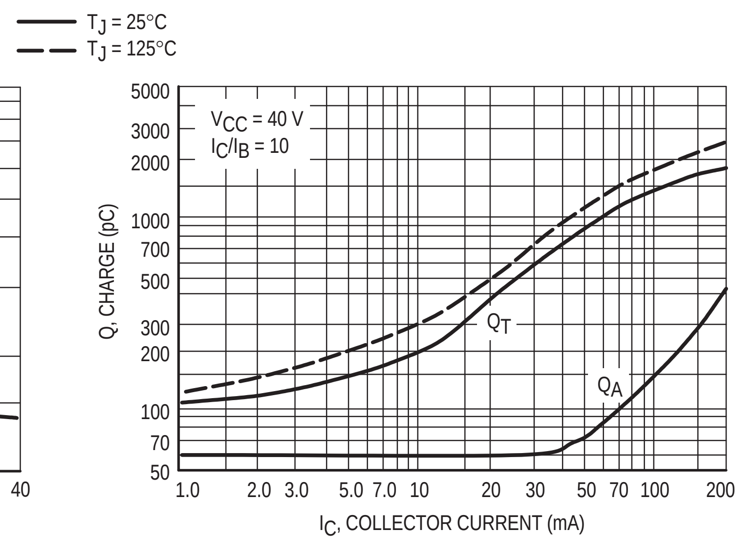


Figure 4. Charge Data

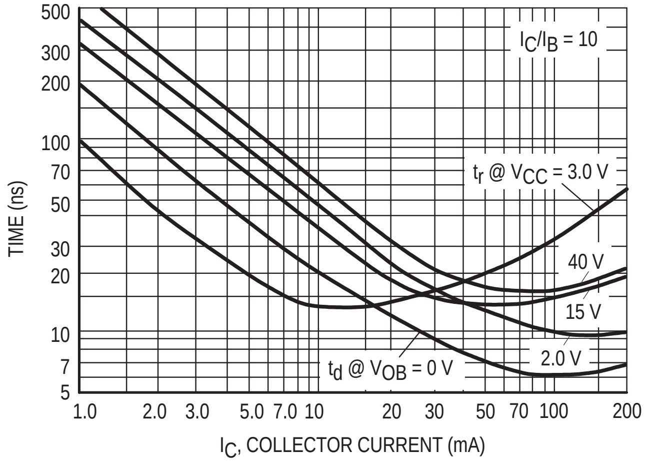


Figure 5. Turn–On Time

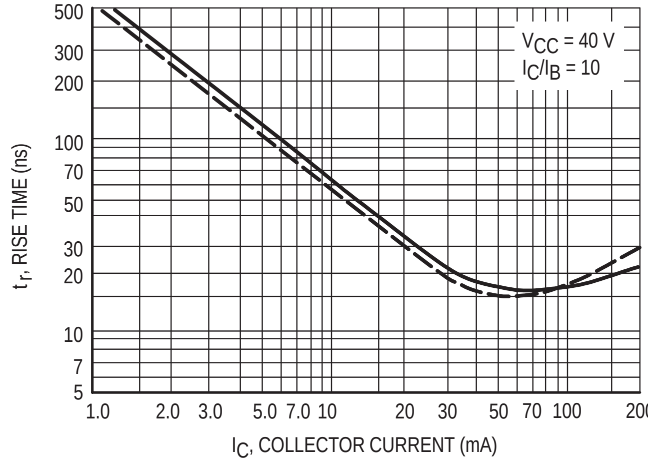


Figure 6. Rise Time

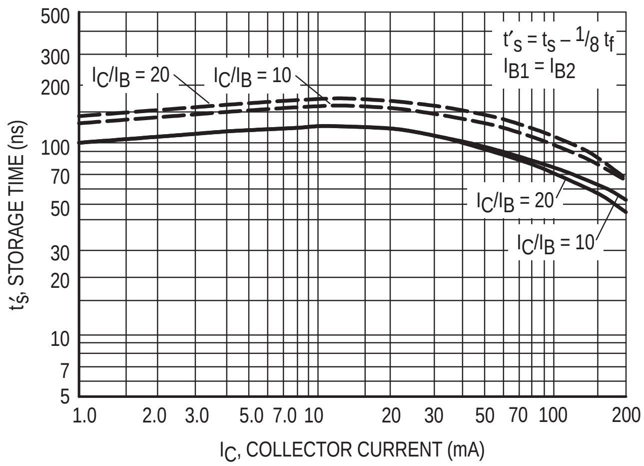


Figure 7. Storage Time

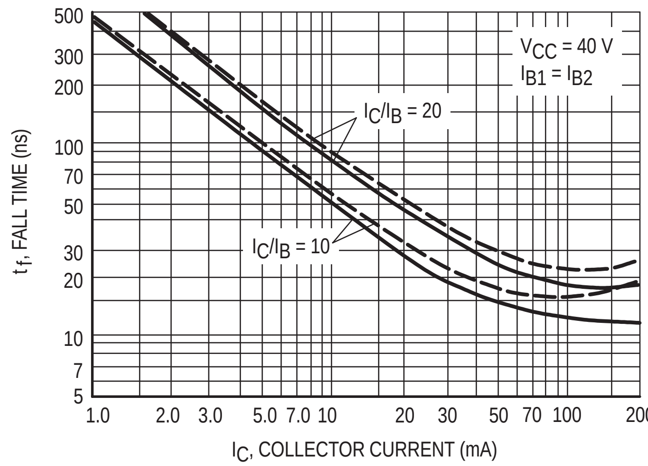


Figure 8. Fall Time

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

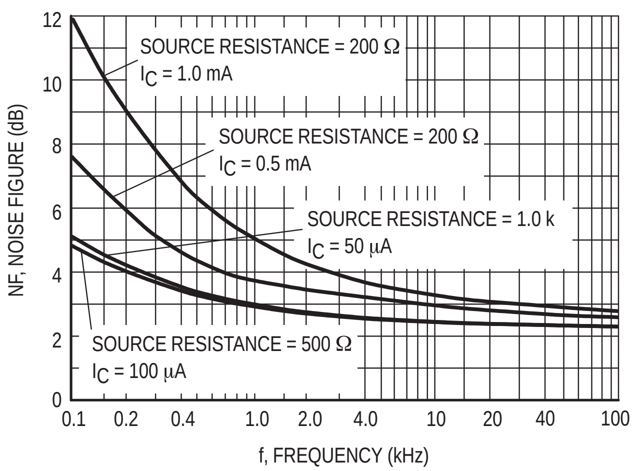


Figure 9.

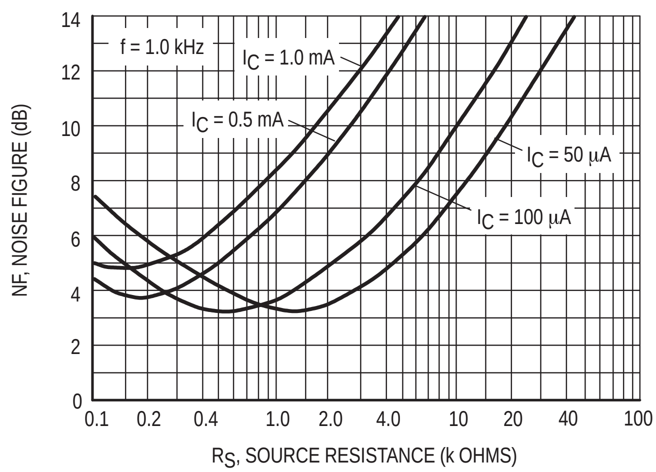


Figure 10.

h PARAMETERS

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

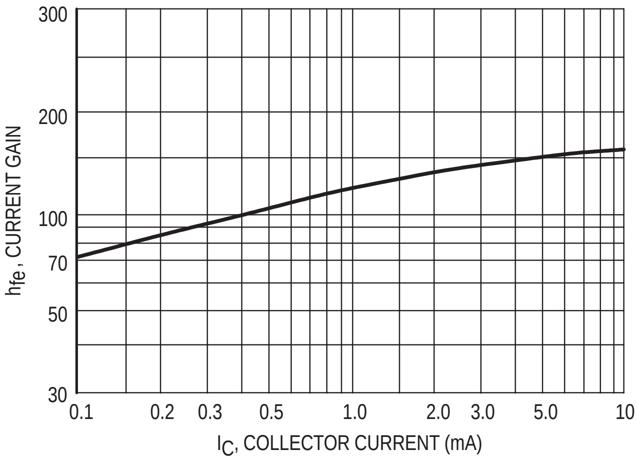


Figure 11. Current Gain

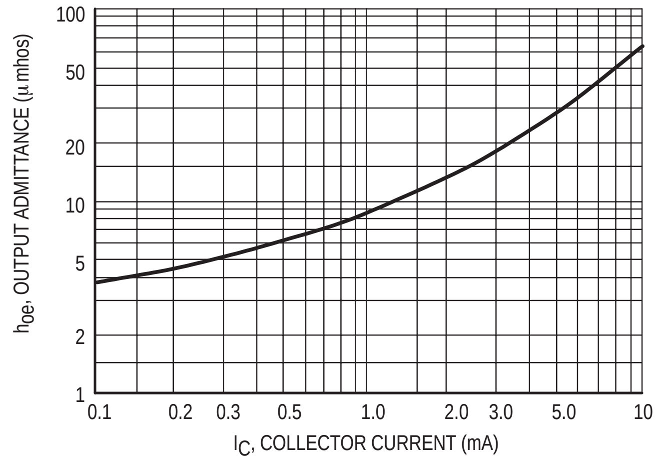


Figure 12. Output Admittance

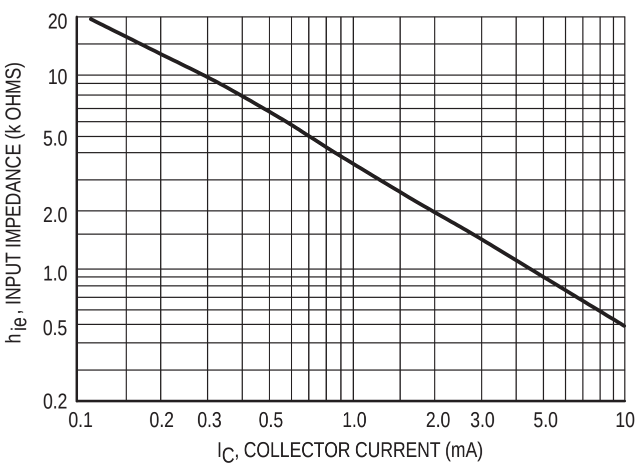


Figure 13. Input Impedance

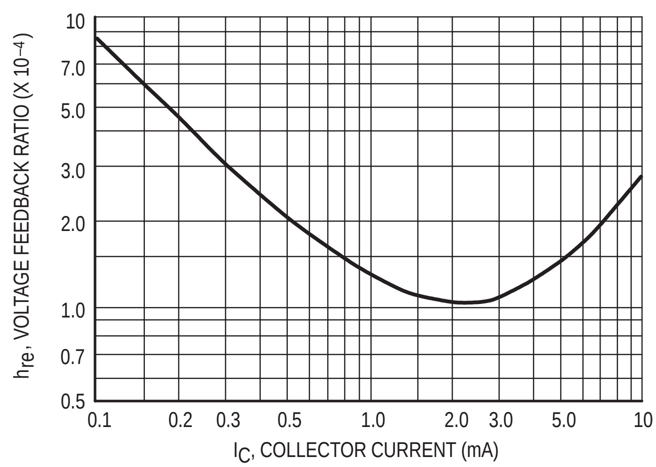


Figure 14. Voltage Feedback Ratio

TYPICAL STATIC CHARACTERISTICS

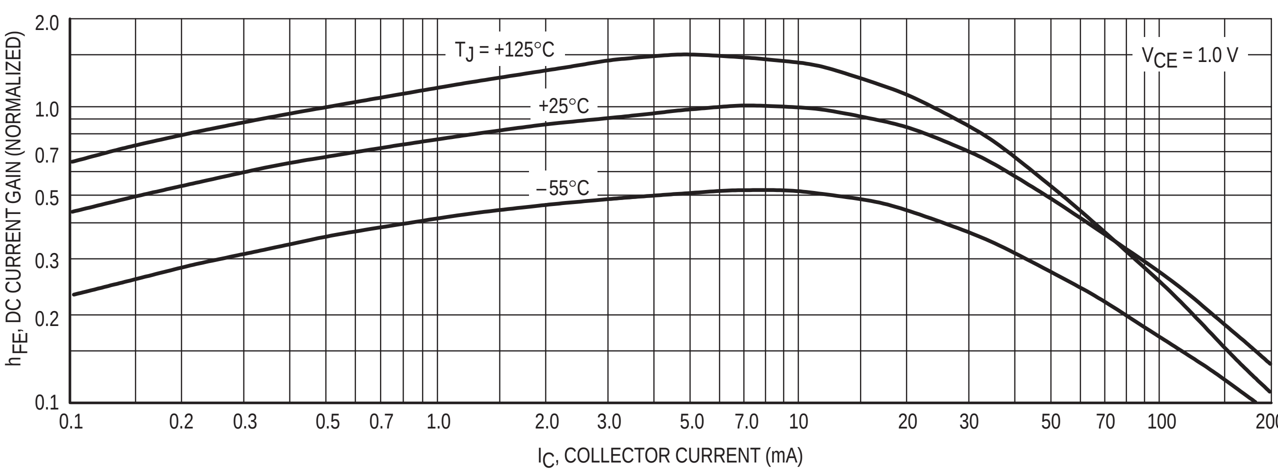


Figure 15. DC Current Gain

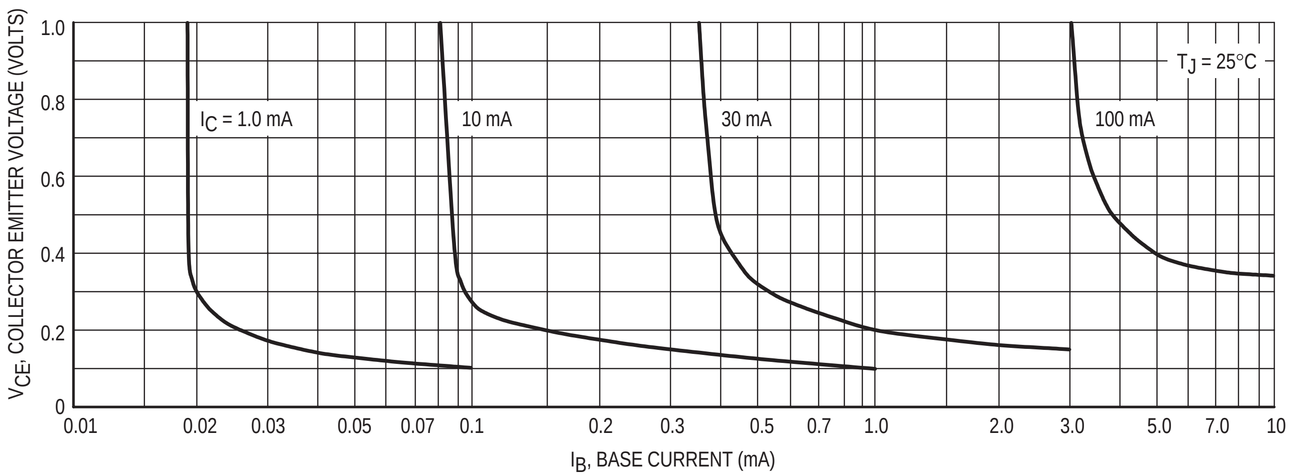


Figure 16. Collector Saturation Region

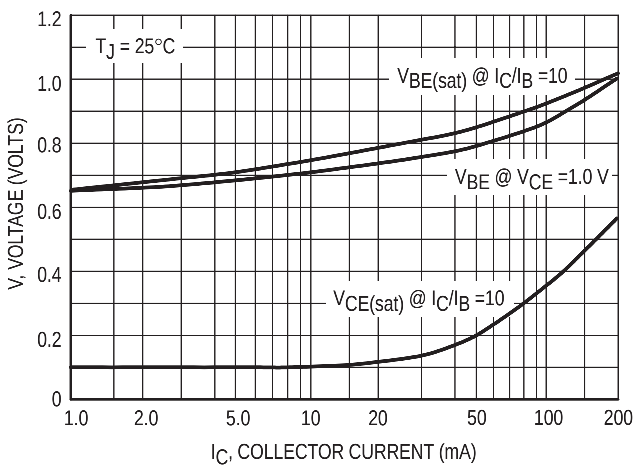


Figure 17. "ON" Voltages

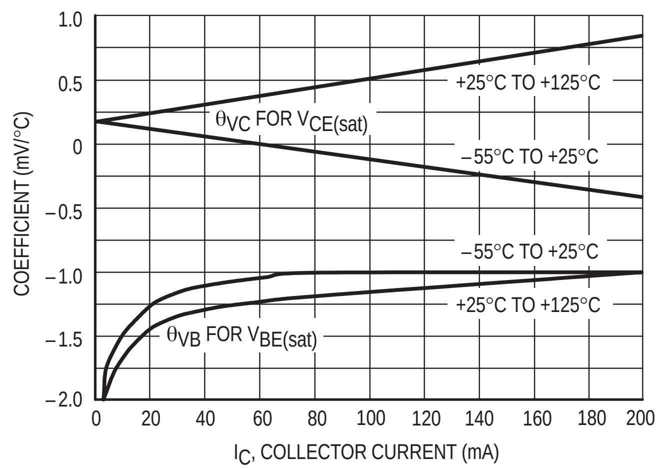


Figure 18. Temperature Coefficients

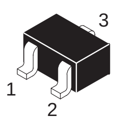
General Purpose Transistors

NPN and PNP Silicon

These transistors are designed for general purpose amplifier applications. They are housed in the SOT–323/SC–70 which is designed for low power surface mount applications.

NPN
MMBT3904WT1
PNP
MMBT3906WT1

GENERAL PURPOSE AMPLIFIER TRANSISTORS SURFACE MOUNT



CASE 419–02, STYLE 3
SOT–323/SC–70

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector–Emitter Voltage	MMBT3904WT1 MMBT3906WT1	V_{CEO}	40 –40	Vdc
Collector–Base Voltage	MMBT3904WT1 MMBT3906WT1	V_{CBO}	60 –40	Vdc
Emitter–Base Voltage	MMBT3904WT1 MMBT3906WT1	V_{EBO}	6.0 –5.0	Vdc
Collector Current — Continuous	MMBT3904WT1 MMBT3906WT1	I_C	200 –200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation(1) T_A = 25°C	P_D	150	mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	833	°C/W
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

DEVICE MARKING

MMBT3904WT1 = AM
MMBT3906WT1 = 2A

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) (I_C = –1.0 mAdc, I_B = 0)	 MMBT3904WT1 MMBT3906WT1	$V_{(BR)CEO}$	 40 –40	 — —	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) (I_C = –10 μAdc, I_E = 0)	 MMBT3904WT1 MMBT3906WT1	$V_{(BR)CBO}$	 60 –40	 — —	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0) (I_E = –10 μAdc, I_C = 0)	 MMBT3904WT1 MMBT3906WT1	$V_{(BR)EBO}$	 6.0 –5.0	 — —	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc) (V_{CE} = –30 Vdc, V_{EB} = –3.0 Vdc)	 MMBT3904WT1 MMBT3906WT1	I_{BL}	 — —	 50 –50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc) (V_{CE} = –30 Vdc, V_{EB} = –3.0 Vdc)	 MMBT3904WT1 MMBT3906WT1	I_{CEX}	 — —	 50 –50	nAdc

1. Device mounted on FR4 glass epoxy printed circuit board using the minimum recommended footprint.
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

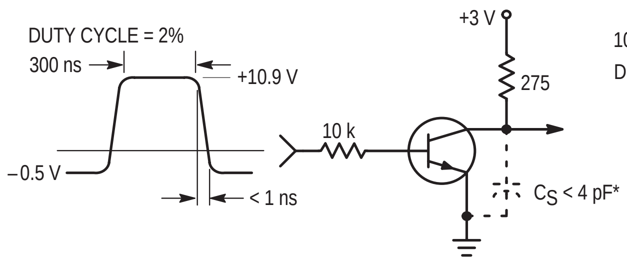
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS(2)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MMBT3904WT1		40	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)			70	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			60	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			30	—	
(I_C = –0.1 mAdc, V_{CE} = –1.0 Vdc)	MMBT3906WT1		60	—	
(I_C = –1.0 mAdc, V_{CE} = –1.0 Vdc)			80	—	
(I_C = –10 mAdc, V_{CE} = –1.0 Vdc)			100	300	
(I_C = –50 mAdc, V_{CE} = –1.0 Vdc)			60	—	
(I_C = –100 mAdc, V_{CE} = –1.0 Vdc)			30	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MMBT3904WT1		—	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.3	
(I_C = –10 mAdc, I_B = –1.0 mAdc)	MMBT3906WT1		—	–0.25	
(I_C = –50 mAdc, I_B = –5.0 mAdc)			—	–0.4	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MMBT3904WT1		0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.95	
(I_C = –10 mAdc, I_B = –1.0 mAdc)	MMBT3906WT1		–0.65	–0.85	
(I_C = –50 mAdc, I_B = –5.0 mAdc)			—	–0.95	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMBT3904WT1		300	—	
(I_C = –10 mAdc, V_{CE} = –20 Vdc, f = 100 MHz)	MMBT3906WT1		250	—	
Output Capacitance		C_{obo}			pF
(V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	MMBT3904WT1		—	4.0	
(V_{CB} = –5.0 Vdc, I_E = 0, f = 1.0 MHz)	MMBT3906WT1		—	4.5	
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MMBT3904WT1		—	8.0	
(V_{EB} = –0.5 Vdc, I_C = 0, f = 1.0 MHz)	MMBT3906WT1		—	10.0	
Input Impedance		h_{ie}			k Ω
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	MMBT3904WT1		1.0	10	
(V_{CE} = –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	MMBT3906WT1		2.0	12	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	MMBT3904WT1		0.5	8.0	
(V_{CE} = –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	MMBT3906WT1		0.1	10	
Small–Signal Current Gain		h_{fe}			—
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	MMBT3904WT1		100	400	
(V_{CE} = –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	MMBT3906WT1		100	400	
Output Admittance		h_{oe}			μmhos
(V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz)	MMBT3904WT1		1.0	40	
(V_{CE} = –10 Vdc, I_C = –1.0 mAdc, f = 1.0 kHz)	MMBT3906WT1		3.0	60	
Noise Figure		NF			dB
(V_{CE} = 5.0 Vdc, I_C = 100 μAdc, R_S = 1.0 k Ω, f = 1.0 kHz)	MMBT3904WT1		—	5.0	
(V_{CE} = –5.0 Vdc, I_C = –100 μAdc, R_S = 1.0 k Ω, f = 1.0 kHz)	MMBT3906WT1		—	4.0	

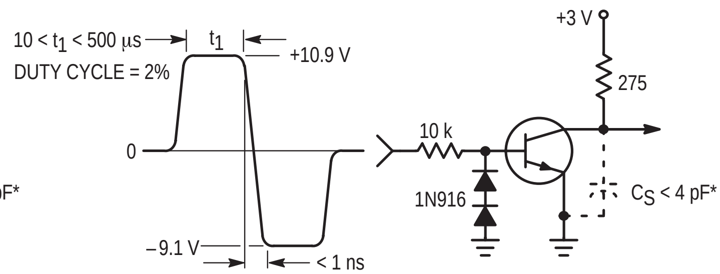
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Device	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = –0.5 Vdc)	MMBT3904WT1	t_d	—	35	ns
	(V_{CC} = –3.0 Vdc, V_{BE} = 0.5 Vdc)	MMBT3906WT1		—	35	
Rise Time	(I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	MMBT3904WT1	t_r	—	35	
	(I_C = –10 mAdc, I_{B1} = –1.0 mAdc)	MMBT3906WT1		—	35	
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc)	MMBT3904WT1	t_s	—	200	ns
	(V_{CC} = –3.0 Vdc, I_C = –10 mAdc)	MMBT3906WT1		—	225	
Fall Time	(I_{B1} = I_{B2} = 1.0 mAdc)	MMBT3904WT1	t_f	—	50	
	(I_{B1} = I_{B2} = –1.0 mAdc)	MMBT3906WT1		—	75	

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

MMBT3904WT1





* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

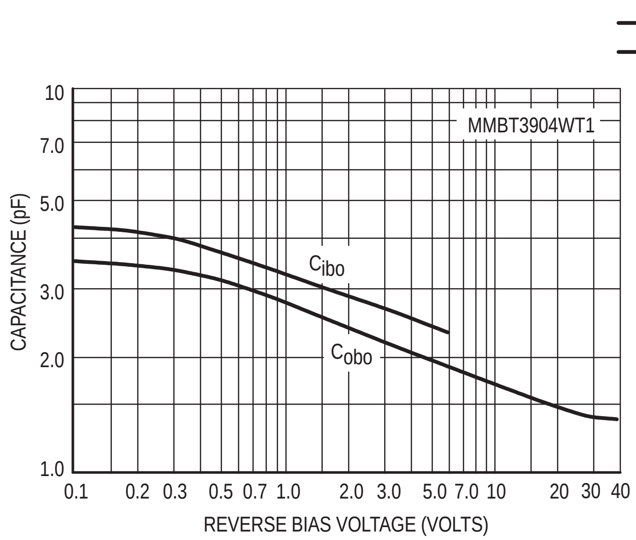


Figure 3. Capacitance

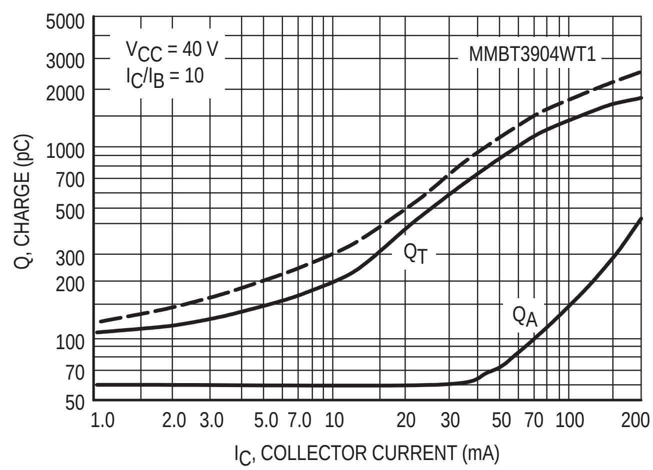


Figure 4. Charge Data

MMBT3904WT1

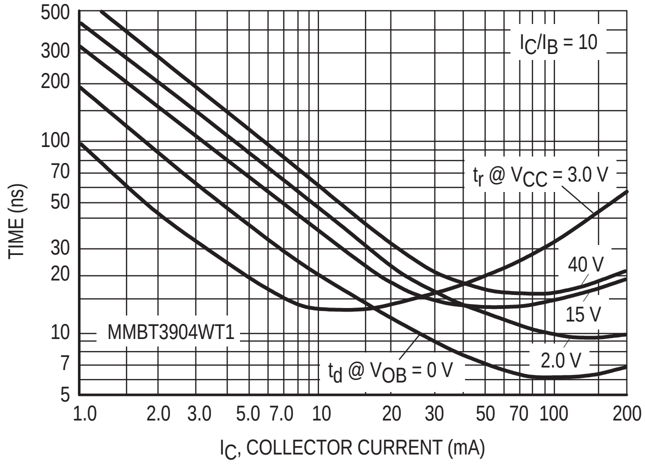


Figure 5. Turn–On Time

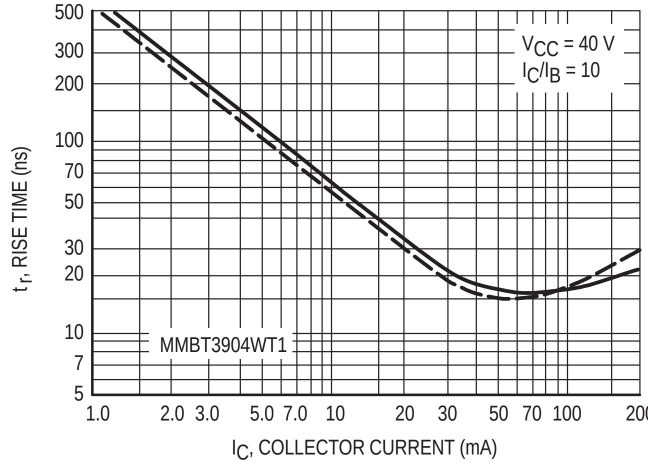


Figure 6. Rise Time

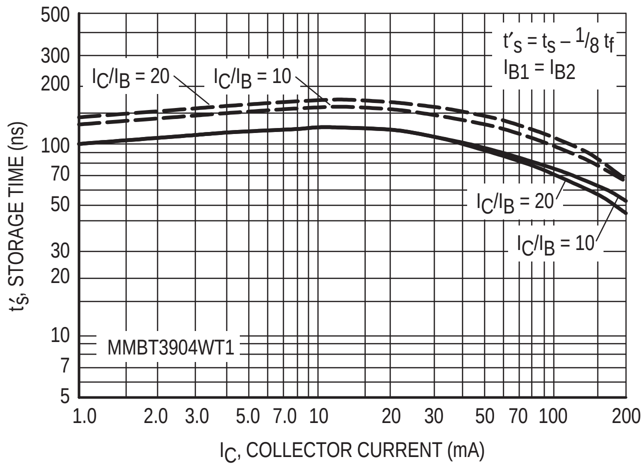


Figure 7. Storage Time

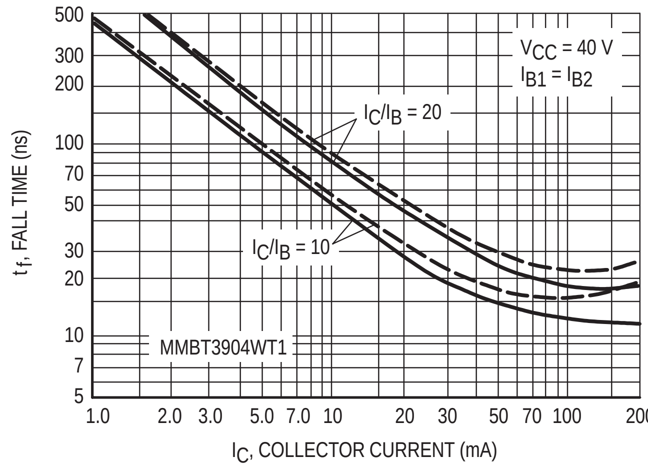


Figure 8. Fall Time

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS NOISE FIGURE VARIATIONS

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

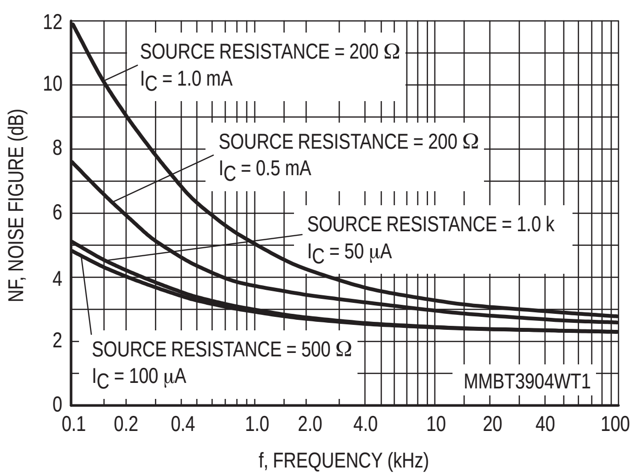


Figure 9. Noise Figure

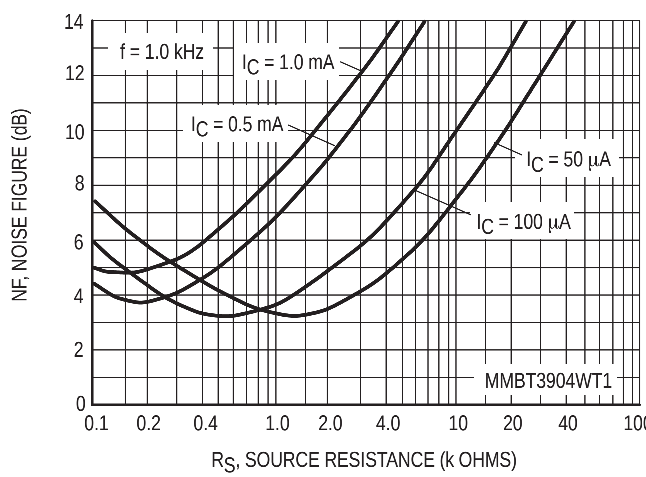


Figure 10. Noise Figure

MMBT3904WT1

h PARAMETERS

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

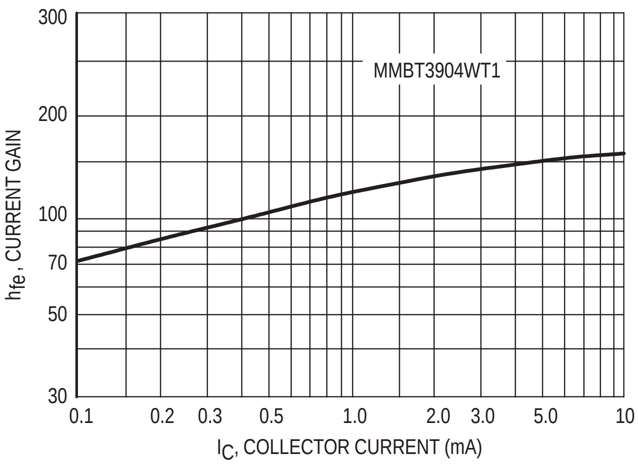


Figure 11. Current Gain

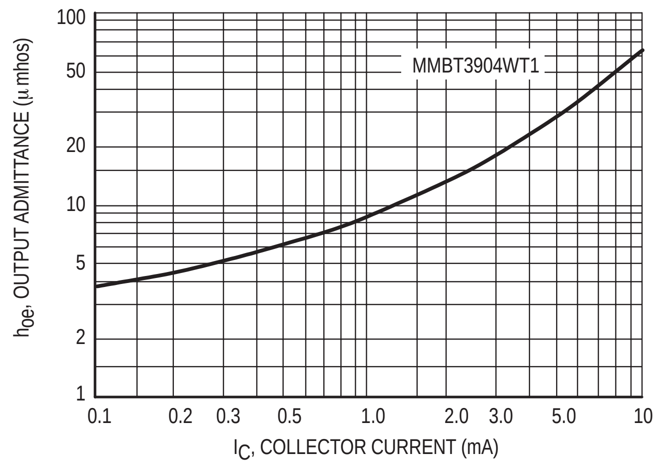


Figure 12. Output Admittance

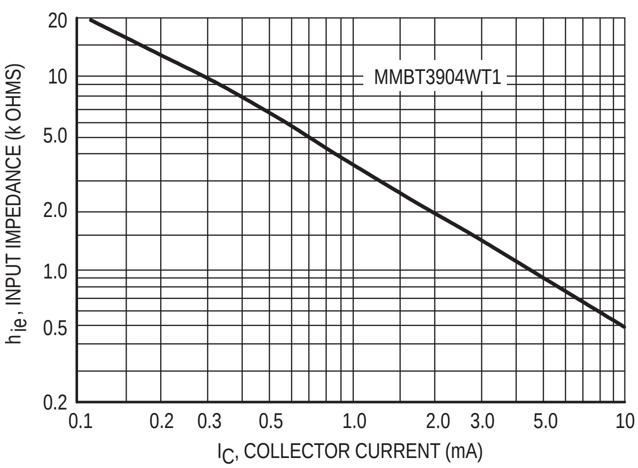


Figure 13. Input Impedance

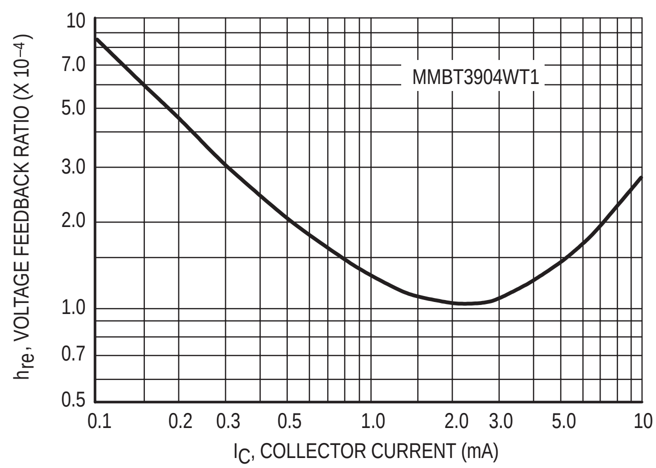


Figure 14. Voltage Feedback Ratio

MMBT3904WT1

TYPICAL STATIC CHARACTERISTICS

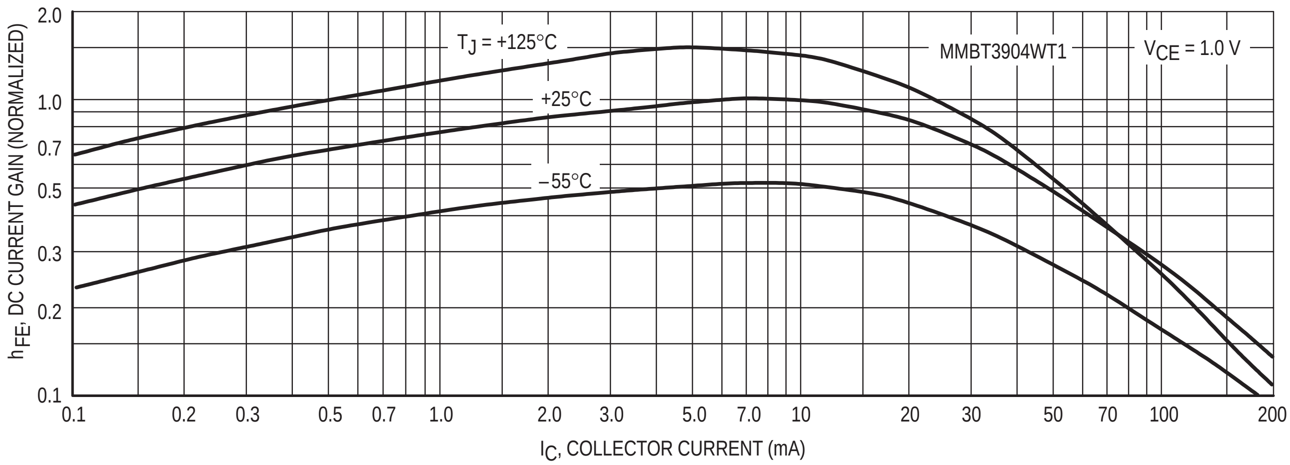


Figure 15. DC Current Gain

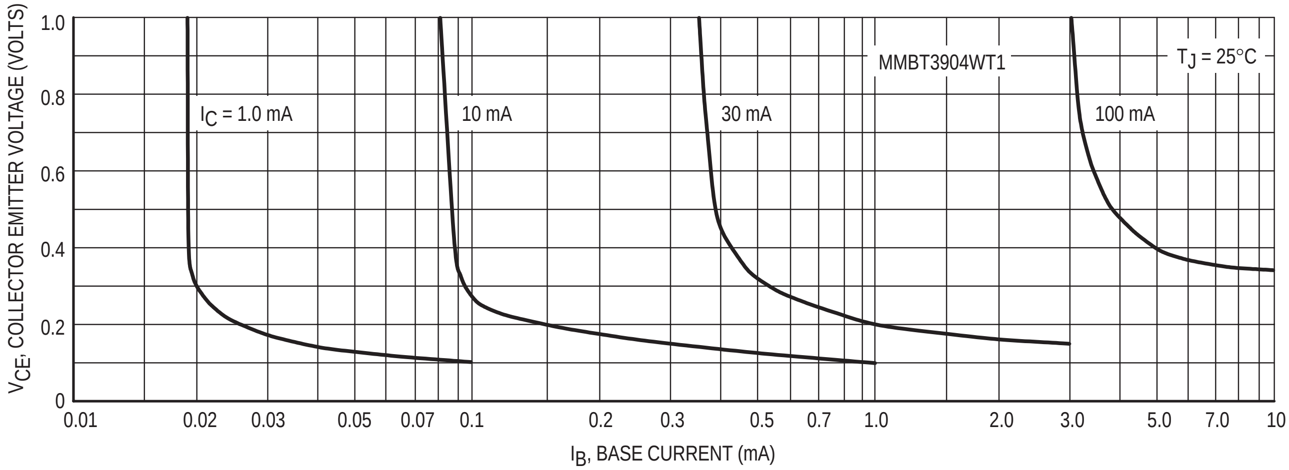


Figure 16. Collector Saturation Region

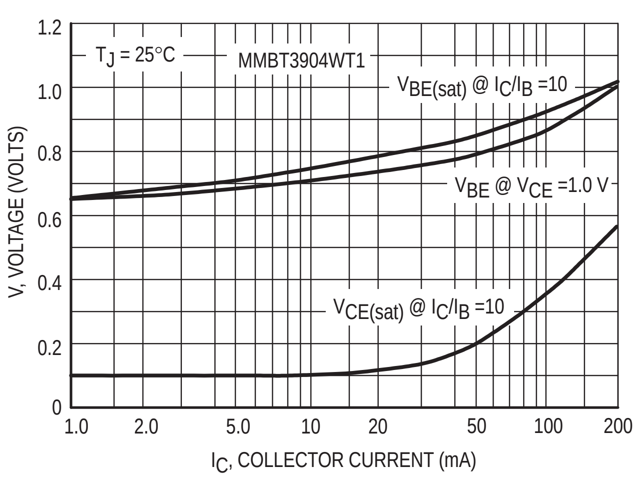


Figure 17. “ON” Voltages

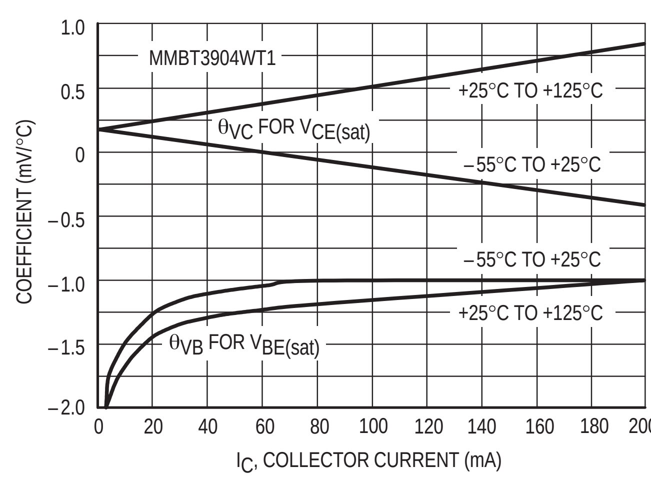
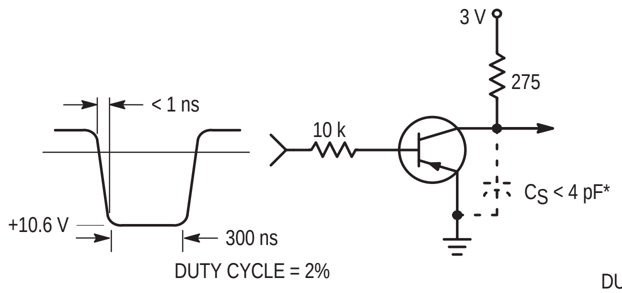
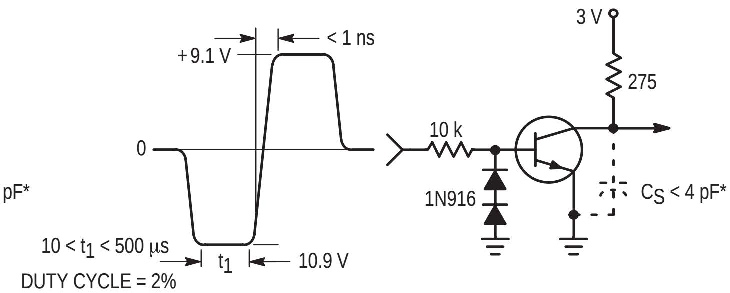


Figure 18. Temperature Coefficients

MMBT3906WT1





* Total shunt capacitance of test jig and connectors

Figure 19. Delay and Rise Time Equivalent Test Circuit

Figure 20. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

—— T_J = 25°C
– – – T_J = 125°C

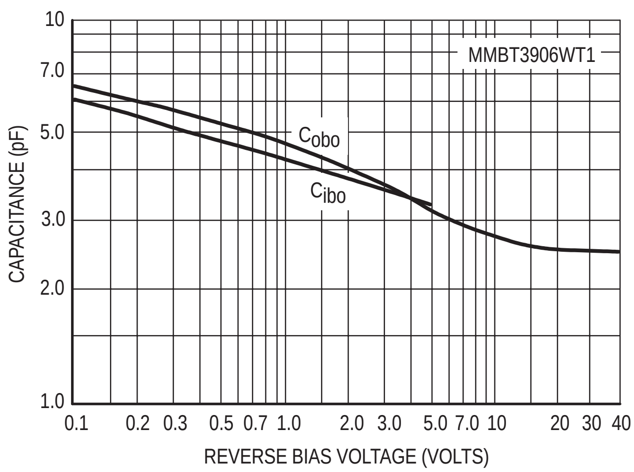


Figure 21. Capacitance

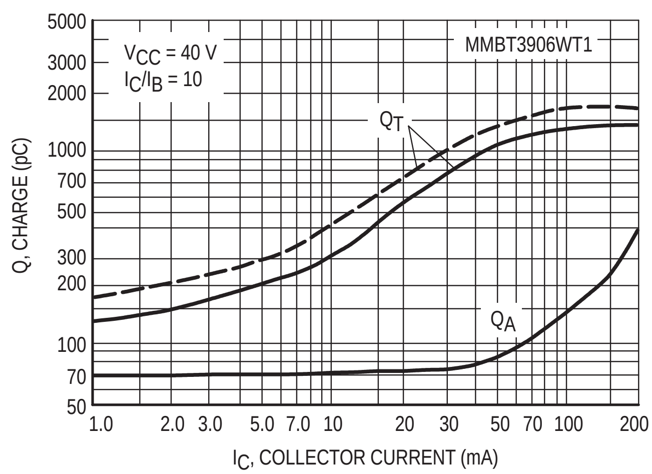


Figure 22. Charge Data

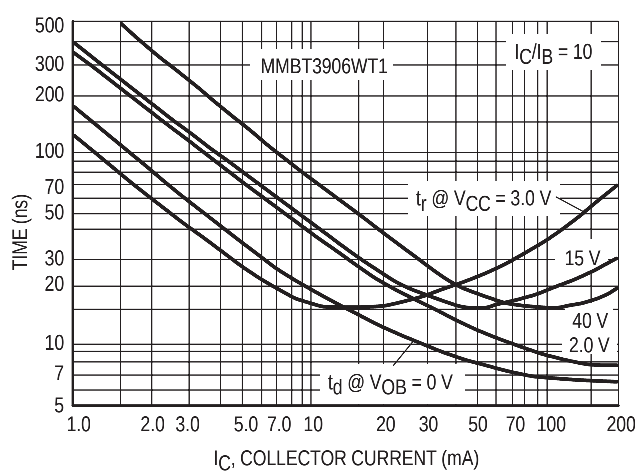


Figure 23. Turn–On Time

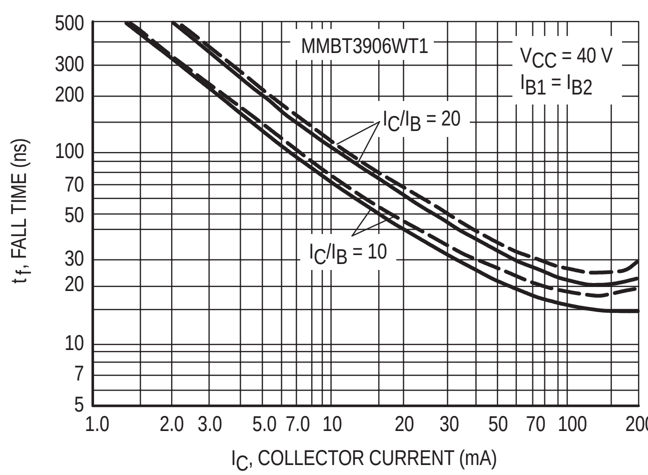


Figure 24. Fall Time

MMBT3906WT1

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

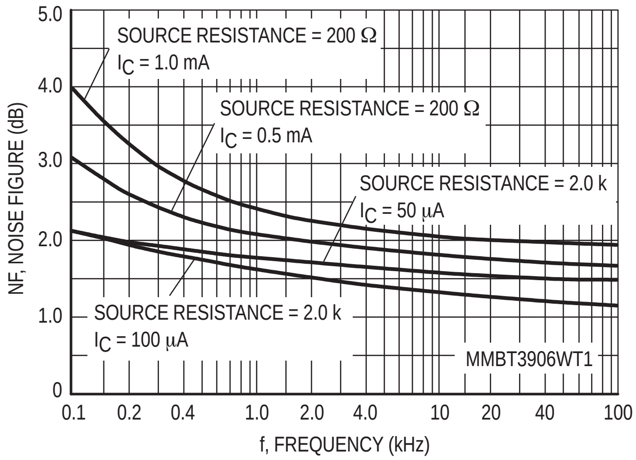


Figure 25.

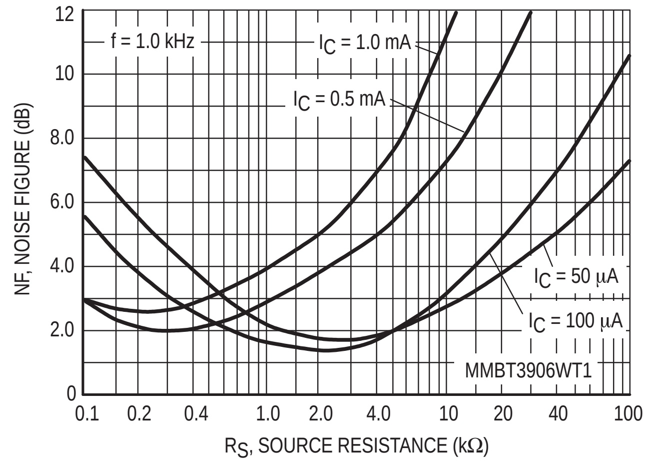


Figure 26.

h PARAMETERS

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

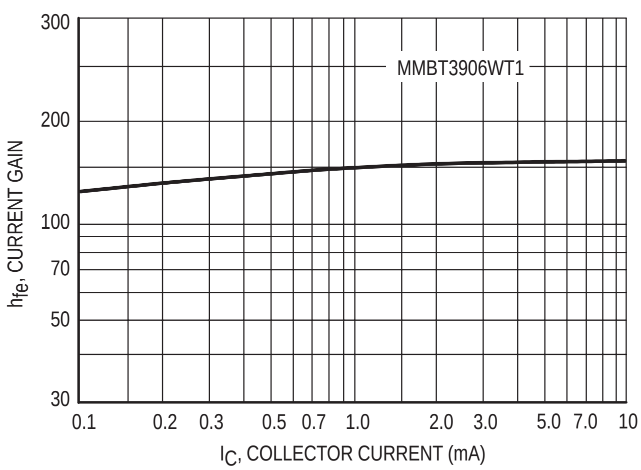


Figure 27. Current Gain

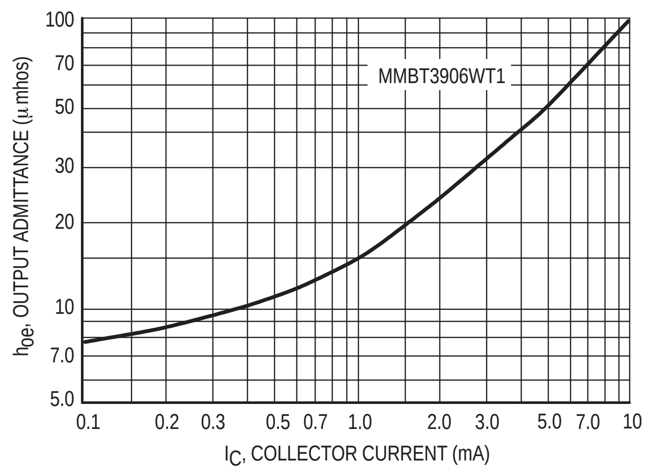


Figure 28. Output Admittance

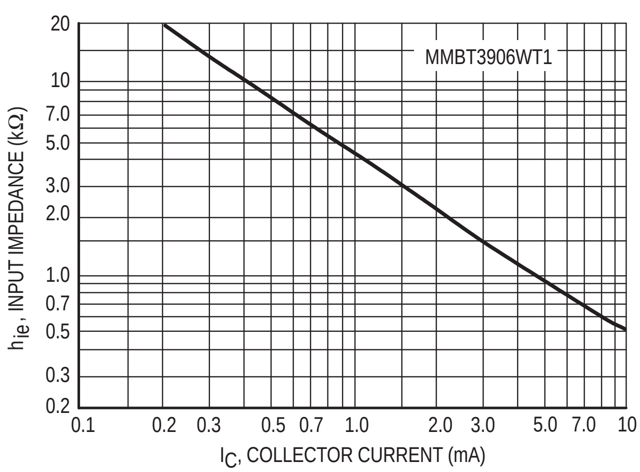


Figure 29. Input Impedance

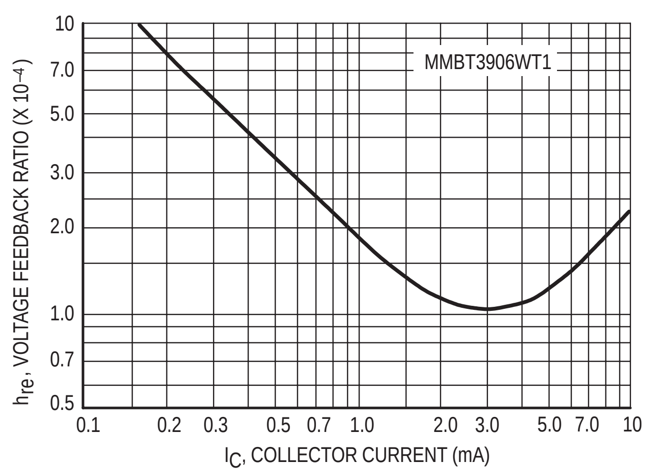


Figure 30. Voltage Feedback Ratio

MMBT3906WT1

STATIC CHARACTERISTICS

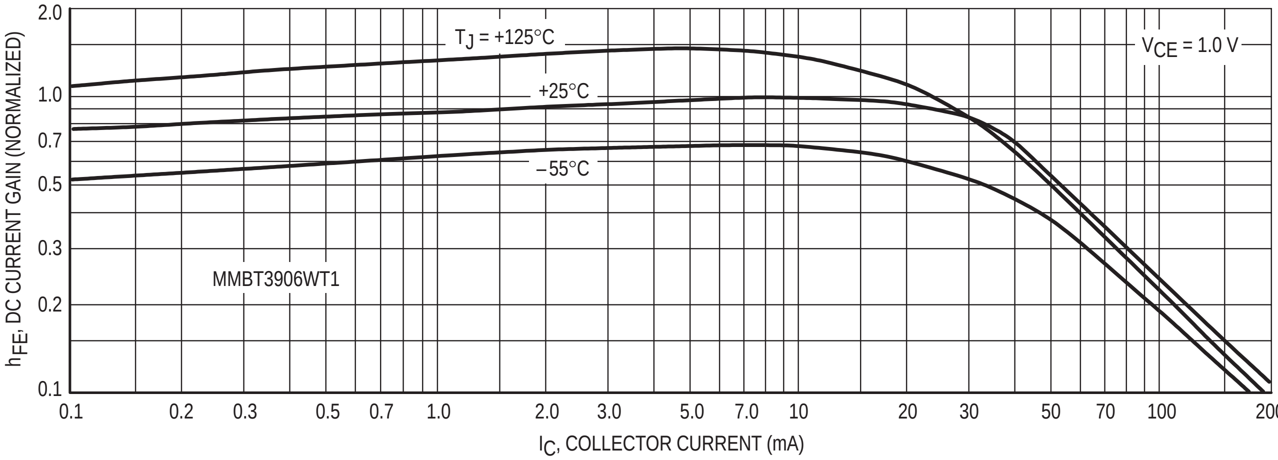


Figure 31. DC Current Gain

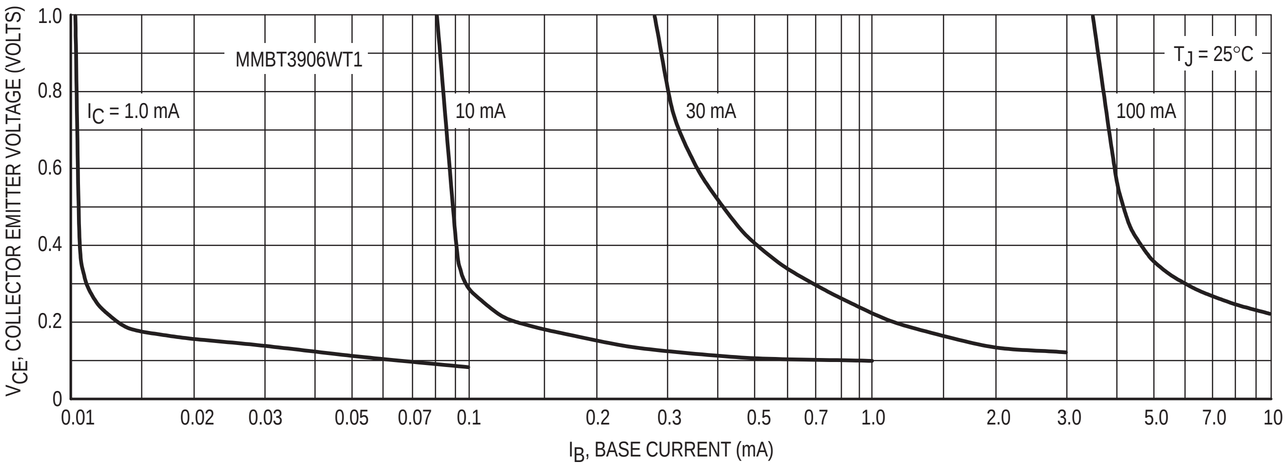


Figure 32. Collector Saturation Region

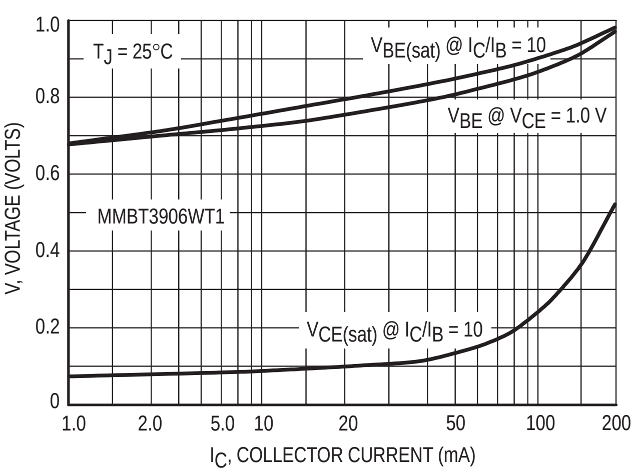


Figure 33. "ON" Voltages

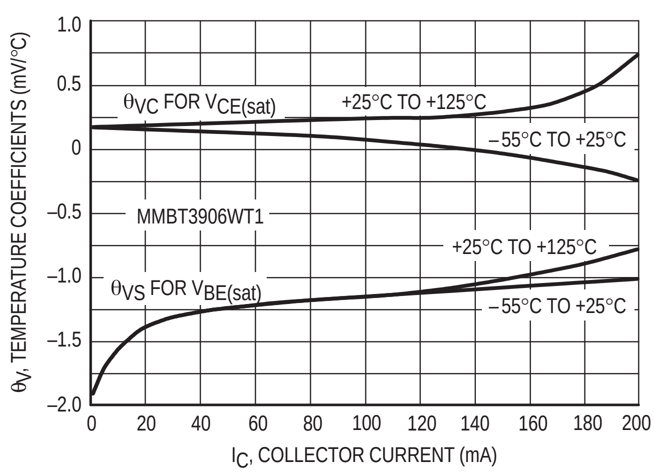
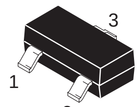


Figure 34. Temperature Coefficients

General Purpose Transistor
PNP Silicon

MMBT3906LT1

Motorola Preferred Device



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

MMBT3906LT1 = 2A

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage(3) (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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.
3. Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

REV 1

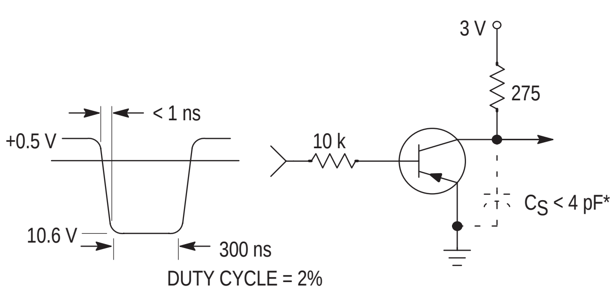
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

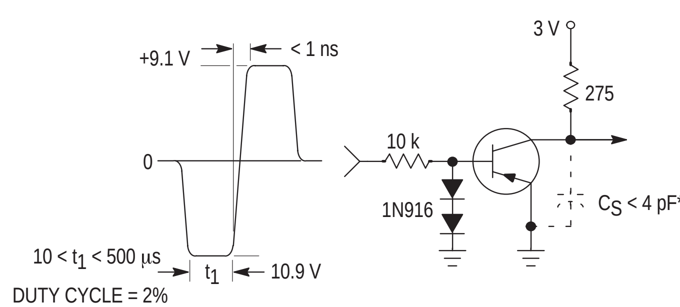
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS(3)				
DC Current Gain	H_{FE}			—
(I_C = –0.1 mAdc, V_{CE} = –1.0 Vdc)		60	—	
(I_C = –1.0 mAdc, V_{CE} = –1.0 Vdc)		80	—	
(I_C = –10 mAdc, V_{CE} = –1.0 Vdc)		100	300	
(I_C = –50 mAdc, V_{CE} = –1.0 Vdc)		60	—	
(I_C = –100 mAdc, V_{CE} = –1.0 Vdc)		30	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = –10 mAdc, I_B = –1.0 mAdc)		—	–0.25	
(I_C = –50 mAdc, I_B = –5.0 mAdc)		—	–0.4	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = –10 mAdc, I_B = –1.0 mAdc)		–0.65	–0.85	
(I_C = –50 mAdc, I_B = –5.0 mAdc)		—	–0.95	
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	pF
Input Impedance (I_C = –1.0 mAdc, V_{CE} = –10 Vdc, f = 1.0 kHz)	h_{ie}	2.0	12	kΩ
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	—
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 kΩ, f = 1.0 kHz)	NF	—	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	
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	

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



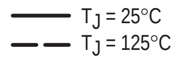


* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS



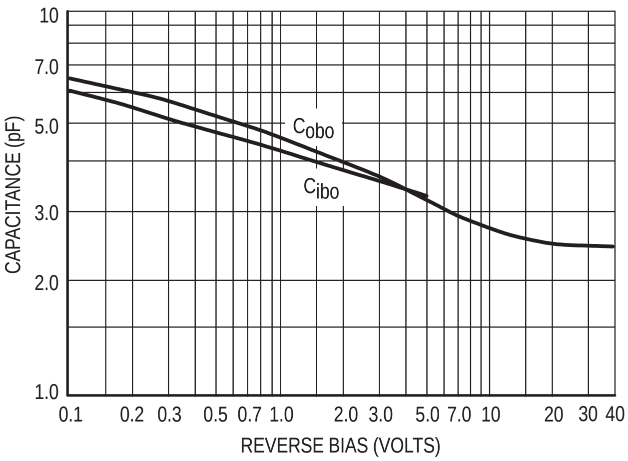


Figure 3. Capacitance

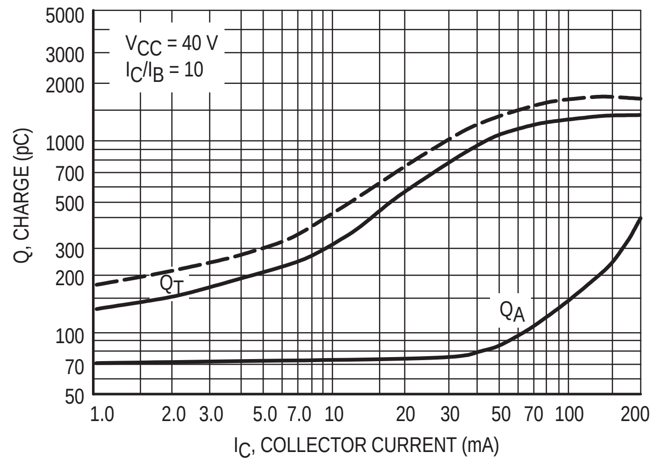


Figure 4. Charge Data

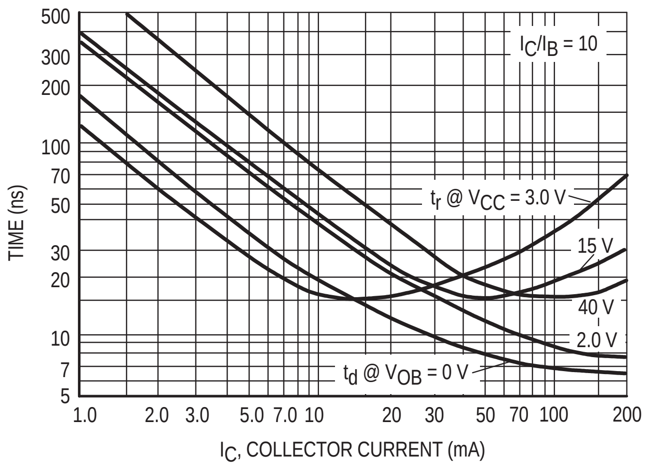


Figure 5. Turn–On Time

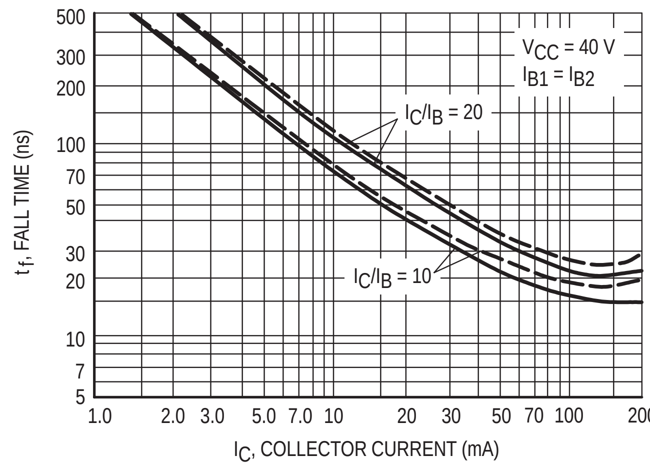


Figure 6. Fall Time

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

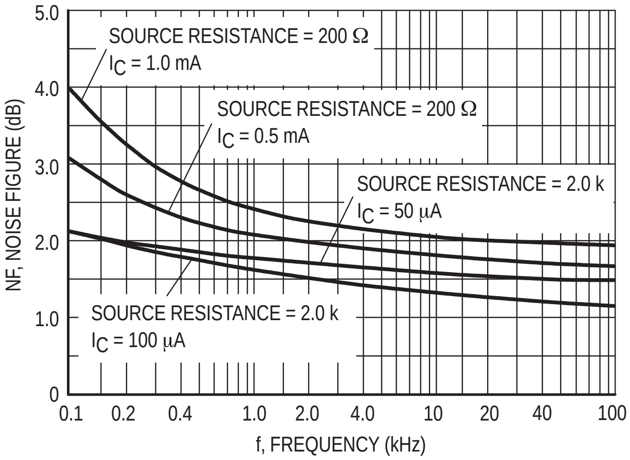


Figure 7.

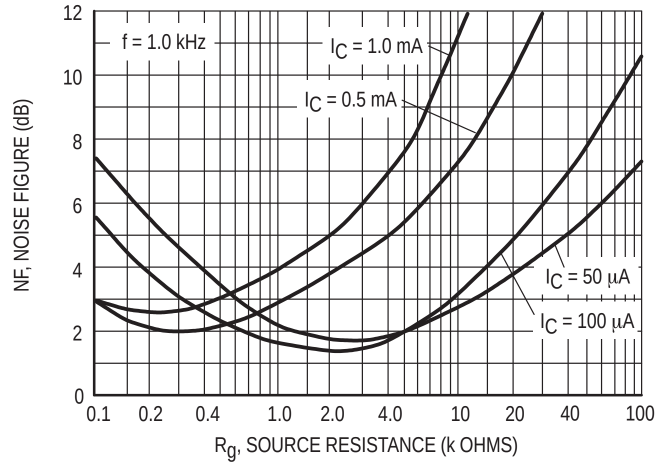


Figure 8.

h PARAMETERS

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

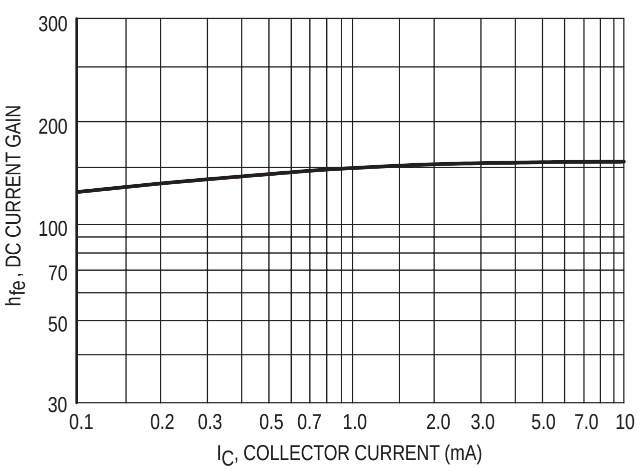


Figure 9. Current Gain

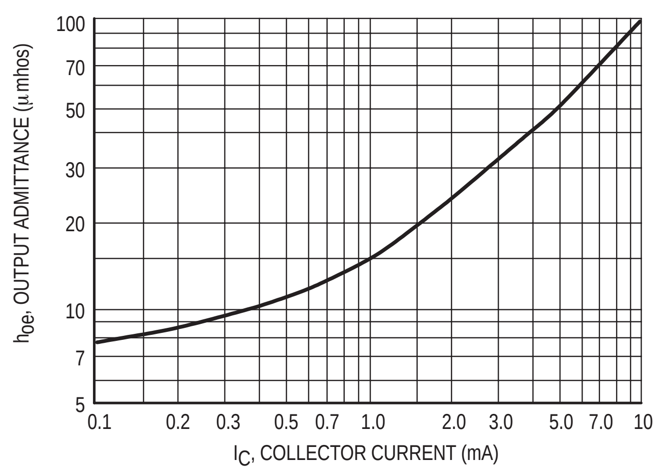


Figure 10. Output Admittance

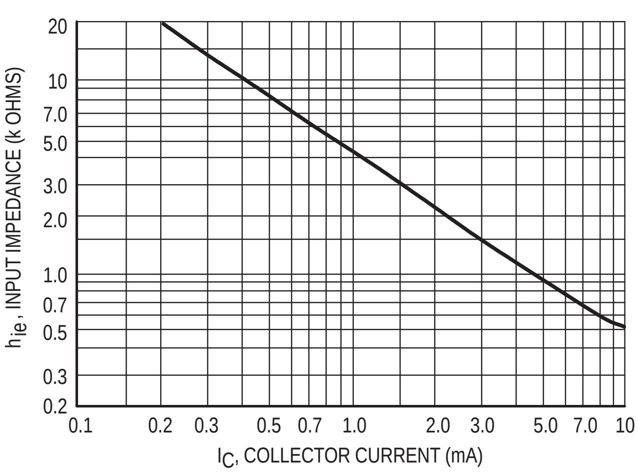


Figure 11. Input Impedance

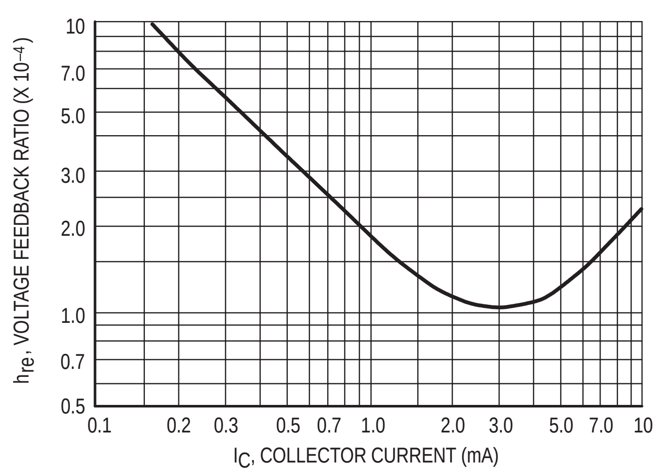


Figure 12. Voltage Feedback Ratio

TYPICAL STATIC CHARACTERISTICS

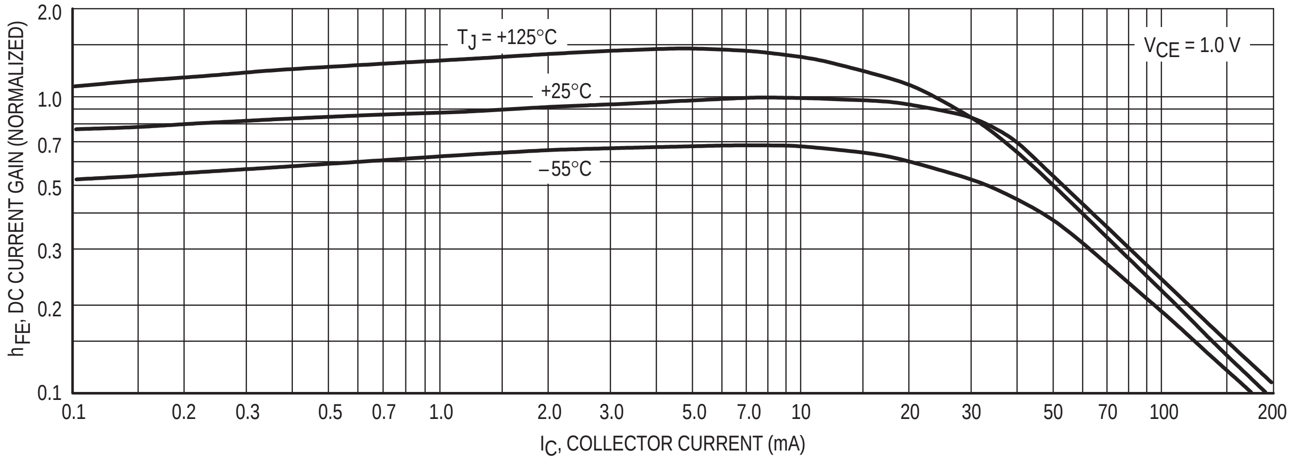


Figure 13. DC Current Gain

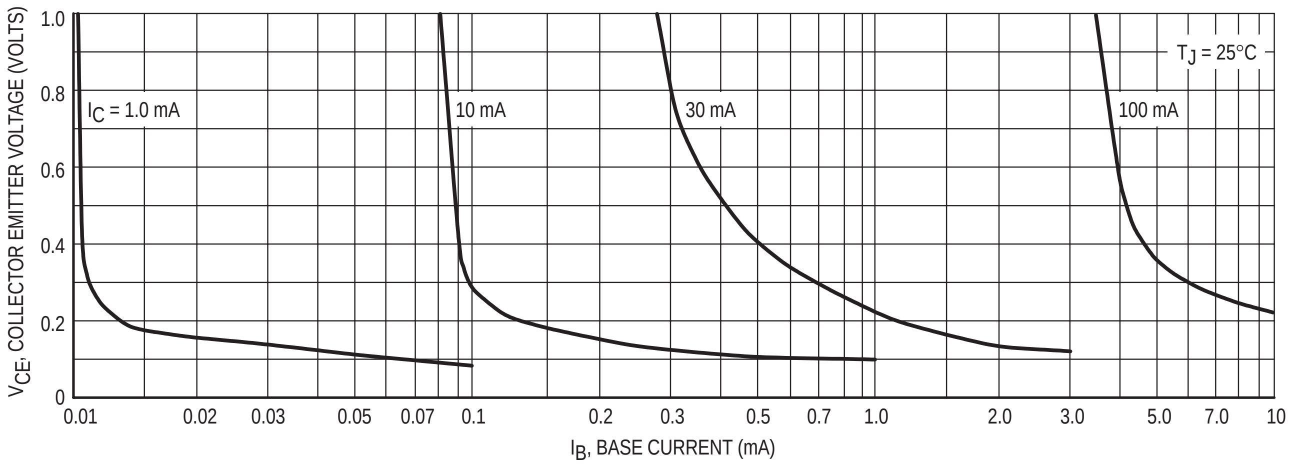


Figure 14. Collector Saturation Region

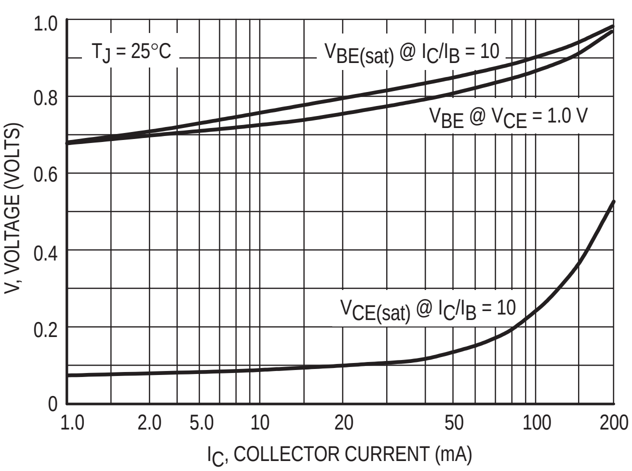


Figure 15. “ON” Voltages

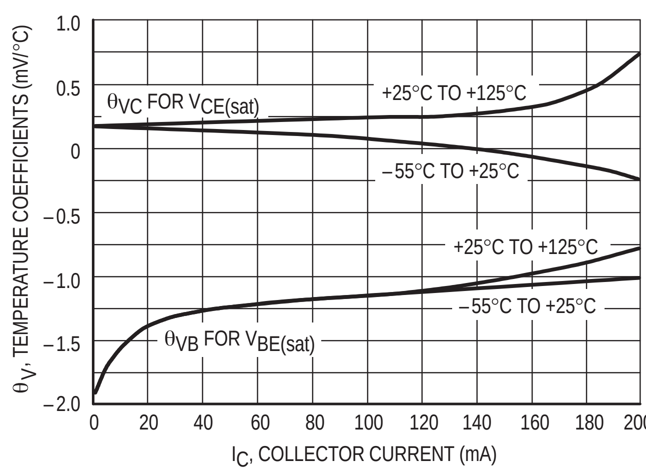


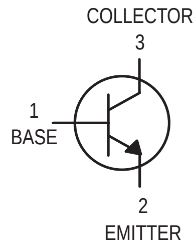
Figure 16. Temperature Coefficients

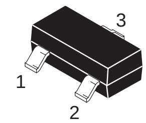
Switching Transistor

NPN Silicon

MMBT4401LT1

Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

MMBT4401LT1 = 2X

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage(3) (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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

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

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

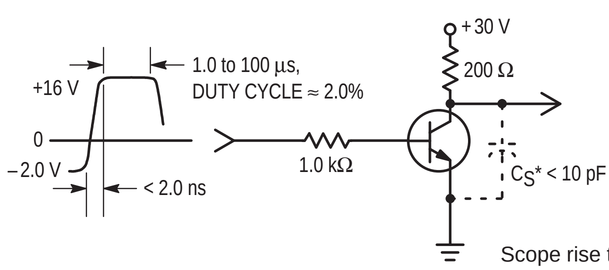
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS(3)				
DC Current Gain	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		20	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		40	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		80	—	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		100	300	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		40	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		—	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.75	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		0.75	0.95	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	1.2	
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	kΩ
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

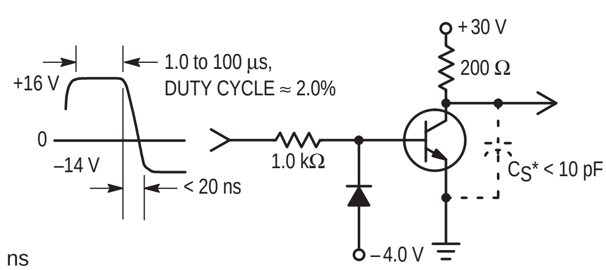
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
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	
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	

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

SWITCHING TIME EQUIVALENT TEST CIRCUITS





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

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

TRANSIENT CHARACTERISTICS

—— 25°C   — — 100°C

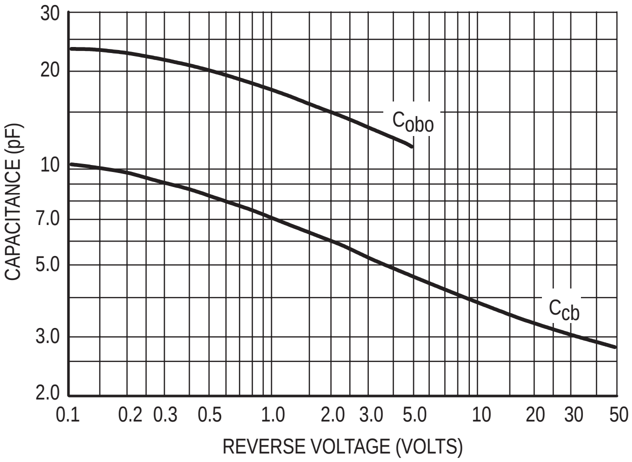


Figure 3. Capacitances

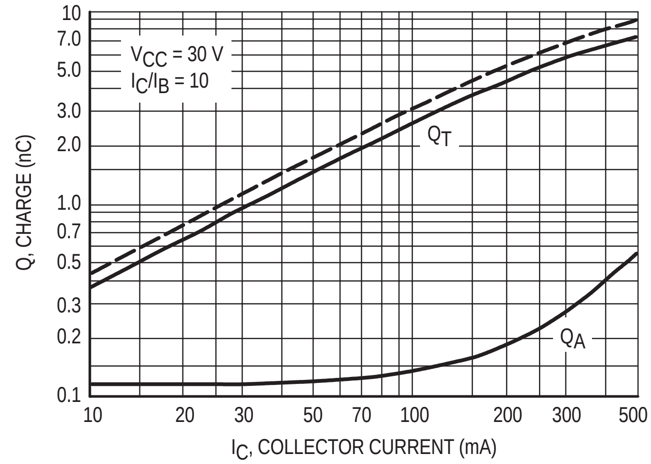


Figure 4. Charge Data

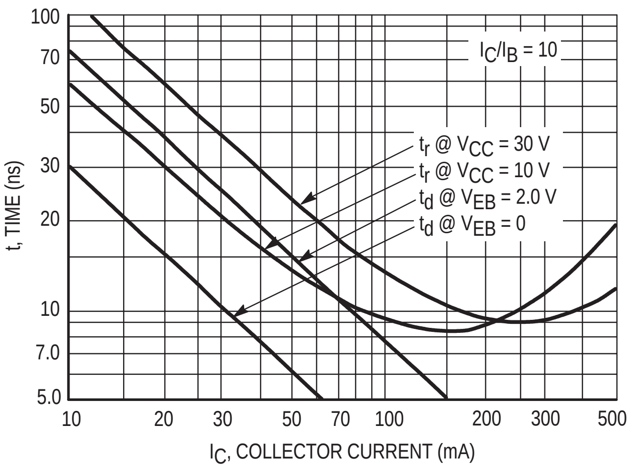


Figure 5. Turn–On Time

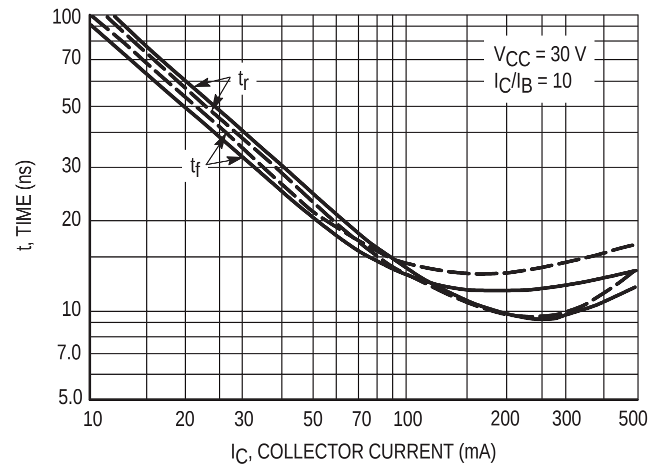


Figure 6. Rise and Fall Times

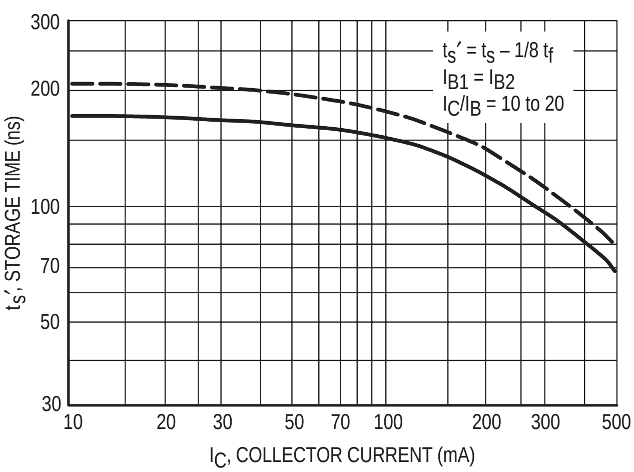


Figure 7. Storage Time

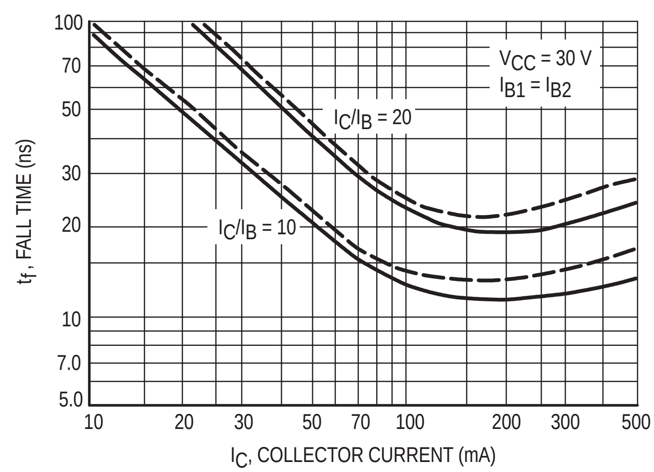


Figure 8. Fall Time

SMALL–SIGNAL CHARACTERISTICS

NOISE FIGURE

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

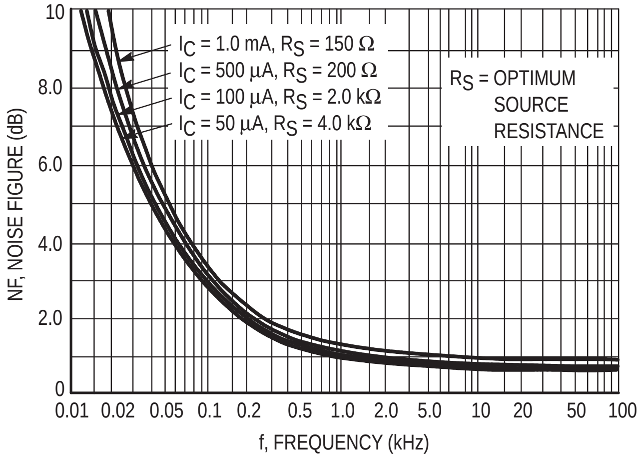


Figure 9. Frequency Effects

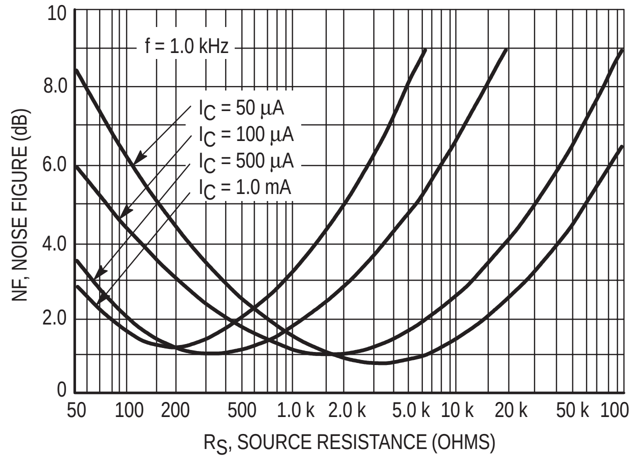


Figure 10. Source Resistance Effects

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 the MMBT4401LT1 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

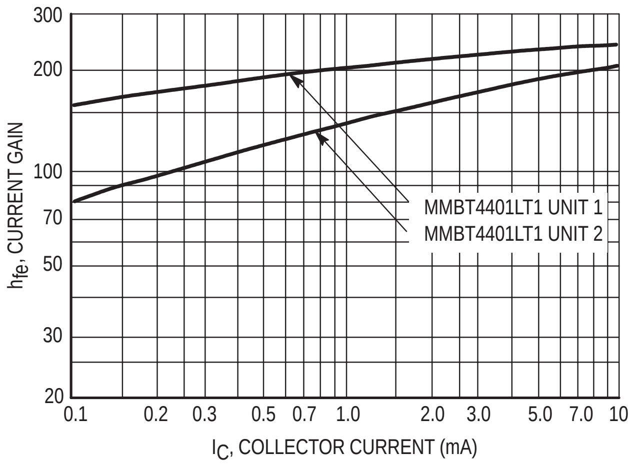


Figure 11. Current Gain

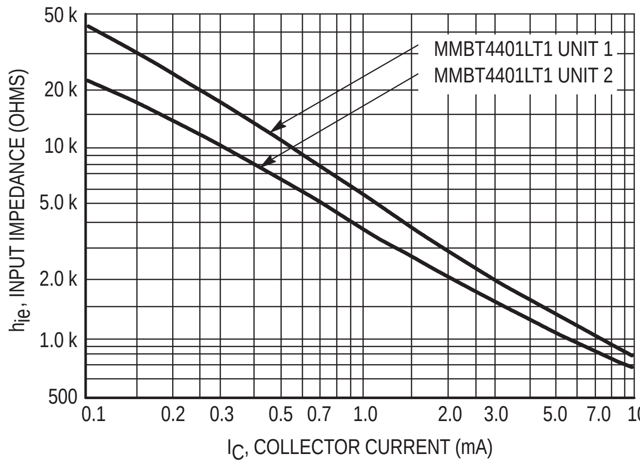


Figure 12. Input Impedance

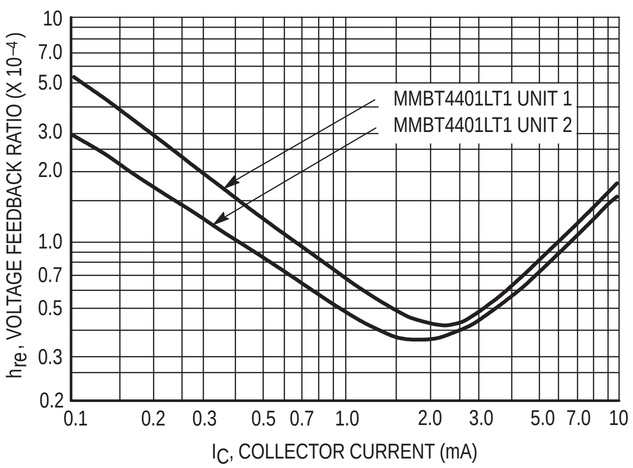


Figure 13. Voltage Feedback Ratio

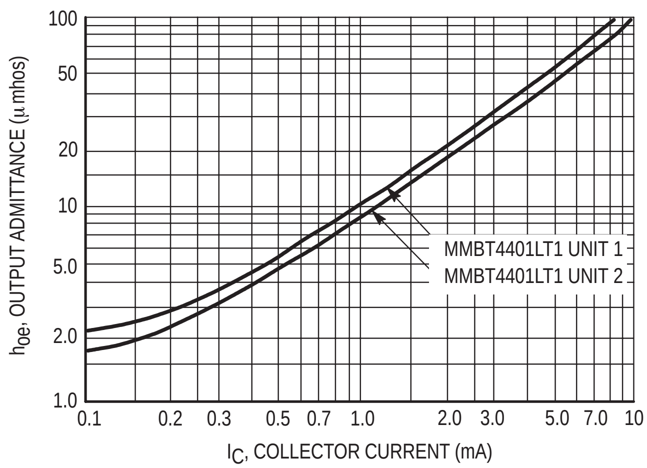


Figure 14. Output Admittance

STATIC CHARACTERISTICS

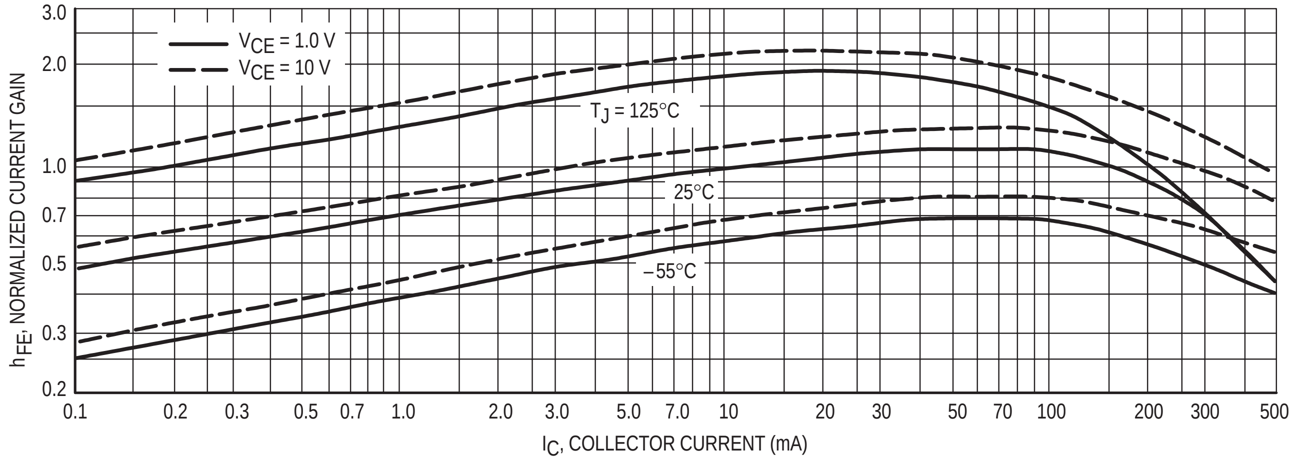


Figure 15. DC Current Gain

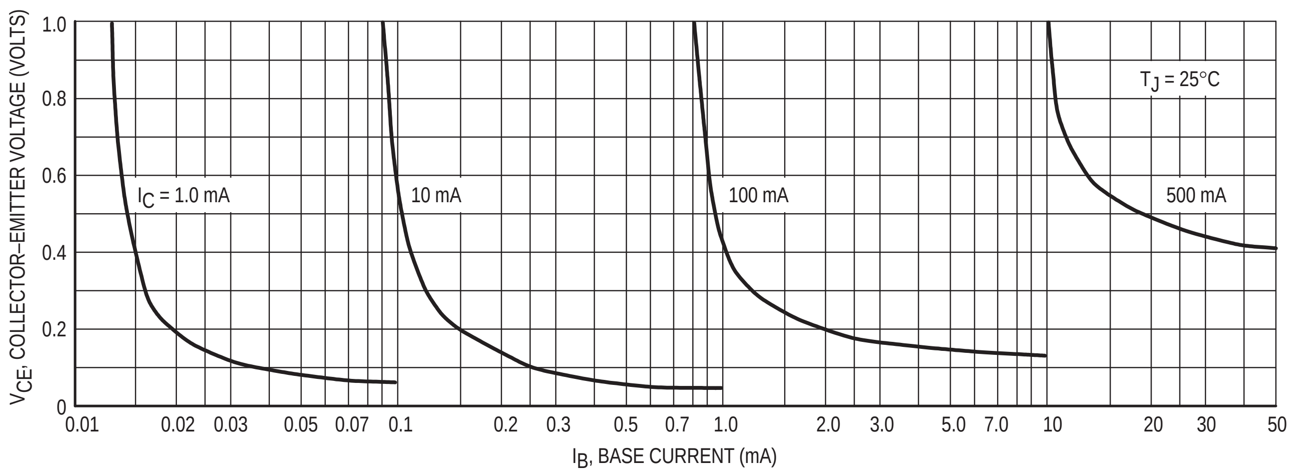


Figure 16. Collector Saturation Region

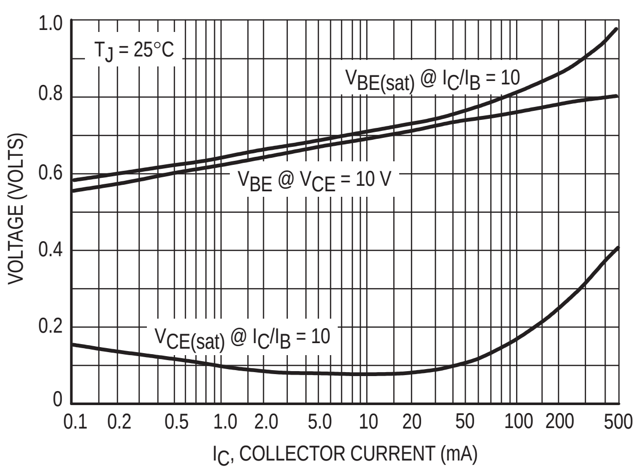


Figure 17. “On” Voltages

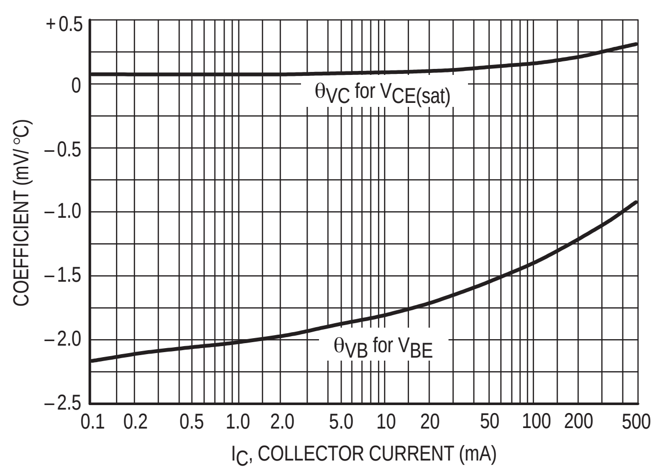


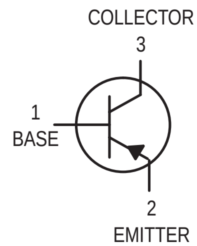
Figure 18. Temperature Coefficients

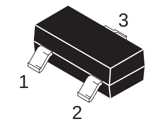
Switching Transistor

PNP Silicon

MMBT4403LT1

Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	–40	Vdc
Collector–Base Voltage	V_{CBO}	–40	Vdc
Emitter–Base Voltage	V_{EBO}	–5.0	Vdc
Collector Current — Continuous	I_C	–600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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,(2) 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

DEVICE MARKING

MMBT4403LT1 = 2T

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage(3) (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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

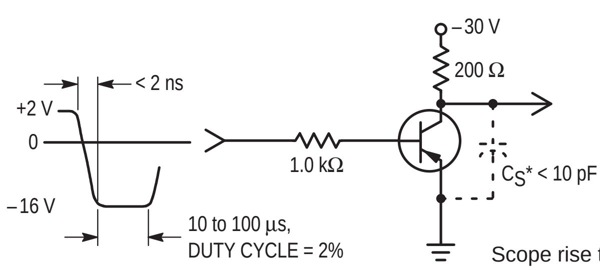
Preferred devices are Motorola recommended choices for future use and best overall value.

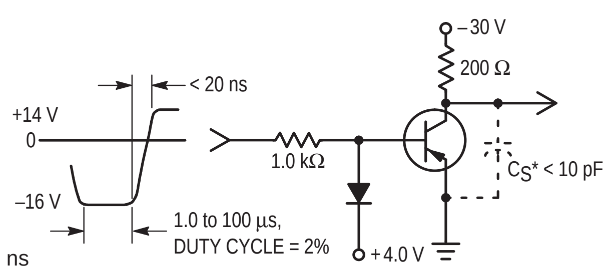
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = –0.1 mAdc, V_{CE} = –1.0 Vdc)			30	—	
(I_C = –1.0 mAdc, V_{CE} = –1.0 Vdc)			60	—	
(I_C = –10 mAdc, V_{CE} = –1.0 Vdc)			100	—	
(I_C = –150 mAdc, V_{CE} = –2.0 Vdc)(3)			100	300	
(I_C = –500 mAdc, V_{CE} = –2.0 Vdc)(3)			20	—	
Collector–Emitter Saturation Voltage(3)		$V_{CE(sat)}$			Vdc
(I_C = –150 mAdc, I_B = –15 mAdc)			—	–0.4	
(I_C = –500 mAdc, I_B = –50 mAdc)			—	–0.75	
Base–Emitter Saturation Voltage (3)		$V_{BE(sat)}$			Vdc
(I_C = –150 mAdc, I_B = –15 mAdc)			–0.75	–0.95	
(I_C = –500 mAdc, I_B = –50 mAdc)			—	–1.3	
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}	1.5	15	kΩ
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	
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	

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

SWITCHING TIME EQUIVALENT TEST CIRCUIT





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

Figure 1. Turn–On Time **Figure 2. Turn–Off Time**

TRANSIENT CHARACTERISTICS

—— 25°C   – – – 100°C

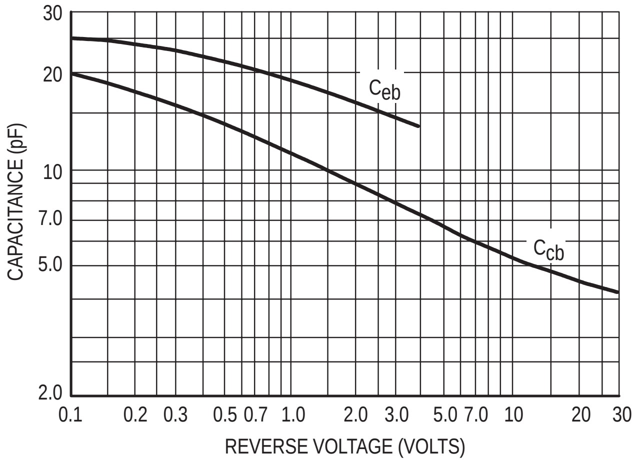


Figure 3. Capacitances

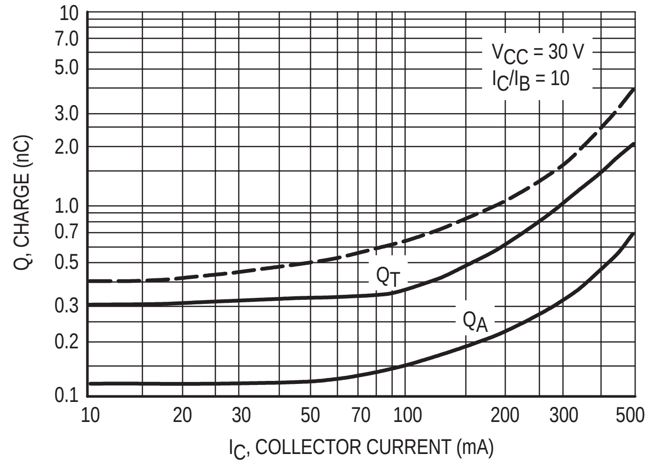


Figure 4. Charge Data

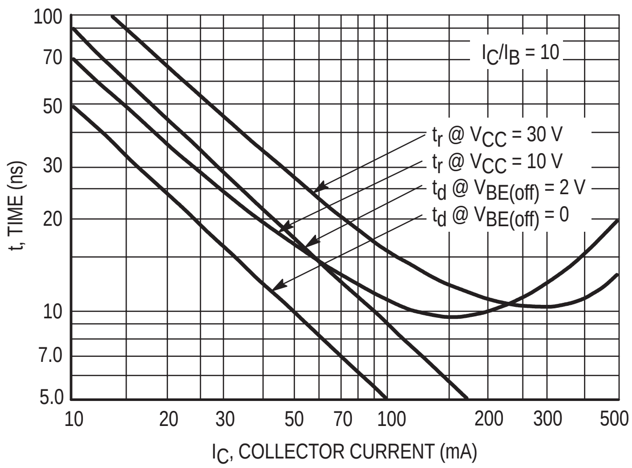


Figure 5. Turn–On Time

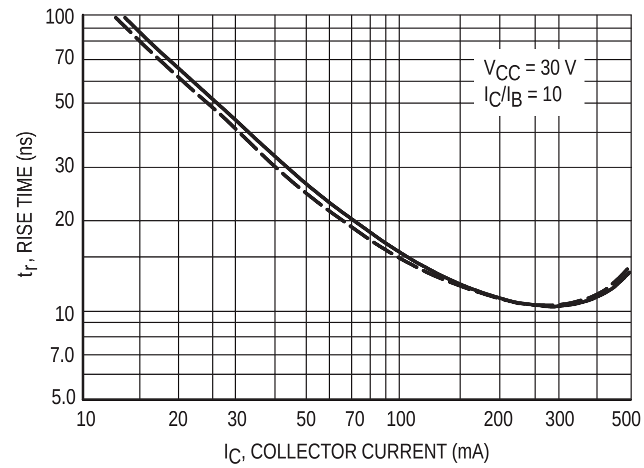


Figure 6. Rise Time

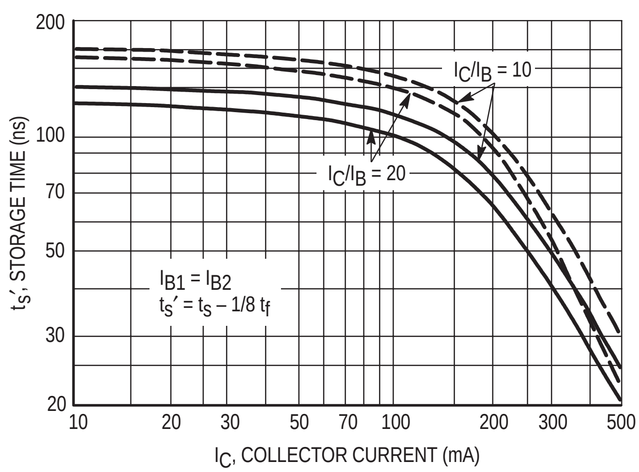


Figure 7. Storage Time

SMALL–SIGNAL CHARACTERISTICS

NOISE FIGURE

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

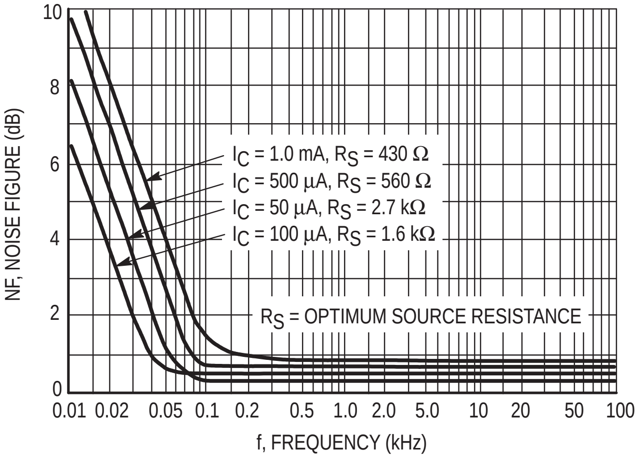


Figure 8. Frequency Effects

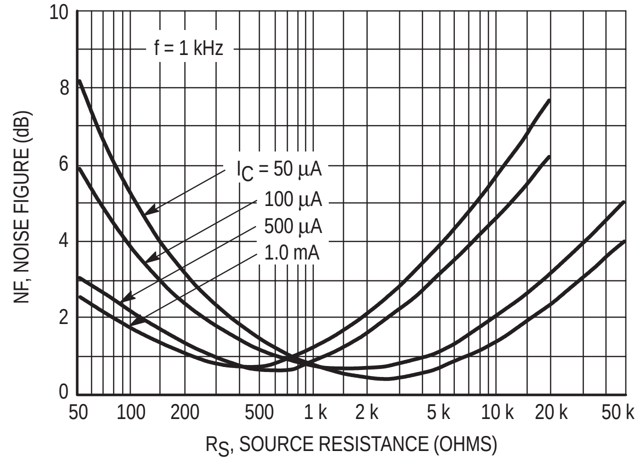


Figure 9. Source Resistance Effects

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 the MMBT4403LT1 lines, and the same units were used to develop the correspondingly–numbered curves on each graph.

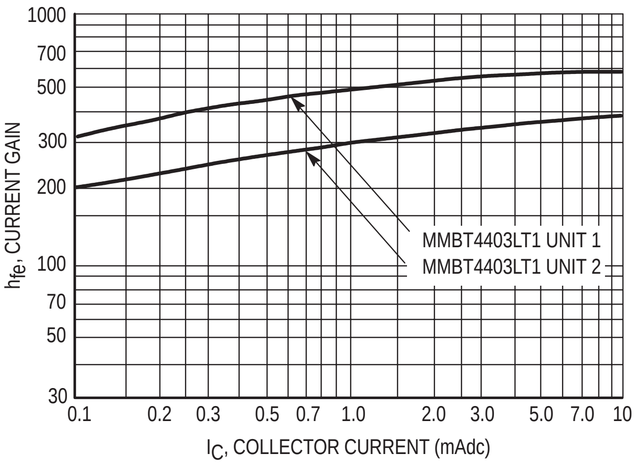


Figure 10. Current Gain

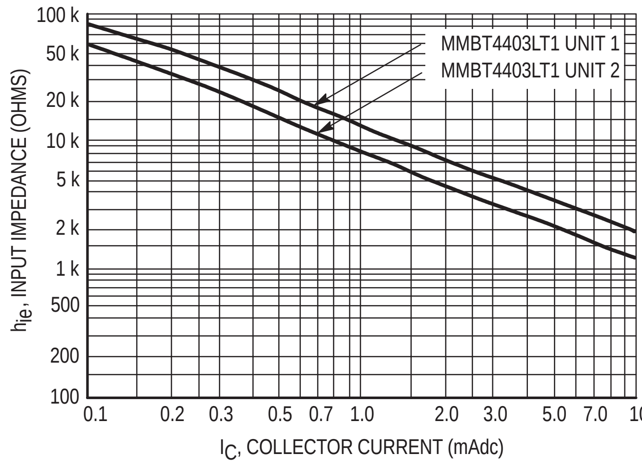


Figure 11. Input Impedance

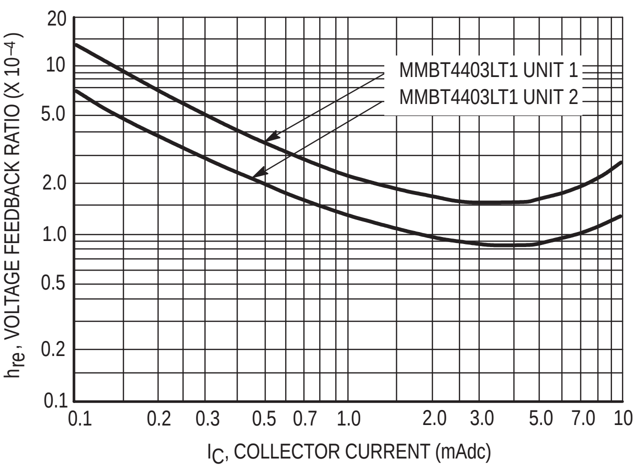


Figure 12. Voltage Feedback Ratio

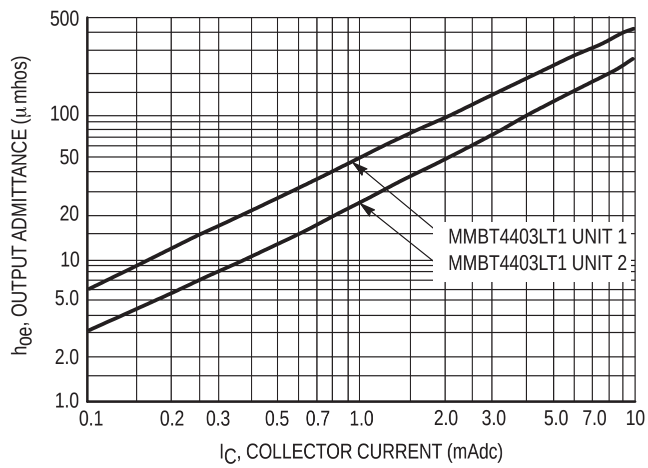


Figure 13. Output Admittance

STATIC CHARACTERISTICS

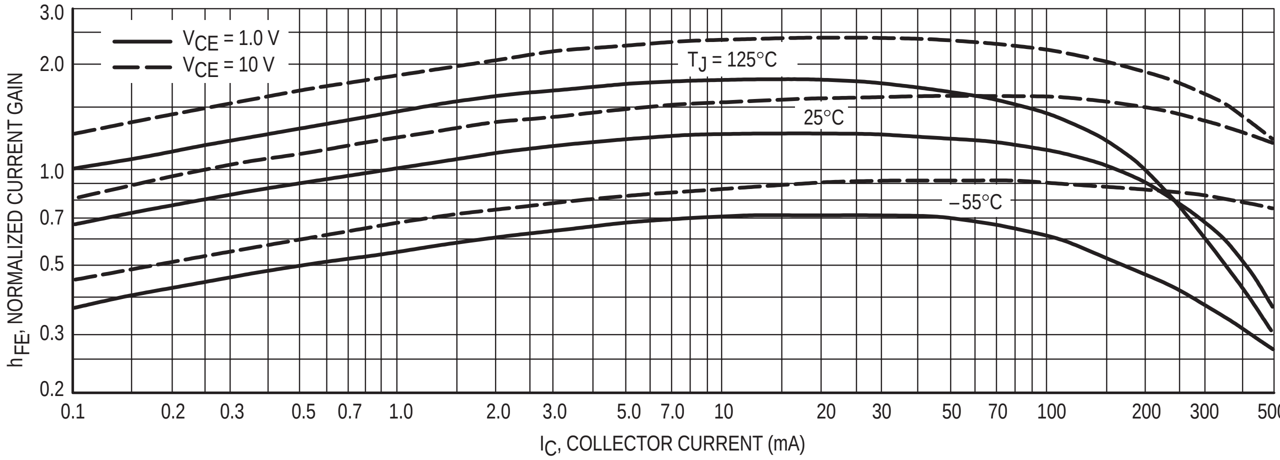


Figure 14. DC Current Gain

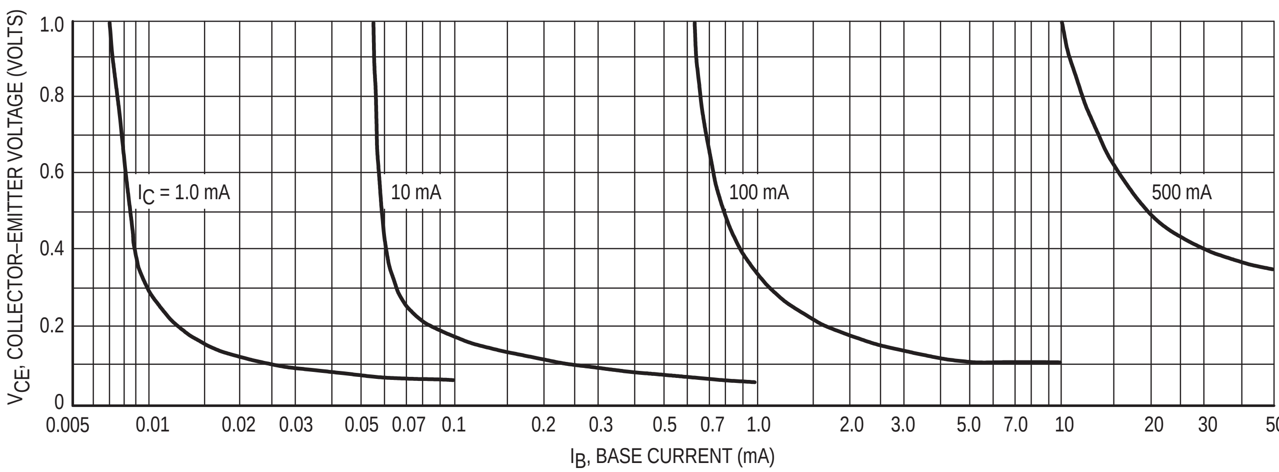


Figure 15. Collector Saturation Region

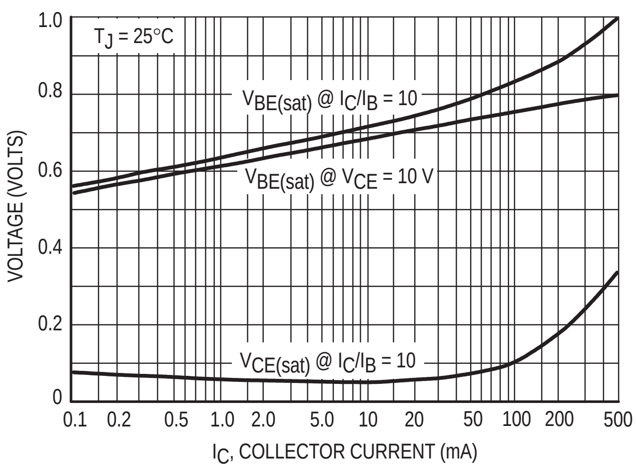


Figure 16. "On" Voltages

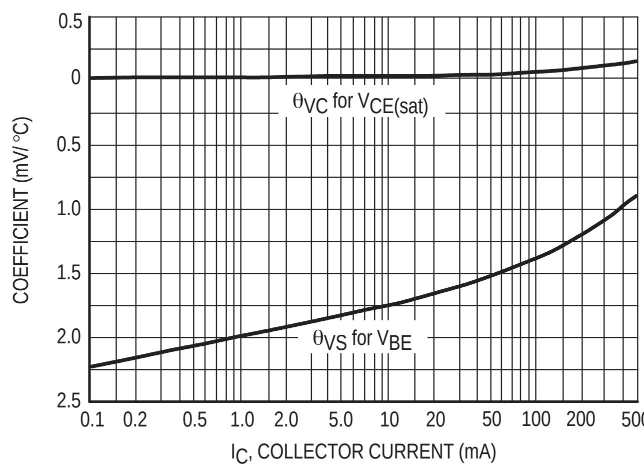


Figure 17. Temperature Coefficients

Low Noise Transistor
PNP Silicon

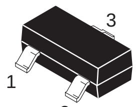
MMBT5087LT1

Motorola Preferred Device

COLLECTOR
3

1
BASE

2
EMITTER



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBT5087LT1 = 2Q

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board (1) 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, (2) 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

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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

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

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = –100 µAdc, V_{CE} = –5.0 Vdc)		250	800	
(I_C = –1.0 mAdc, V_{CE} = –5.0 Vdc)		250	—	
(I_C = –10 mAdc, V_{CE} = –5.0 Vdc)		250	—	
Collector–Emitter Saturation Voltage (I_C = –10 mAdc, I_B = –1.0 mAdc)	$V_{CE(sat)}$	—	–0.3	Vdc
Base–Emitter Saturation Voltage (I_C = –10 mAdc, I_B = –1.0 mAdc)	$V_{BE(sat)}$	—	0.85	Vdc
SMALL–SIGNAL CHARACTERISTICS				
Current–Gain — Bandwidth Product (I_C = –500 µAdc, V_{CE} = –5.0 Vdc, f = 20 MHz)	f_T	40	—	MHz
Output Capacitance (V_{CB} = –5.0 Vdc, I_E = 0, f = 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	NF			dB
(I_C = –20 mAdc, V_{CE} = –5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz)		—	2.0	
(I_C = –100 µAdc, V_{CE} = –5.0 Vdc, R_S = 3.0 kΩ, f = 1.0 kHz)		—	2.0	

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

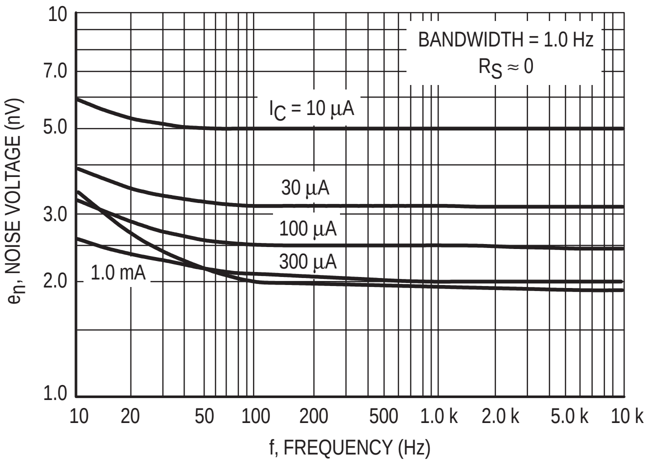


Figure 1. Noise Voltage

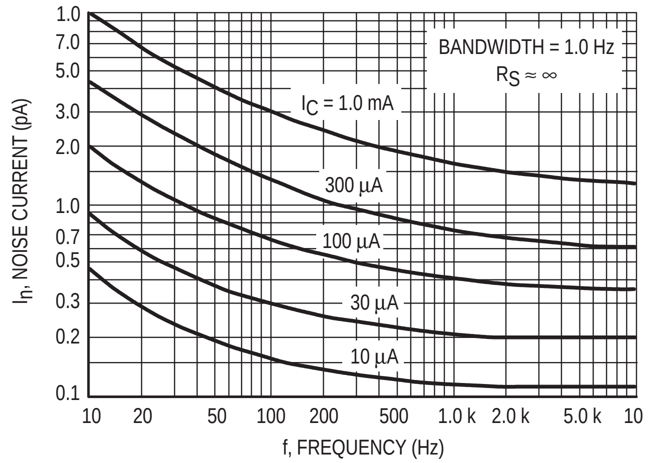


Figure 2. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

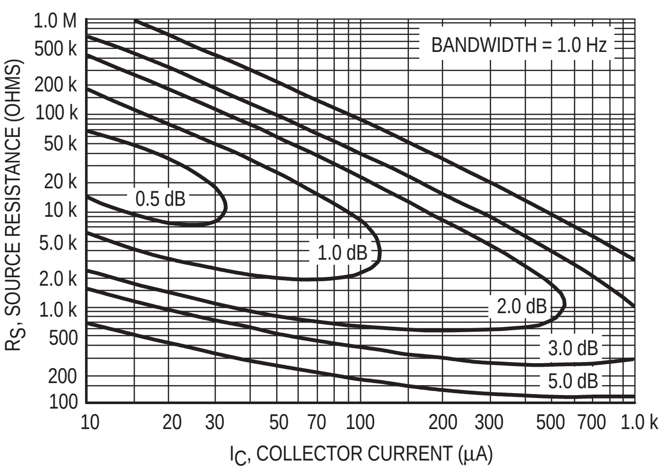


Figure 3. Narrow Band, 100 Hz

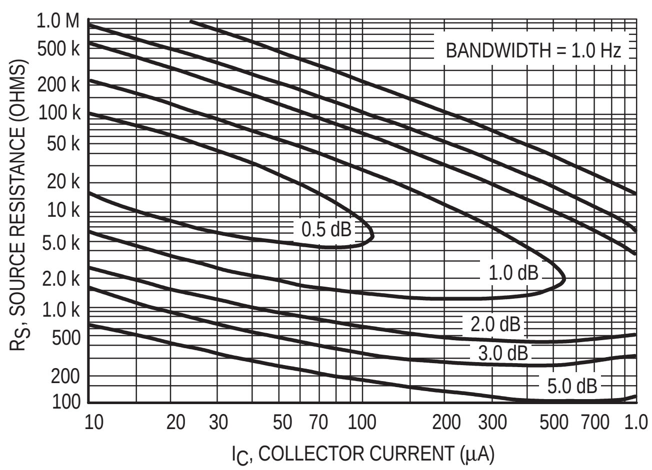


Figure 4. Narrow Band, 1.0 kHz

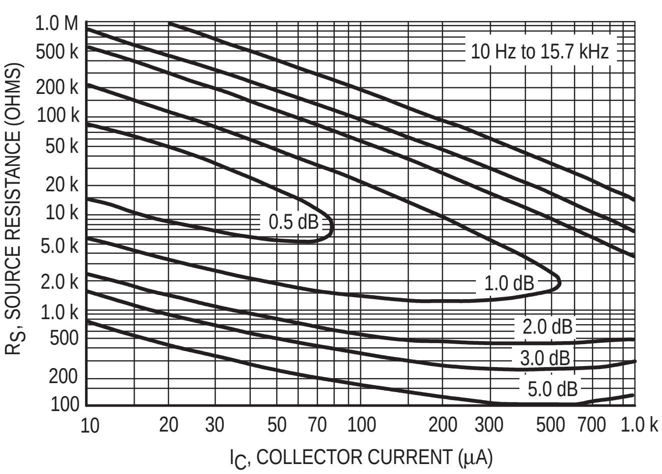


Figure 5. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

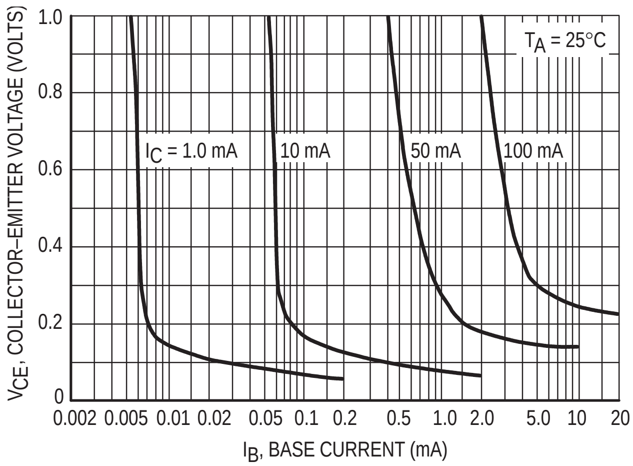


Figure 6. Collector Saturation Region

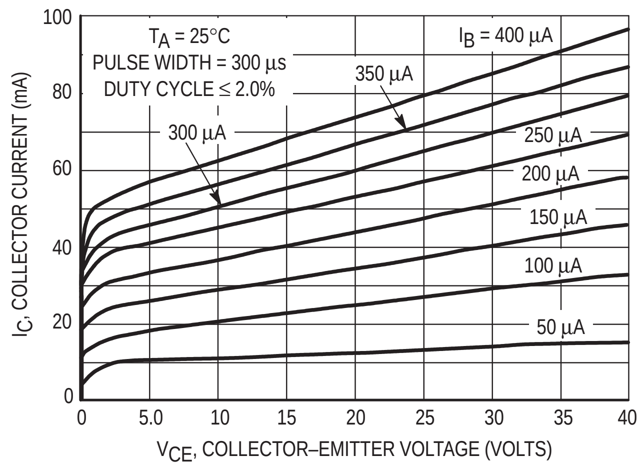


Figure 7. Collector Characteristics

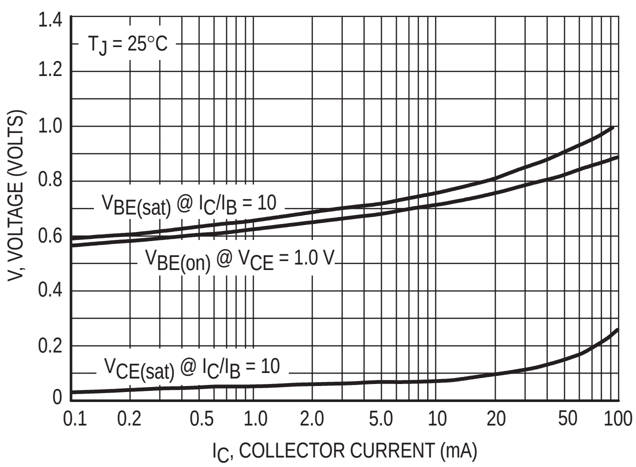


Figure 8. "On" Voltages

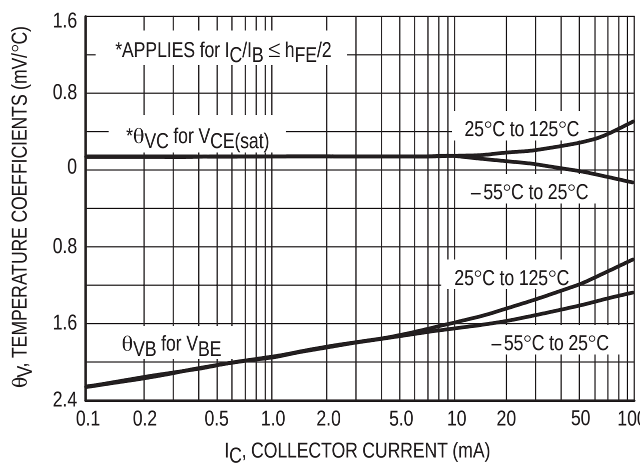


Figure 9. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

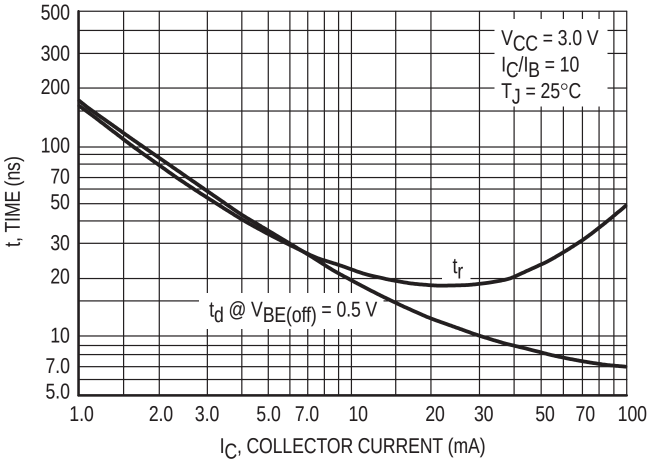


Figure 10. Turn–On Time

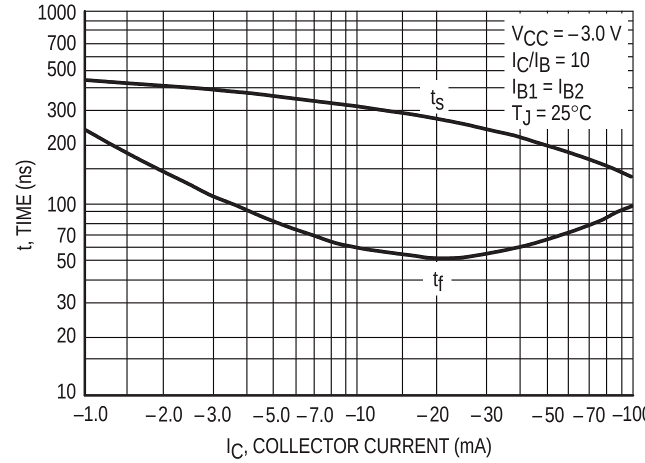


Figure 11. Turn–Off Time

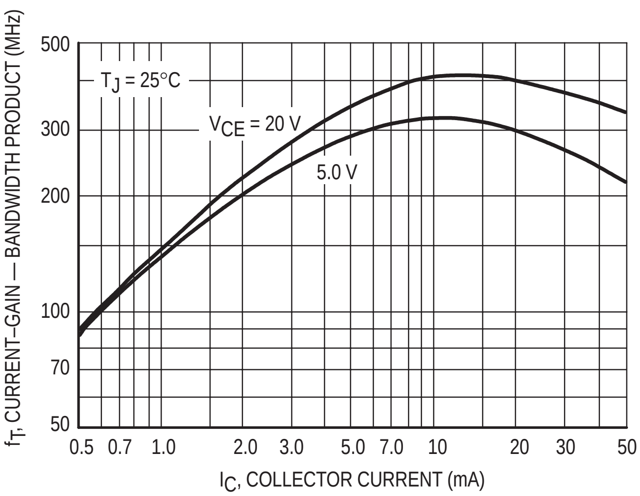


Figure 12. Current–Gain — Bandwidth Product

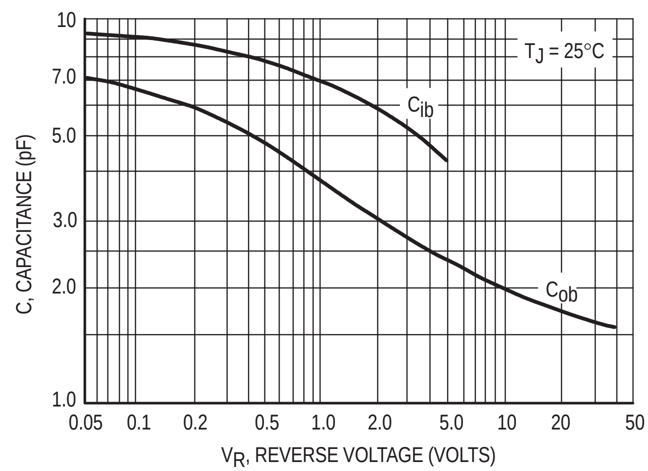


Figure 13. Capacitance

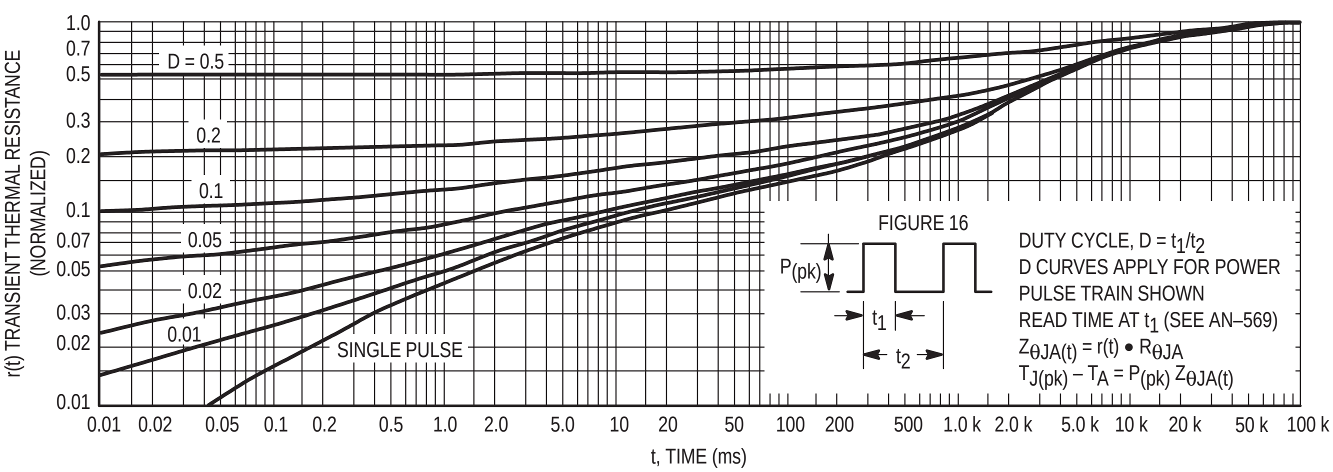


Figure 14. Thermal Response

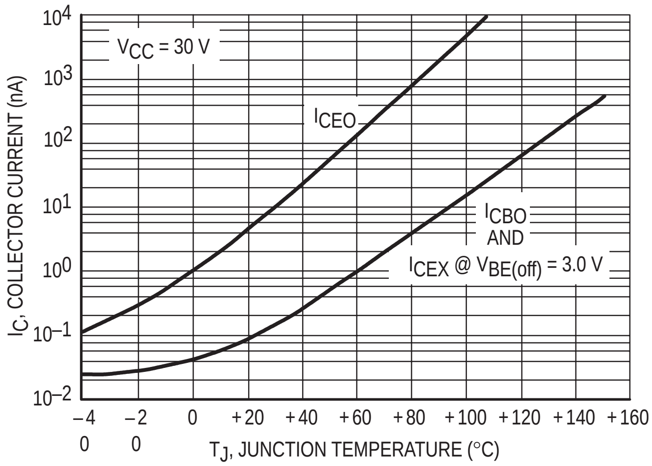


Figure 15. Typical Collector Leakage Current

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 16. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 14 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 14 by the steady state value $R_{\theta JA}$.

Example:

Dissipating 2.0 watts peak under the following conditions:

t_1 = 1.0 ms, t_2 = 5.0 ms (D = 0.2)

Using Figure 14 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

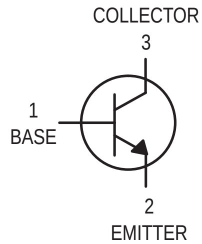
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C$.

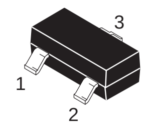
For more information, see AN–569.

Low Noise Transistors
NPN Silicon

MMBT5088LT1
MMBT5089LT1*

*Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	5088LT1	5089LT1	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(1) 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,(2) 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

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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMBT5088		300	900	
	MMBT5089		400	1200	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088		350	—	
	MMBT5089		450	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088		300	—	
	MMBT5089		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		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	MMBT5088		350	1400	
	MMBT5089		450	1800	
Noise Figure		NF			dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz)	MMBT5088		—	3.0	
	MMBT5089		—	2.0	

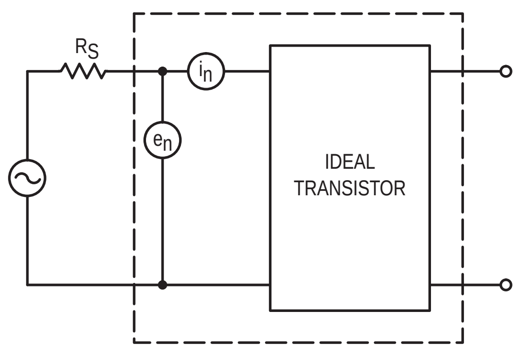


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

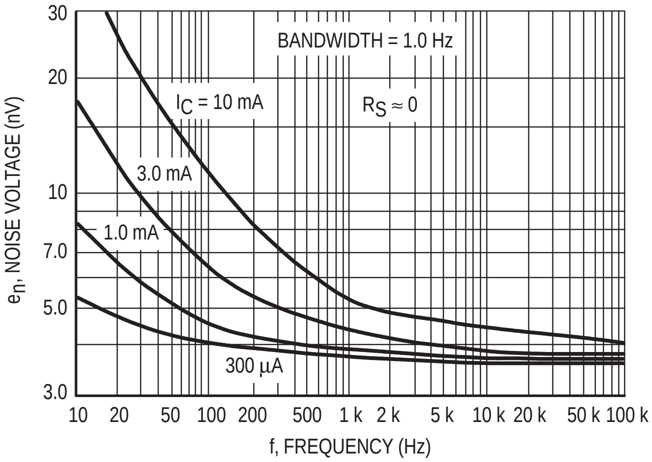


Figure 2. Effects of Frequency

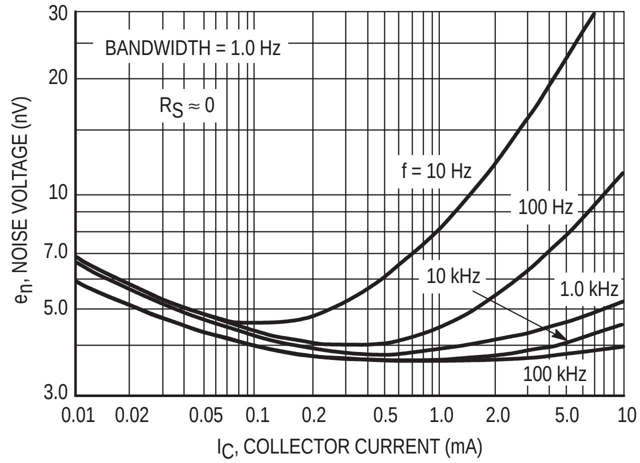


Figure 3. Effects of Collector Current

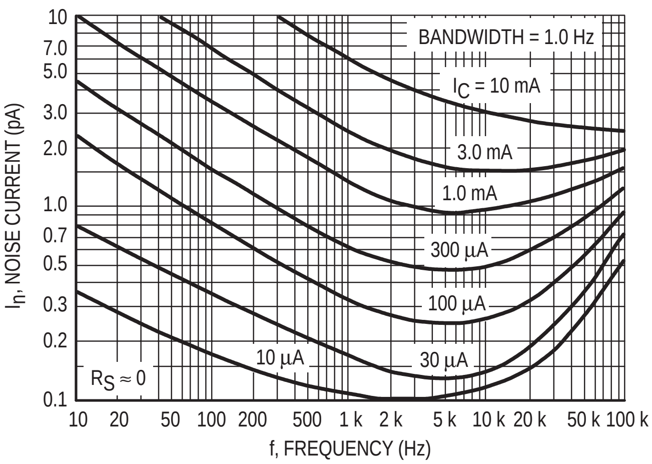


Figure 4. Noise Current

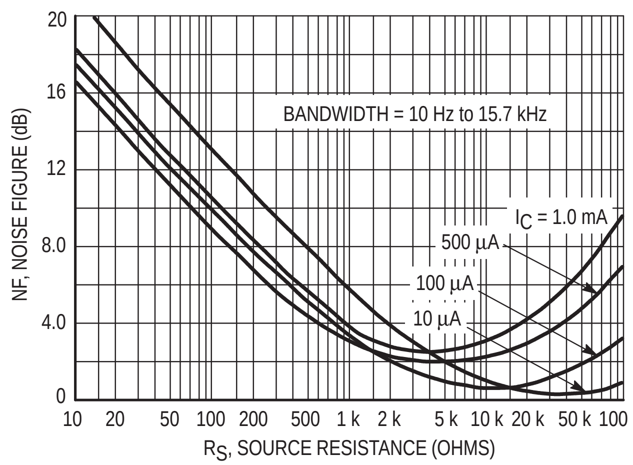


Figure 5. Wideband Noise Figure

100 Hz NOISE DATA

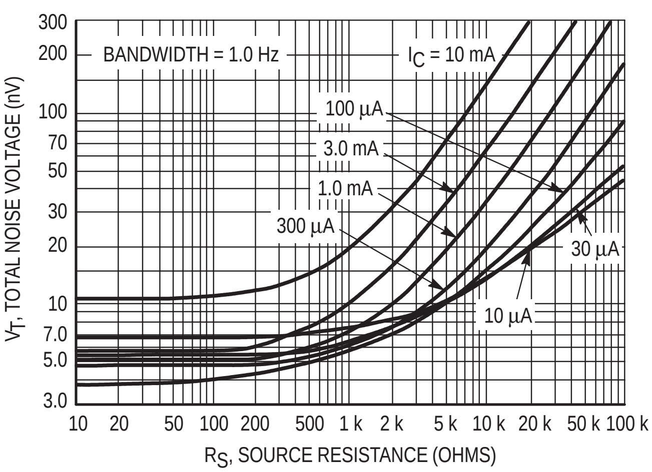


Figure 6. Total Noise Voltage

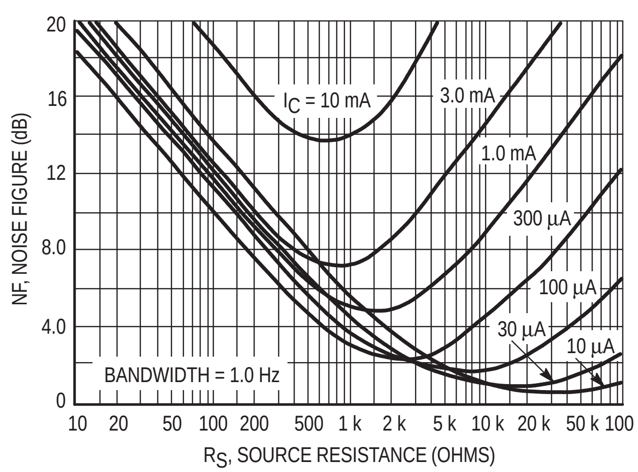


Figure 7. Noise Figure

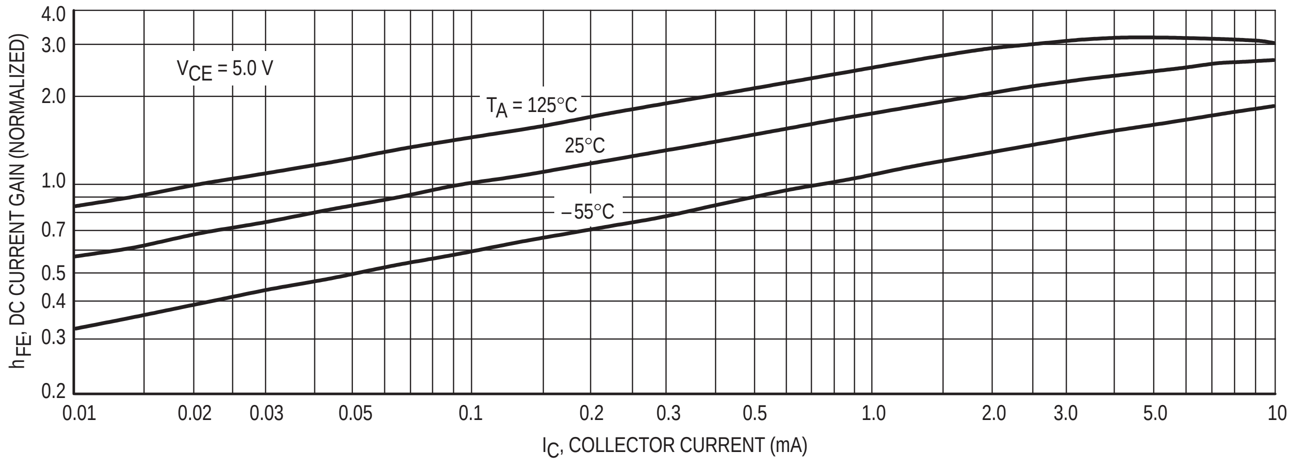


Figure 8. DC Current Gain

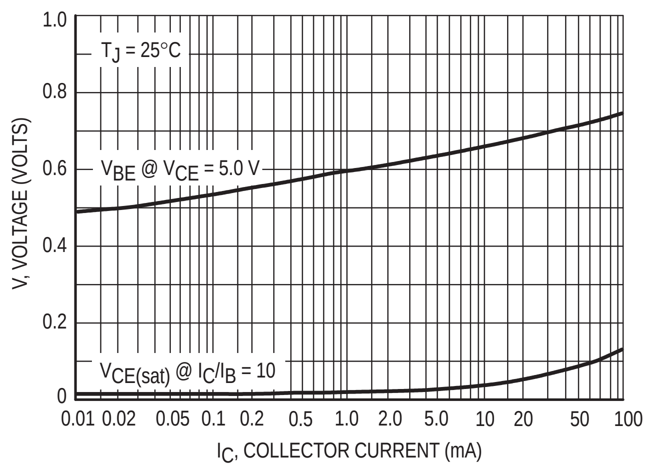


Figure 9. "On" Voltages

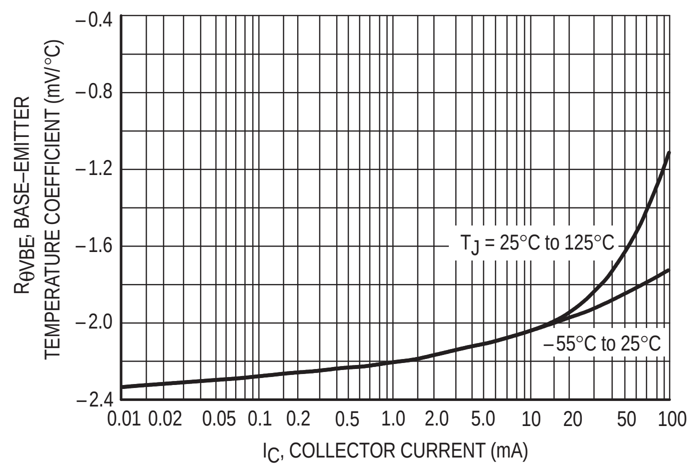


Figure 10. Temperature Coefficients

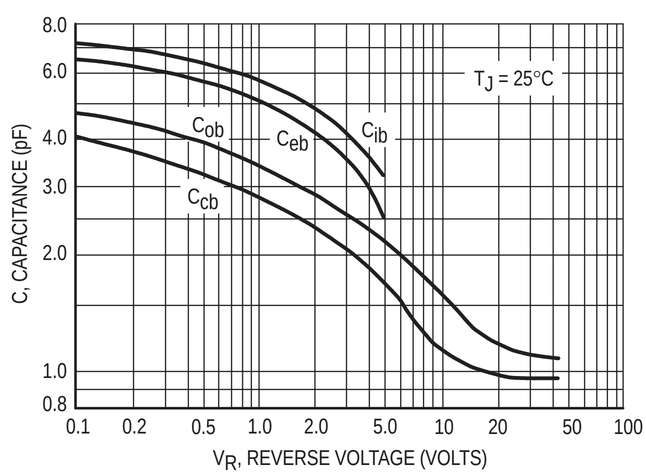


Figure 11. Capacitance

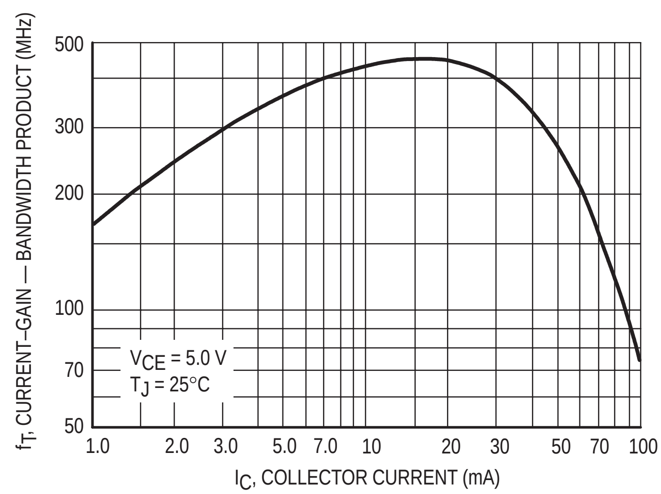
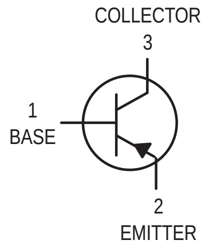


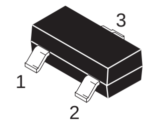
Figure 12. Current–Gain — Bandwidth Product

High Voltage Transistor
PNP Silicon



MMBT5401LT1

Motorola Preferred Device



CASE 318 – 08, STYLE 6
SOT– 23 (TO – 236AB)

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(1) 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,(2) 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

DEVICE MARKING

MMBT5401LT1 = 2L

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_{CES}	 — —	 –50 –50	 nAdc μAdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = –1.0 mAdc, V_{CE} = –5.0 Vdc)		50	—	
(I_C = –10 mAdc, V_{CE} = –5.0 Vdc)		60	240	
(I_C = –50 mAdc, V_{CE} = –5.0 Vdc)		50	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = –10 mAdc, I_B = –1.0 mAdc)		—	–0.2	
(I_C = –50 mAdc, I_B = –5.0 mAdc)		—	–0.5	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = –10 mAdc, I_B = –1.0 mAdc)		—	–1.0	
(I_C = –50 mAdc, I_B = –5.0 mAdc)		—	–1.0	
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 Ω, f = 1.0 kHz)	NF	—	8.0	dB

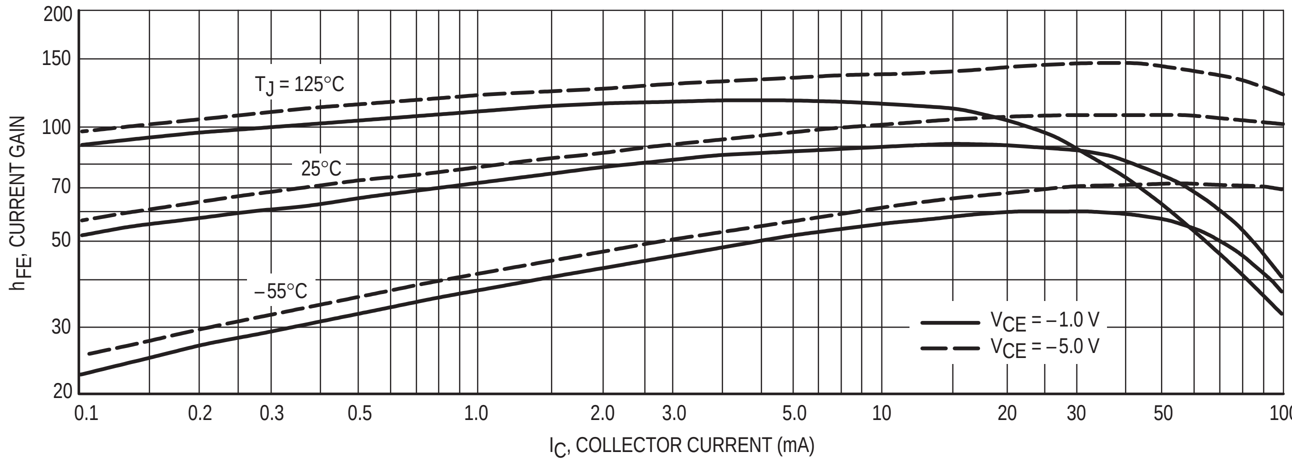


Figure 1. DC Current Gain

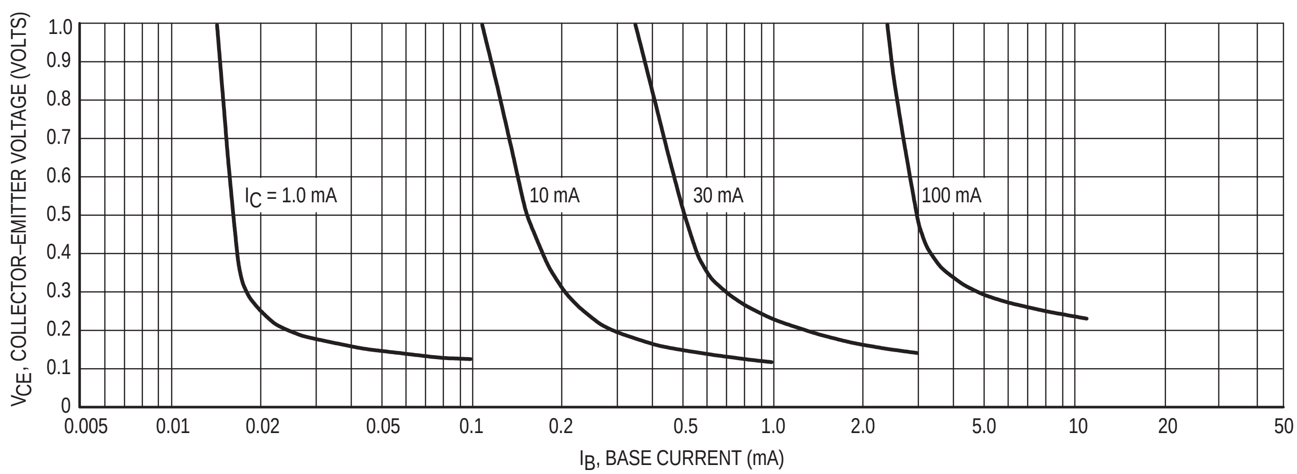


Figure 2. Collector Saturation Region

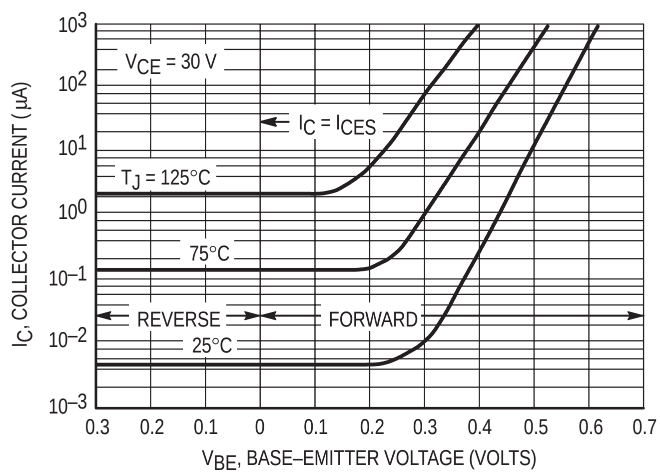


Figure 3. Collector Cut–Off Region

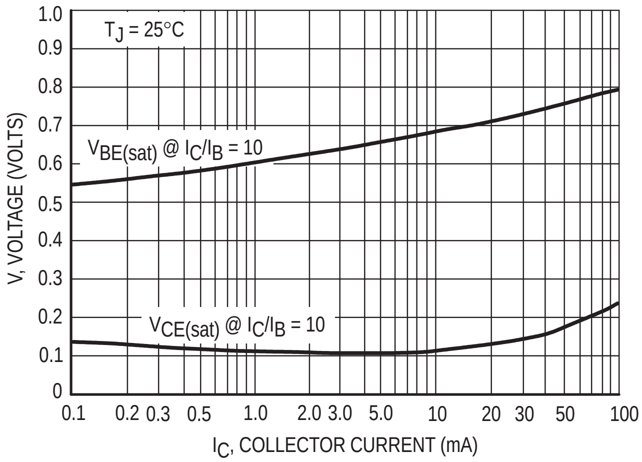


Figure 4. "On" Voltages

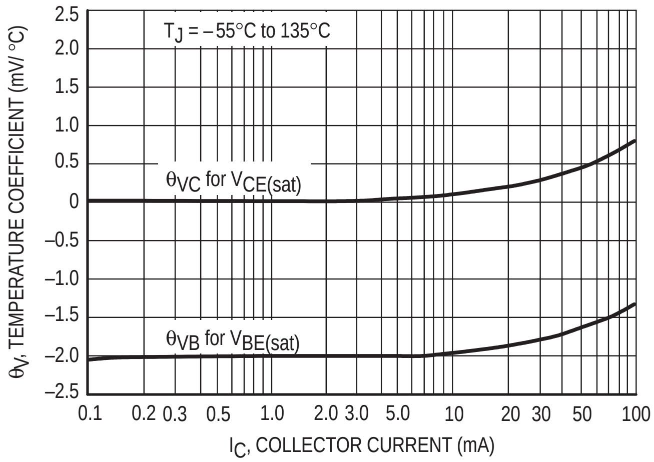


Figure 5. Temperature Coefficients

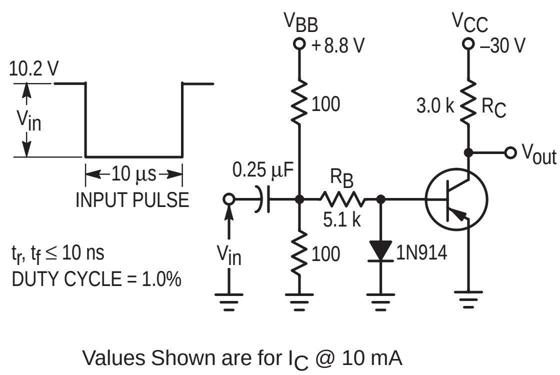


Figure 6. Switching Time Test Circuit

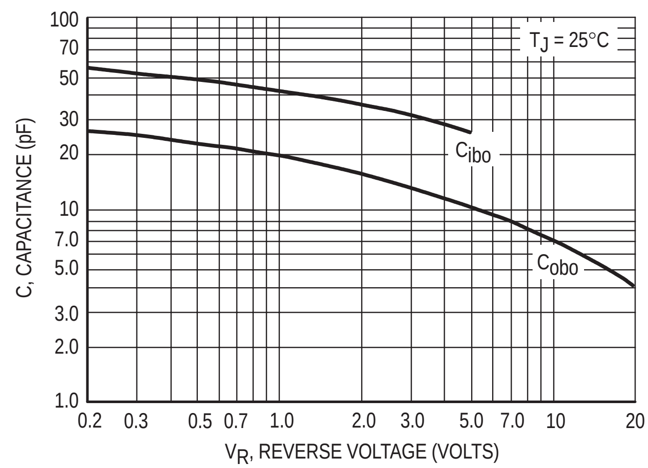


Figure 7. Capacitances

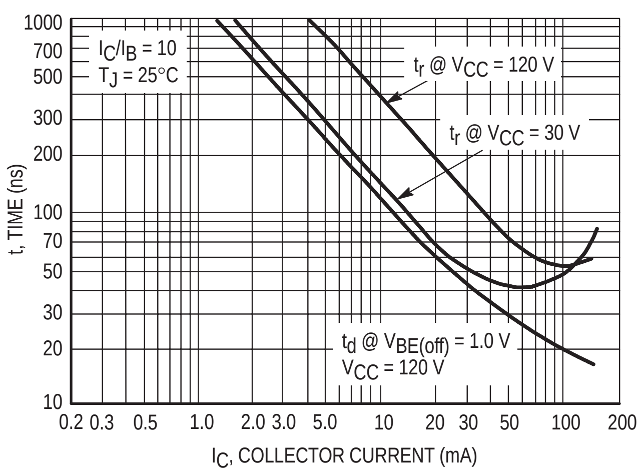


Figure 8. Turn–On Time

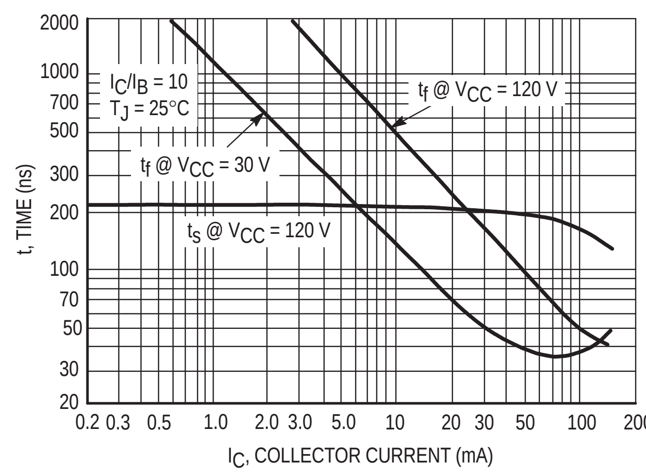


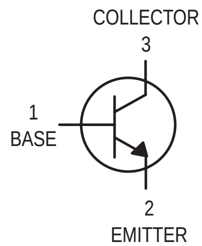
Figure 9. Turn–Off Time

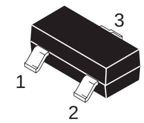
High Voltage Transistors

NPN Silicon

MMBT5550LT1
MMBT5551LT1*

*Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

MMBT5550LT1 = M1F; MMBT5551LT1 = G1

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(3) (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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT5550		60	—	
	MMBT5551		80	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT5550		60	250	
	MMBT5551		80	250	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	MMBT5550		20	—	
	MMBT5551		30	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	Both Types		—	0.15	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	MMBT5550		—	0.25	
	MMBT5551		—	0.20	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	Both Types		—	1.0	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	MMBT5550		—	1.2	
	MMBT5551		—	1.0	

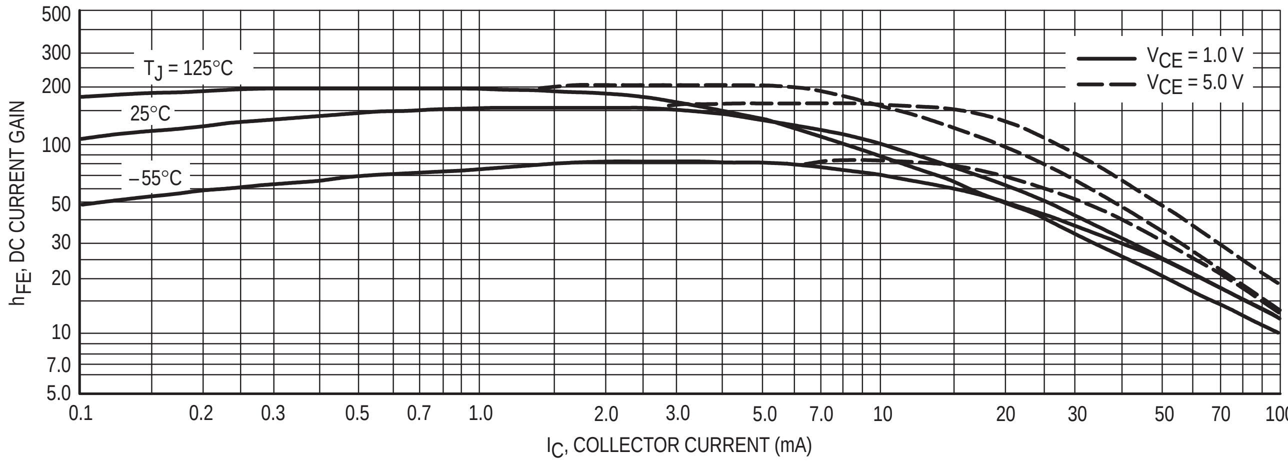


Figure 1. DC Current Gain

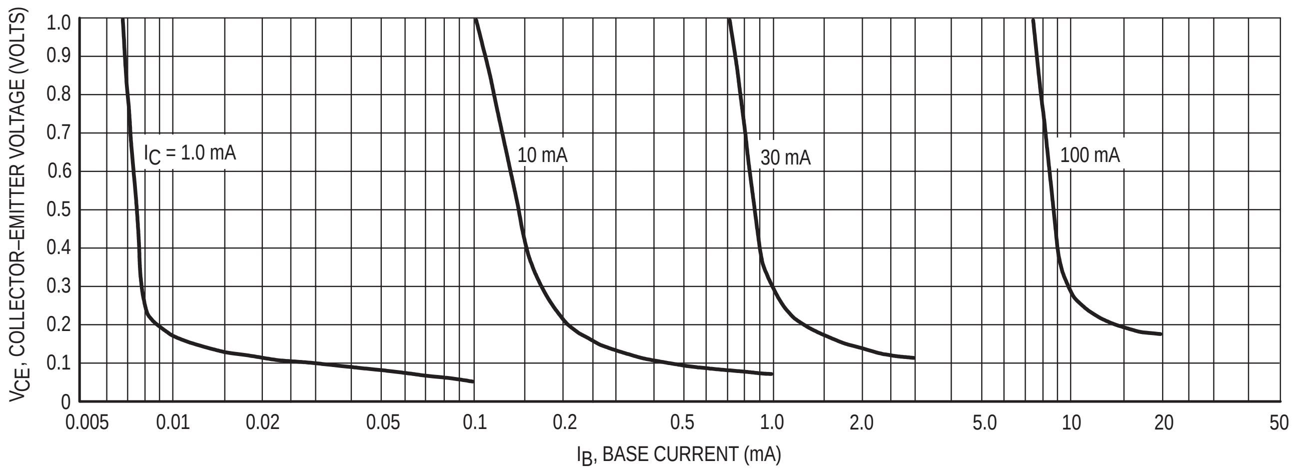


Figure 2. Collector Saturation Region

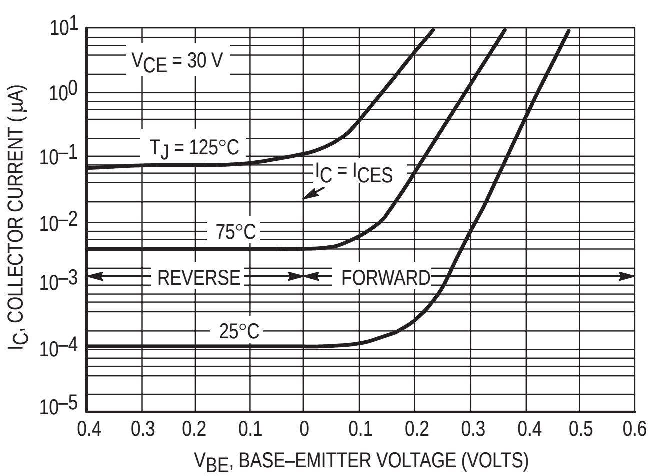


Figure 3. Collector Cut–Off Region

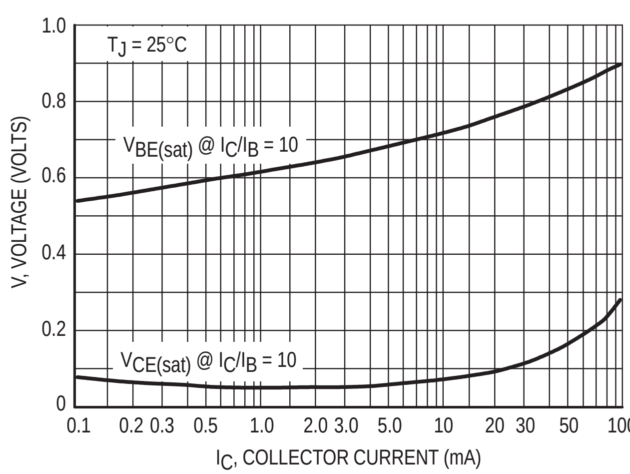


Figure 4. “On” Voltages

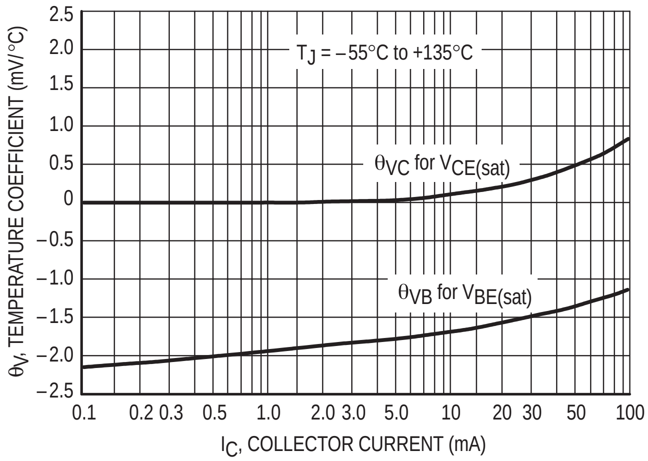
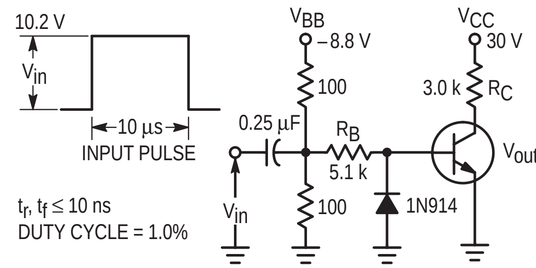


Figure 5. Temperature Coefficients



Values Shown are for I_C @ 10 mA

Figure 6. Switching Time Test Circuit

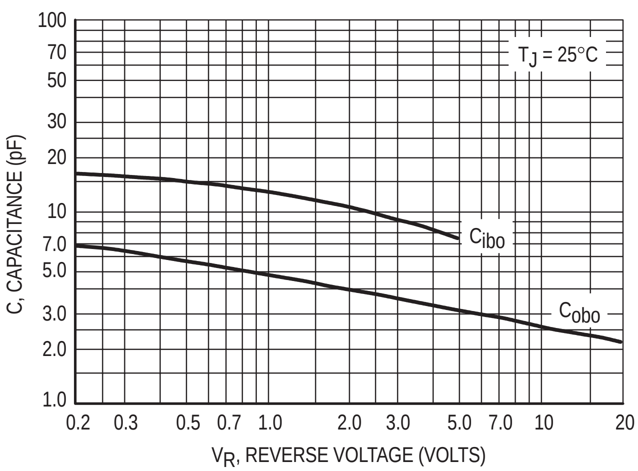


Figure 7. Capacitances

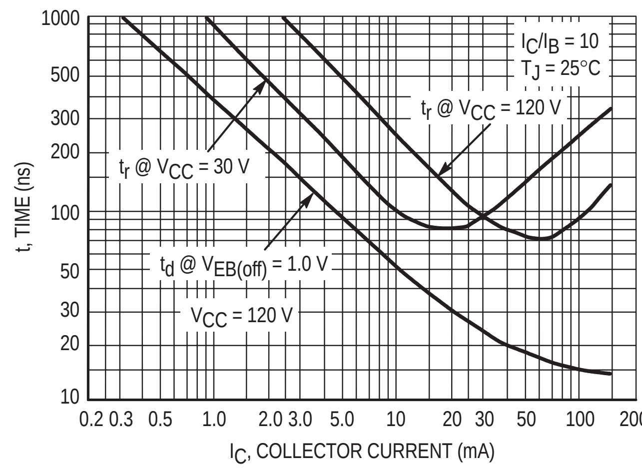


Figure 8. Turn–On Time

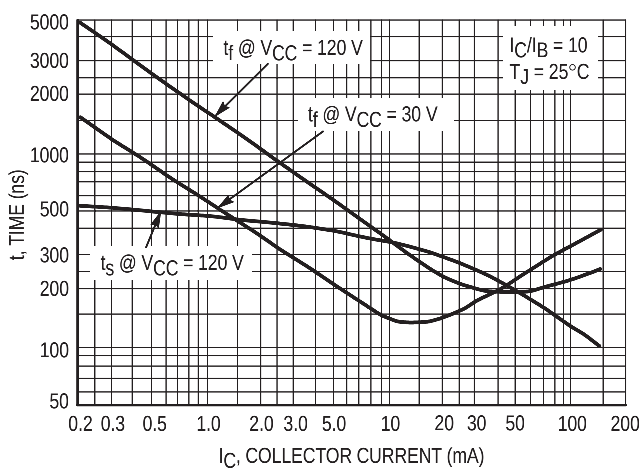
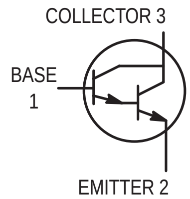


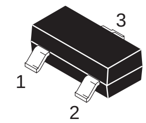
Figure 9. Turn–Off Time

Darlington Transistor
NPN Silicon

MMBT6427LT1

Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

MMBT6427LT1 = 1V

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 µAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter–Base Breakdown Voltage (I_C = 10 µAdc, I_C = 0)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)	I_{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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		10,000	100,000	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		20,000	200,000	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		14,000	140,000	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$(3)			Vdc
(I_C = 50 mAdc, I_B = 0.5 mAdc)		—	1.2	
(I_C = 500 mAdc, I_B = 0.5 mAdc)		—	1.5	
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 Vdc, 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

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

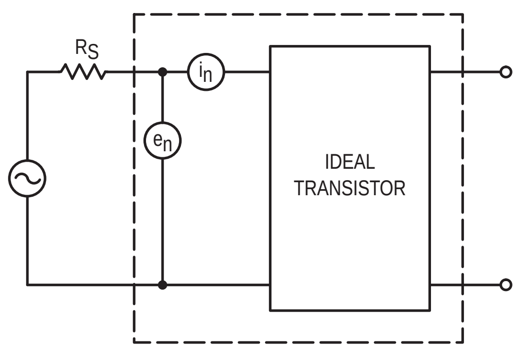


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

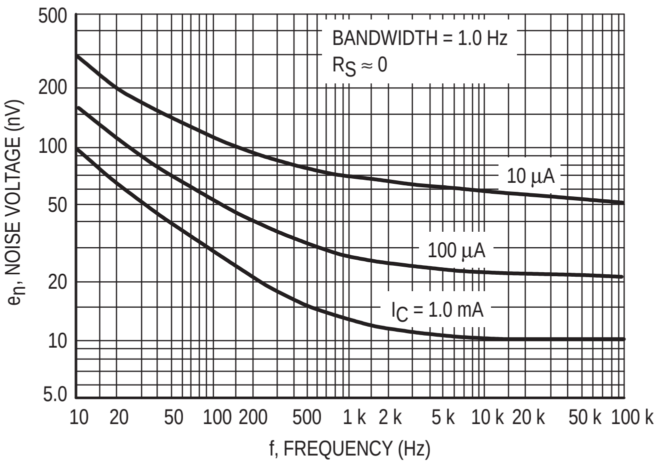


Figure 2. Noise Voltage

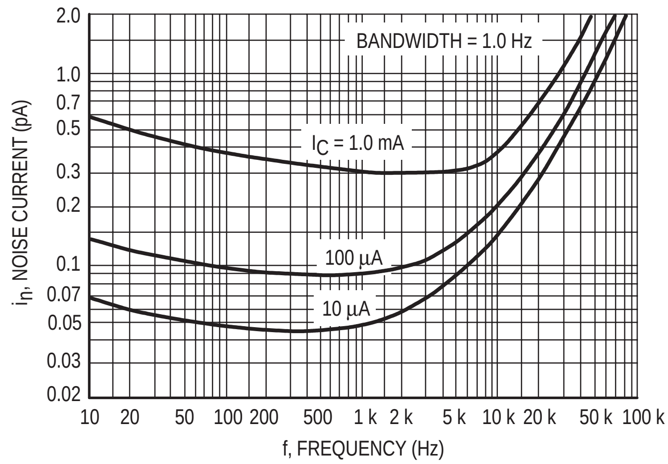


Figure 3. Noise Current

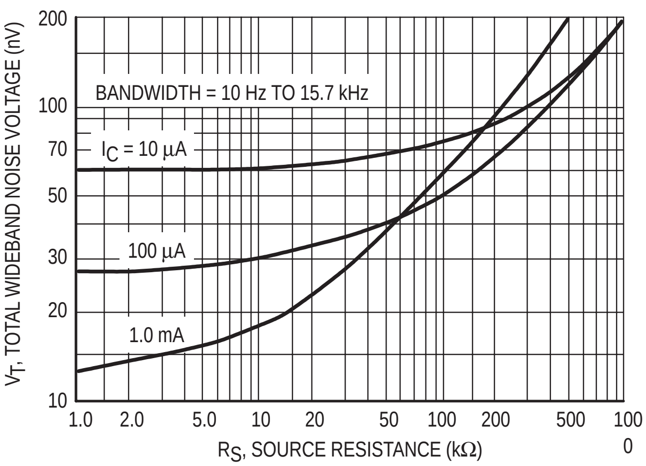


Figure 4. Total Wideband Noise Voltage

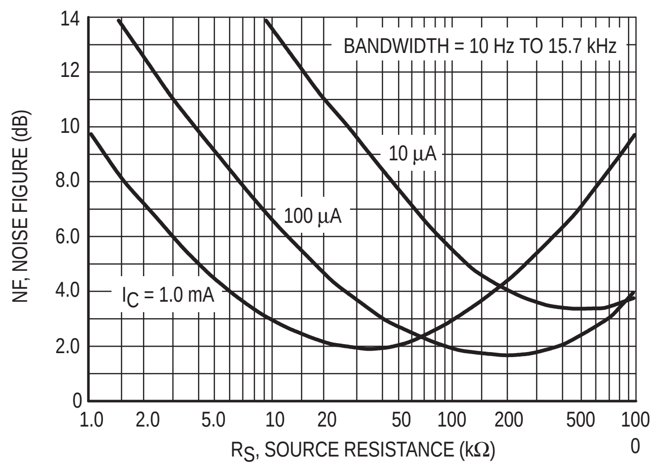


Figure 5. Wideband Noise Figure

SMALL–SIGNAL CHARACTERISTICS

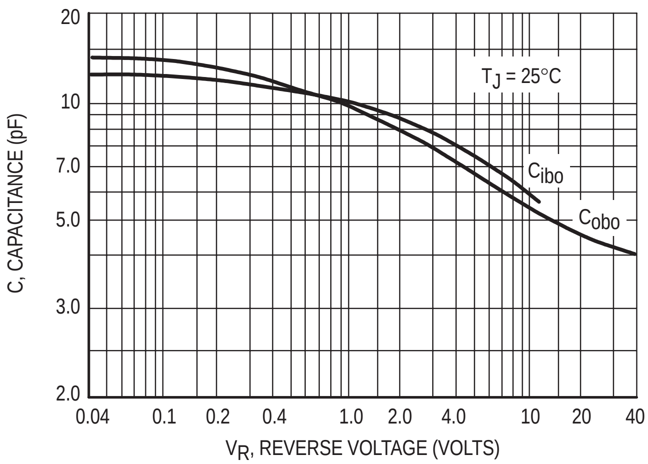


Figure 6. Capacitance

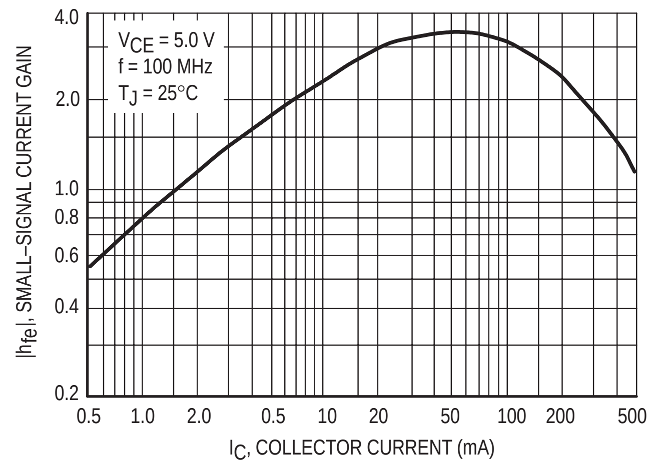


Figure 7. High Frequency Current Gain

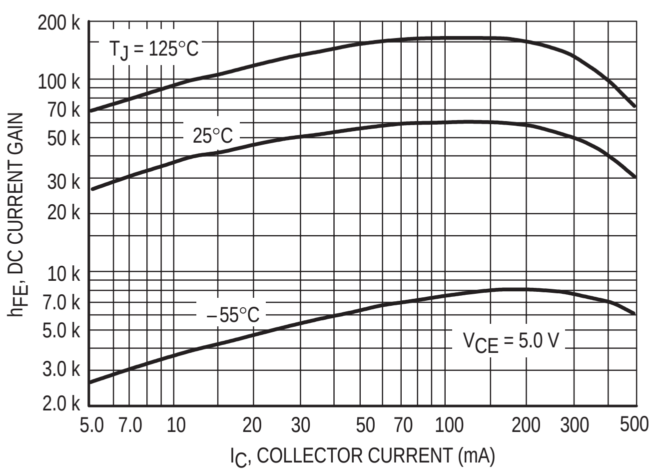


Figure 8. DC Current Gain

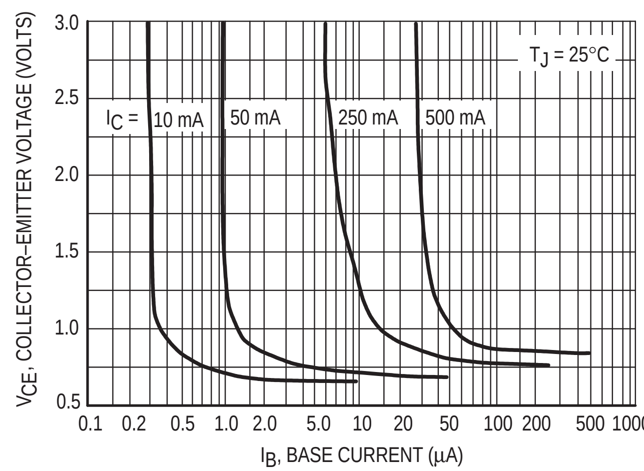


Figure 9. Collector Saturation Region

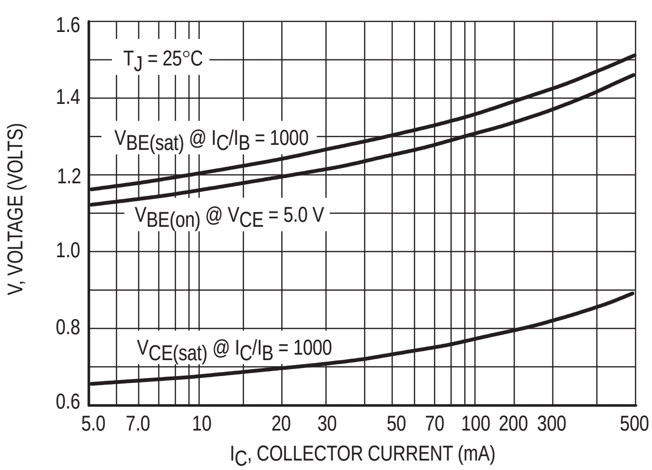


Figure 10. “On” Voltages

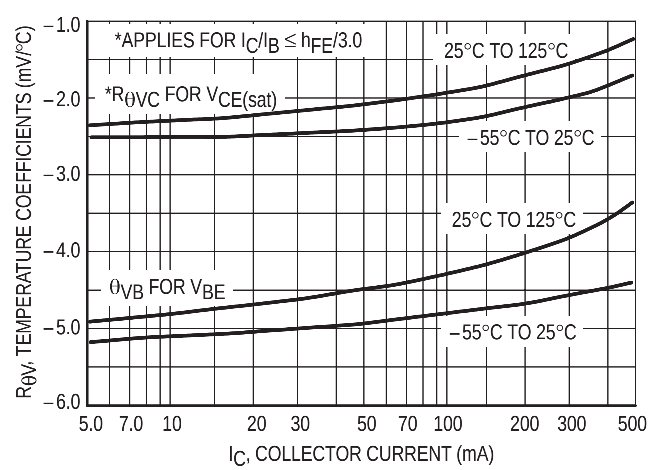


Figure 11. Temperature Coefficients

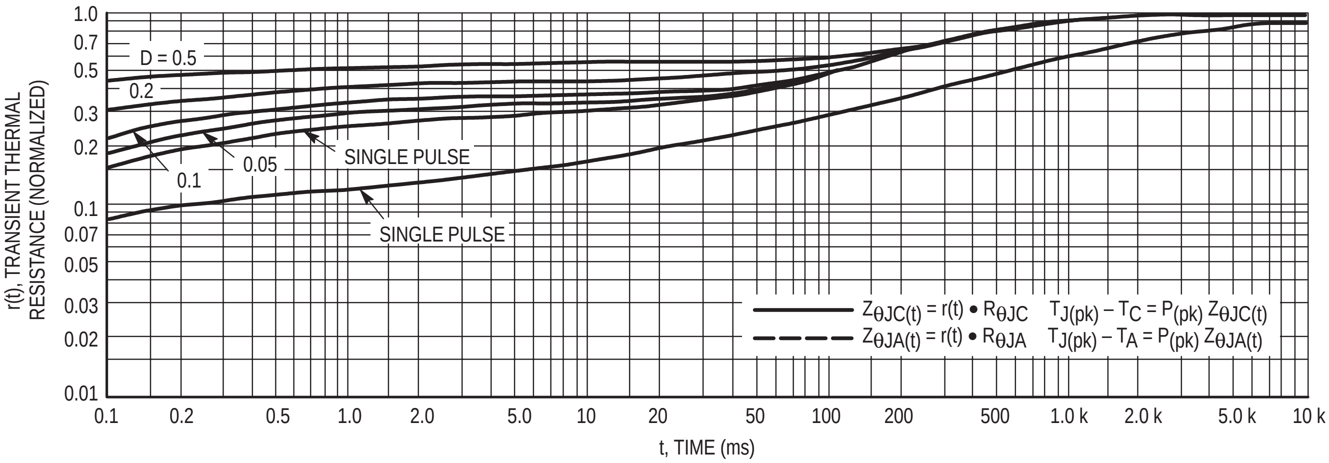
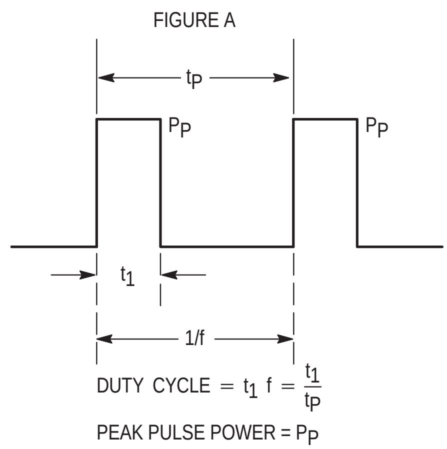


Figure 12. Thermal Response

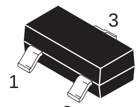


Design Note: Use of Transient Thermal Resistance Data

Amplifier Transistors

NPN Silicon

MMBT6428LT1
MMBT6429LT1



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	6428LT1	6429LT1	Unit
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(1) 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,(2) 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

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 (I_C = 1.0 mAdc, I_B = 0) (I_C = 1.0 mAdc, I_B = 0)	 MMBT6428 MMBT6429	$V_{(BR)CEO}$	 50 45	 — —	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0) (I_C = 0.1 mAdc, I_E = 0)	 MMBT6428 MMBT6429	$V_{(BR)CBO}$	 60 55	 — —	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc)		I_{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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic		Symbol	Min	Max	Unit
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 mAdc)		$V_{BE(on)}$	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

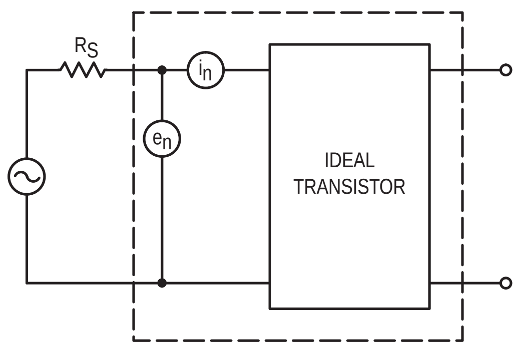


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

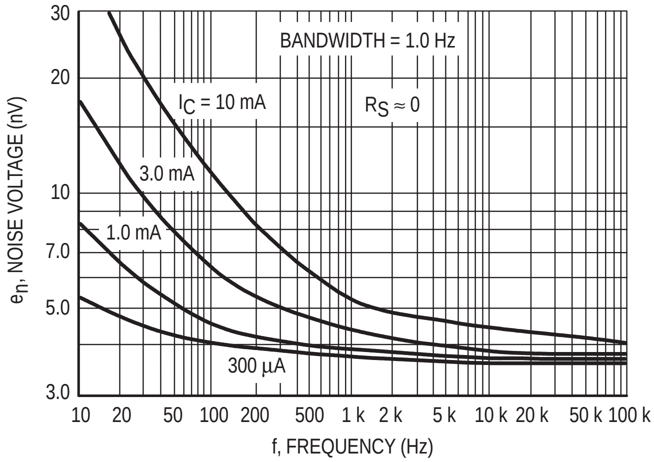


Figure 2. Effects of Frequency

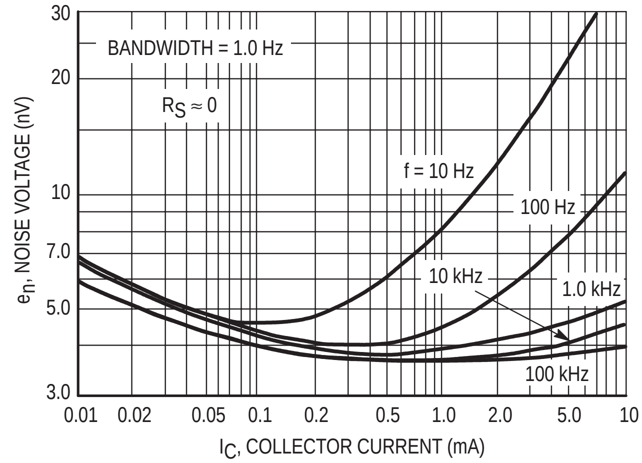


Figure 3. Effects of Collector Current

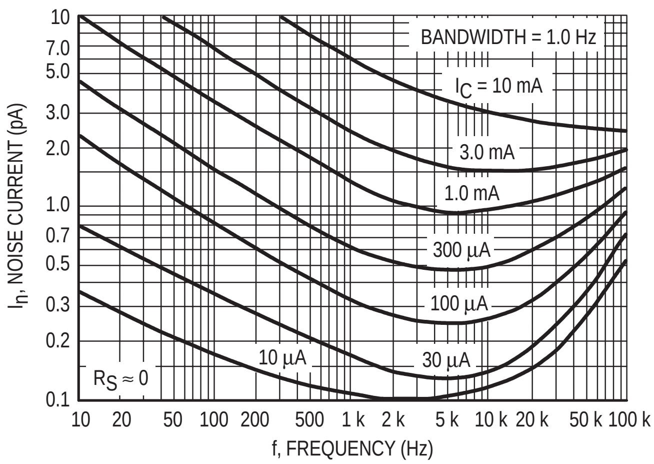


Figure 4. Noise Current

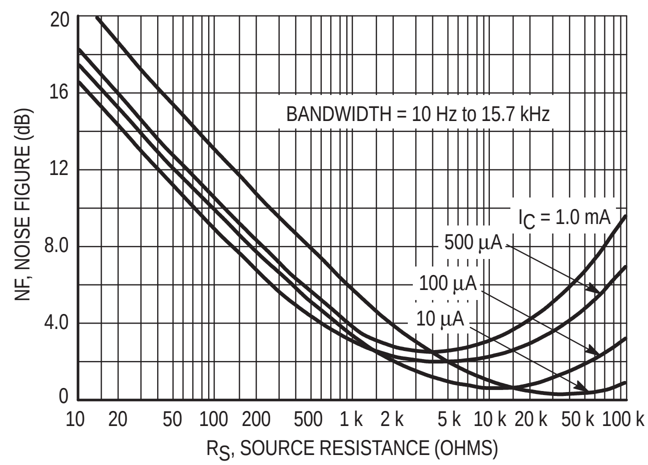


Figure 5. Wideband Noise Figure

100 Hz NOISE DATA

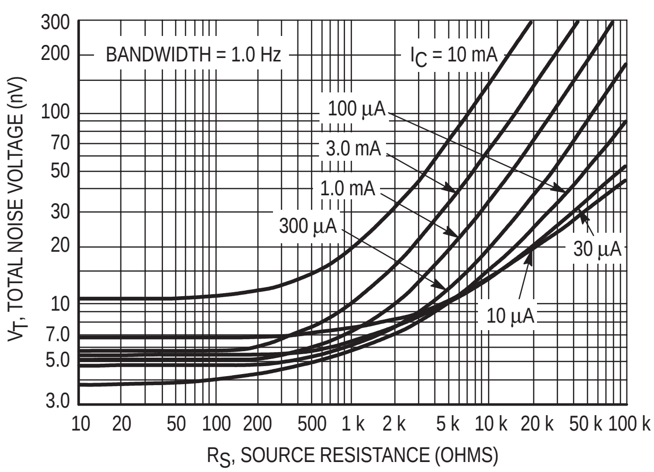


Figure 6. Total Noise Voltage

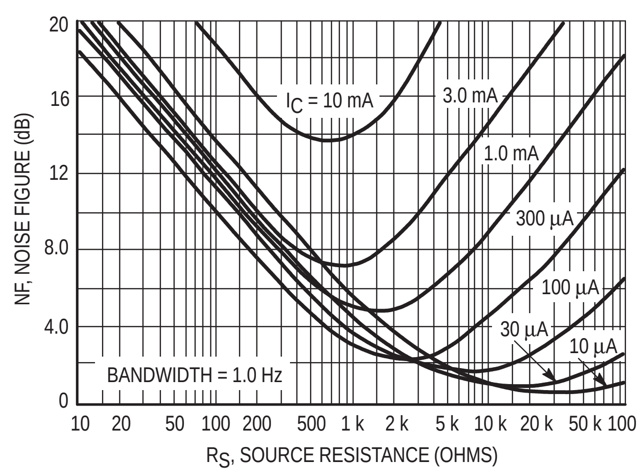


Figure 7. Noise Figure

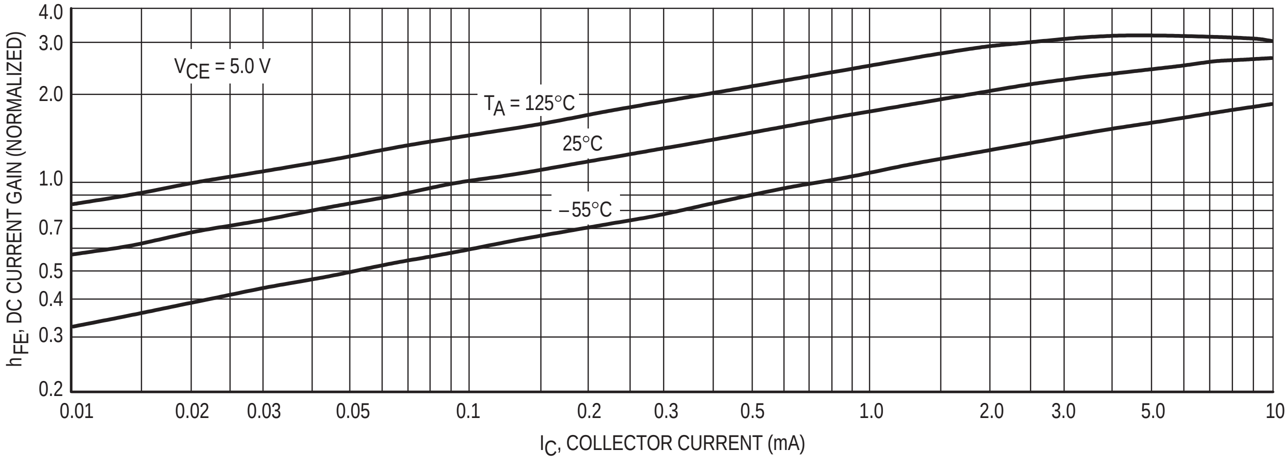


Figure 8. DC Current Gain

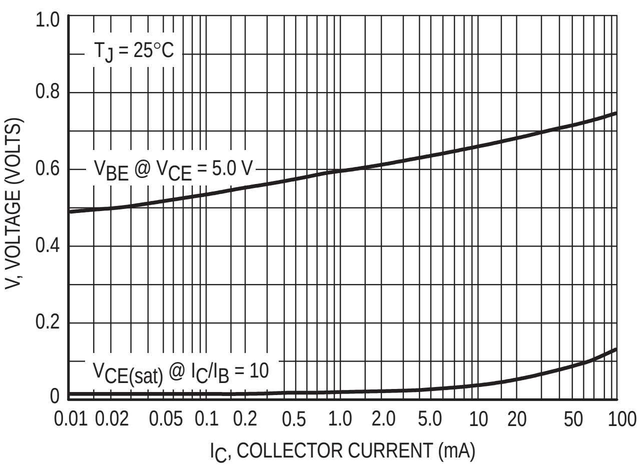


Figure 9. "On" Voltages

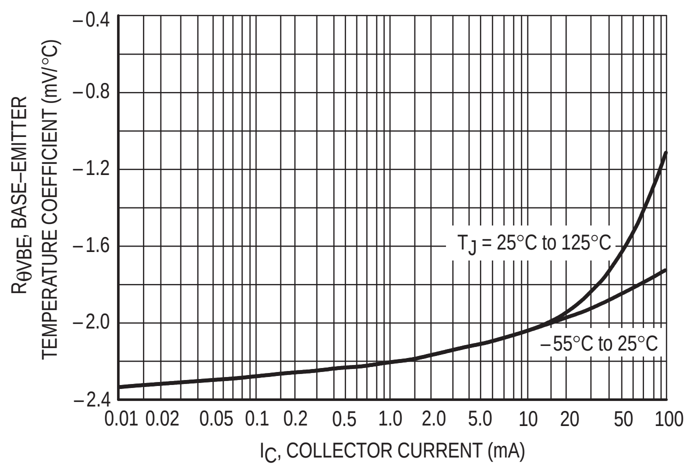


Figure 10. Temperature Coefficients

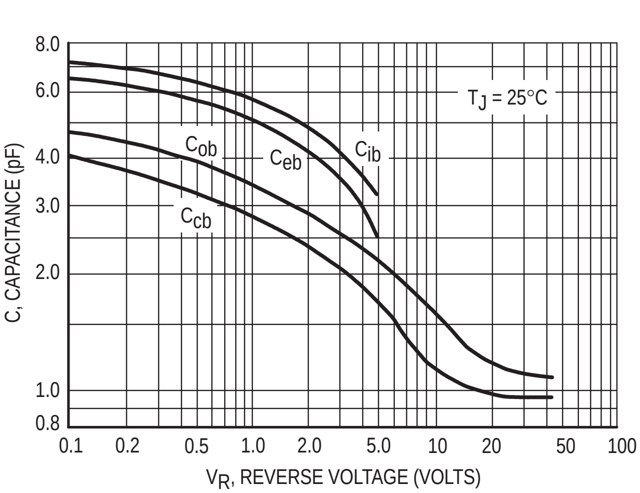


Figure 11. Capacitance

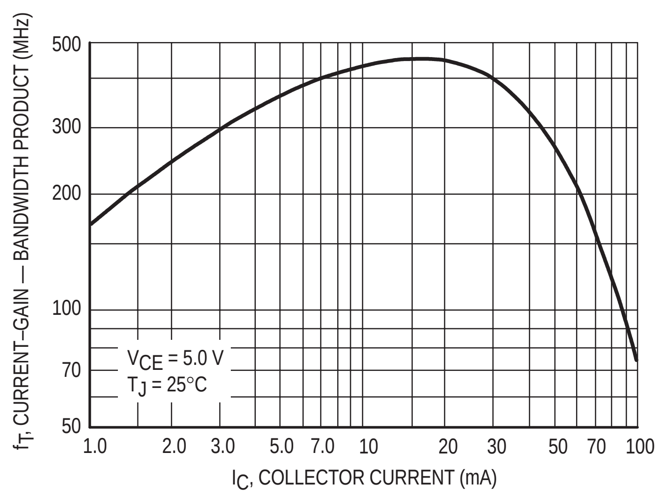


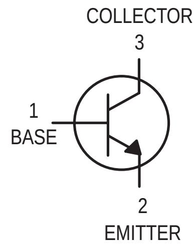
Figure 12. Current–Gain — Bandwidth Product

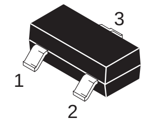
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

High Voltage Transistor
NPN Silicon

MMBT6517LT1

Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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	mAdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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,(2) 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

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 mAdc)	$V_{(BR)CEO}$	350	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μAdc)	$V_{(BR)CBO}$	350	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 250 Vdc)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc)	I_{EBO}	—	50	nAdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		20	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		30	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		30	200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)		20	200	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)		15	—	
Collector–Emitter Saturation Voltage (3)	$V_{CE(sat)}$			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 (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	40	200	MHz
Collector–Base Capacitance (V_{CB} = 20 Vdc, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter–Base Capacitance (V_{EB} = 0.5 Vdc, f = 1.0 MHz)	C_{eb}	—	80	pF

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

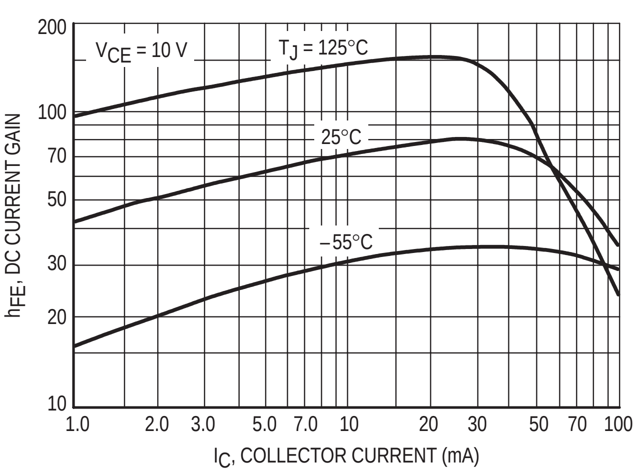


Figure 1. DC Current Gain

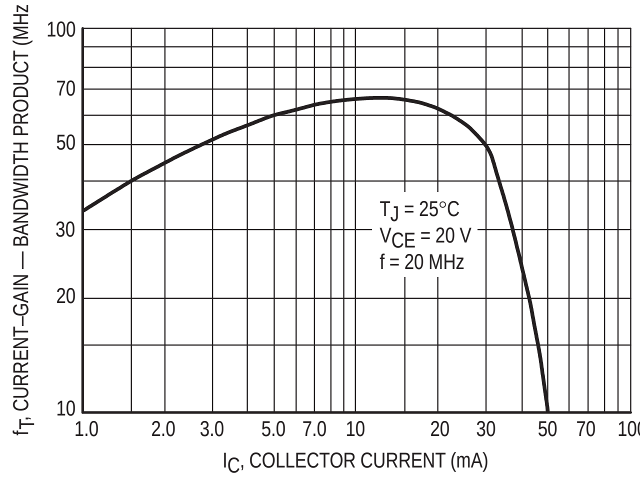


Figure 2. Current–Gain — Bandwidth Product

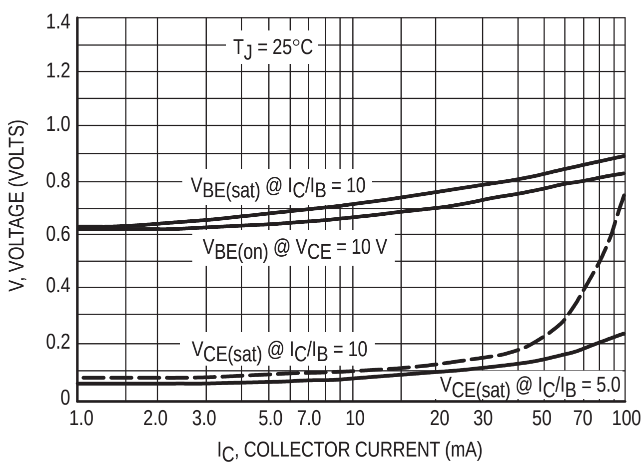


Figure 3. “On” Voltages

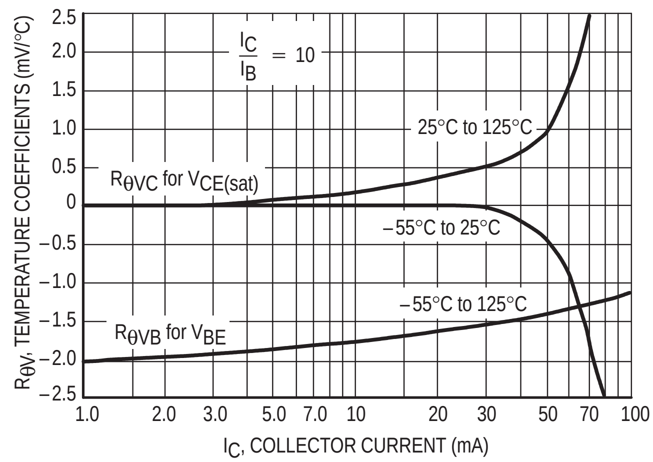


Figure 4. Temperature Coefficients

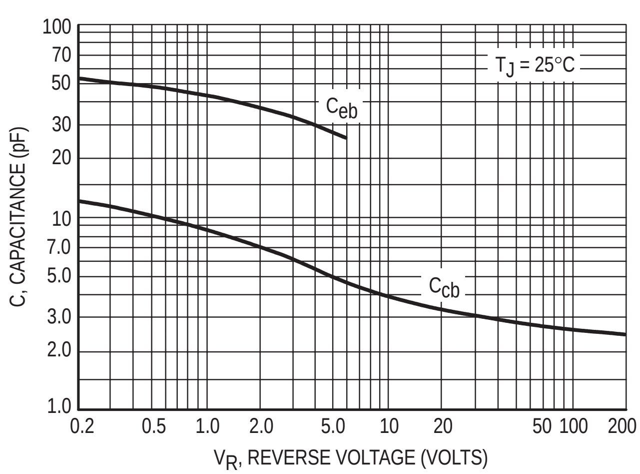


Figure 5. Capacitance

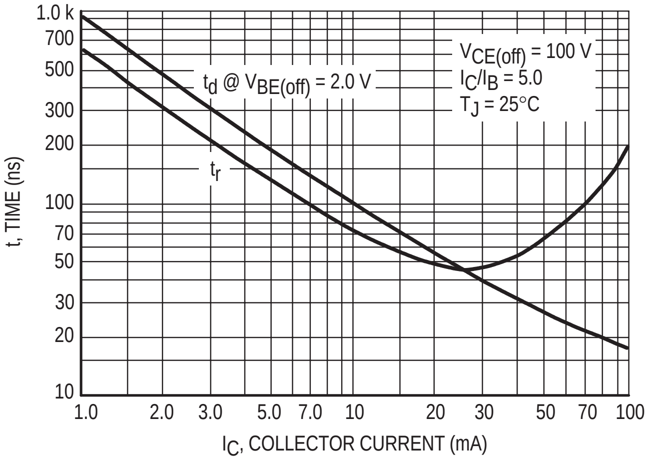


Figure 6. Turn–On Time

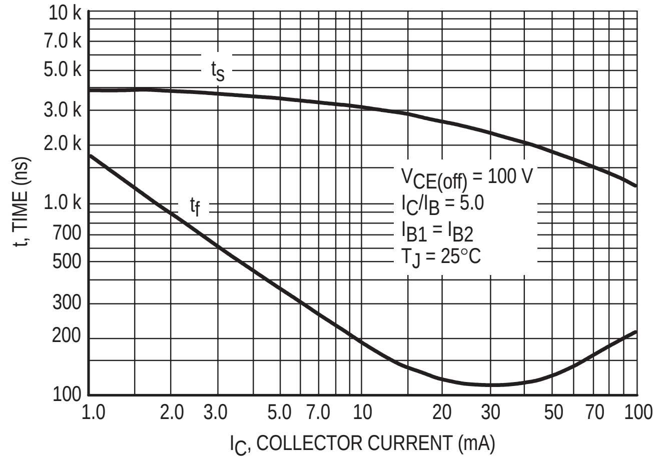


Figure 7. Turn–Off Time

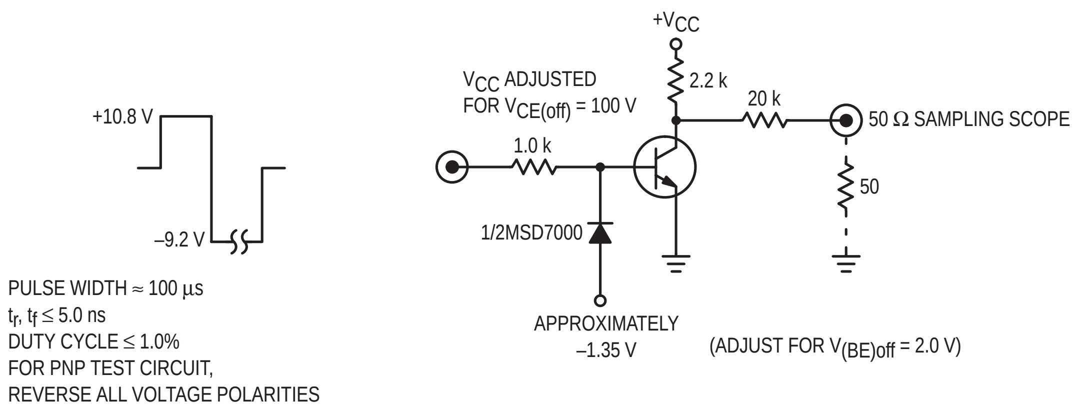


Figure 8. Switching Time Test Circuit

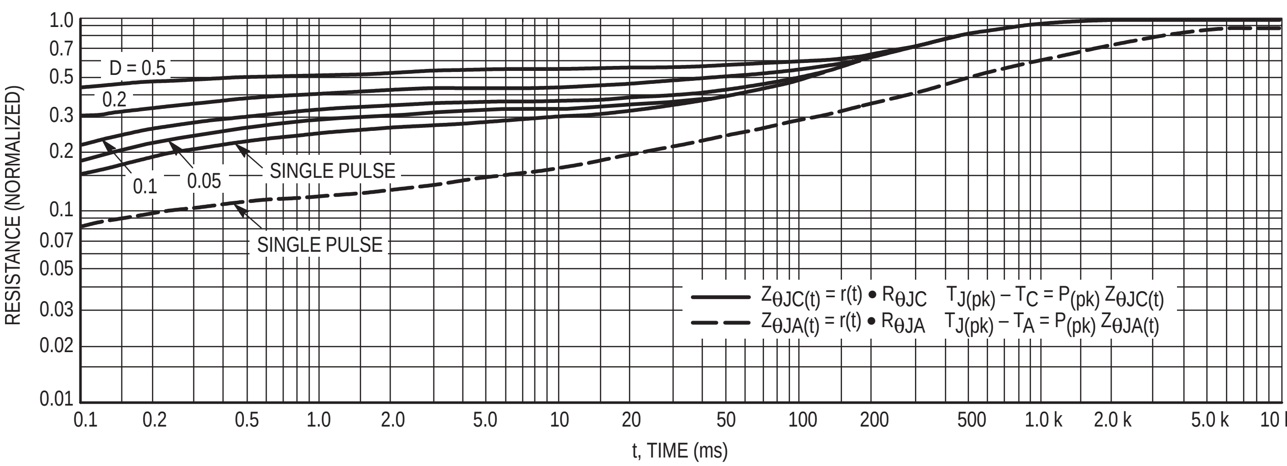
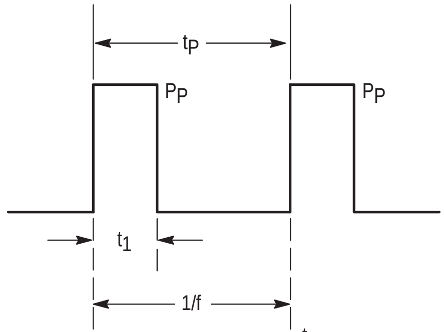


Figure 9. Thermal Response

FIGURE A



DUTY CYCLE $= t_1 f = \frac{t_1}{t_P}$

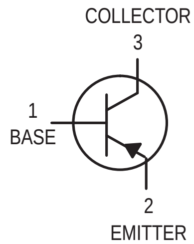
PEAK PULSE POWER = P_P

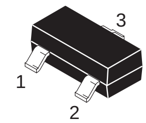
Design Note: Use of Transient Thermal Resistance Data

High Voltage Transistor
PNP Silicon

MMBT6520LT1

Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBT6520LT1 = 2Z

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board (1) 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, (2) 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

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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

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

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

Characteristic	Symbol	Min	Max	Unit
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}	—	100	pF

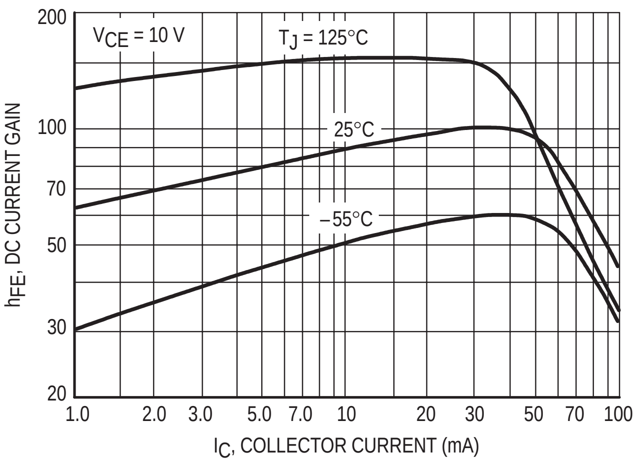


Figure 1. DC Current Gain

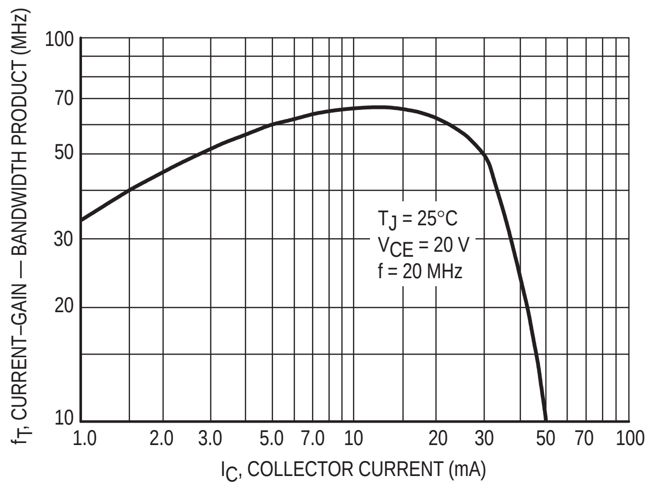


Figure 2. Current–Gain — Bandwidth Product

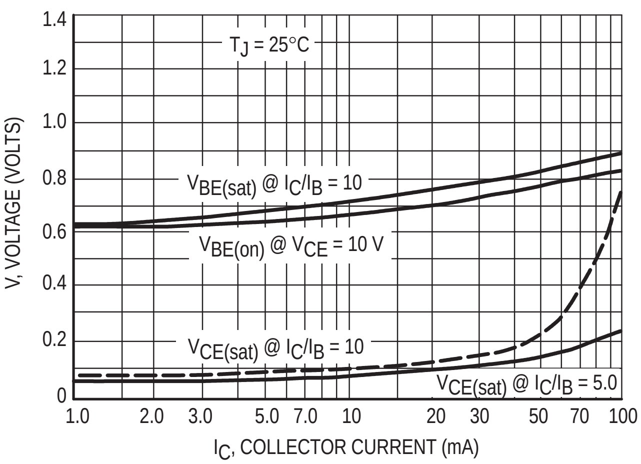


Figure 3. "On" Voltages

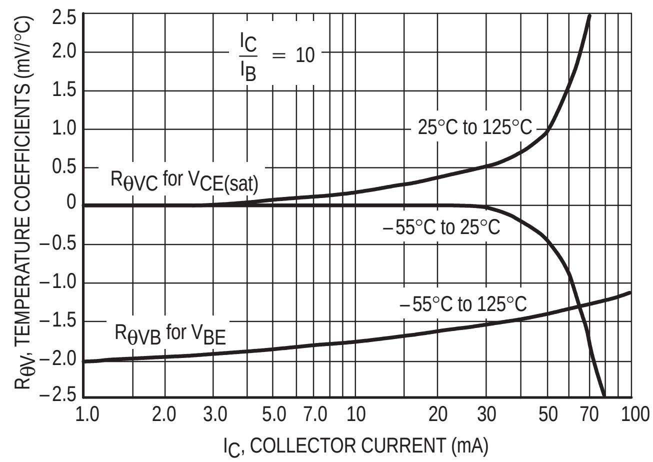


Figure 4. Temperature Coefficients

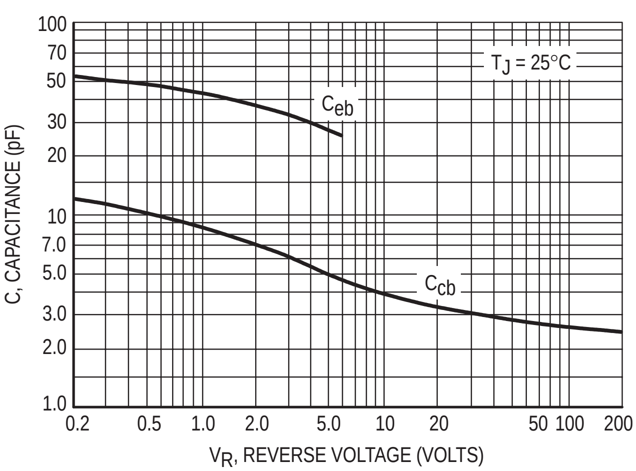


Figure 5. Capacitance

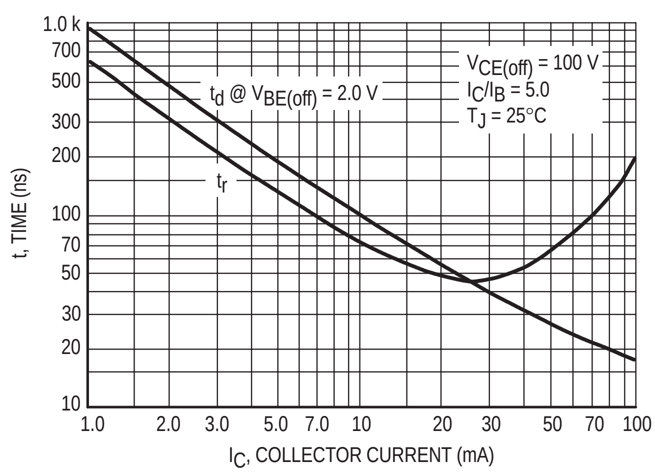


Figure 6. Turn–On Time

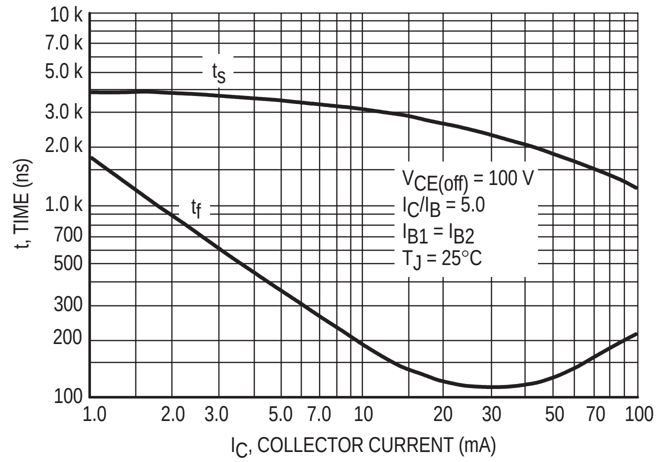


Figure 7. Turn–Off Time

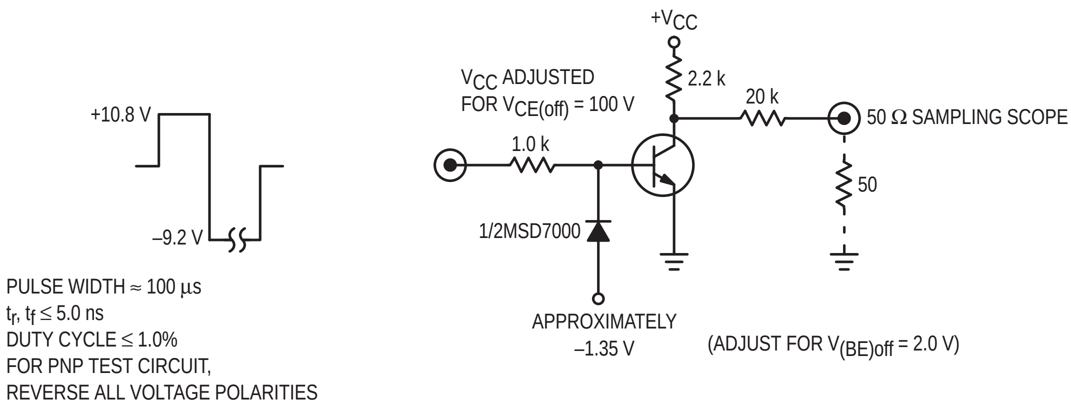


Figure 8. Switching Time Test Circuit

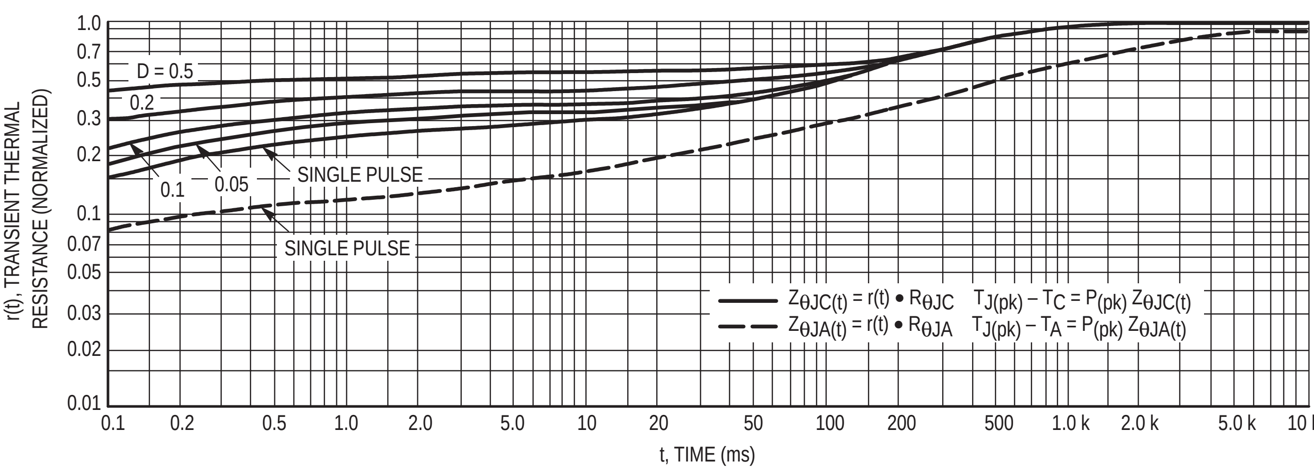
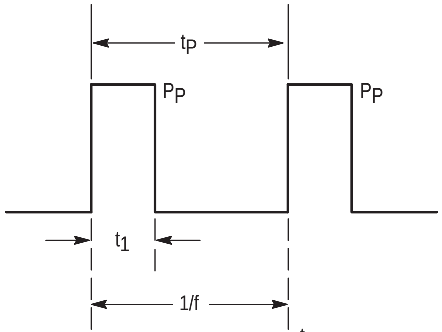


Figure 9. Thermal Response

FIGURE A



$$\text{DUTY CYCLE} = t_1 f = \frac{t_1}{t_P}$$

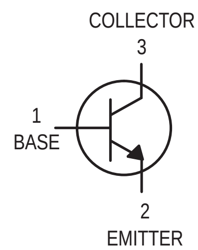
PEAK PULSE POWER = P_P

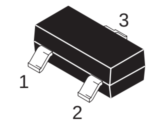
Design Note: Use of Transient Thermal Resistance Data

Driver Transistors
NPN Silicon

MMBTA05LT1
MMBTA06LT1*

***Motorola Preferred Device**





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

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 (3) (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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

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

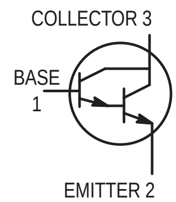
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		100	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		100	—	
Collector–Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base–Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	—	1.2	Vdc
SMALL–SIGNAL CHARACTERISTICS				
Current–Gain — Bandwidth Product(4) (I_C = 10 mA, V_{CE} = 2.0 V, f = 100 MHz)	f_T	100	—	MHz

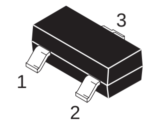
4. f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

Darlington Amplifier Transistors
NPN Silicon

MMBTA13LT1
MMBTA14LT1*

***Motorola Preferred Device**





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) $T_A = 25°C$ 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,(2) $T_A = 25°C$ 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

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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS(3)					
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(4) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz

3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
4. $f_T = |h_{fe}| \bullet f_{test}$.

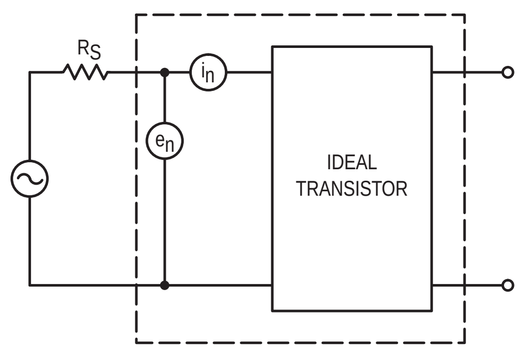


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

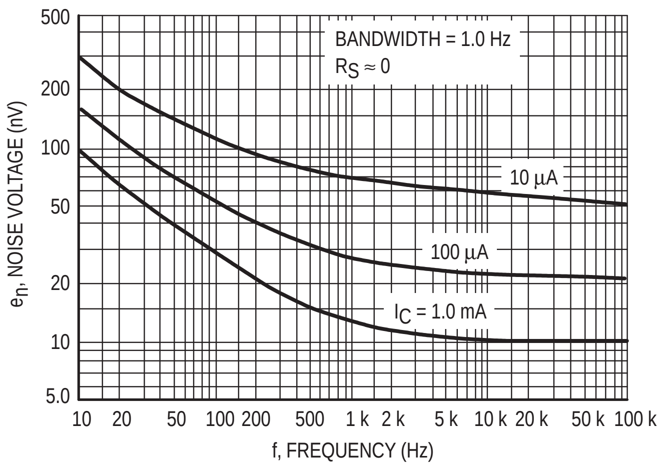


Figure 2. Noise Voltage

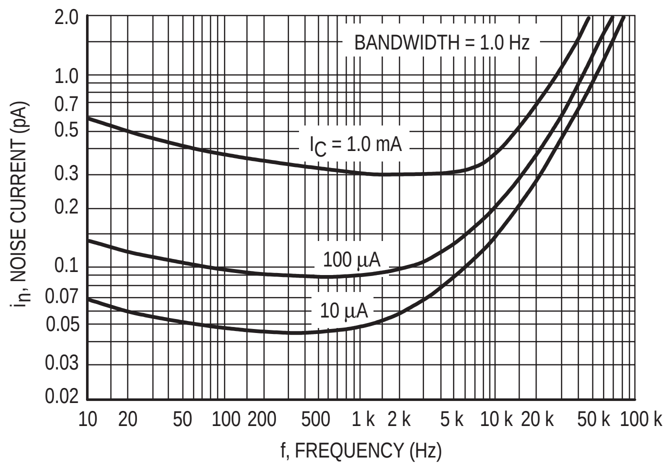


Figure 3. Noise Current

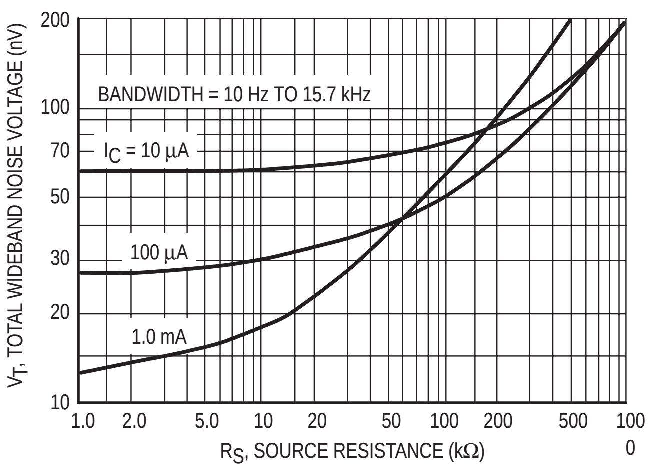


Figure 4. Total Wideband Noise Voltage

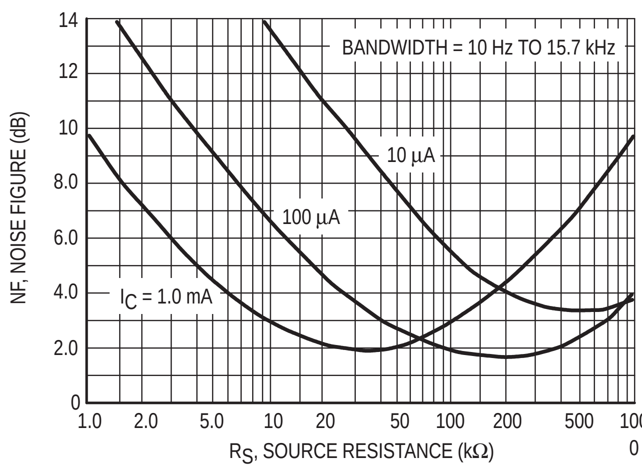


Figure 5. Wideband Noise Figure

SMALL–SIGNAL CHARACTERISTICS

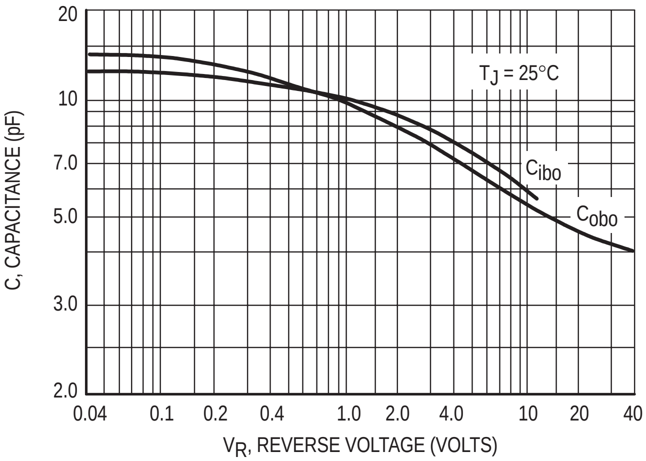


Figure 6. Capacitance

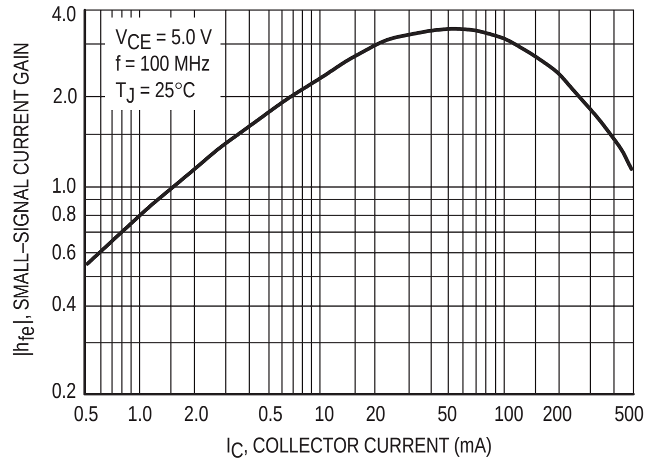


Figure 7. High Frequency Current Gain

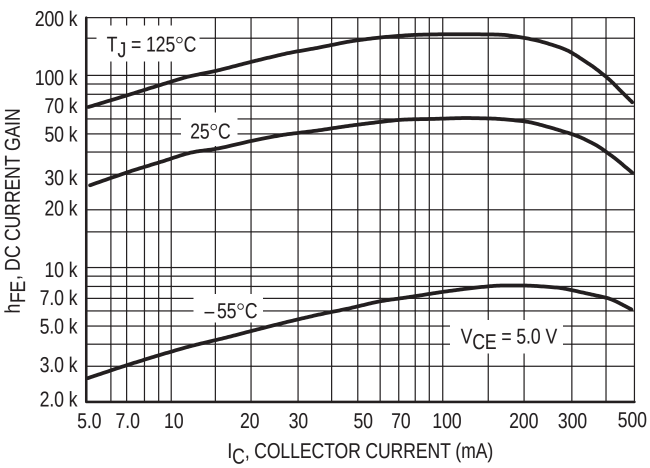


Figure 8. DC Current Gain

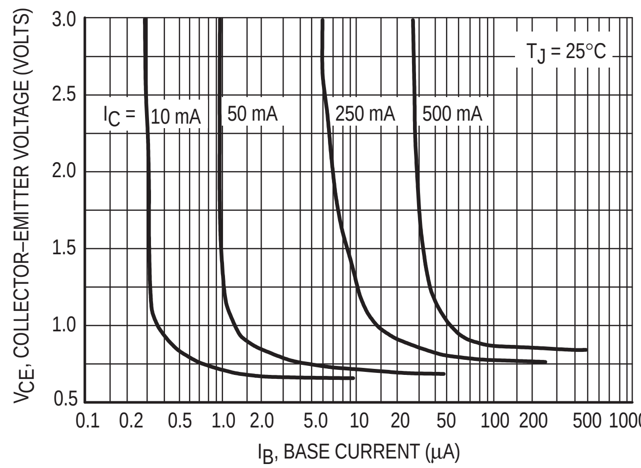


Figure 9. Collector Saturation Region

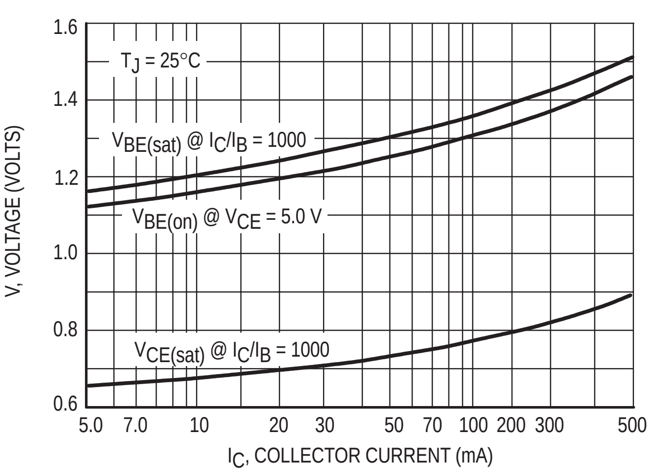


Figure 10. "On" Voltages

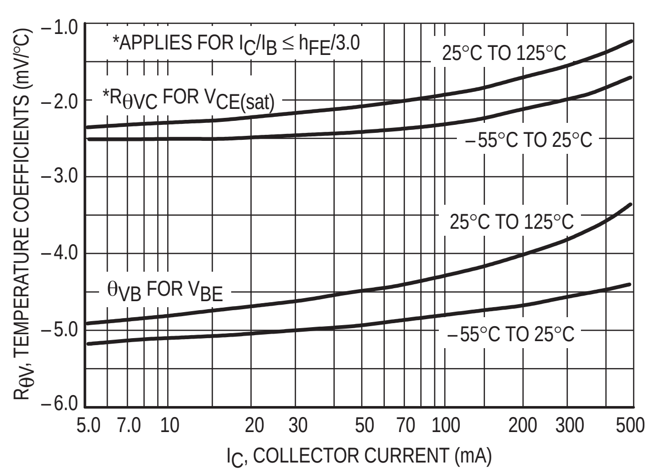


Figure 11. Temperature Coefficients

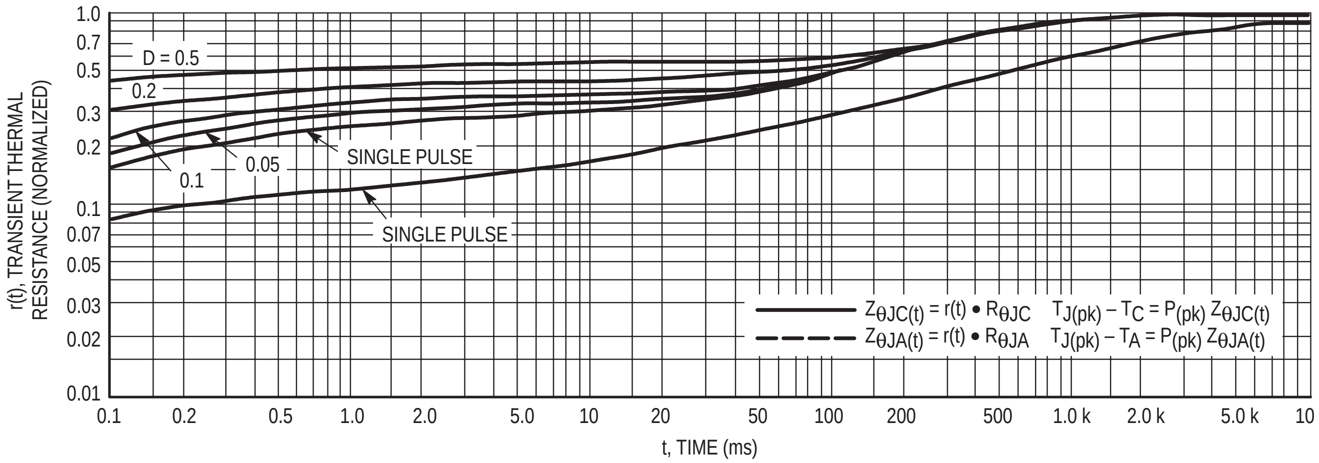


Figure 12. Thermal Response

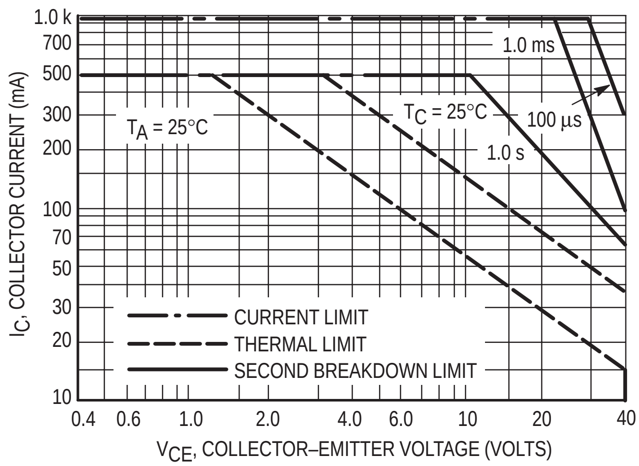
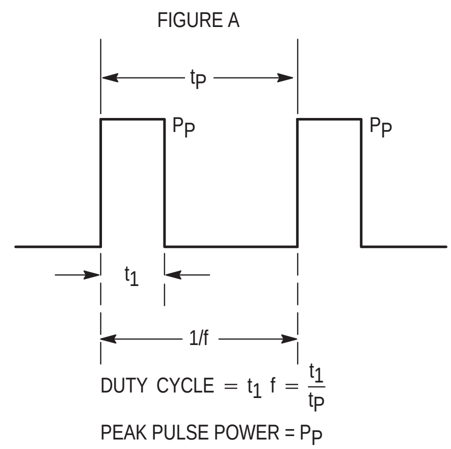


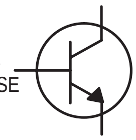
Figure 13. Active Region Safe Operating Area

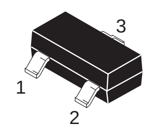


Design Note: Use of Transient Thermal Resistance Data

General Purpose Amplifier
NPN Silicon

MMBTA20LT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

MMBTA20LT1 = 1C

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

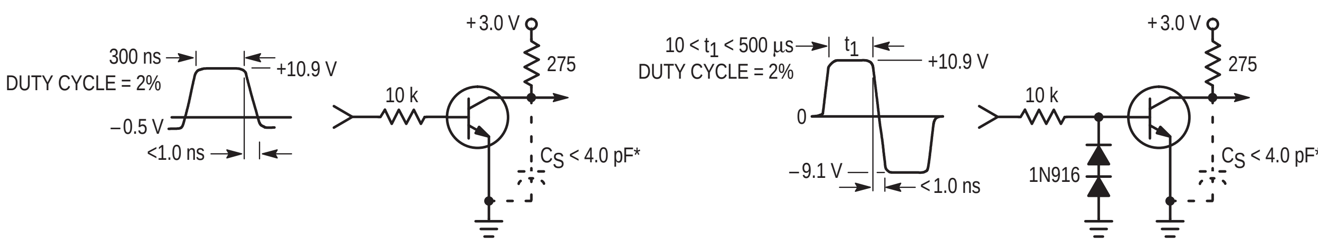
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

Characteristic	Symbol	Min	Max	Unit
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

EQUIVALENT SWITCHING TIME TEST CIRCUITS



*Total shunt capacitance of test jig and connectors

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

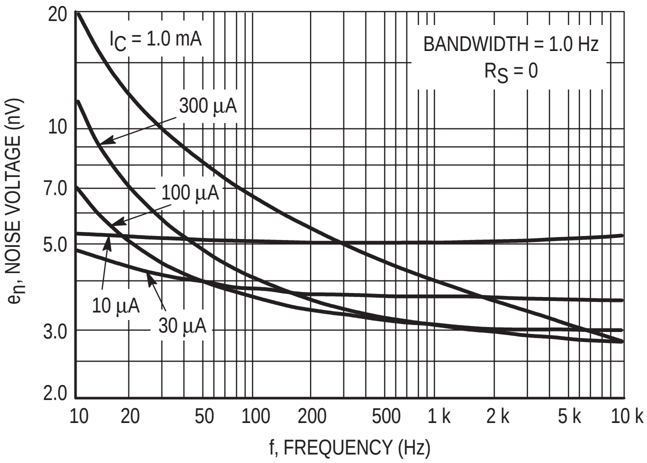


Figure 3. Noise Voltage

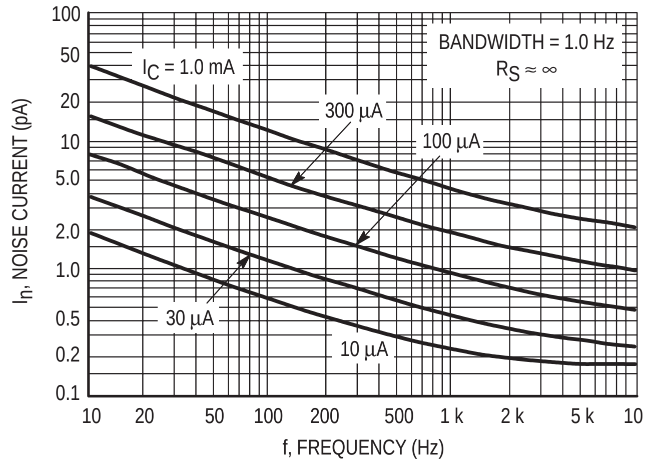


Figure 4. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

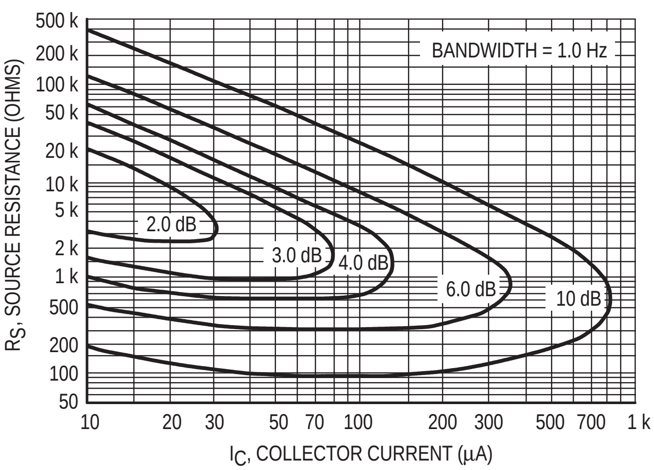


Figure 5. Narrow Band, 100 Hz

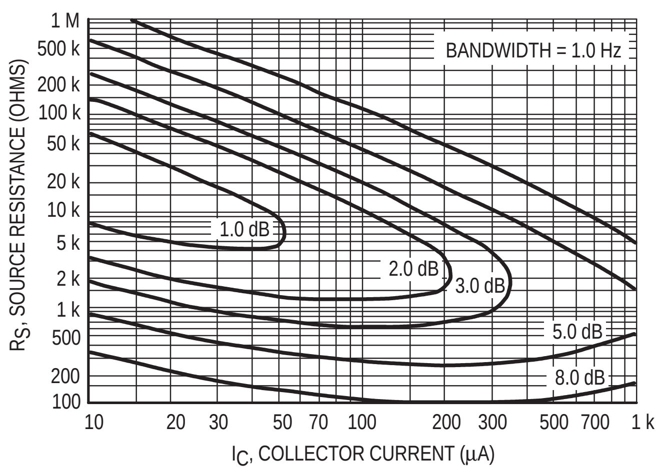


Figure 6. Narrow Band, 1.0 kHz

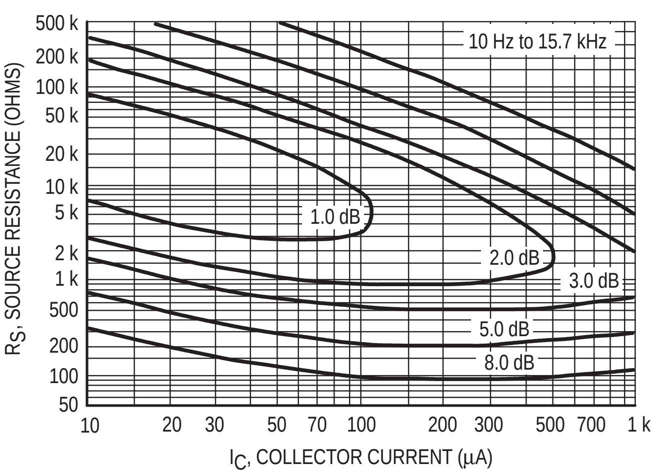


Figure 7. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

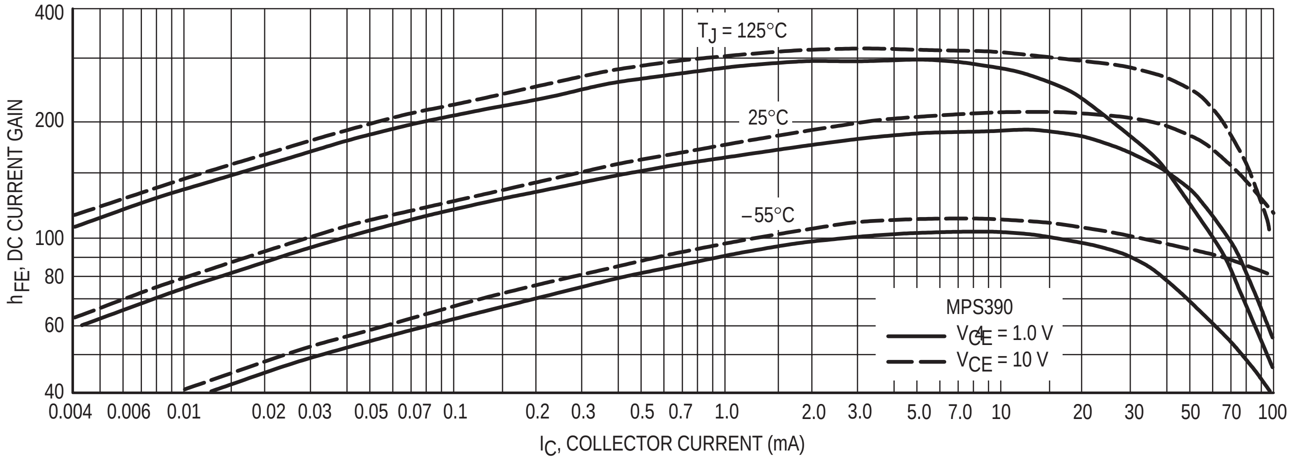


Figure 8. DC Current Gain

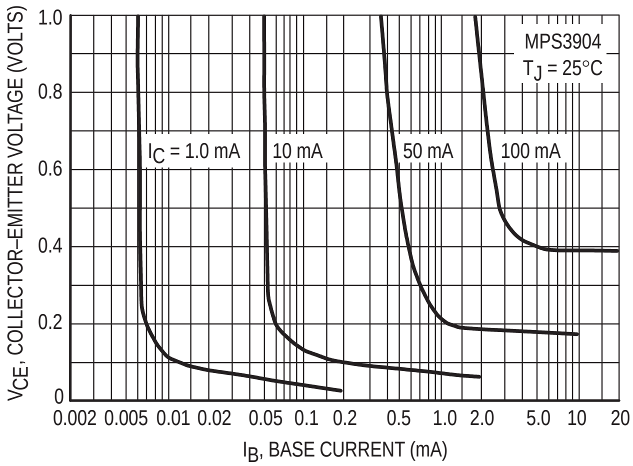


Figure 9. Collector Saturation Region

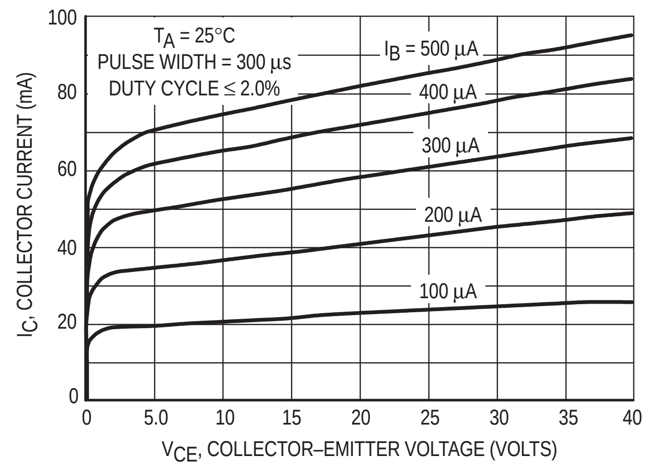


Figure 10. Collector Characteristics

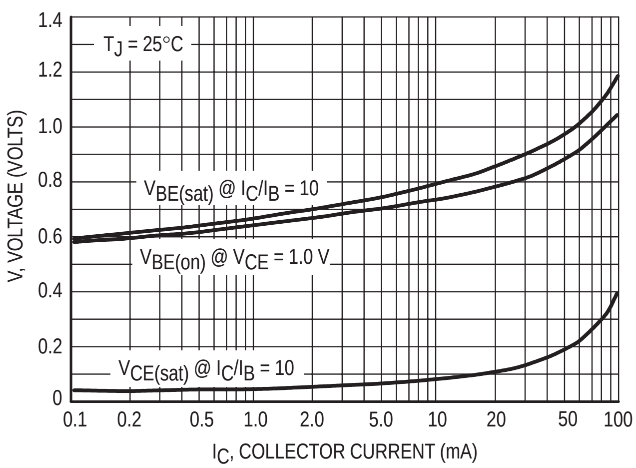


Figure 11. “On” Voltages

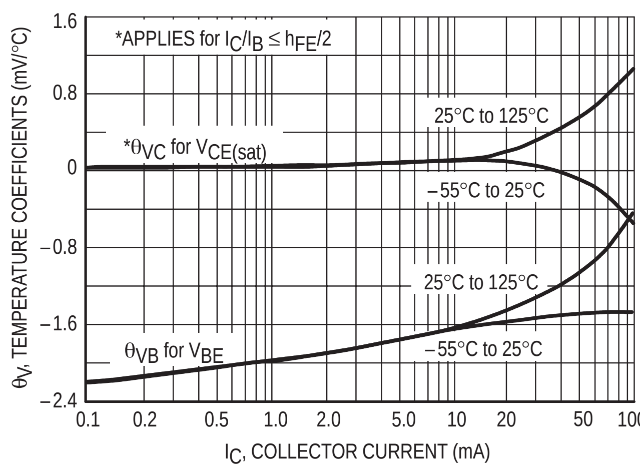


Figure 12. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

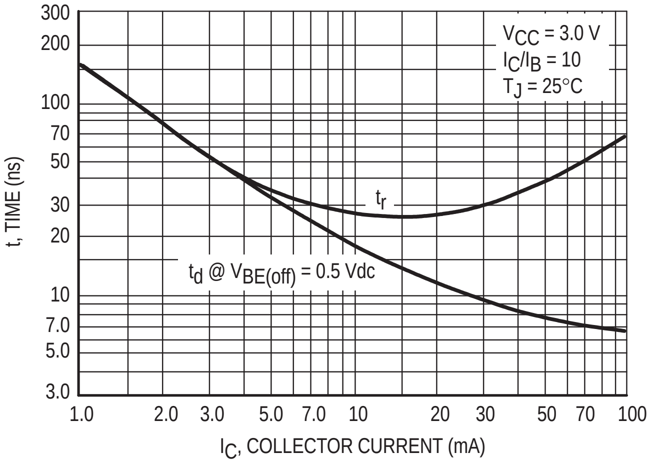


Figure 13. Turn–On Time

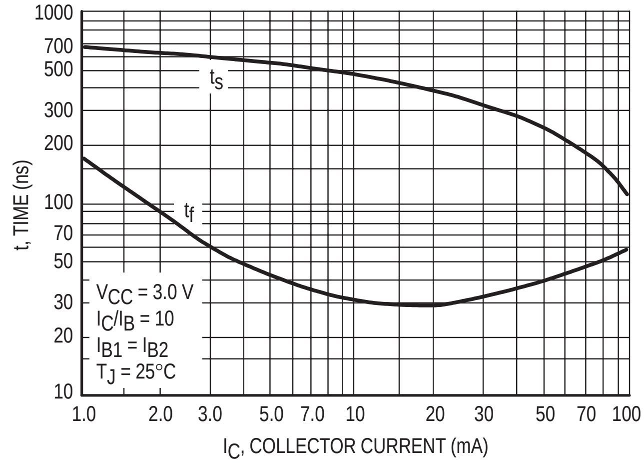


Figure 14. Turn–Off Time

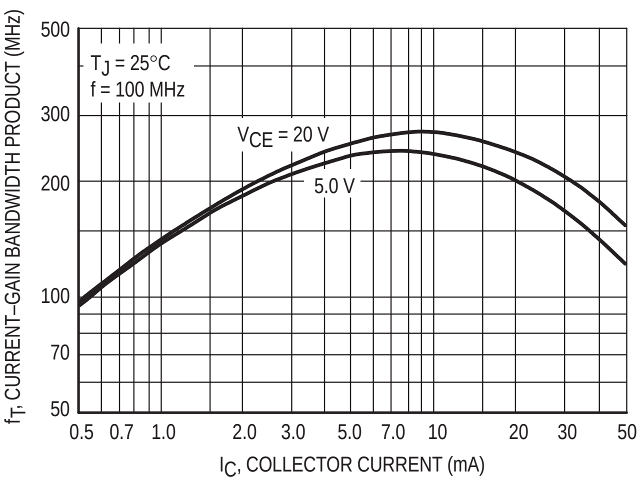


Figure 15. Current–Gain — Bandwidth Product

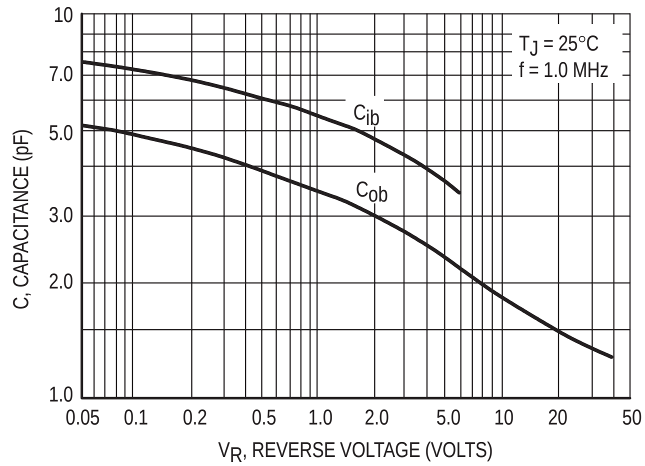


Figure 16. Capacitance

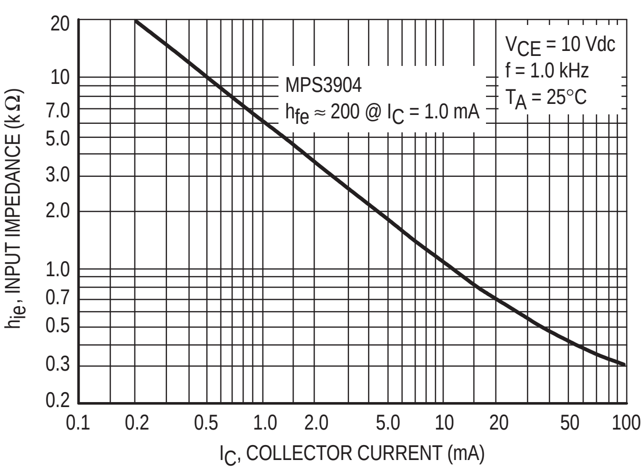


Figure 17. Input Impedance

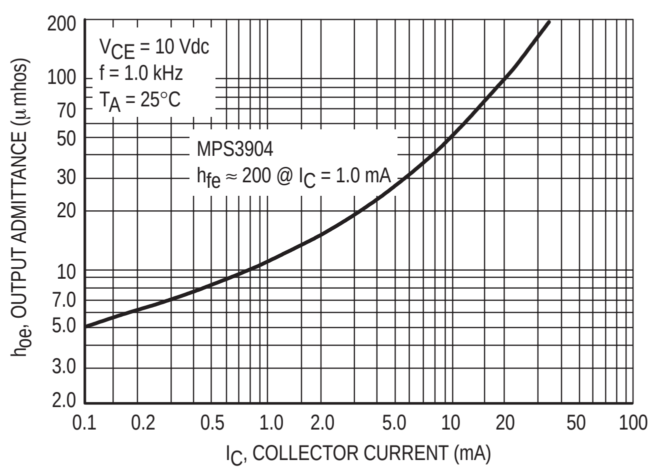


Figure 18. Output Admittance

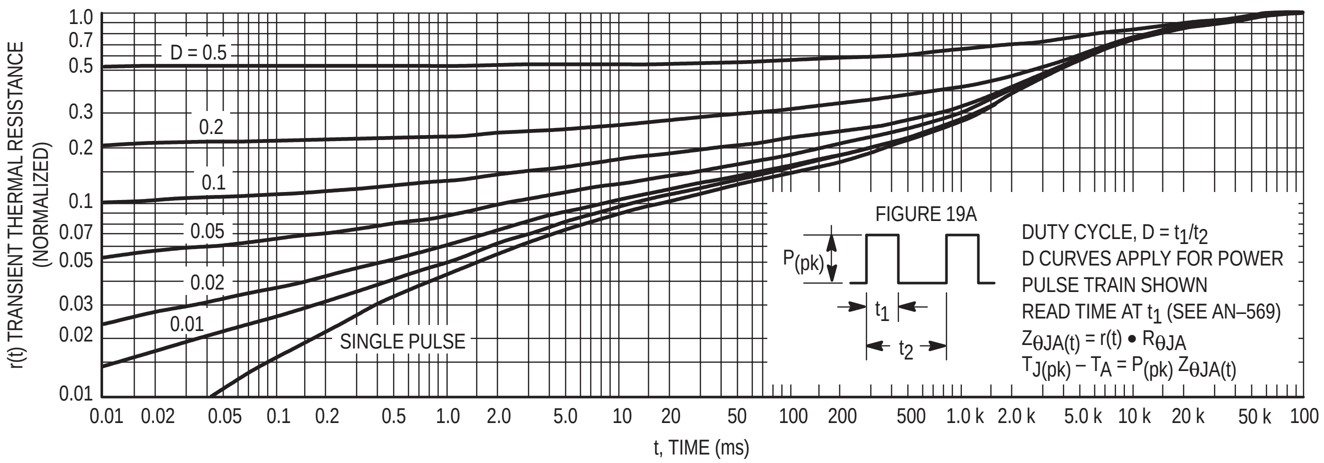


Figure 19. Thermal Response

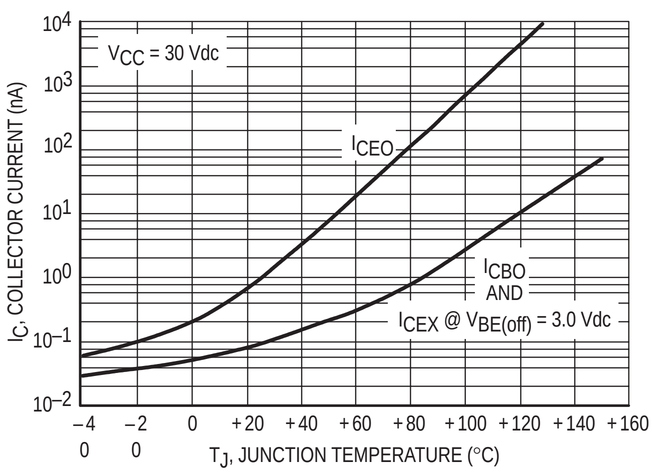


Figure 19A.

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.

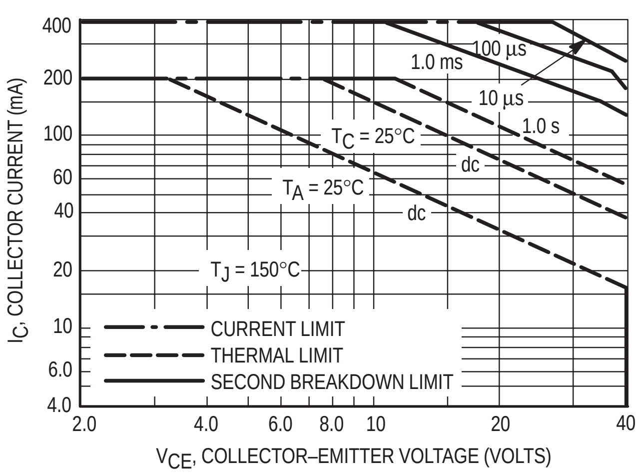


Figure 20.

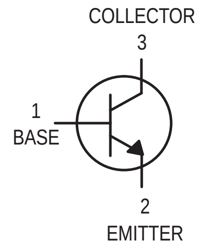
The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

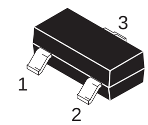
The data of Figure 20 is based upon $T_{J(pk)}$ = 150°C; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 19. At high case or ambient temperatures, thermal limitations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

High Voltage Transistors
NPN Silicon

MMBTA42LT1*
MMBTA43LT1

*Motorola Preferred Device





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBTA42LT1 = 1D; MMBTA43LT1 = M1E

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board,(1) $T_A = 25°C$	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,(2) $T_A = 25°C$	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

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(3)		$V_{(BR)CEO}$			Vdc
(I_C = 1.0 mAdc, I_B = 0)	MMBTA42		300	—	
	MMBTA43		200	—	
Collector–Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 100 μAdc, I_E = 0)	MMBTA42		300	—	
	MMBTA43		200	—	
Emitter–Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 200 Vdc, I_E = 0)	MMBTA42		—	0.1	
(V_{CB} = 160 Vdc, I_E = 0)	MMBTA43		—	0.1	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 6.0 Vdc, I_C = 0)	MMBTA42		—	0.1	
(V_{EB} = 4.0 Vdc, I_C = 0)	MMBTA43		—	0.1	

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS(3)					
DC Current Gain		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	Both Types		25	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	Both Types		40	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)	MMBTA42		40	—	
	MMBTA43		40	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 20 mAdc, I_B = 2.0 mAdc)	MMBTA42		—	0.5	
	MMBTA43		—	0.5	
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		C_{cb}			pF
(V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MMBTA42		—	3.0	
	MMBTA43		—	4.0	

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

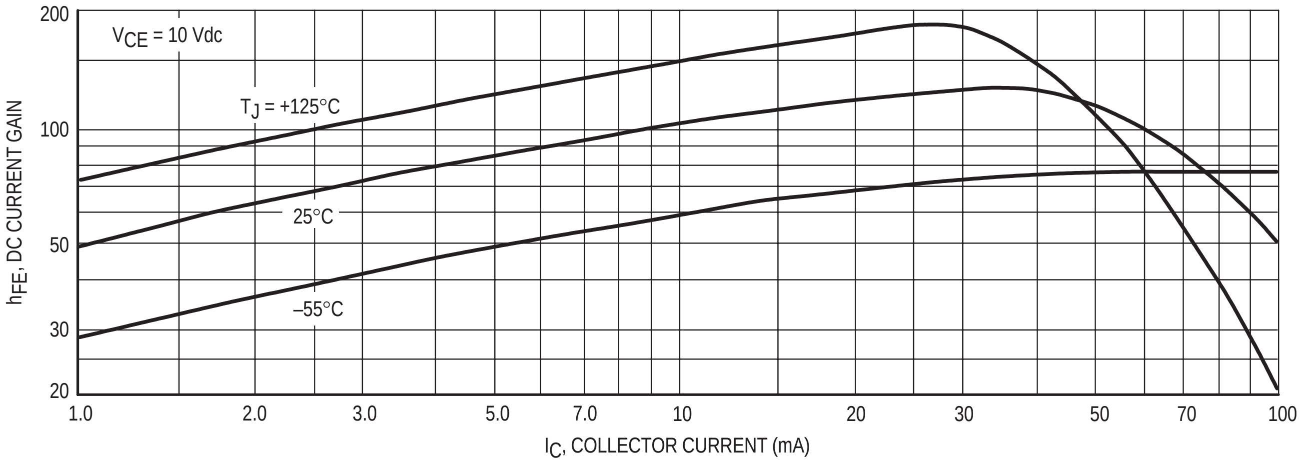


Figure 1. DC Current Gain

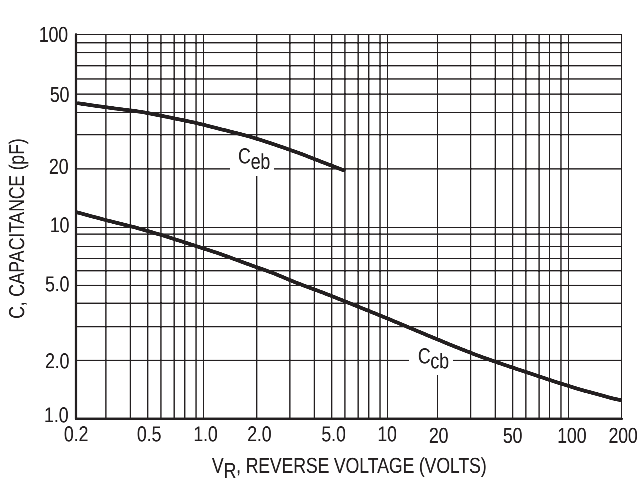


Figure 2. Capacitances

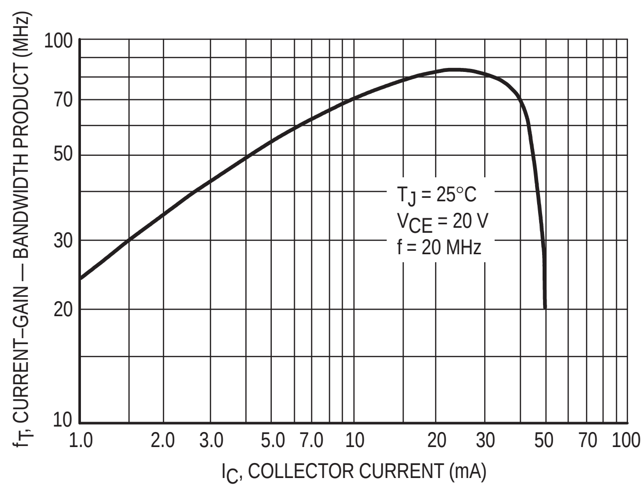


Figure 3. Current–Gain — Bandwidth Product

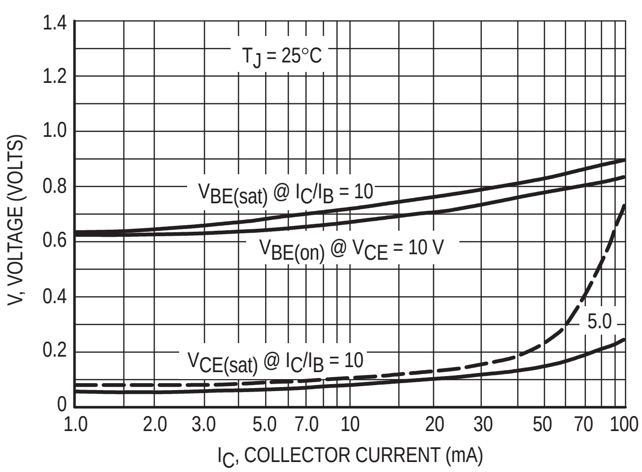


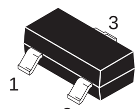
Figure 4. “On” Voltages

Driver Transistors

PNP Silicon

MMBTA55LT1
MMBTA56LT1*

*Motorola Preferred Device



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBTA55LT1 = 2H; MMBTA56LT1 = 2GM

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board,(1) 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,(2) 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

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(3) (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(4) (I_C = –100 mAdc, V_{CE} = –1.0 Vdc, f = 100 MHz)		f_T	50	—	MHz

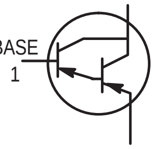
1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
4. f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

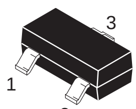
Preferred devices are Motorola recommended choices for future use and best overall value.

Darlington Transistors
PNP Silicon

MMBTA63LT1
MMBTA64LT1*

***Motorola Preferred Device**





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBTA63LT1 = 2U; MMBTA64LT1 = 2V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board,(1) 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,(2) 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

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = –100 μAdc)		$V_{(BR)CEO}$	–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(3)		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. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

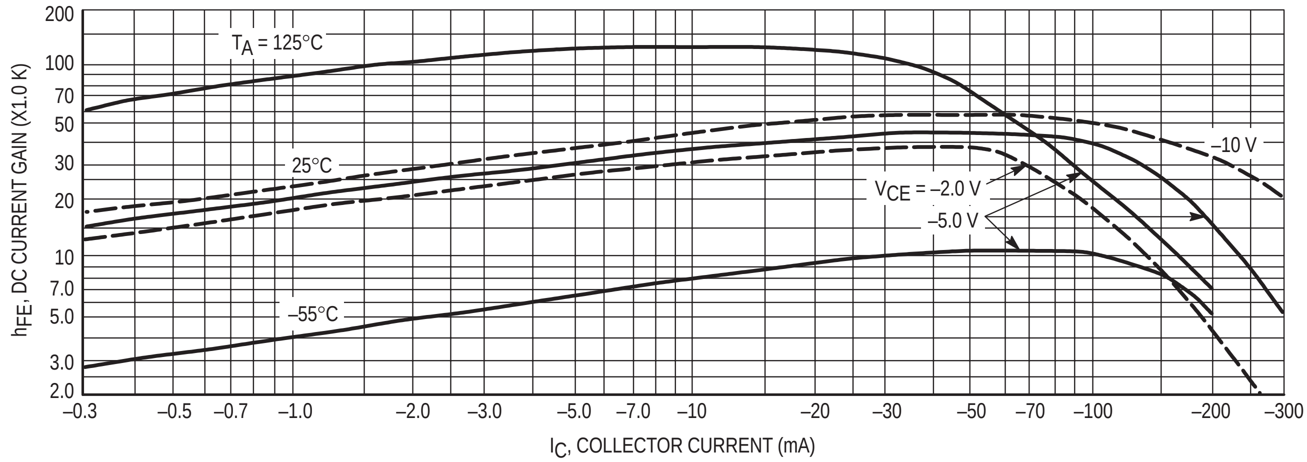


Figure 1. DC Current Gain

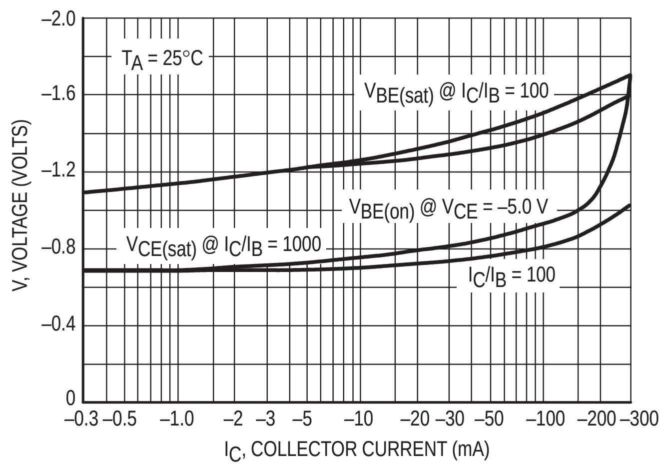


Figure 2. "On" Voltage

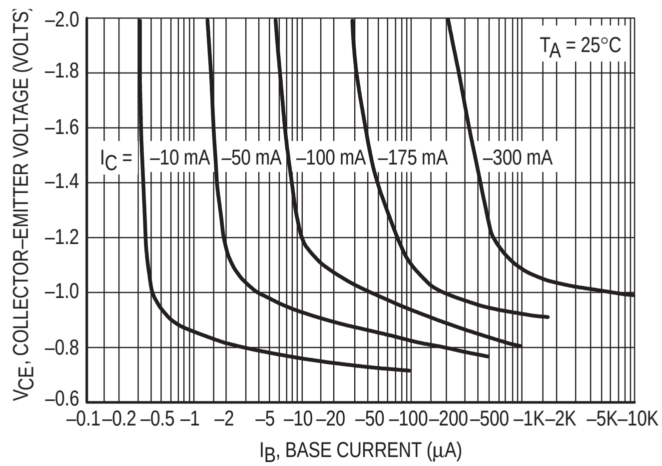


Figure 3. Collector Saturation Region

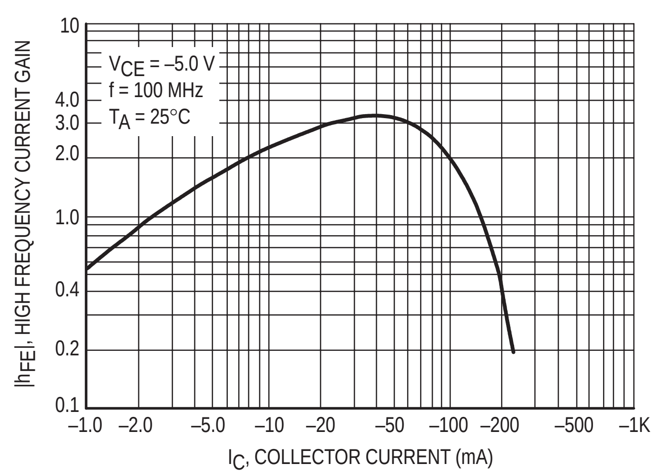
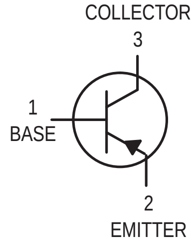


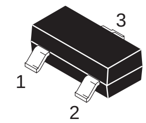
Figure 4. High Frequency Current Gain

General Purpose Transistor

PNP Silicon

MMBTA70LT1





CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBTA70LT1 = M2C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,(1) 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,(2) 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

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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

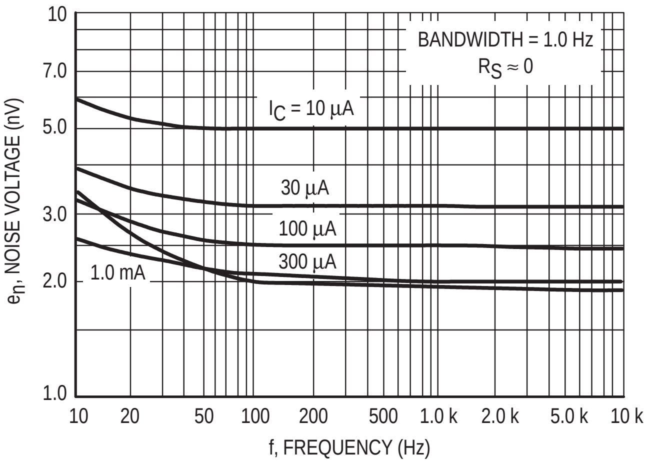


Figure 1. Noise Voltage

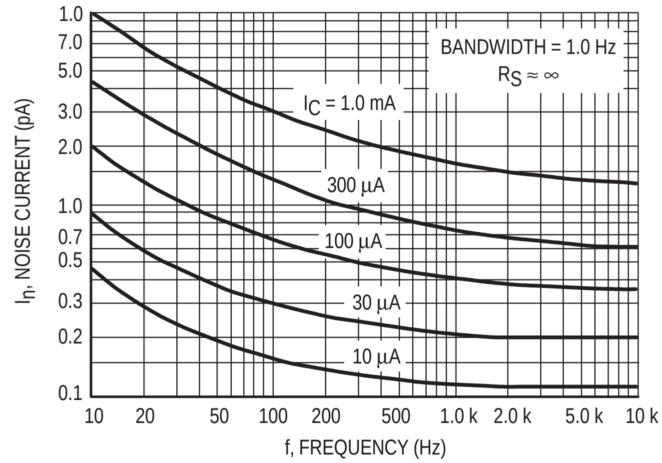


Figure 2. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

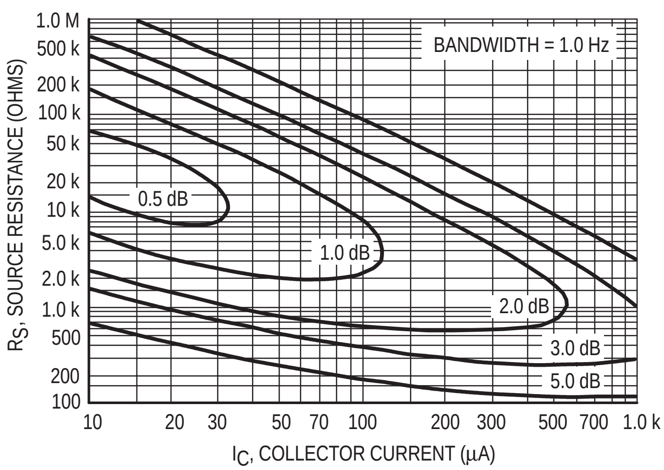


Figure 3. Narrow Band, 100 Hz

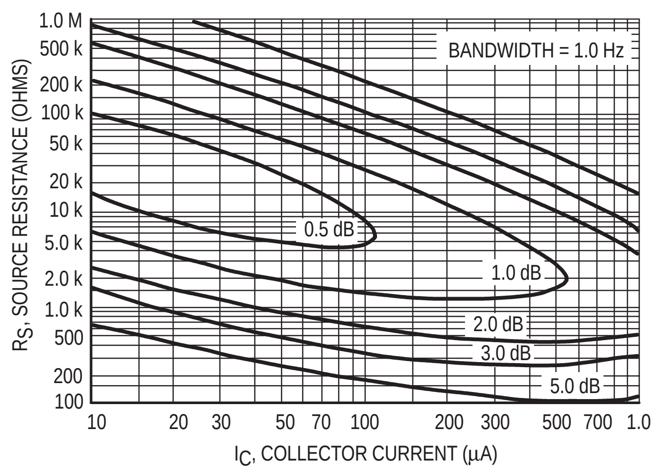


Figure 4. Narrow Band, 1.0 kHz

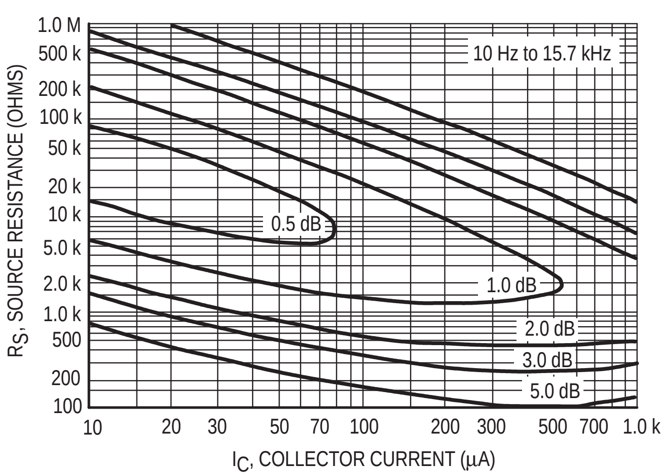


Figure 5. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

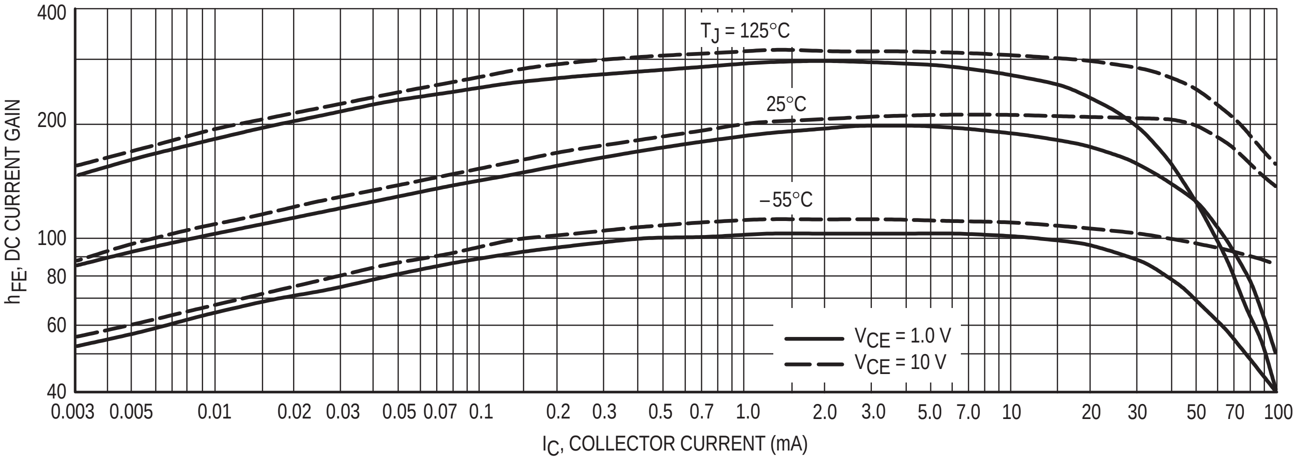


Figure 6. DC Current Gain

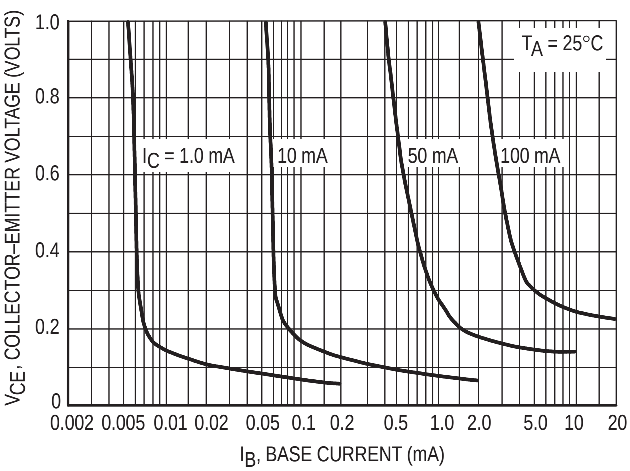


Figure 7. Collector Saturation Region

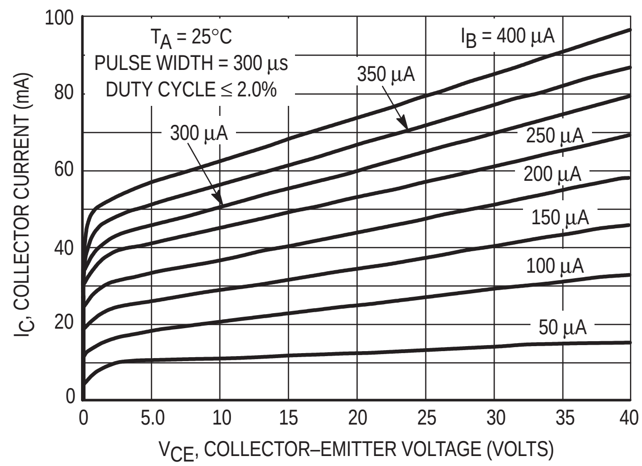


Figure 8. Collector Characteristics

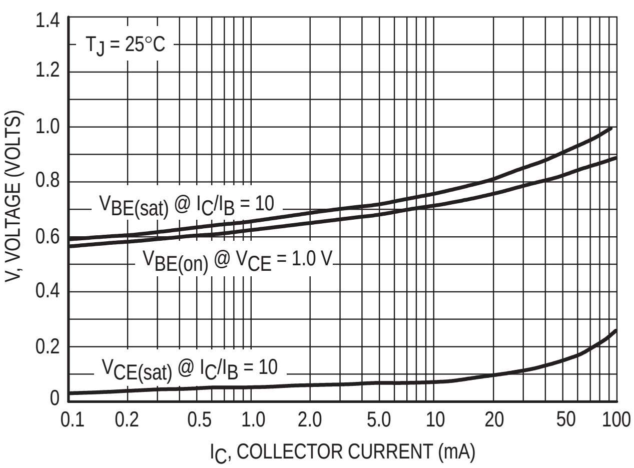


Figure 9. "On" Voltages

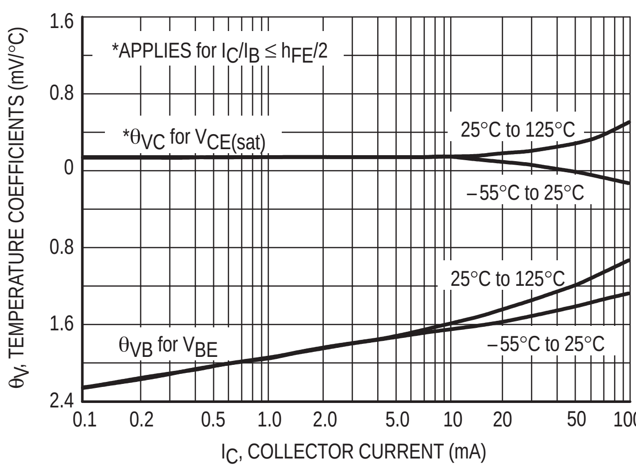


Figure 10. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

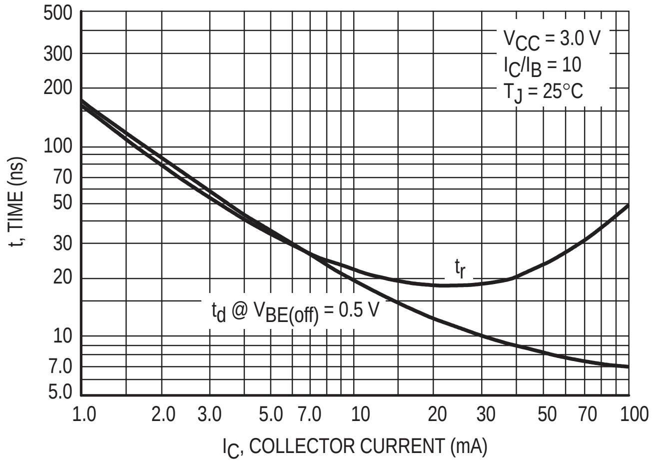


Figure 11. Turn–On Time

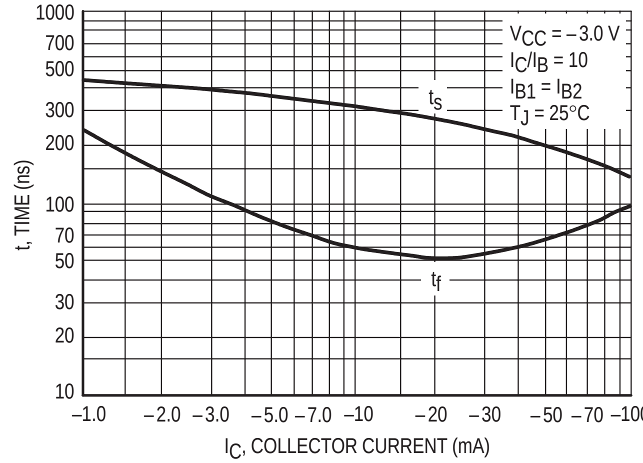


Figure 12. Turn–Off Time

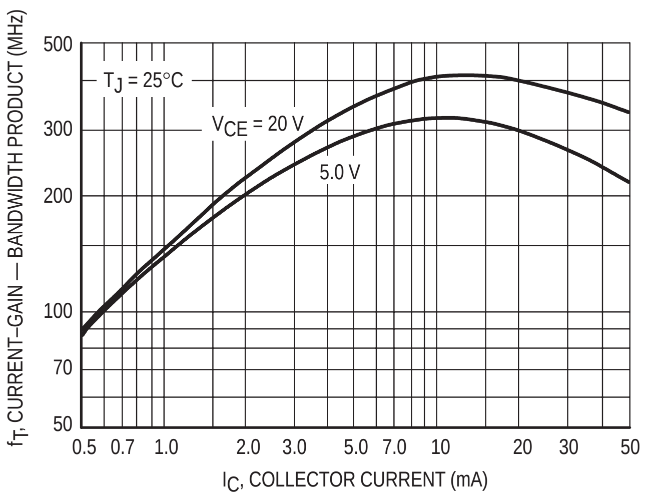


Figure 13. Current–Gain — Bandwidth Product

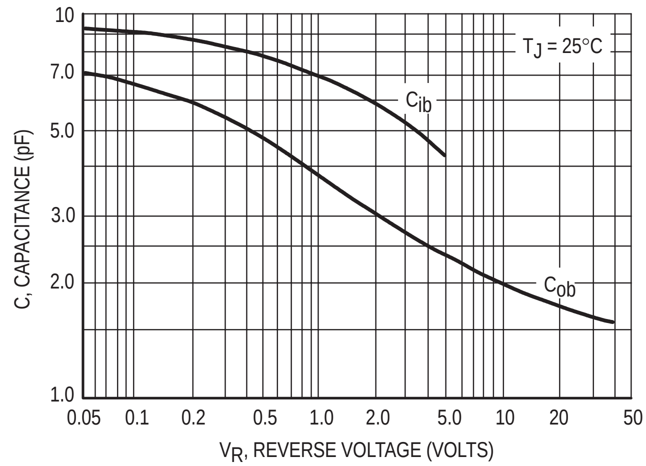


Figure 14. Capacitance

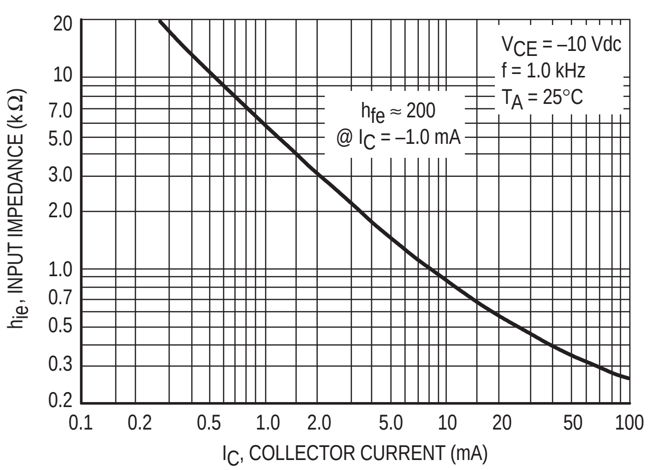


Figure 15. Input Impedance

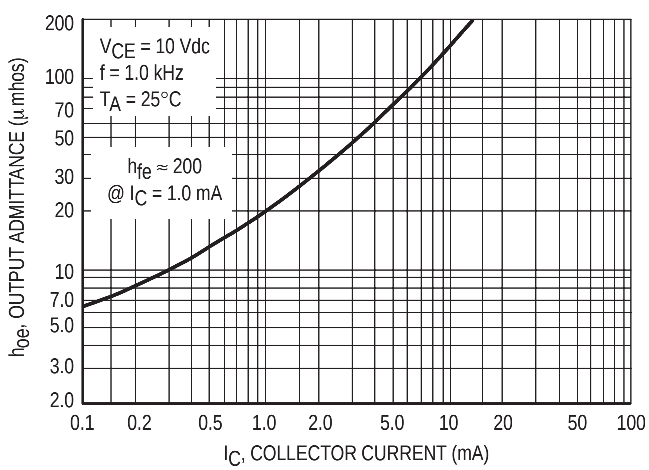


Figure 16. Output Admittance

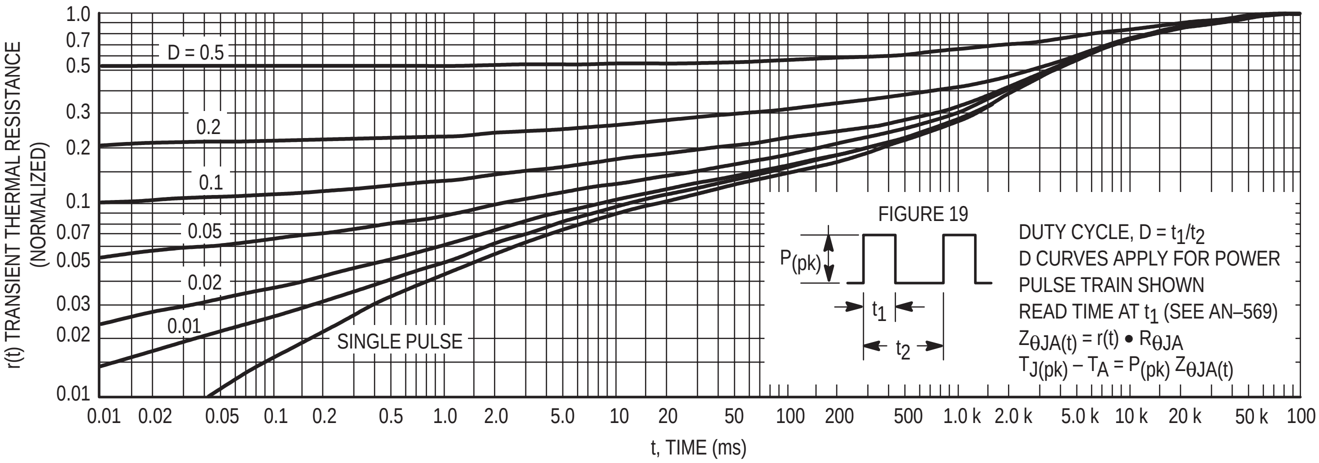


Figure 17. Thermal Response

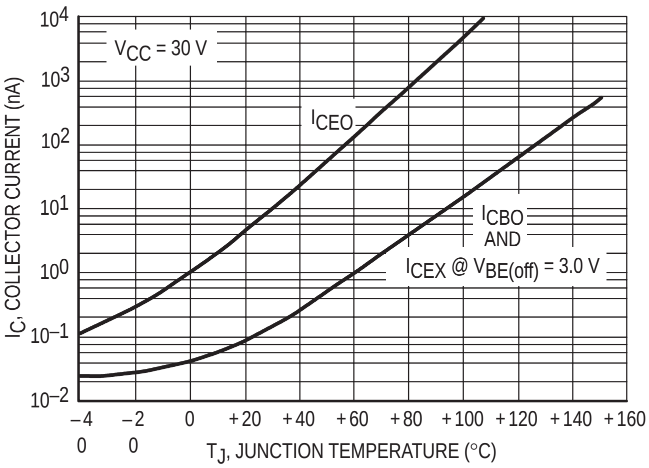


Figure 18. Typical Collector Leakage Current

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 17 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 17 by the steady state value $R_{\theta JA}$.

Example:

Dissipating 2.0 watts peak under the following conditions:

t_1 = 1.0 ms, t_2 = 5.0 ms (D = 0.2)

Using Figure 17 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

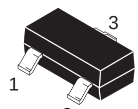
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C$.

For more information, see AN–569.

High Voltage Transistors
PNP Silicon

MMBTA92LT1*
MMBTA93LT1

***Motorola Preferred Device**



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBTA92LT1 = 2D; MMBTA93LT1 = 2E

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board,(1) 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,(2) 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

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(3) (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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[3]					
DC Current Gain		h_{FE}			—
(I_C = –1.0 mAdc, V_{CE} = –10 Vdc)	Both Types		25	—	
(I_C = –10 mAdc, V_{CE} = –10 Vdc)	Both Types		40	—	
(I_C = –30 mAdc, V_{CE} = –10 Vdc)	MMBTA92		25	—	
	MMBTA93		25	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = –20 mAdc, I_B = –2.0 mAdc)	MMBTA92		—	–0.5	
	MMBTA93		—	–0.5	
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		C_{cb}			pF
(V_{CB} = –20 Vdc, I_E = 0, f = 1.0 MHz)	MMBTA92		—	6.0	
	MMBTA93		—	8.0	

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

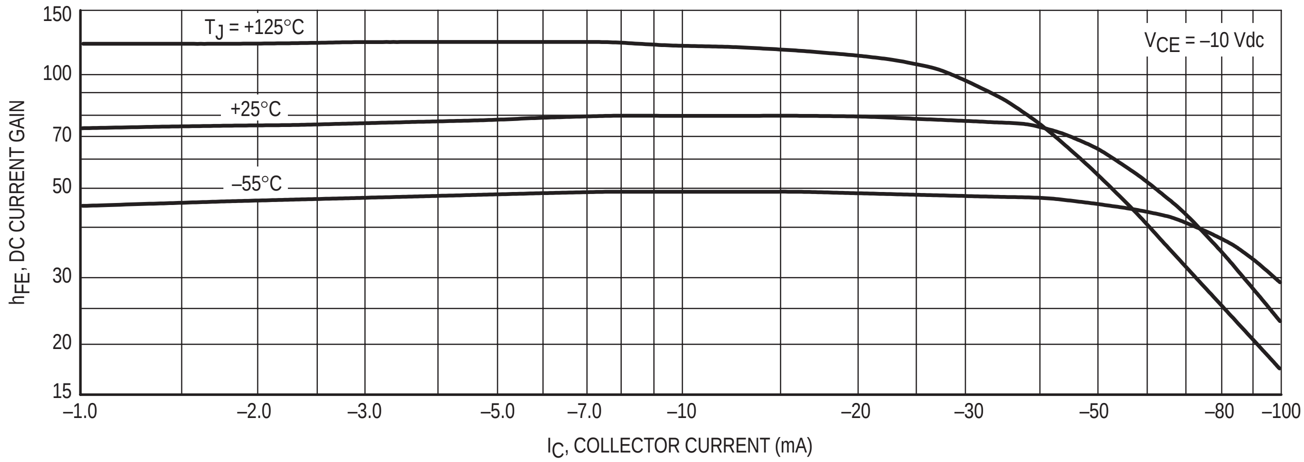


Figure 1. DC Current Gain

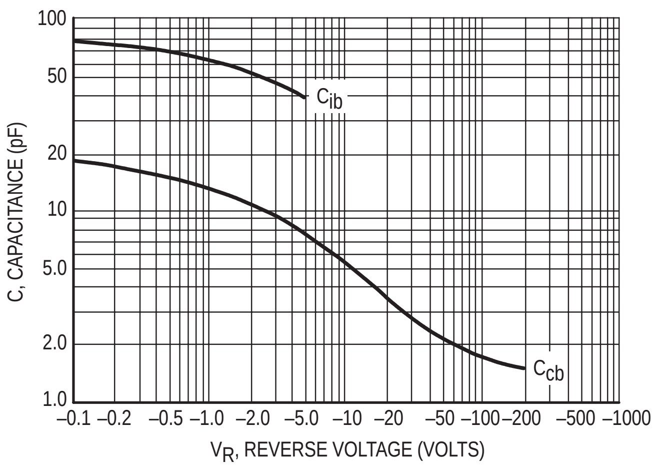


Figure 2. Capacitances

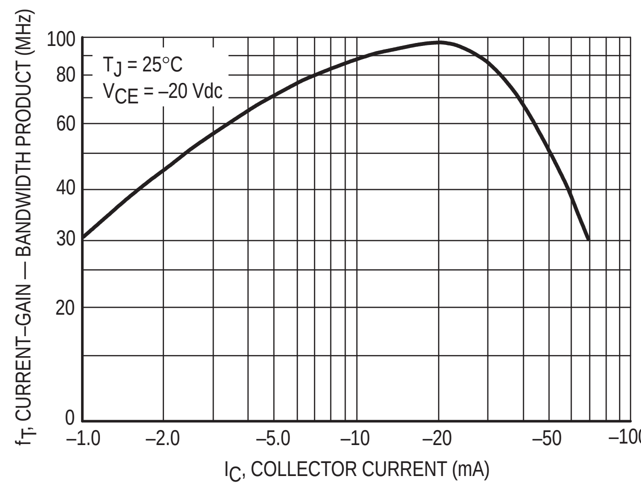


Figure 3. Current–Gain — Bandwidth Product

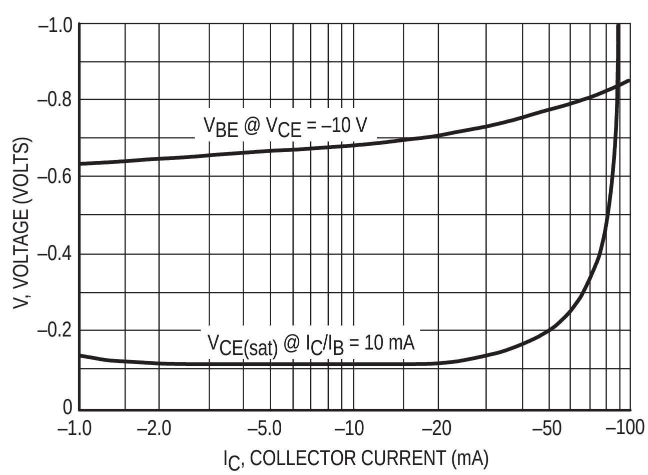
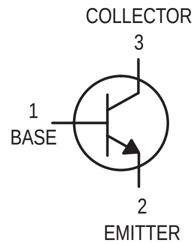


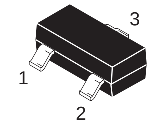
Figure 4. "On" Voltages

VHF/UHF Transistor
NPN Silicon



MMBTH10LT1

Motorola Preferred Device



CASE 318-08, STYLE 6
SOT-23 (TO-236AB)

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

DEVICE MARKING

MMBTH10LT1 = 3EM

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board (1) 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, (2) 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

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 = 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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
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

TYPICAL CHARACTERISTICS

COMMON–BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{ib}, INPUT ADMITTANCE

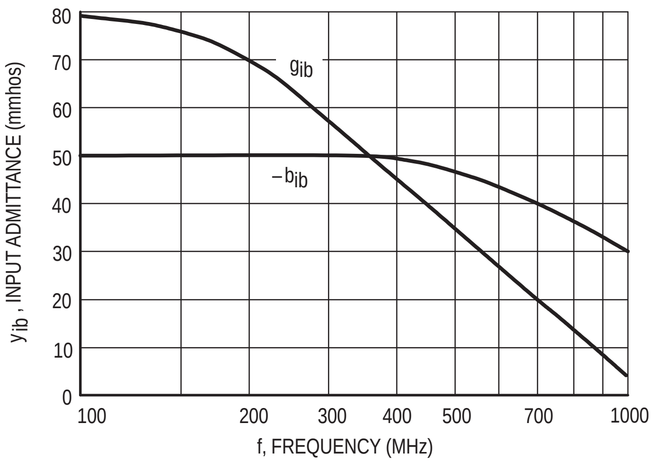


Figure 1. Rectangular Form

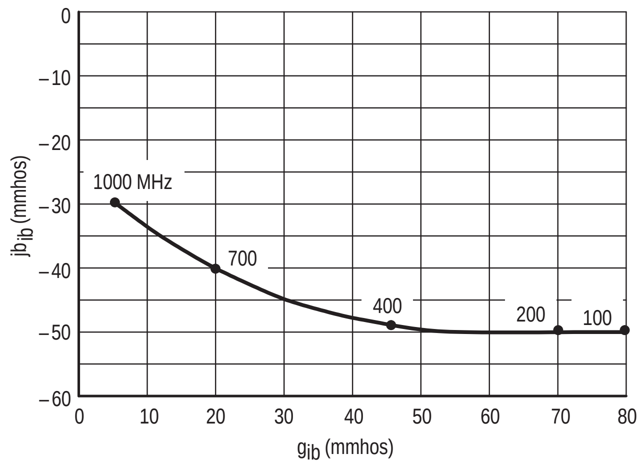


Figure 2. Polar Form

y_{fb}, FORWARD TRANSFER ADMITTANCE

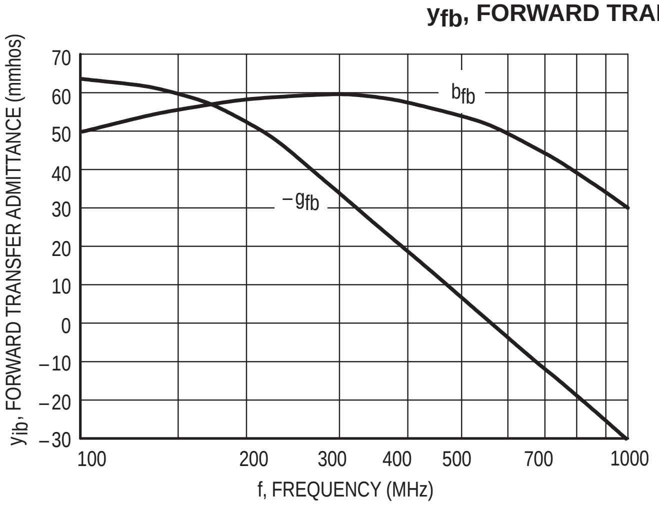


Figure 3. Rectangular Form

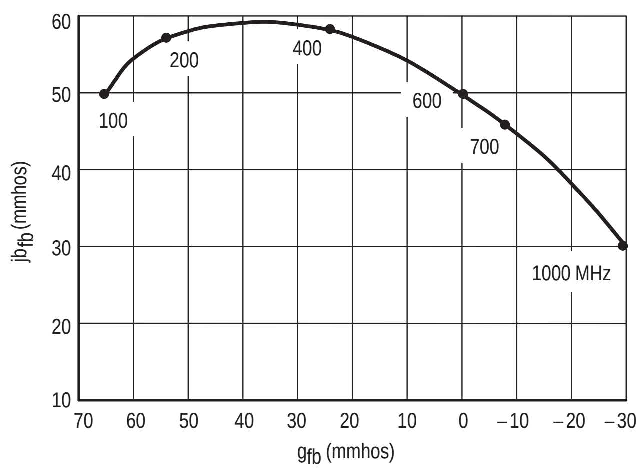


Figure 4. Polar Form

TYPICAL CHARACTERISTICS

COMMON–BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{rb}, REVERSE TRANSFER ADMITTANCE

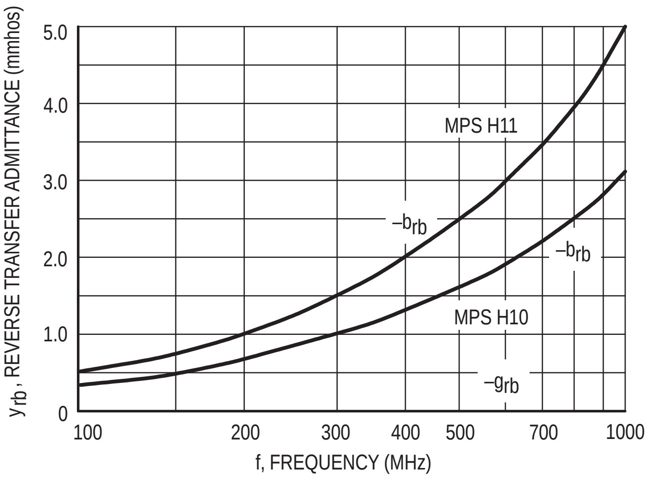


Figure 5. Rectangular Form

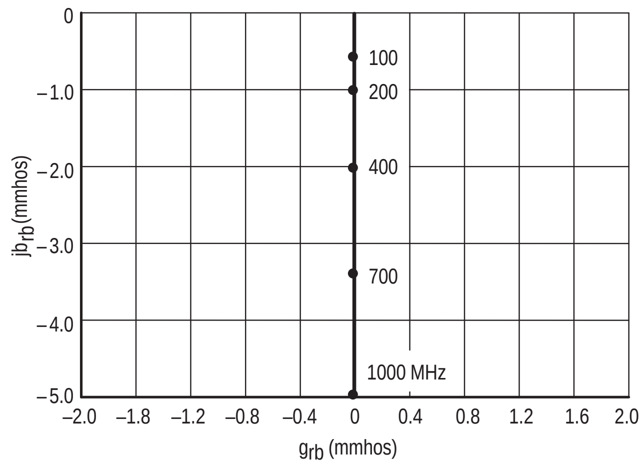


Figure 6. Polar Form

y_{ob}, OUTPUT ADMITTANCE

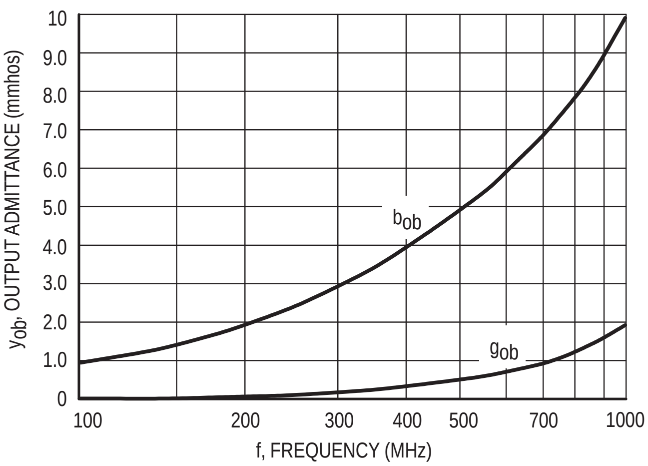


Figure 7. Rectangular Form

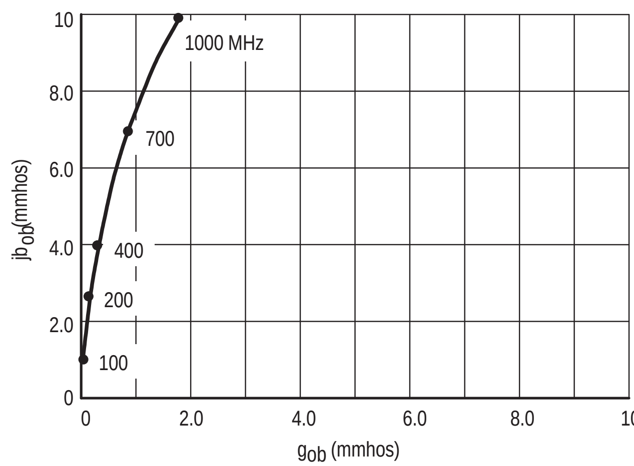
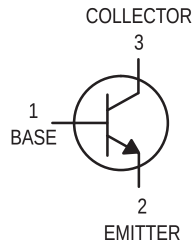


Figure 8. Polar Form

VHF Mixer Transistor

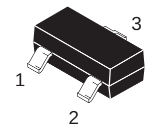
NPN Silicon

- Designed for
- f_T = 400 MHz Min @ 8 mA



MMBTH24LT1

Motorola Preferred Device



**CASE 318-08, STYLE 6
SOT-23 (TO-236AB)**

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

DEVICE MARKING

MMBTH24LT1 = M3A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board (1) 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, (2) 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

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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	—	—
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain – Bandwidth Product(3) (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	20	—	

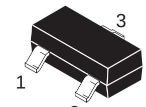
3. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

UHF/VHF Transistor
PNP Silicon

- Designed for UHF/VHF Amplifier Applications
- High Current Gain Bandwidth Product
  f_T = 2000 MHz Min @ 10 mA

MMBTH69LT1

Motorola Preferred Device



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBTH69LT1 = M3J

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board (1) 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, (2) 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

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

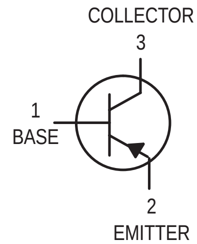
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = –1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	–15	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = –10 µAdc, I_E = 0)	$V_{(BR)CBO}$	–15	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = –10 µAdc, I_C = 0)	$V_{(BR)EBO}$	–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

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

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

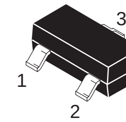
UHF/VHF Transistor

PNP Silicon



MMBTH81LT1

Motorola Preferred Device



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

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

DEVICE MARKING

MMBTH81LT1 = 3D

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,(1) 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,(2) 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

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

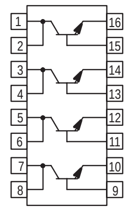
1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

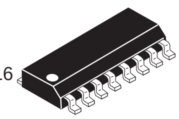
Preferred devices are Motorola recommended choices for future use and best overall value.

Quad General Purpose Transistors
NPN Silicon

MMPQ2222
MMPQ2222A*

*Motorola Preferred Device





CASE 751B–05, STYLE 4
SO–16

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)		I_{EBO}	—	—	100	nAdc

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

REV 1

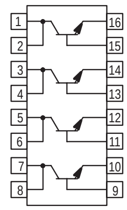
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = 100 μA, V_{CE} = 10 V)	MMPQ2222A		35	—	—	
(I_C = 1.0 mA, V_{CE} = 10 V)	MMPQ2222A		50	—	—	
(I_C = 10 mA, V_{CE} = 10 V)	MMPQ2222		75	—	—	
	MMPQ2222A		75	—	—	
(I_C = 150 mA, V_{CE} = 10 V)	MMPQ2222		100	—	—	
	MMPQ2222A		100	—	300	
(I_C = 300 mA, V_{CE} = 10 V)	MMPQ2222		30	—	—	
(I_C = 500 mA, V_{CE} = 10 V)	MMPQ2222A		40	—	—	
(I_C = 150 mA, V_{CE} = 1.0 V)	MMPQ2222A		50	—	—	
Collector–Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MMPQ2222		—	—	0.4	
	MMPQ2222A		—	—	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)	MMPQ2222		—	—	1.6	
(I_C = 500 mAdc, I_B = 50 mAdc)	MMPQ2222A		—	—	1.0	
Base–Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MMPQ2222		—	—	1.3	
	MMPQ2222A		—	—	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	MMPQ2222		—	—	2.6	
(I_C = 500 mAdc, I_B = 50 mAdc)	MMPQ2222A		—	—	2.0	
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%.

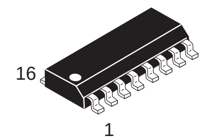
Quad Switching Transistor

NPN Silicon



MMPQ2369

Motorola Preferred Device



CASE 751B–05, STYLE 4
SO–16

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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

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

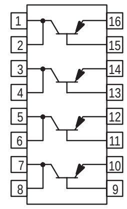
Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain[1]	h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		40	—	—	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)		20	—	—	
Collector–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base–Emitter Saturation 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

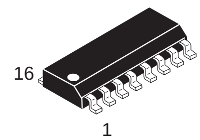
1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

Quad General Purpose Transistors

PNP Silicon

MMPQ2907
MMPQ2907A





CASE 751B–05, STYLE 4
SO–16

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

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

REV 1

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

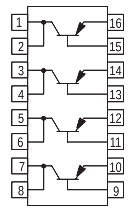
Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = –100 μAdc, V_{CE} = –10 Vdc)	MMPQ2907A		75	—	—	
(I_C = –1.0 mAdc, V_{CE} = –10 Vdc)	MMPQ2907A		100	—	—	
(I_C = –10 mAdc, V_{CE} = –10 Vdc)	MMPQ2907/2907A		75/100	—	—	
(I_C = –150 mAdc, V_{CE} = –10 Vdc)	MMPQ2907/2907A		100	—	300	
(I_C = –300 mAdc, V_{CE} = –10 Vdc)	MMPQ2907/2907A		30/50	—	—	
(I_C = –500 mAdc, V_{CE} = –10 Vdc)	MMPQ2907/2907A		50	—	—	
Collector–Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = –150 mAdc, I_B = –15 mAdc)	MMPQ2907		—	—	–0.4	
(I_C = –300 mAdc, I_B = –30 mAdc)	MMPQ2907		—	—	–1.6	
(I_C = –500 mAdc, I_B = –50 mAdc)	MMPQ2907		—	—	–1.6	
Base–Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = –150 mAdc, I_B = –15 mAdc)	MMPQ2907		—	—	–1.3	
(I_C = –300 mAdc, I_B = –30 mAdc)	MMPQ2907		—	—	–2.6	
(I_C = –500 mAdc, I_B = –50 mAdc)	MMPQ2907A		—	—	–2.6	
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

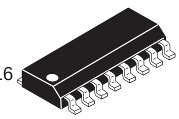
1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

Quad Memory Driver Transistor
PNP Silicon

MMPQ3467

Motorola Preferred Device





CASE 751B–05, STYLE 4
SO–16

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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

REV 2

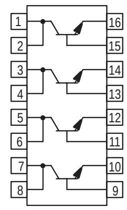
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Typ	Max	Unit
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

1. Pulse Test: Pulse Width $\leq$ 300 μs; Duty Cycle $\leq$ 2.0%.

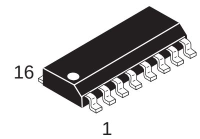
Quad Core Driver Transistor

NPN Silicon



MMPQ3725

Motorola Preferred Device



CASE 751B–05, STYLE 4
SO–16

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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

REV 1

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain	h_{FE}				—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		35	75	200	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		25	45	—	
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	1.1	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

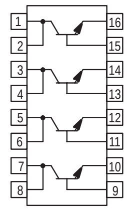
1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

Quad Amplifier/Switch Transistor

NPN Silicon

MMPQ3904

Motorola Preferred Device



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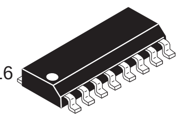
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CASE 751B–05, STYLE 4
SO–16

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	800 6.4	mW 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 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} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

REV 1

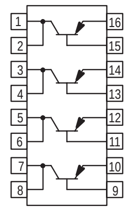
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Typ	Max	Unit
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
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 $\leq$ 300 μs; Duty Cycle $\leq$ 2.0%.

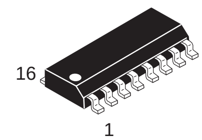
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Quad Amplifier/Switch Transistor
PNP Silicon



MMPQ3906

Motorola Preferred Device



CASE 751B–05, STYLE 4
SO–16

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	800 6.4	mW 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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

REV 1

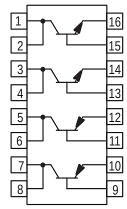
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				—
(I_C = –0.1 mAdc, V_{CE} = –1.0 Vdc)		40	160	—	
(I_C = –1.0 mAdc, V_{CE} = –1.0 Vdc)		60	180	—	
(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	–0.25	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 $\leq$ 300 μs; Duty Cycle $\leq$ 2.0%.

Quad Complementary Pair Transistor

PNP/NPN Silicon



MMPQ6700

Voltage and current are negative for PNP transistors

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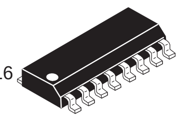
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CASE 751B–05, STYLE 4
SO–16

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

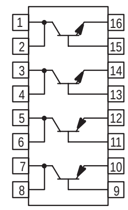
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

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}	 35 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%.

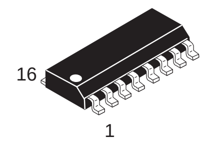
Quad MPU Clock Buffer Transistor

NPN/PNP Silicon



MMPQ6842

Voltage and current are negative for PNP transistors



CASE 751B–05, STYLE 4
SO–16

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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain	h_{FE}				—
(I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc)		30	—	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		50	—	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		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
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)	C_{ib}				pF
PNP		—	5.0	10	
NPN		—	4.0	8.0	
SWITCHING CHARACTERISTICS (T_A = 25°C, V_{CC} = 5.0 Vdc)					
Propagation Delay Time					ns
(50% Points TP1 to TP3)	t_{PLH}	—	15	25	
(50% Points TP2 to TP4)	t_{PHL}	—	6.0	15	
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%.

Bias Resistor Transistor

PNP Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

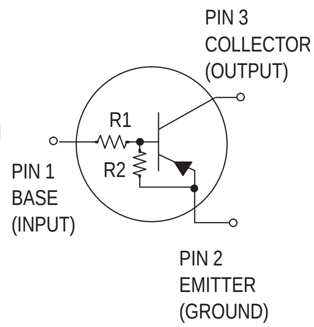
MMUN2111LT1 SERIES

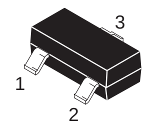
Motorola Preferred Devices

PNP SILICON BIAS RESISTOR TRANSISTOR

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.





CASE 318-08, 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(1) Derate above 25°C	P_D	200 1.6	mW mW/°C

THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
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 10	°C Sec

DEVICE MARKING AND RESISTOR VALUES

Device	Marking	R1 (K)	R2 (K)
MMUN2111LT1	A6A	10	10
MMUN2112LT1	A6B	22	22
MMUN2113LT1	A6C	47	47
MMUN2114LT1	A6D	10	47
MMUN2115LT1(2)	A6E	10	∞

1. Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.
2. New devices. Updated curves to follow in subsequent data sheets.

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

(Replaces MMUN2111T1/D)

DEVICE MARKING AND RESISTOR VALUES (Continued)

Device	Marking	R1 (K)	R2 (K)
MMUN2116LT1(2)	A6F	4.7	∞
MMUN2130LT1(2)	A6G	1.0	1.0
MMUN2131LT1(2)	A6H	2.2	2.2
MMUN2132LT1(2)	A6J	4.7	4.7
MMUN2133LT1(2)	A6K	4.7	47
MMUN2134LT1(2)	A6L	22	47

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)	MMUN2111LT1	I_{EBO}	—	—	0.5	mAdc
	MMUN2112LT1		—	—	0.2	
	MMUN2113LT1		—	—	0.1	
	MMUN2114LT1		—	—	0.2	
	MMUN2115LT1		—	—	0.9	
	MMUN2116LT1		—	—	1.9	
	MMUN2130LT1		—	—	4.3	
	MMUN2131LT1		—	—	2.3	
	MMUN2132LT1		—	—	1.5	
	MMUN2133LT1		—	—	0.18	
	MMUN2134LT1		—	—	0.13	
Collector-Base Breakdown Voltage (I_C = 10 µA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage(3) (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS(3)						
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA)	MMUN2111LT1	h_{FE}	35	60	—	
	MMUN2112LT1		60	100	—	
	MMUN2113LT1		80	140	—	
	MMUN2114LT1		80	140	—	
	MMUN2115LT1		160	250	—	
	MMUN2116LT1		160	250	—	
	MMUN2130LT1		3.0	5.0	—	
	MMUN2131LT1		8.0	15	—	
	MMUN2132LT1		15	27	—	
	MMUN2133LT1		80	140	—	
	MMUN2134LT1		80	130	—	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_E = 0.3 mA) (I_C = 10 mA, I_B = 5 mA) MMUN2130LT1/MMUN2131LT1 (I_C = 10 mA, I_B = 1 mA) MMUN2115LT1/MMUN2116LT1/ MMUN2132LT1/MMUN2133LT1/MMUN2134LT1		$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (on)		V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ)	MMUN2111LT1		—	—	0.2	
	MMUN2112LT1		—	—	0.2	
	MMUN2114LT1		—	—	0.2	
	MMUN2115LT1		—	—	0.2	
	MMUN2116LT1		—	—	0.2	
	MMUN2130LT1		—	—	0.2	
	MMUN2131LT1		—	—	0.2	
	MMUN2132LT1		—	—	0.2	
	MMUN2133LT1		—	—	0.2	
	MMUN2134LT1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MMUN2113LT1		—	—	0.2	

2. New devices. Updated curves to follow in subsequent data sheets.
3. Pulse Test: Pulse Width < 300 µs, Duty Cycle < 2.0%

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

Characteristic		Symbol	Min	Typ	Max	Unit
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
(V_{CC} = 5.0 V, V_B = 0.25 V, R_L = 1.0 kΩ)	MMUN2115LT1					
	MMUN2116LT1					
	MMUN2131LT1					
	MMUN2132LT1					
(V_{CC} = 5.0 V, V_B = 0.050 V, R_L = 1.0 kΩ)	MMUN2130LT1					
Input Resistor	MMUN2111LT1	R1	7.0	10	13	k Ω
	MMUN2112LT1		15.4	22	28.6	
	MMUN2113LT1		32.9	47	61.1	
	MMUN2114LT1		7.0	10	13	
	MMUN2115LT1		7.0	10	13	
	MMUN2116LT1		3.3	4.7	6.1	
	MMUN2130LT1		0.7	1.0	1.3	
	MMUN2131LT1		1.5	2.2	2.9	
	MMUN2132LT1		3.3	4.7	6.1	
	MMUN2133LT1		3.3	4.7	6.1	
	MMUN2134LT1		15.4	22	28.6	
Resistor Ratio	MMUN2111LT1/MMUN2112LT1/MMUN2113LT1	R_1/R_2	0.8	1.0	1.2	
	MMUN2114LT1		0.17	0.21	0.25	
	MMUN2115LT1/MMUN2116LT1		—	—	—	
	MMUN2130LT1/MMUN2131LT1/MMUN2132LT1		0.8	1.0	1.2	
	MMUN2133LT1		0.055	0.1	0.185	

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2111LT1

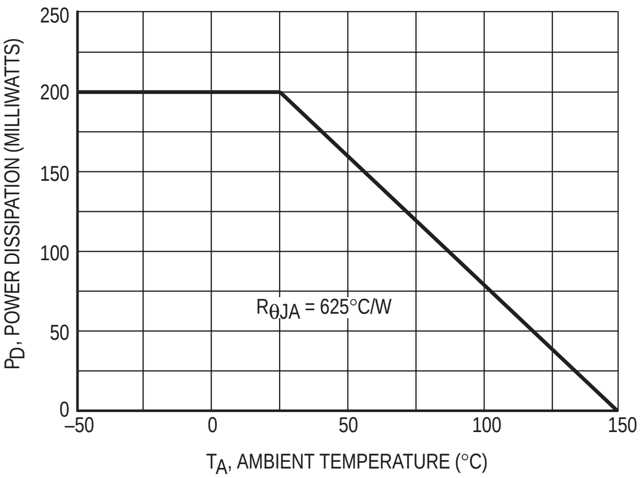


Figure 1. Derating Curve

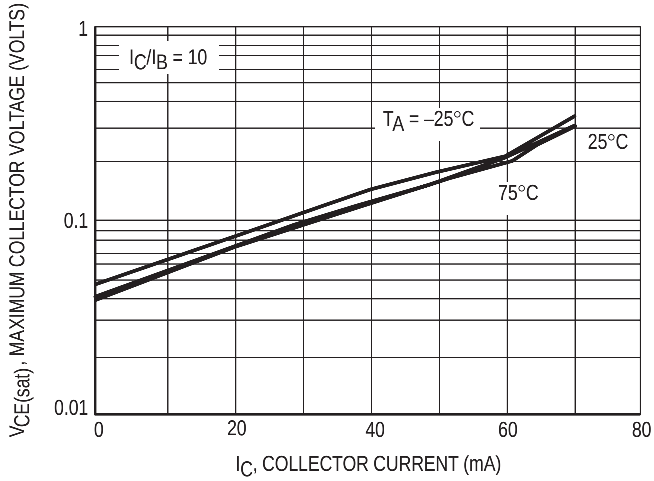


Figure 2. $V_{CE(sat)}$ versus I_C

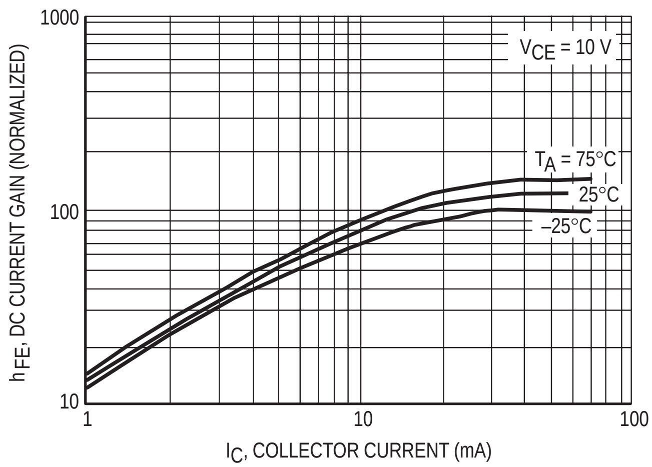


Figure 3. DC Current Gain

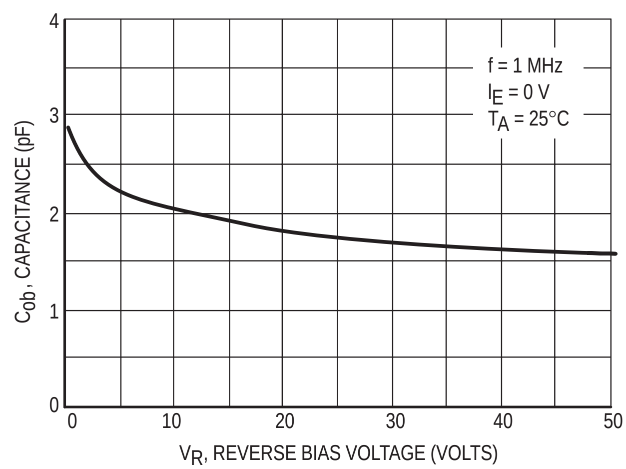


Figure 4. Output Capacitance

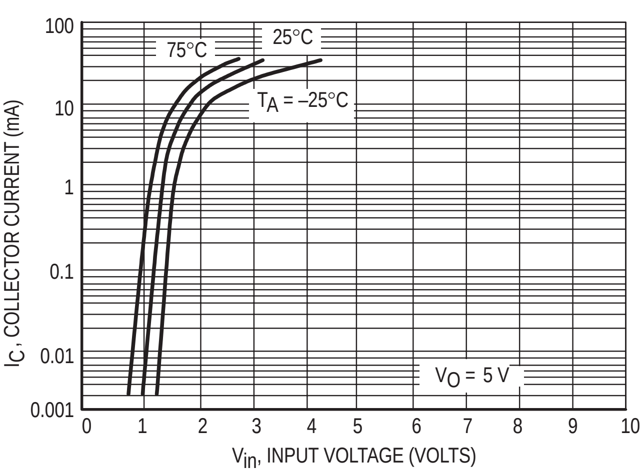


Figure 5. Output Current versus Input Voltage

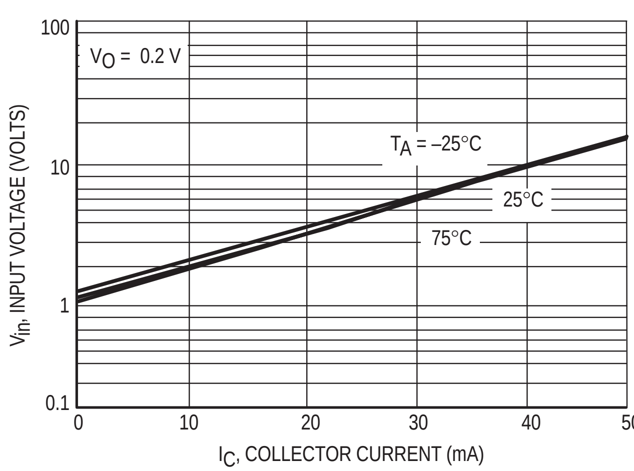


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2112LT1

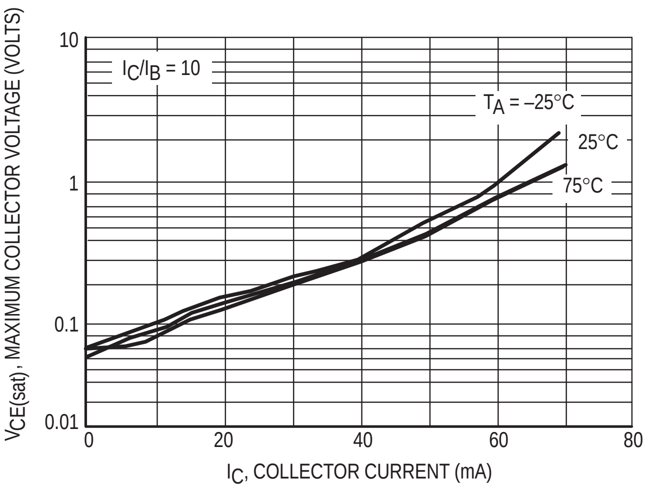


Figure 7. $V_{CE(sat)}$ versus I_C

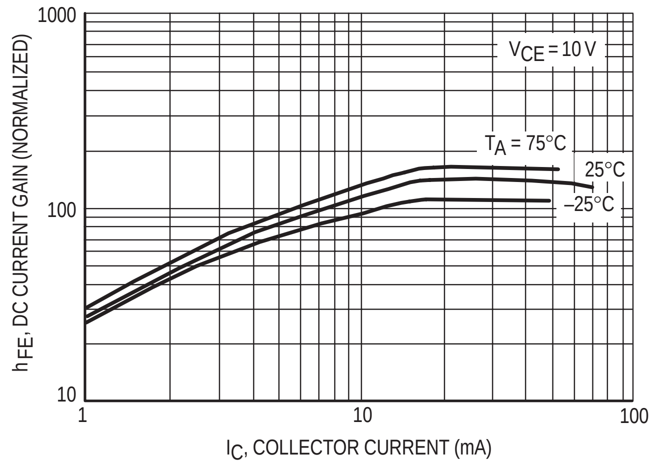


Figure 8. DC Current Gain

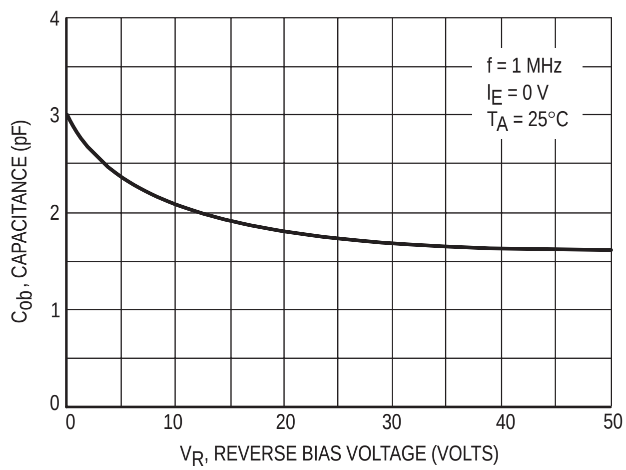


Figure 9. Output Capacitance

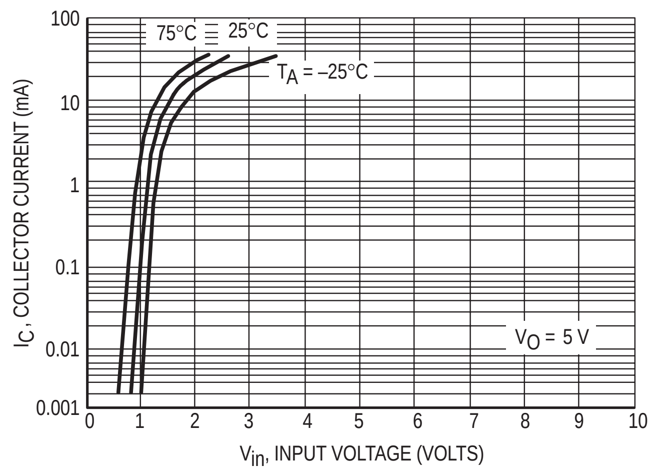


Figure 10. Output Current versus Input Voltage

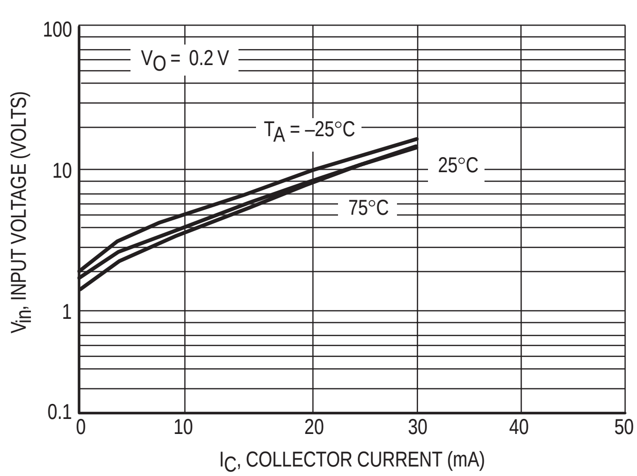


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2113LT1

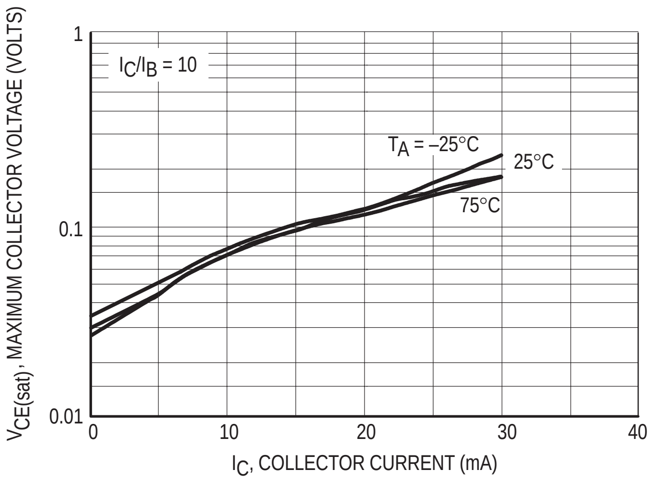


Figure 12. $V_{CE(sat)}$ versus I_C

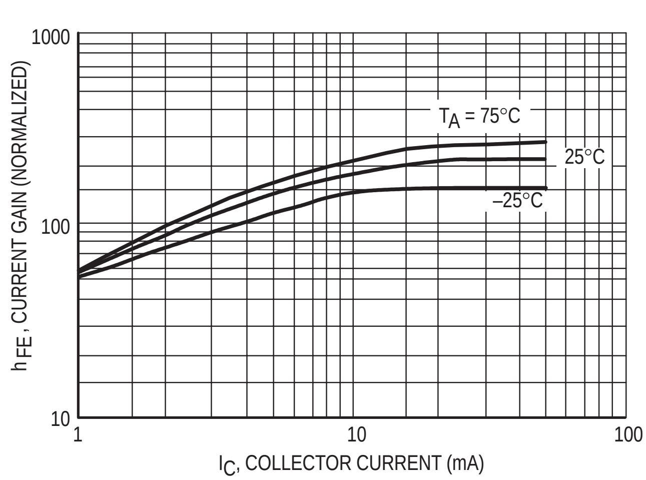


Figure 13. DC Current Gain

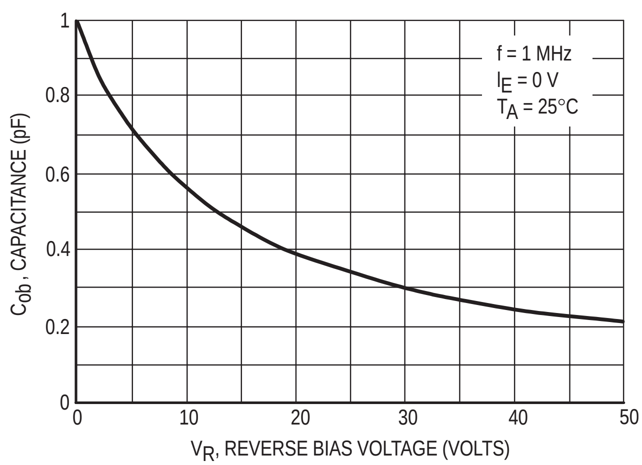


Figure 14. Output Capacitance

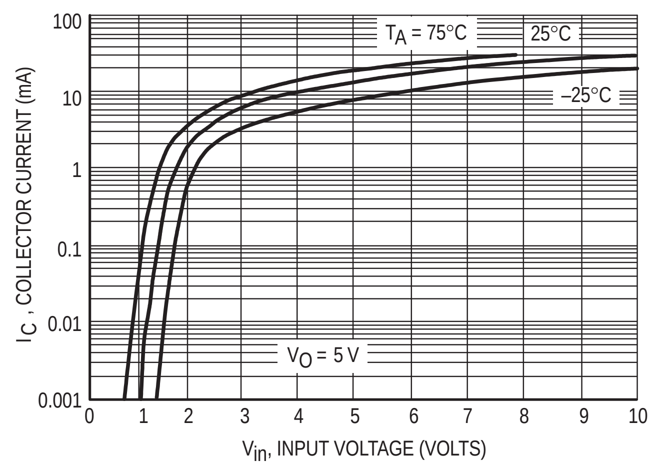


Figure 15. Output Current versus Input Voltage

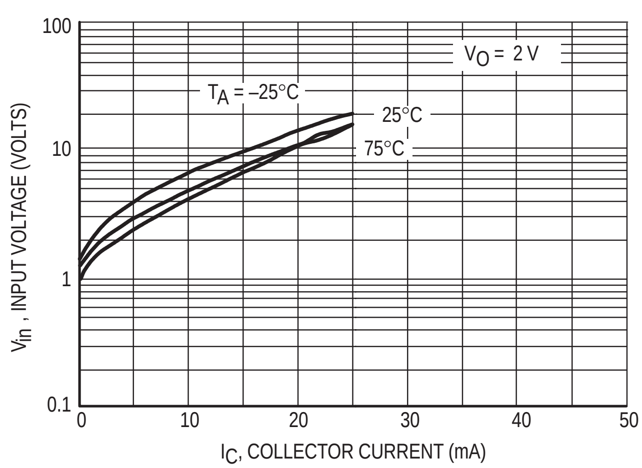


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2114LT1

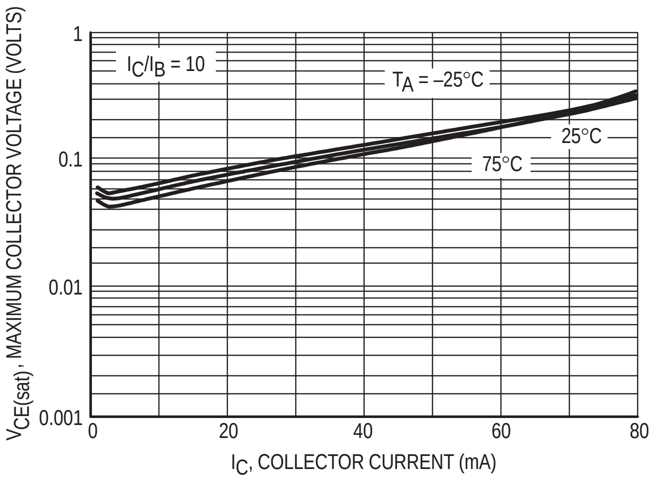


Figure 17. $V_{CE(sat)}$ versus I_C

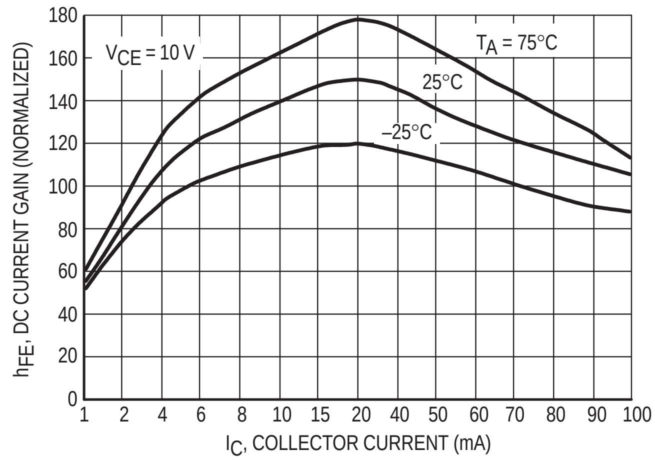


Figure 18. DC Current Gain

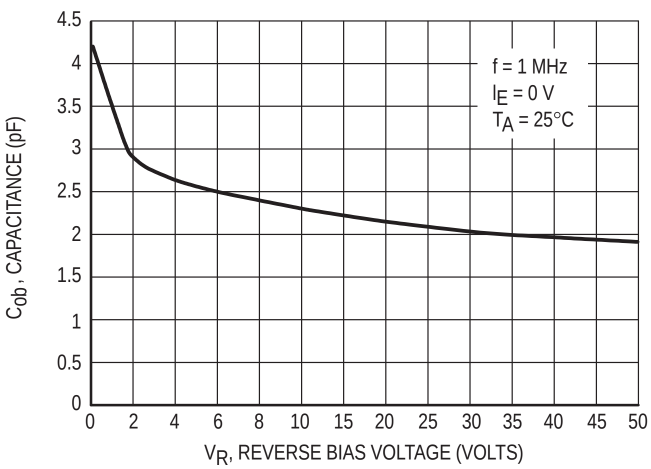


Figure 19. Output Capacitance

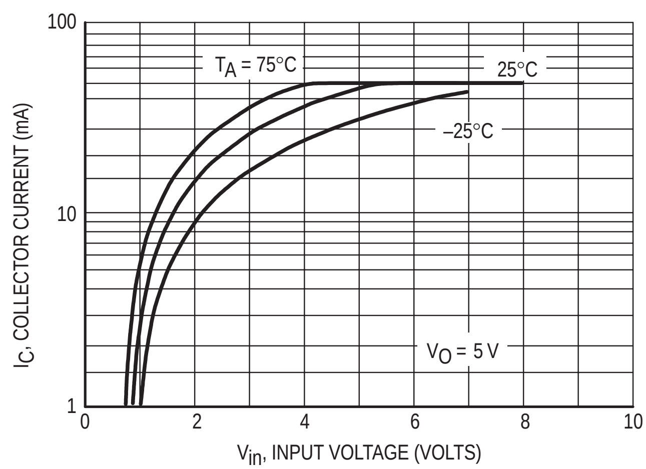


Figure 20. Output Current versus Input Voltage

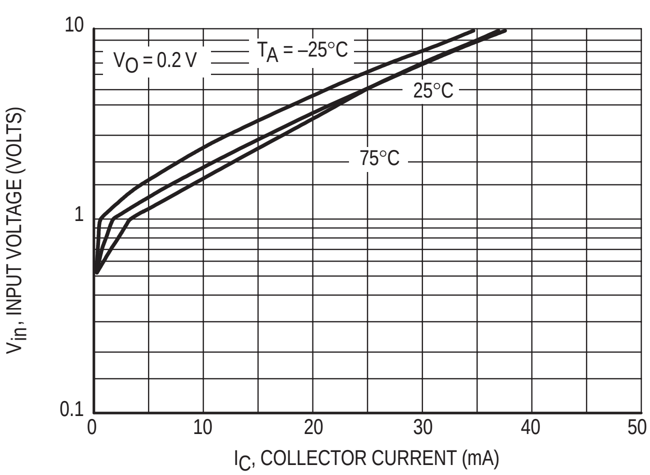


Figure 21. Input Voltage versus Output Current

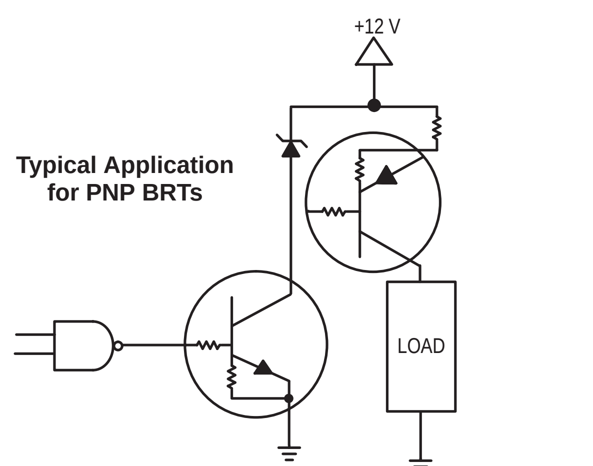


Figure 22. Inexpensive, Unregulated Current Source

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

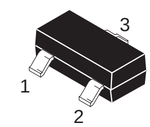
Bias Resistor Transistor

NPN Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

MMUN2211LT1 SERIES

Motorola Preferred Devices

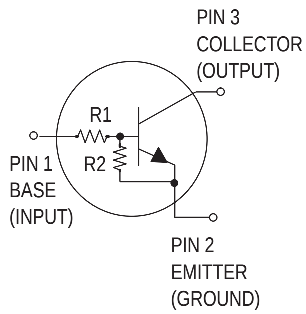
NPN SILICON BIAS RESISTOR TRANSISTOR



CASE 318-08, STYLE 6
SOT-23 (TO-236AB)

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 the13 inch/10,000 unit reel.



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(1) 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 10	°C Sec

DEVICE MARKING AND RESISTOR VALUES

Device	Marking	R1 (K)	R2 (K)
MMUN2211LT1	A8A	10	10
MMUN2212LT1	A8B	22	22
MMUN2213LT1	A8C	47	47
MMUN2214LT1	A8D	10	47
MMUN2215LT1(2)	A8E	10	∞
MMUN2216LT1(2)	A8F	4.7	∞
MMUN2230LT1(2)	A8G	1	1
MMUN2231LT1(2)	A8H	2.2	2.2
MMUN2232LT1(2)	A8J	4.7	4.7
MMUN2233LT1(2)	A8K	4.7	47
MMUN2234LT1(2)	A8L	22	47

1. Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.
2. New devices. Updated curves to follow in subsequent data sheets.

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

(Replaces MMUN2211T1/D)

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	MMUN2211LT1	I_{EBO}	—	—	0.5	mAdc
(V_{EB} = 6.0 V, I_C = 0)	MMUN2212LT1		—	—	0.2	
	MMUN2213LT1		—	—	0.1	
	MMUN2214LT1		—	—	0.2	
	MMUN2215LT1		—	—	0.9	
	MMUN2216LT1		—	—	1.9	
	MMUN2230LT1		—	—	4.3	
	MMUN2231LT1		—	—	2.3	
	MMUN2232LT1		—	—	1.5	
	MMUN2233LT1		—	—	0.18	
	MMUN2234LT1		—	—	0.13	
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage(3) (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS(3)						
DC Current Gain	MMUN2211LT1	h_{FE}	35	60	—	
(V_{CE} = 10 V, I_C = 5.0 mA)	MMUN2212LT1		60	100	—	
	MMUN2213LT1		80	140	—	
	MMUN2214LT1		80	140	—	
	MMUN2215LT1		160	350	—	
	MMUN2216LT1		160	350	—	
	MMUN2230LT1		3.0	5.0	—	
	MMUN2231LT1		8.0	15	—	
	MMUN2232LT1		15	30	—	
	MMUN2233LT1		80	200	—	
	MMUN2234LT1		80	150	—	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA) (I_C = 10 mA, I_B = 5 mA) MMUN2230LT1/MMUN2231LT1 (I_C = 10 mA, I_B = 1 mA) MMUN2215LT1/MMUN2216LT1 MMUN2232LT1/MMUN2233LT1/MMUN2234LT1		$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (on)		V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 k Ω)	MMUN2211LT1		—	—	0.2	
	MMUN2212LT1		—	—	0.2	
	MMUN2214LT1		—	—	0.2	
	MMUN2215LT1		—	—	0.2	
	MMUN2216LT1		—	—	0.2	
	MMUN2230LT1		—	—	0.2	
	MMUN2231LT1		—	—	0.2	
	MMUN2232LT1		—	—	0.2	
	MMUN2233LT1		—	—	0.2	
	MMUN2234LT1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 k Ω)	MMUN2213LT1		—	—	0.2	
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 k Ω)		V_{OH}	4.9	—	—	Vdc
(V_{CC} = 5.0 V, V_B = 0.050 V, R_L = 1.0 k Ω)	MMUN2230LT1					
(V_{CC} = 5.0 V, V_B = 0.25 V, R_L = 1.0 k Ω)	MMUN2215LT1					
	MMUN2216LT1					
	MMUN2233LT1					

3. Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(3)						
Input Resistor	MMUN2211LT1	R1	7.0	10	13	k Ω
	MMUN2212LT1		15.4	22	28.6	
	MMUN2213LT1		32.9	47	61.1	
	MMUN2214LT1		7.0	10	13	
	MMUN2215LT1		7.0	10	13	
	MMUN2216LT1		3.3	4.7	6.1	
	MMUN2230LT1		0.7	1.0	1.3	
	MMUN2231LT1		1.5	2.2	2.9	
	MMUN2232LT1		3.3	4.7	6.1	
	MMUN2233LT1		3.3	4.7	6.1	
	MMUN2234LT1		15.4	22	28.6	
Resistor Ratio	MMUN2211LT1/MMUN2212LT1/MMUN2213LT1	R1/R2	0.8	1.0	1.2	
	MMUN2214LT1		0.17	0.21	0.25	
	MMUN2215LT1/MMUN2216LT1		—	—	—	
	MMUN2230LT1/MMUN2231LT1/MMUN2232LT1		0.8	1.0	1.2	
	MMUN2233LT1		0.055	0.1	0.185	
	MMUN2234LT1		0.38	0.47	0.56	

3. Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2211LT1

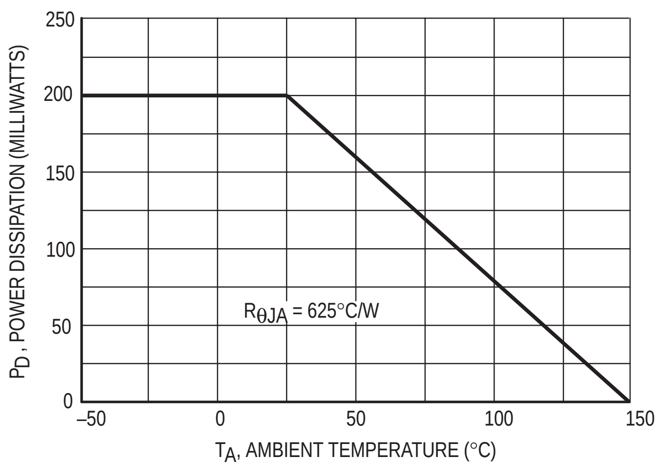


Figure 1. Derating Curve

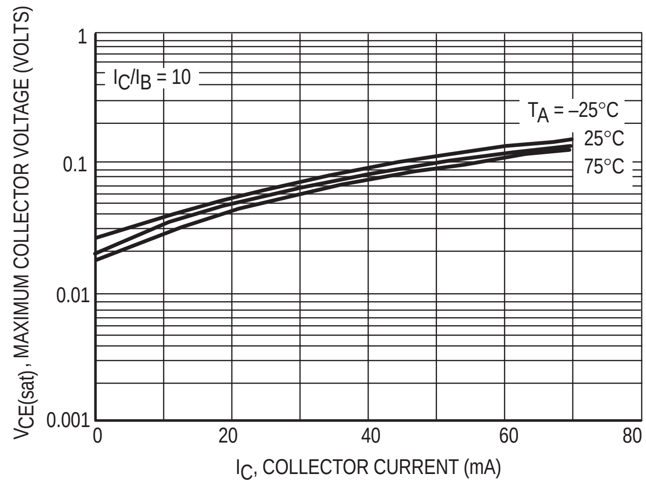


Figure 2. $V_{CE(sat)}$ versus I_C

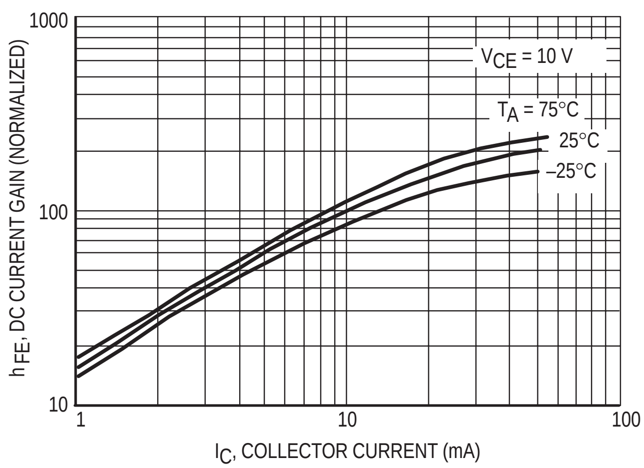


Figure 3. DC Current Gain

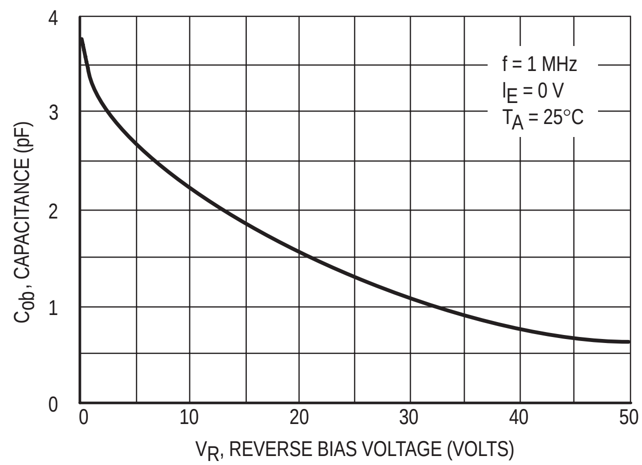


Figure 4. Output Capacitance

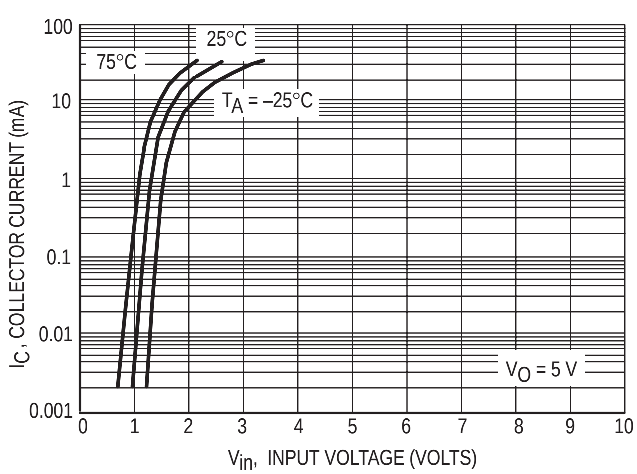


Figure 5. $V_{CE(sat)}$ versus I_C

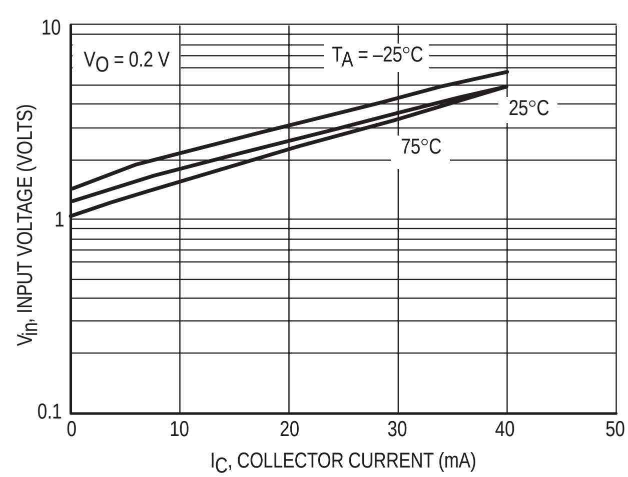


Figure 6. $V_{CE(sat)}$ versus I_C

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2212LT1

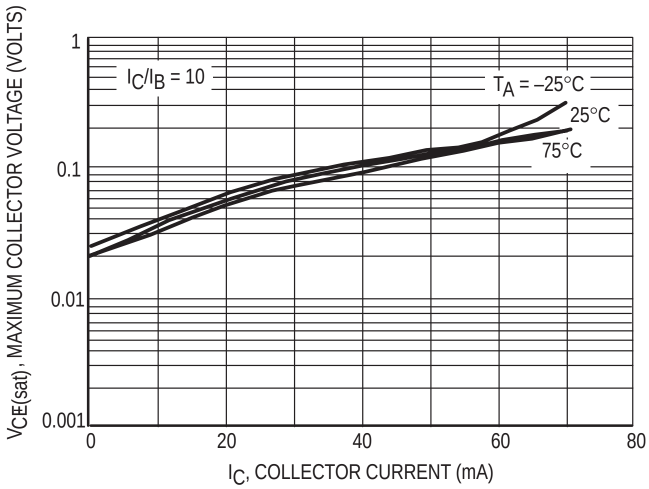


Figure 7. $V_{CE(sat)}$ versus I_C

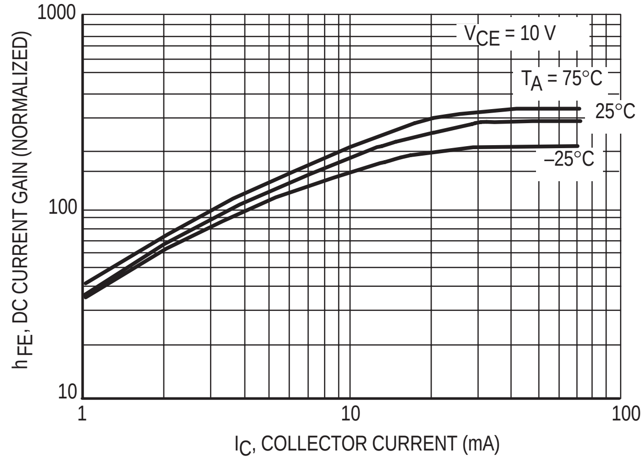


Figure 8. DC Current Gain

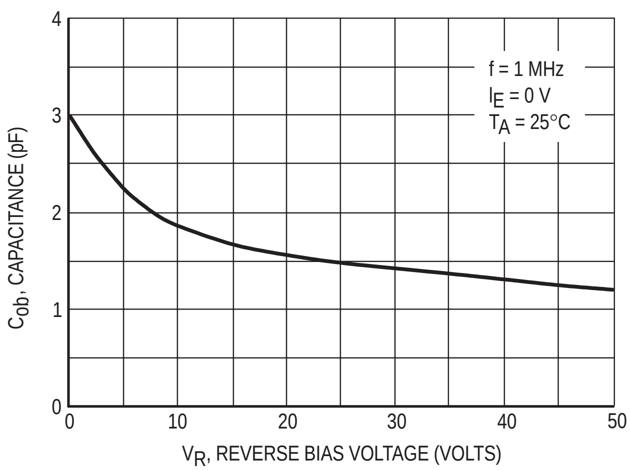


Figure 9. Output Capacitance

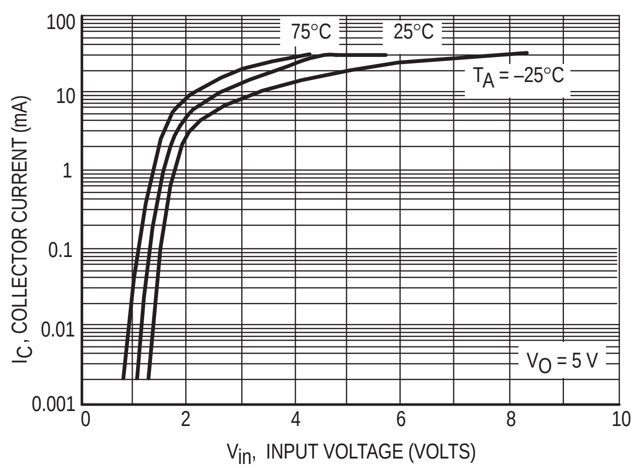


Figure 10. Output Current versus Input Voltage

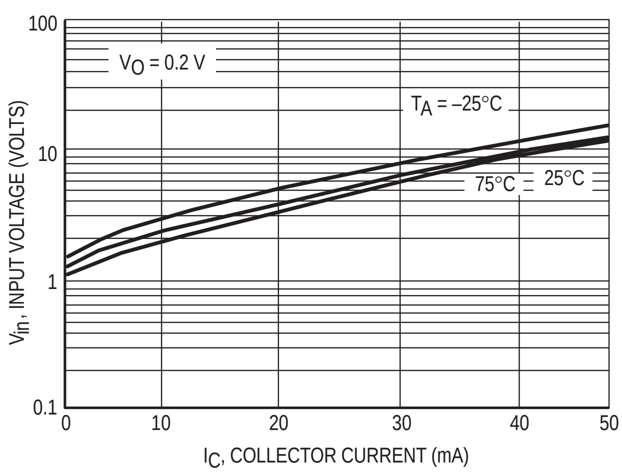


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2213LT1

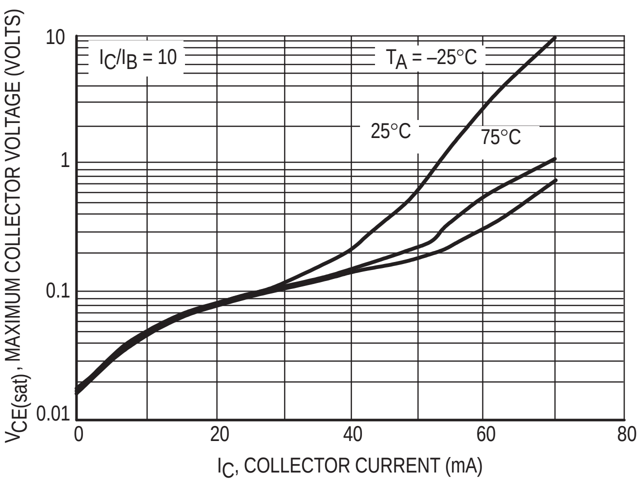


Figure 12. $V_{CE(sat)}$ versus I_C

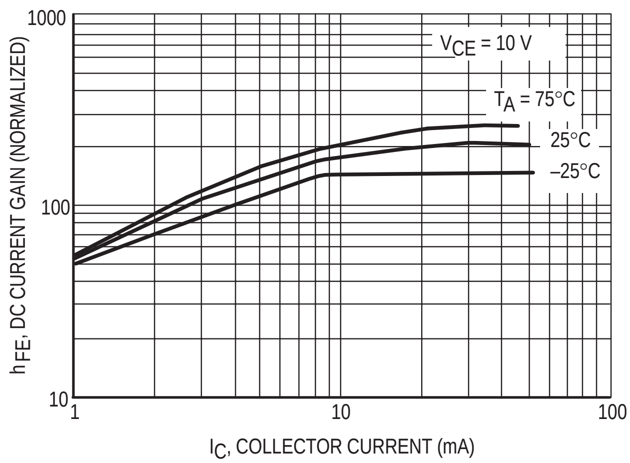


Figure 13. DC Current Gain

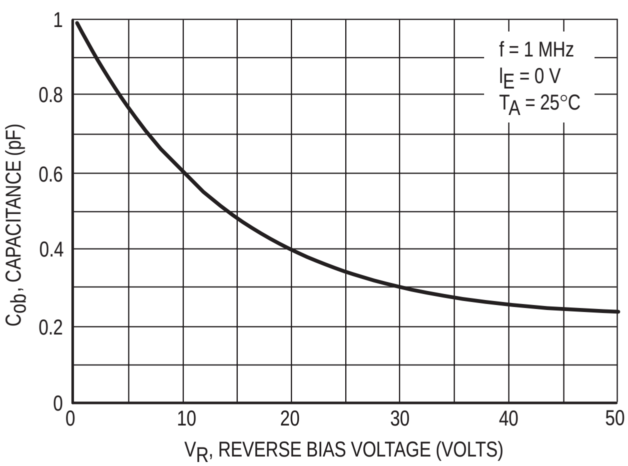


Figure 14. Output Capacitance

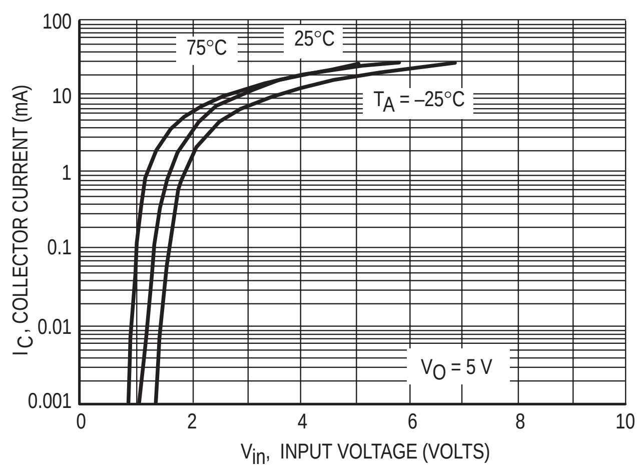


Figure 15. Output Current versus Input Voltage

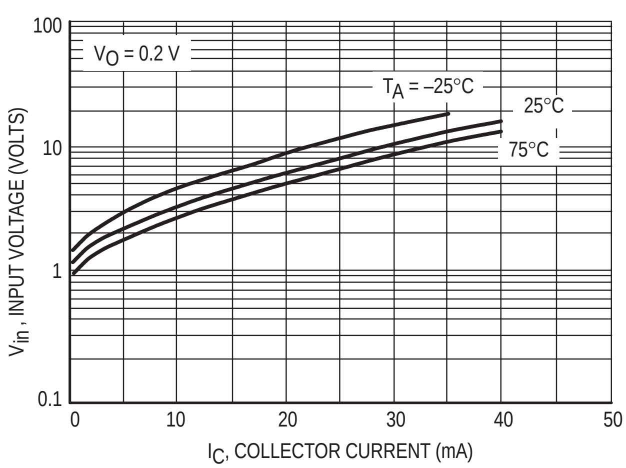


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2214LT1

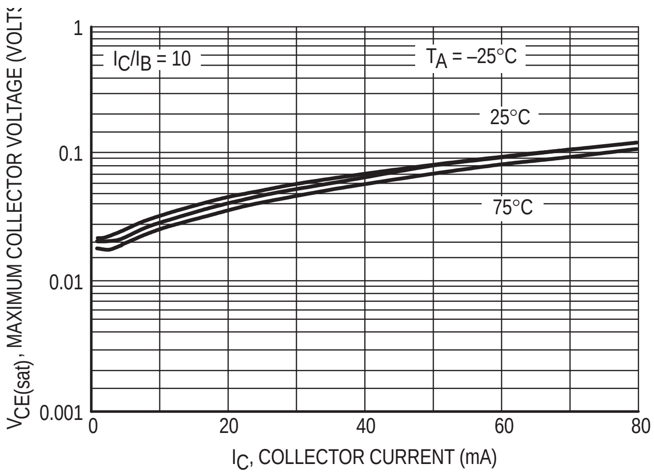


Figure 17. $V_{CE(sat)}$ versus I_C

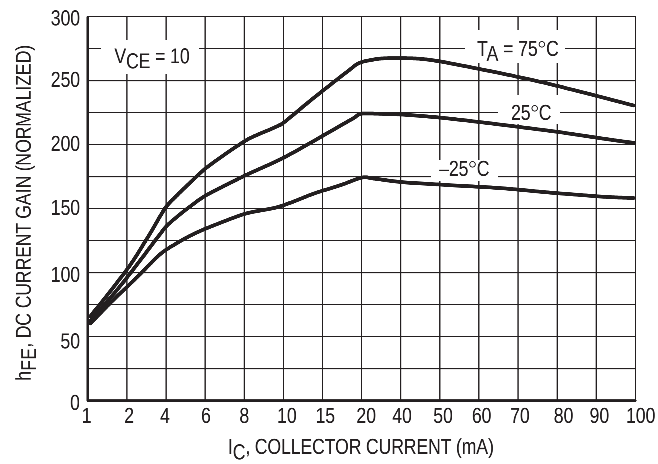


Figure 18. DC Current Gain

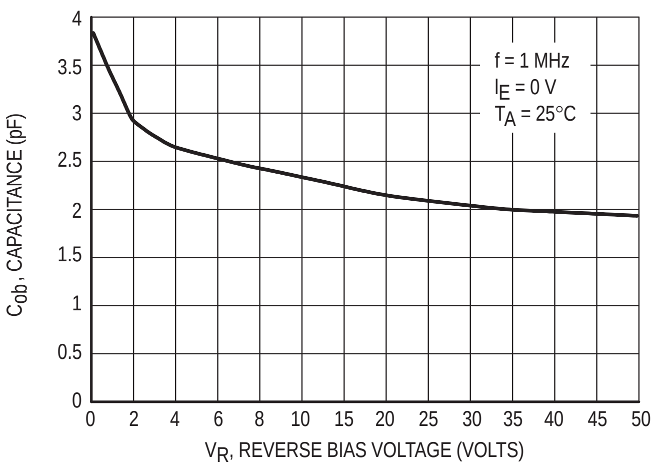


Figure 19. Output Capacitance

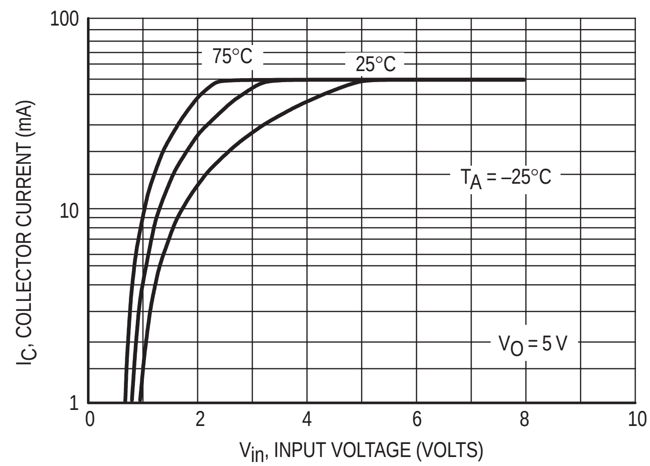


Figure 20. Output Current versus Input Voltage

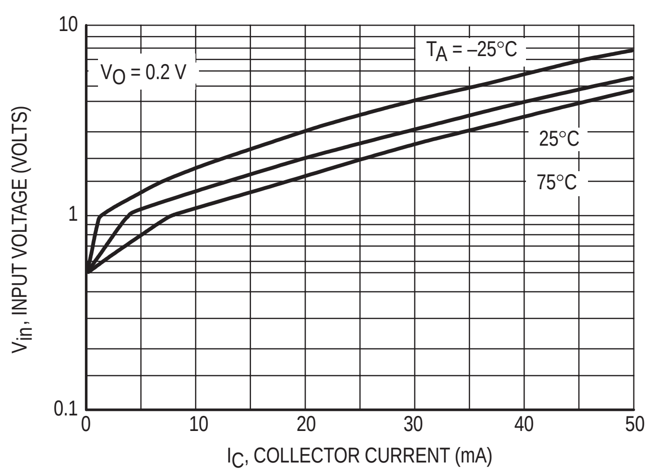


Figure 21. Input Voltage versus Output Current

TYPICAL APPLICATIONS FOR NPN BRTs

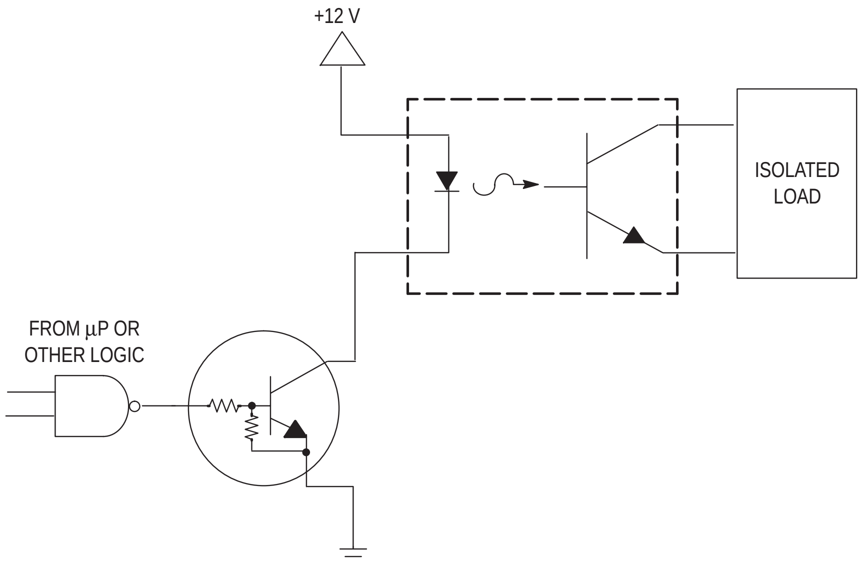


Figure 22. Level Shifter: Connects 12 or 24 Volt Circuits to Logic

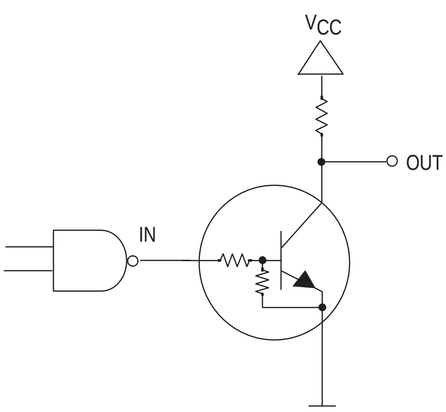


Figure 23. Open Collector Inverter: Inverts the Input Signal

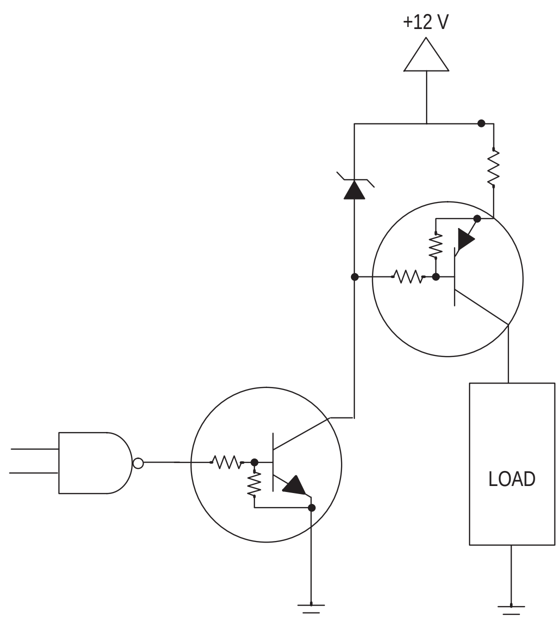
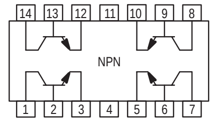


Figure 24. Inexpensive, Unregulated Current Source

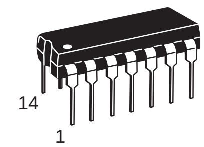
Quad General Purpose Transistors

NPN Silicon



MPQ2222
MPQ2222A*

*Motorola Preferred Device



CASE 646–06, STYLE 1
TO–116

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) (I_C = 10 mAdc, I_B = 0)	MPQ2222 MPQ2222A	$V_{(BR)CEO}$	40 40	— —	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPQ2222 MPQ2222A	$V_{(BR)CBO}$	60 75	— —	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPQ2222 MPQ2222A	$V_{(BR)EBO}$	5.0 6.0	— —	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	MPQ2222 MPQ2222A	I_{CBO}	— —	50 10	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc

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

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

(Replaces MPQ2221/D)

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

Characteristic		Symbol	Min	Max	Unit
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	
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%.

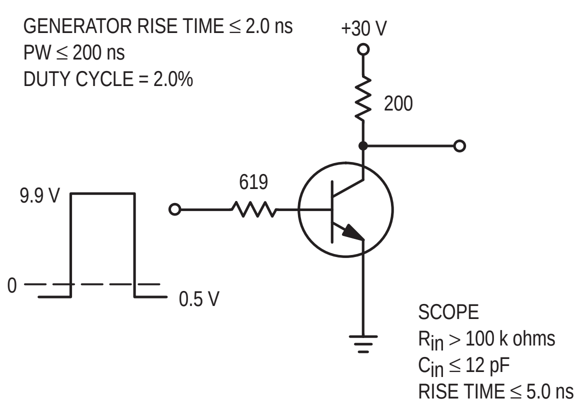


Figure 1. Delay and Rise Time Equivalent Test Circuit

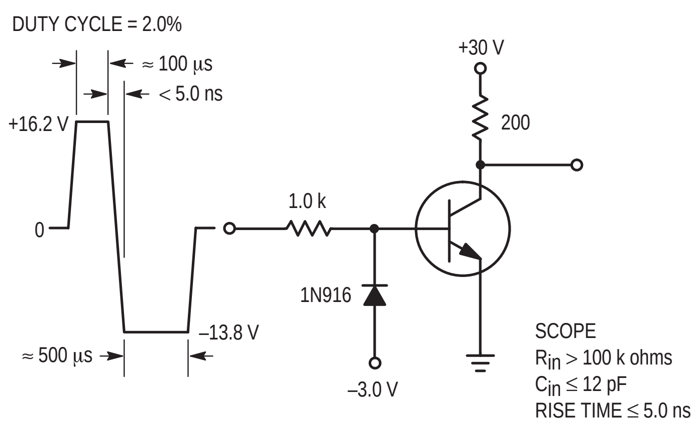


Figure 2. Storage Time and Fall Time Equivalent Test Circuit

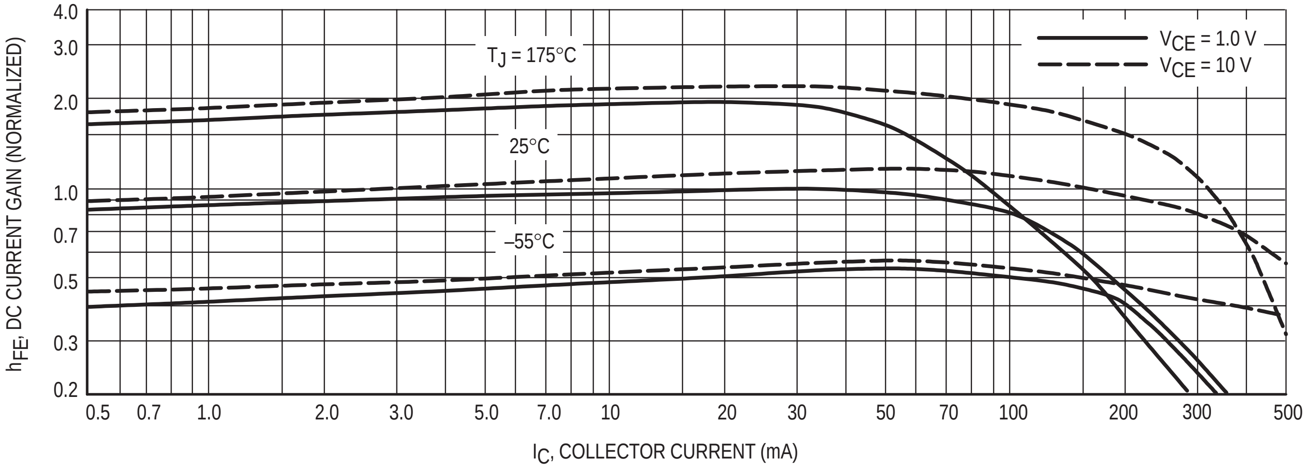


Figure 3. Normalized DC Current Gain

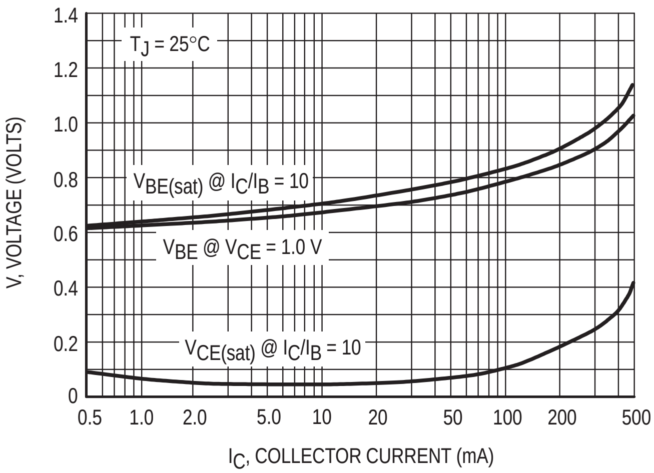


Figure 4. “ON” Voltages

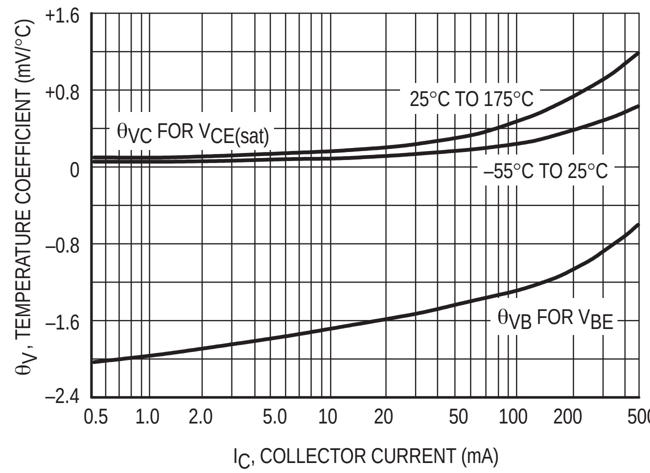


Figure 5. Temperature Coefficients

NOISE FIGURE

(V_{CE} = 10 Vdc, T_A = 25°C)

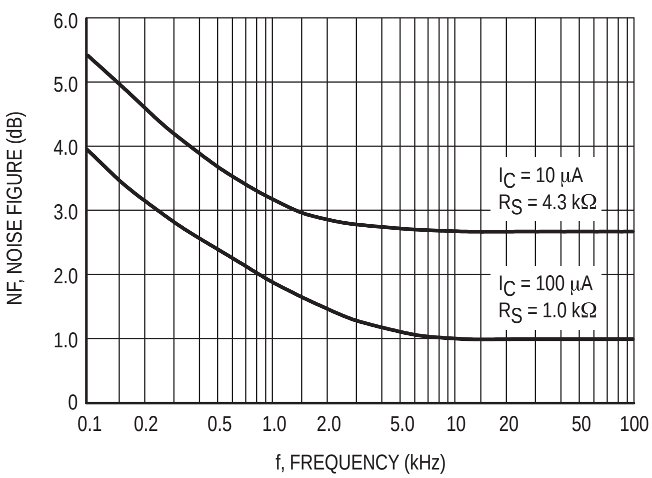


Figure 6. Frequency Effects

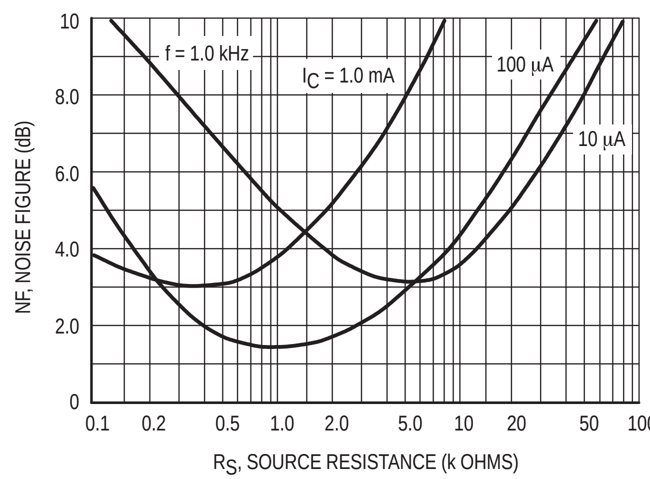


Figure 7. Source Resistance Effects

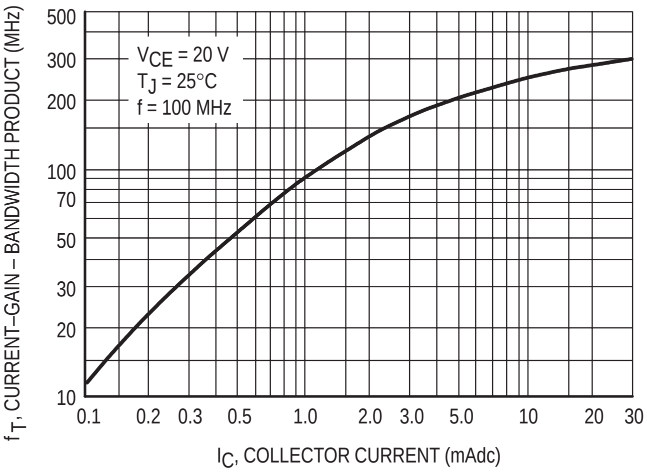


Figure 8. Current–Gain — Bandwidth Product

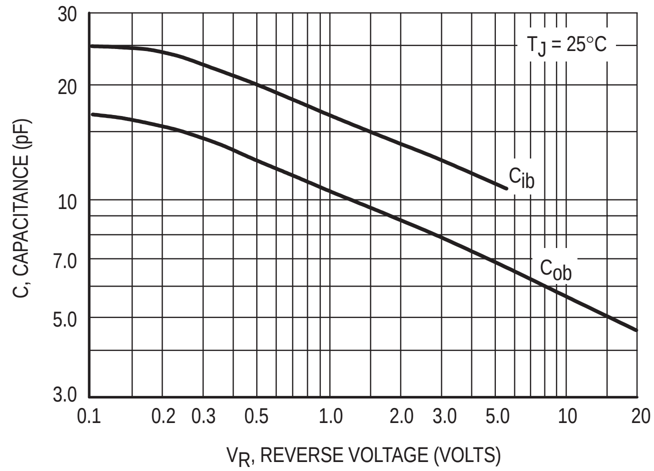


Figure 9. Capacitances

SWITCHING TIME CHARACTERISTICS

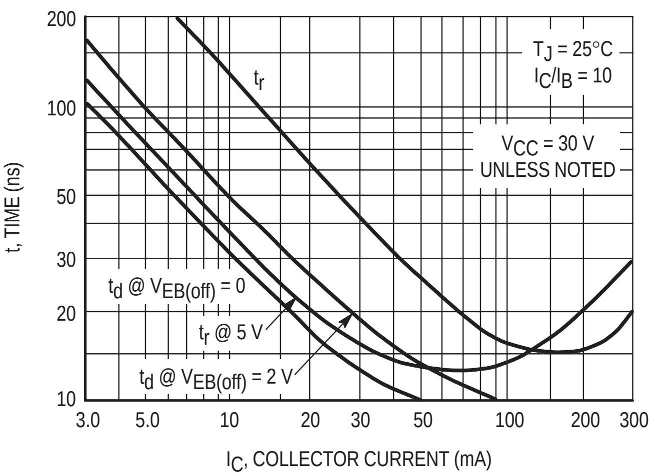


Figure 10. Turn–On Time

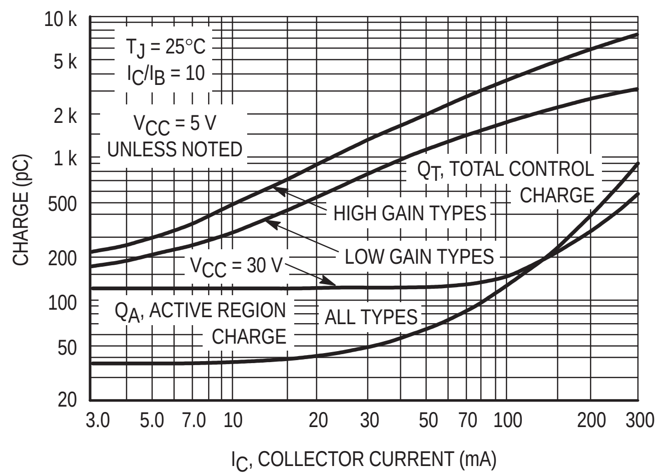


Figure 11. Charge Data

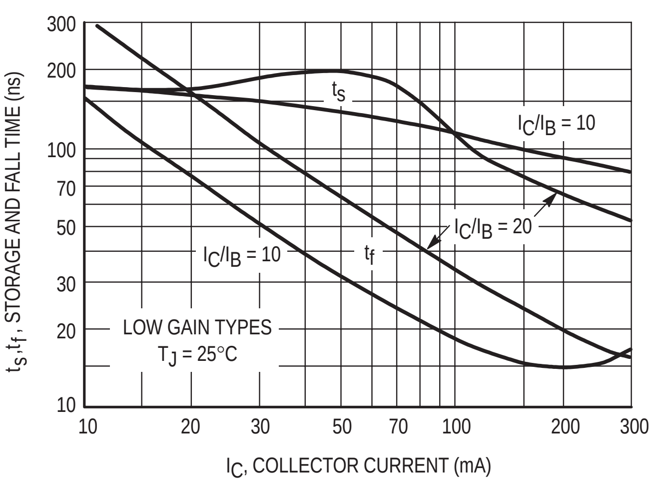


Figure 12. Turn–Off Behavior

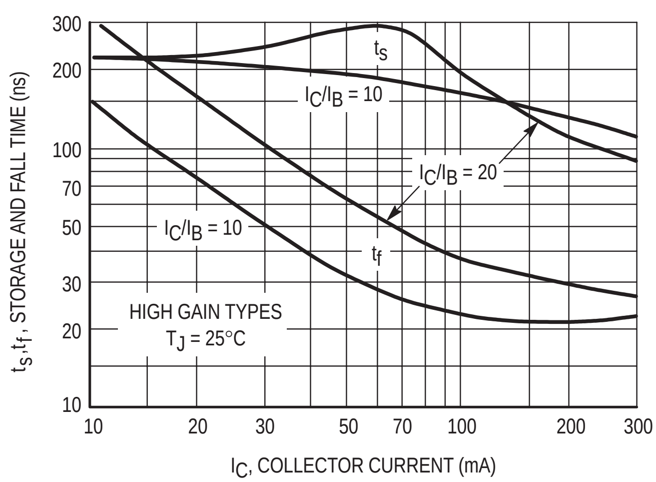


Figure 13. Turn–Off Behavior

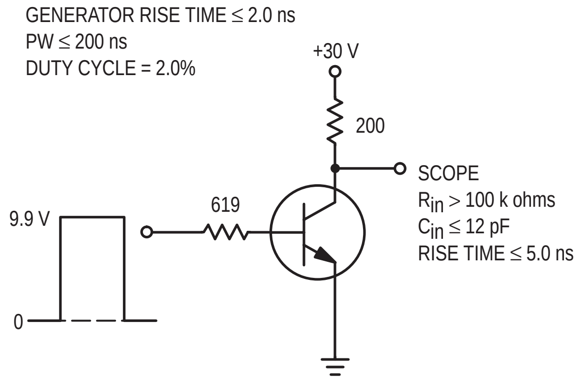


Figure 14. Delay and Rise Time Equivalent Test Circuit

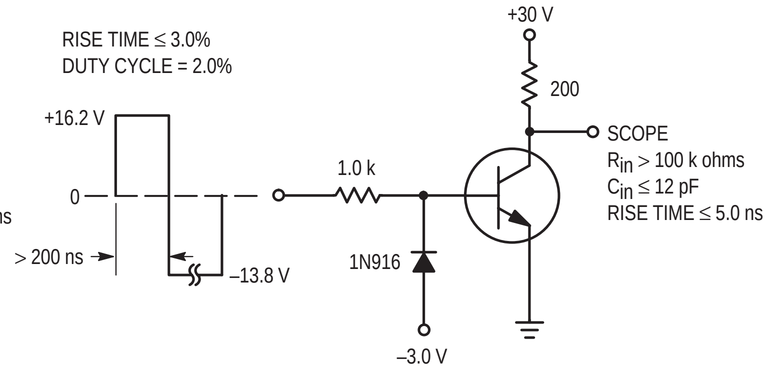
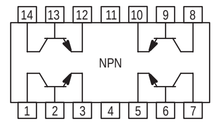


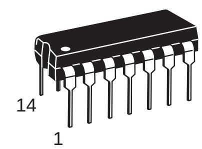
Figure 15. Storage Time and Fall Time Equivalent Test Circuit

Quad Switching Transistor
NPN Silicon

MPQ2369

Motorola Preferred Device





CASE 646–06, STYLE 1
TO–116

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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain(1)	h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		40	—	—	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)		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%.

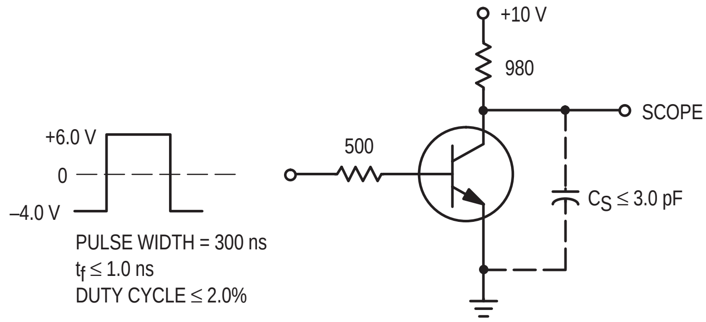


Figure 1. Storage Time Test Circuit

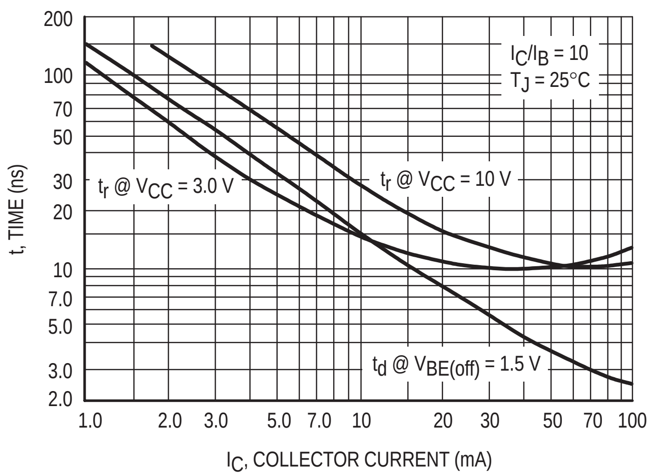


Figure 2. Turn–On Time

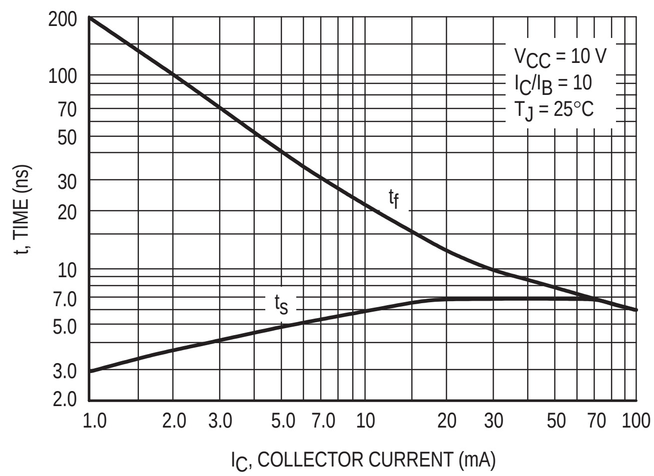


Figure 3. Turn–Off Time

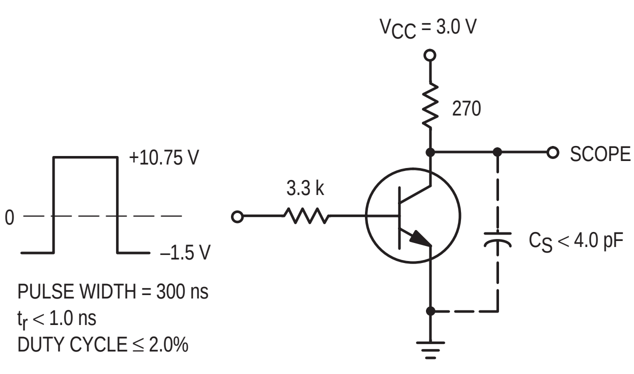


Figure 4. Turn–On Test Circuit

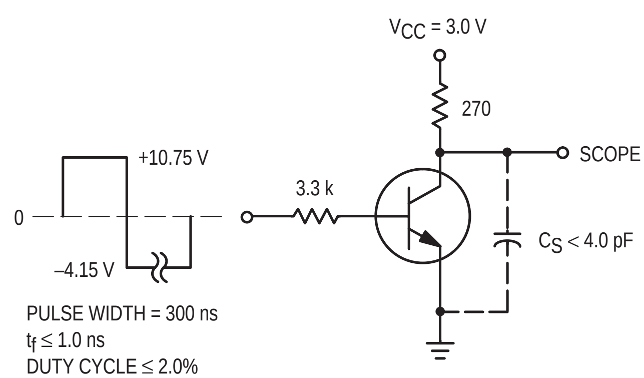


Figure 5. Turn–Off Test Circuit

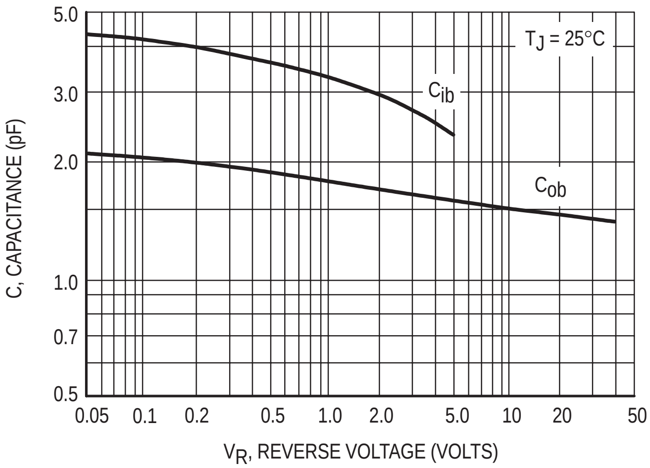


Figure 6. Capacitance

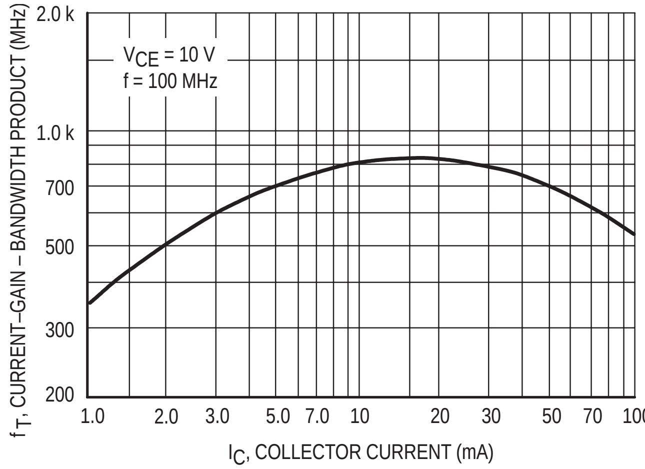


Figure 7. Current–Gain — Bandwidth Product

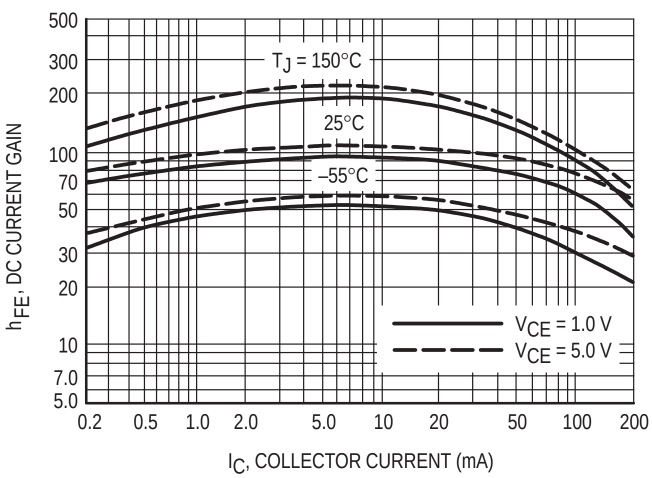


Figure 8. DC Current Gain

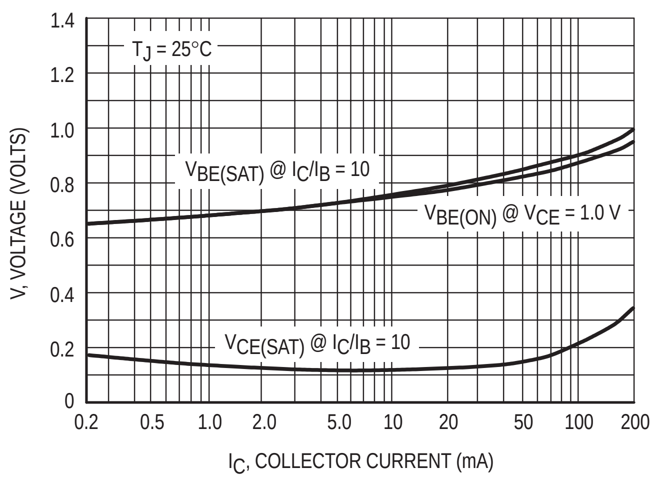


Figure 9. "ON" Voltages

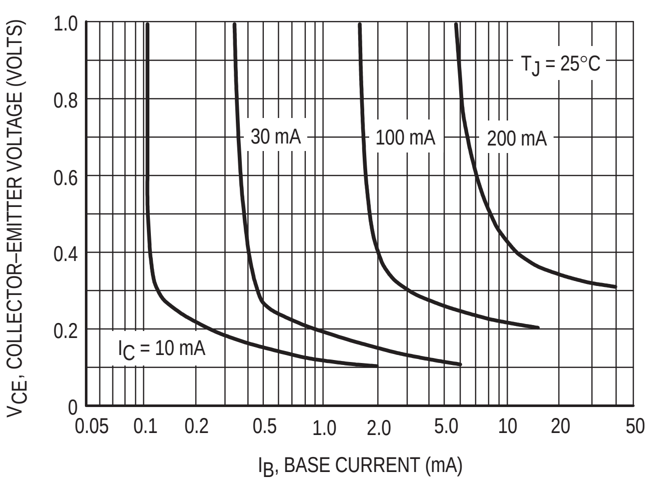


Figure 10. Collector Saturation Region

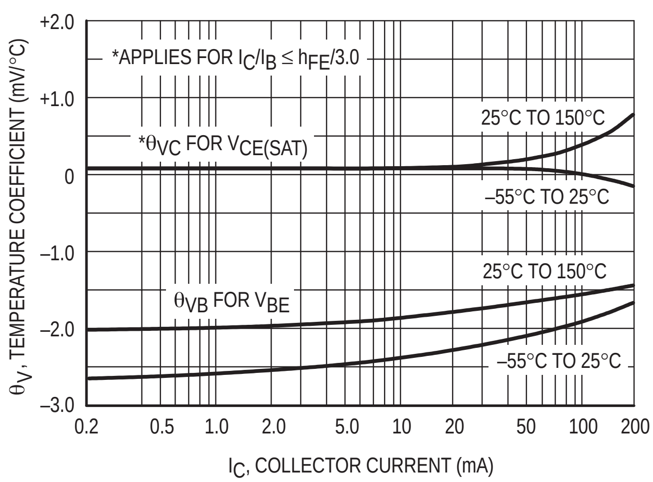
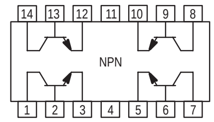


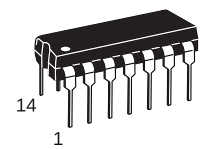
Figure 11. Temperature Coefficients

Quad Amplifier Transistors
NPN Silicon

MPQ2483
MPQ2484*

*Motorola Preferred Device





CASE 646–06, STYLE 1
TO–116

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

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

1. Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.
2. Pulse Test: Pulse Width $\leq$ 300 μs; Duty Cycle $\leq$ 2.0%.

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

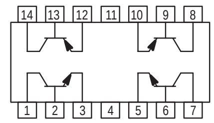
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		100	—	—	
	MPQ2484		200	—	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	—	—	
	MPQ2484		300	—	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	—	—	
	MPQ2484		300	—	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			—	0.13	0.35	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	0.15	0.5	
Base–Emitter Saturation Voltage(2)		$V_{BE(sat)}$				Vdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			—	0.58	0.7	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			—	0.70	0.8	
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		NF				dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms,	MPQ2483		—	3.0	—	
f = 1.0 kHz, BW = 10 kHz)	MPQ2484		—	2.0	—	

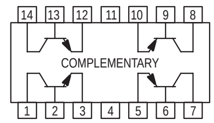
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

Quad Complementary Pair Transistors

NPN/PNP Silicon



MPQ6100A
TYPE A

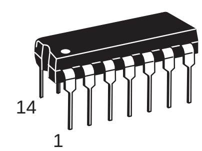


MPQ6600A1
TYPE B

MPQ6100A
MPQ6600A1*

Voltage and Current are negative for PNP Transistors

***Motorola Preferred Device**



CASE 646–06, STYLE 1
TO–116

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 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	% %

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

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

REV 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)	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	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	PNP	C_{ibo}	—	—	8.0	pF
	NPN		—	—	8.0	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, 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

2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

SPOT NOISE FIGURE

(V_{CE} = 10 Vdc, T_A = 25°C)

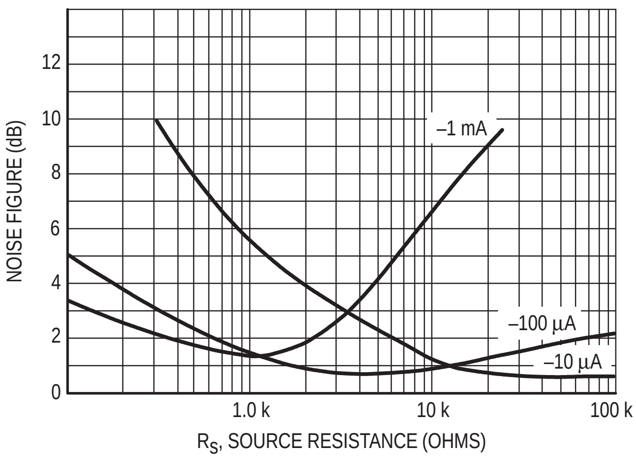


Figure 1. Source Resistance Effects, f = 1.0 kHz

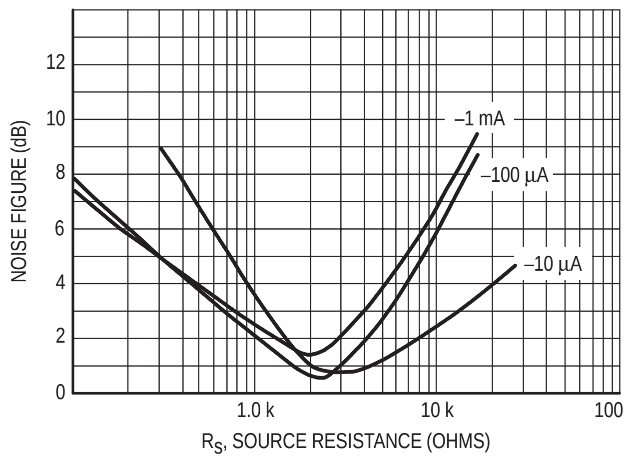


Figure 2. Source Resistance Effects, f = 10 Hz

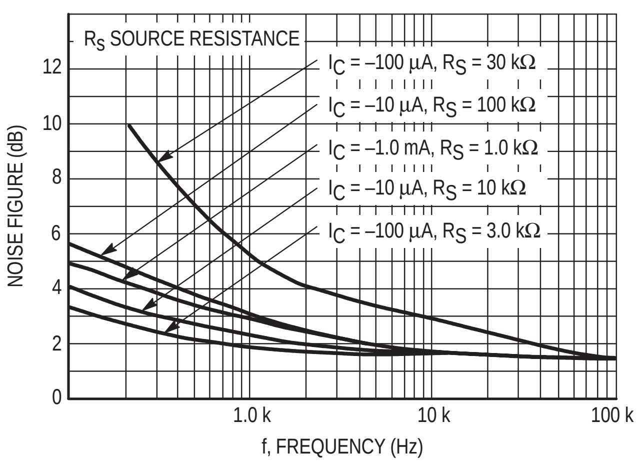


Figure 3. Frequency Effects

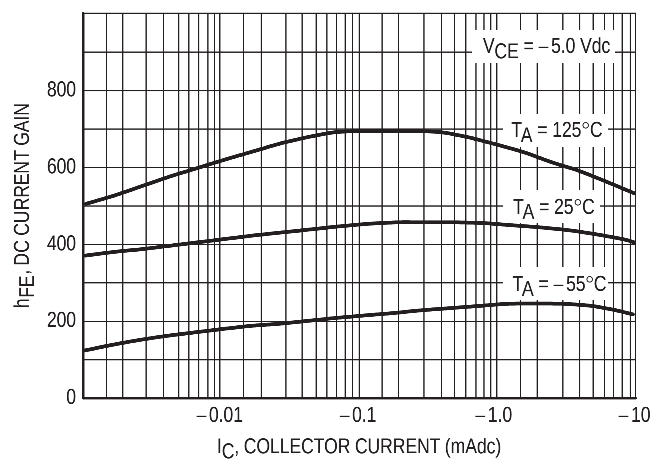
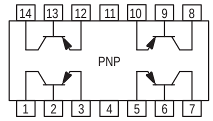


Figure 4. Typical Current Gain Characteristics

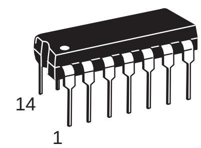
Quad General Purpose Transistors

PNP Silicon



MPQ2906
MPQ2907
MPQ2907A*

*Motorola Preferred Device



CASE 646–06, STYLE 1
TO–116

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) (I_C = –10 mAdc, I_B = 0)	 MPQ2906, MPQ2907 MPQ2907A	$V_{(BR)CEO}$	 –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)	 MPQ2906, MPQ2907 MPQ2907A	I_{CBO}	—	–50	nAdc
Emitter Cutoff Current (V_{EB} = –3.0 Vdc, I_E = 0)	 MPQ2906,7 Only	I_{EBO}	—	–50	nAdc

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

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

REV 3

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

Characteristic		Symbol	Min	Max	Unit
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	
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%.

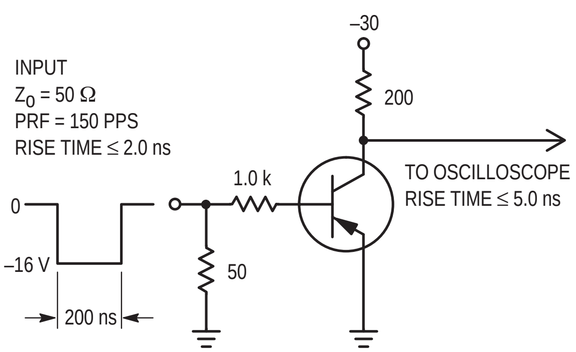


Figure 1. Delay and Rise Time Test Circuit

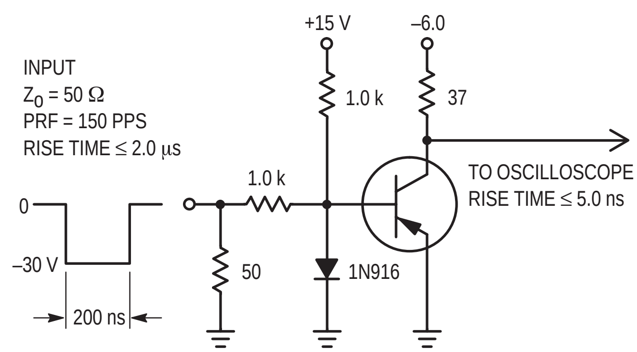


Figure 2. Storage and Fall Time Test Circuit

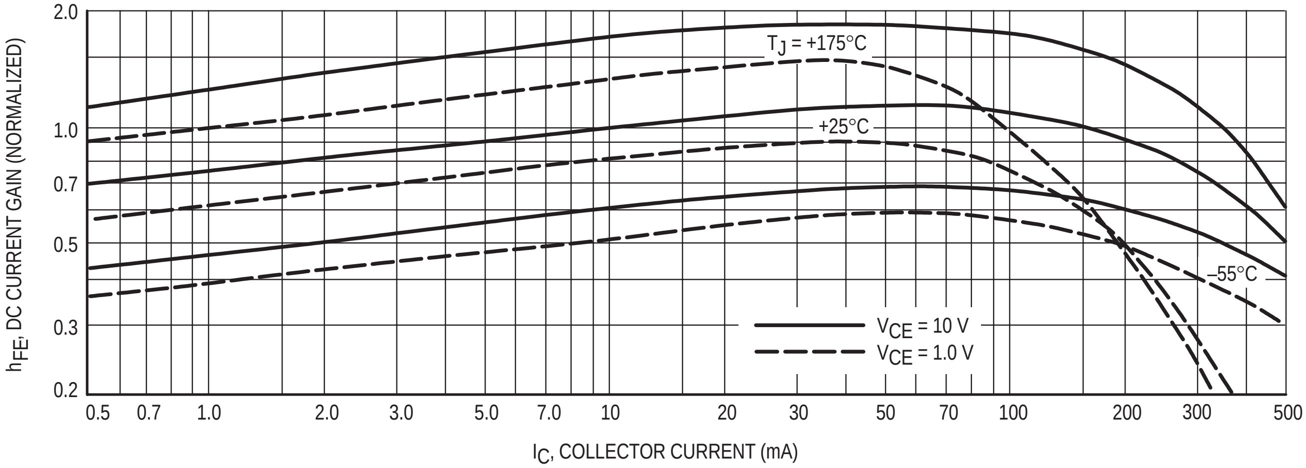


Figure 3. DC Current Gain

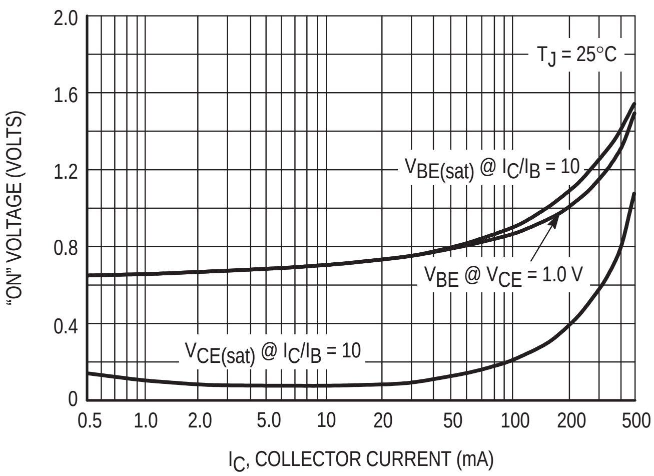


Figure 4. "ON" Voltages

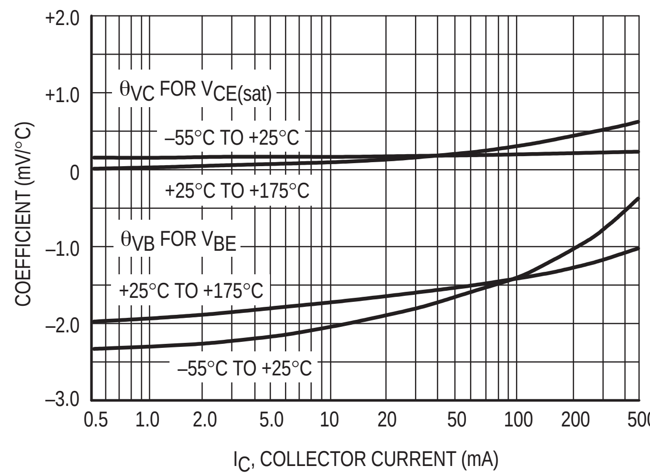


Figure 5. Temperature Coefficients

NOISE FIGURE

(V_{CE} = 10 V, T_A = 25°C)

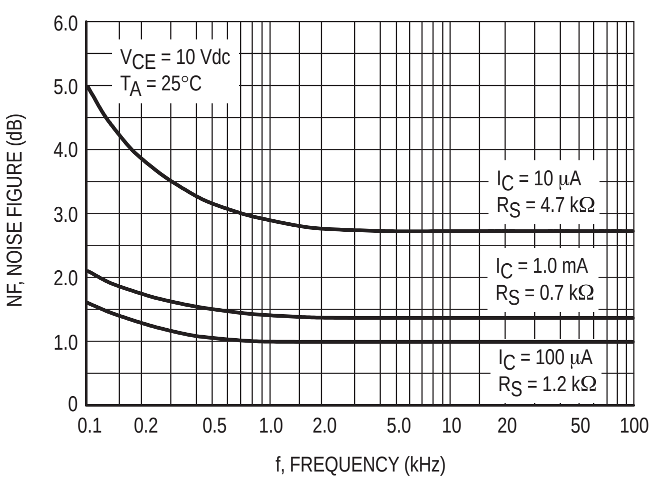


Figure 6. Frequency Effects

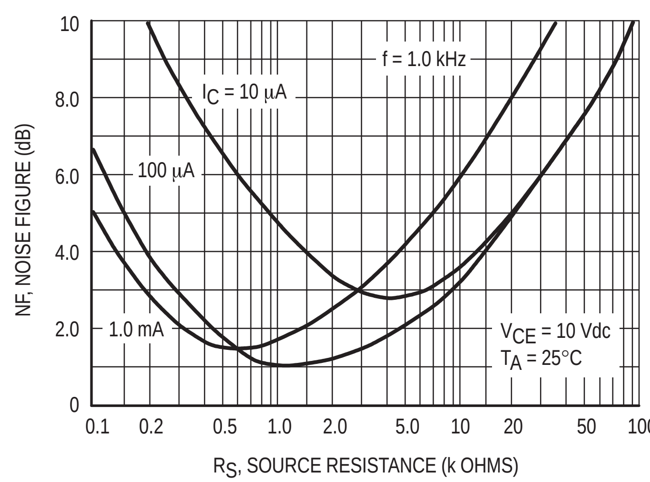


Figure 7. Source Resistance Effects

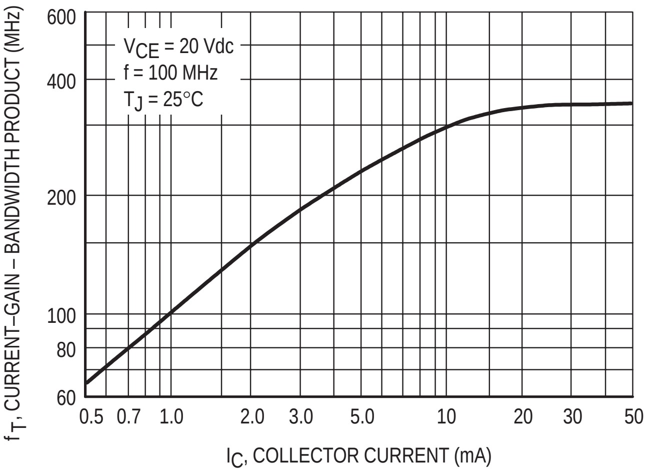


Figure 8. Current–Gain — Bandwidth Product

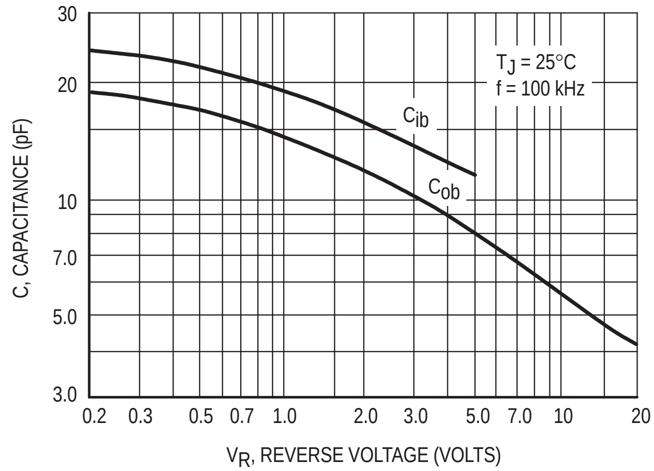


Figure 9. Capacitance

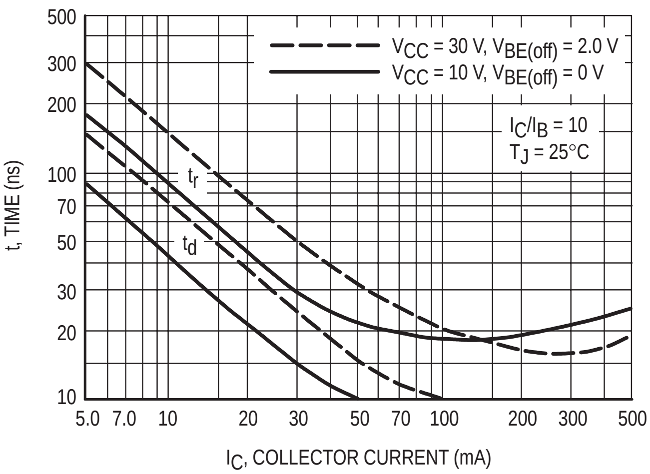


Figure 10. Turn–On Time

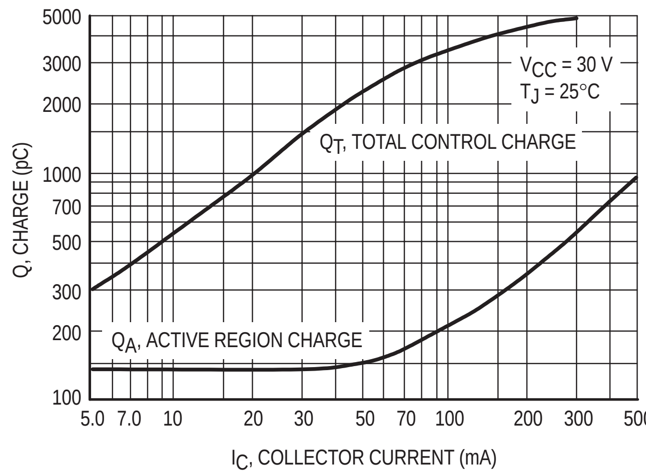


Figure 11. Charge Data

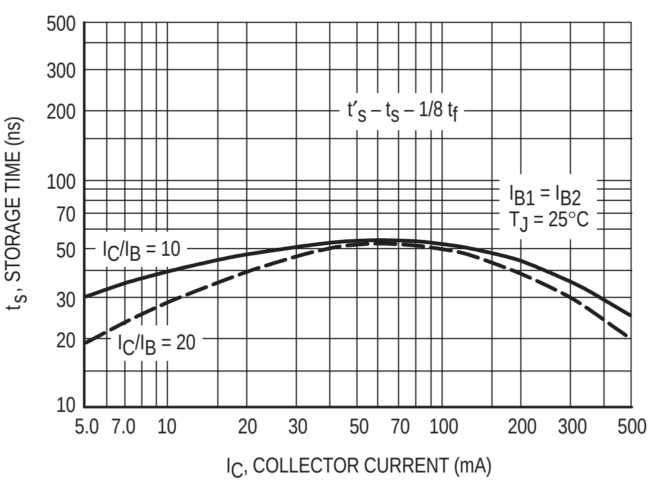


Figure 12. Storage Time

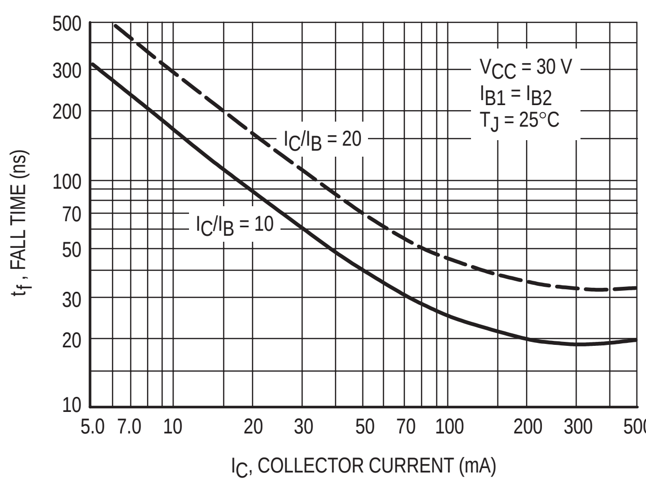


Figure 13. Fall Time

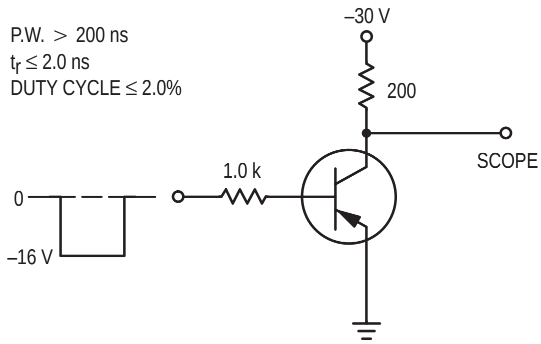


Figure 14. Delay and Rise Time Test Circuit

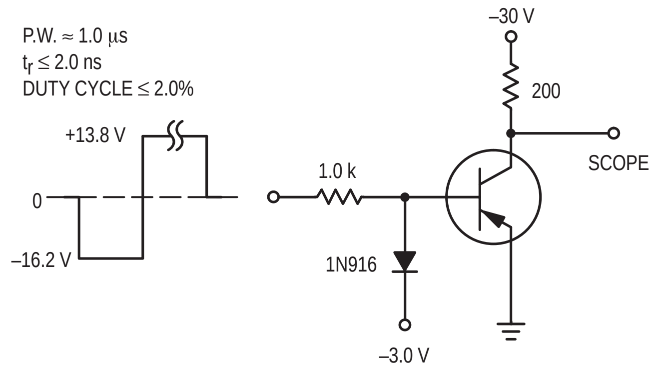
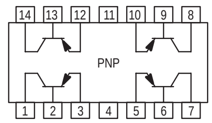


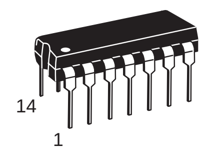
Figure 15. Storage and Fall Time Test Circuit

Quad Memory Driver Transistor
PNP Silicon

MPQ3467

Motorola Preferred Device





CASE 646–06, STYLE 1
TO–116

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

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	% %

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

1. Second Breakdown occurs at power levels greater than 2 times the power dissipation rating.
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
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 $\leq$ 300 μs; Duty Cycle $\leq$ 2.0%.

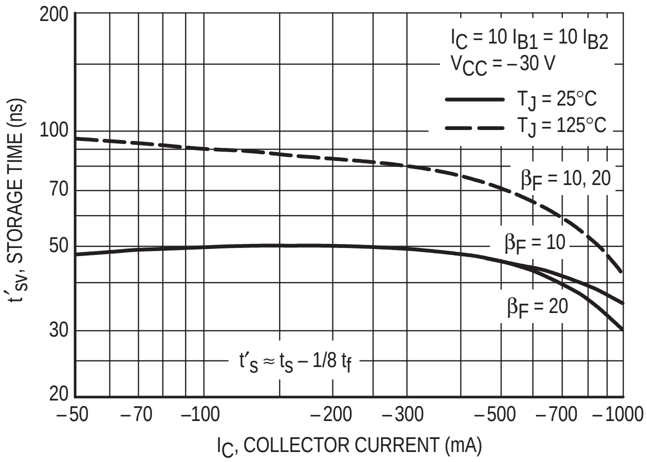


Figure 1. Storage Time Variation with Temperature

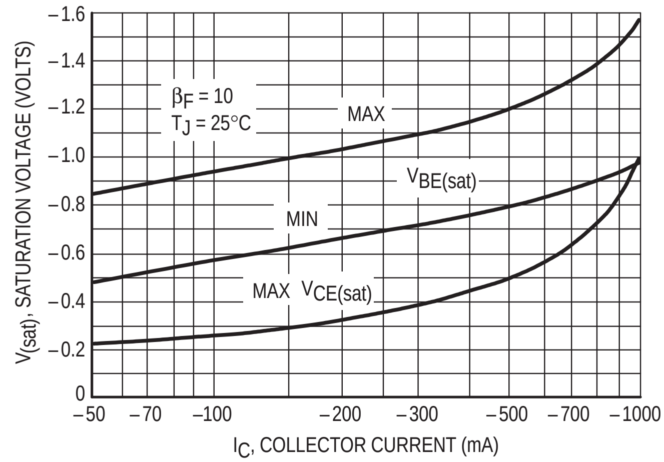


Figure 2. Limits of Saturation Voltage

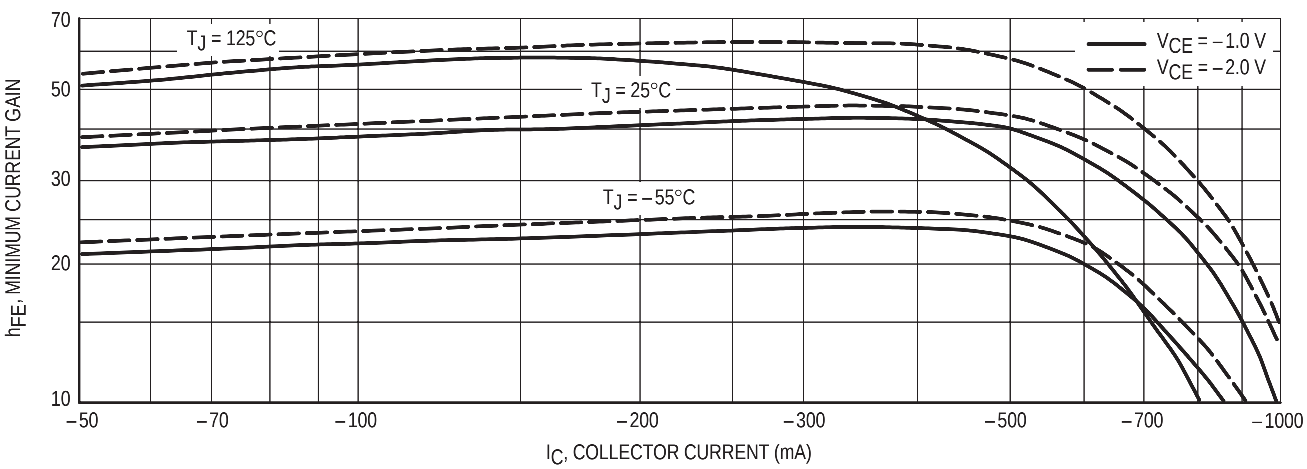
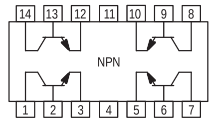


Figure 3. Minimum Current Gain Characteristics

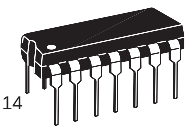
Quad Core Driver Transistor

NPN Silicon



MPQ3725

Motorola Preferred Device



CASE 646–06, STYLE 1
TO–116

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

Characteristic	Symbol	Max		Unit
		One Transistor	**Effective For Four Transistors**	
Thermal Resistance, Junction to Ambient(1)	$R_{\theta JA}$	125	50	°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)	$V_{(BR)CEO}$	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

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%.

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

REV 3

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		35	75	200	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		25	45	—	
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	1.1	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
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

2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

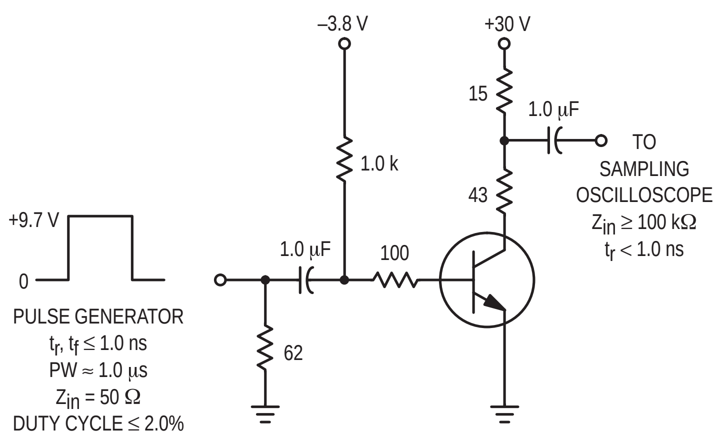


Figure 1. Switching Times Test Circuit

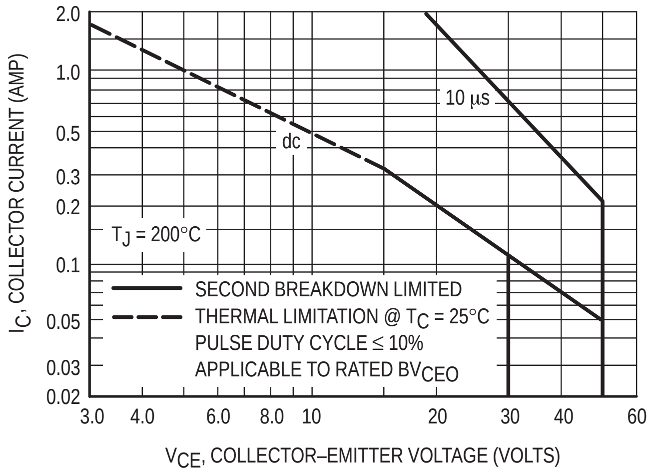


Figure 2. Active–Region Safe Operating Area

TYPICAL DC CHARACTERISTICS

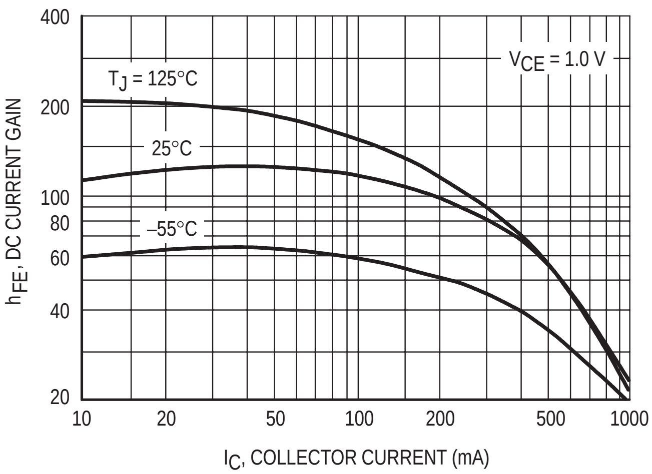


Figure 3. DC Current Gain

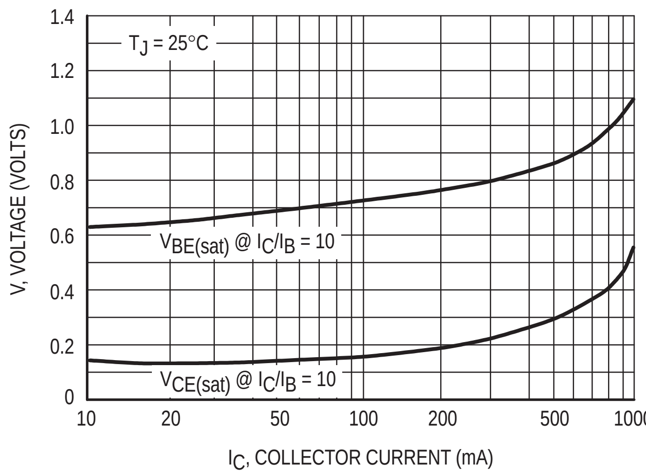


Figure 4. "ON" Voltages

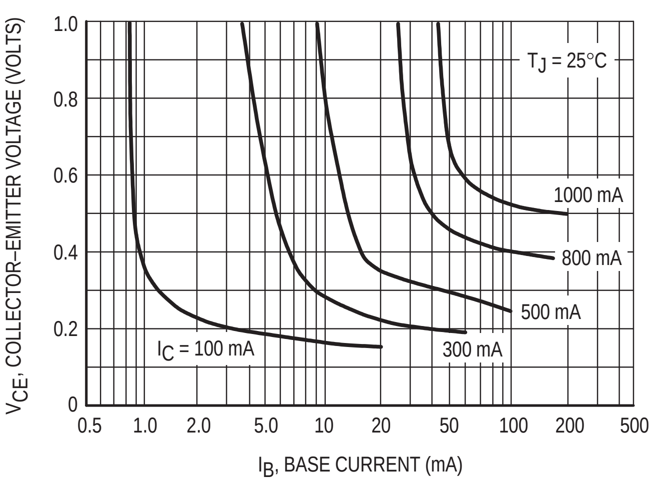


Figure 5. Collector Saturation Region

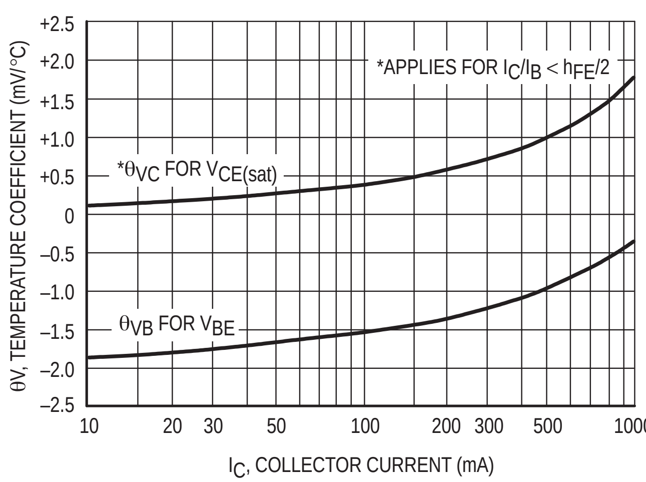


Figure 6. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

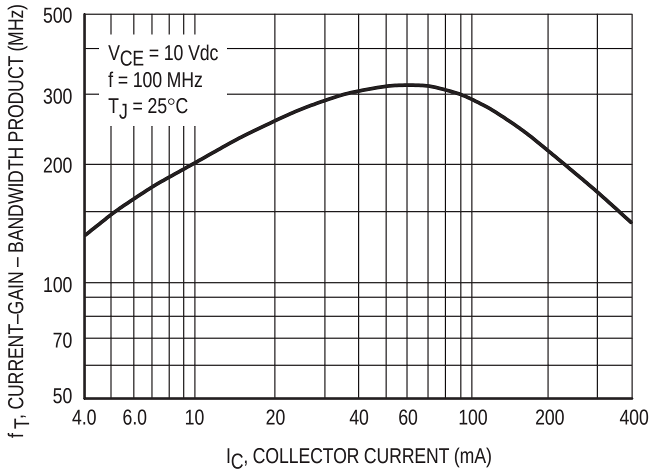


Figure 7. Current–Gain — Bandwidth Product

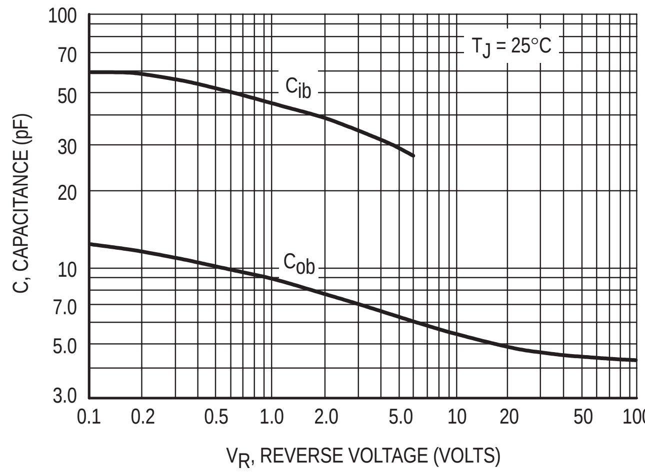


Figure 8. Capacitance

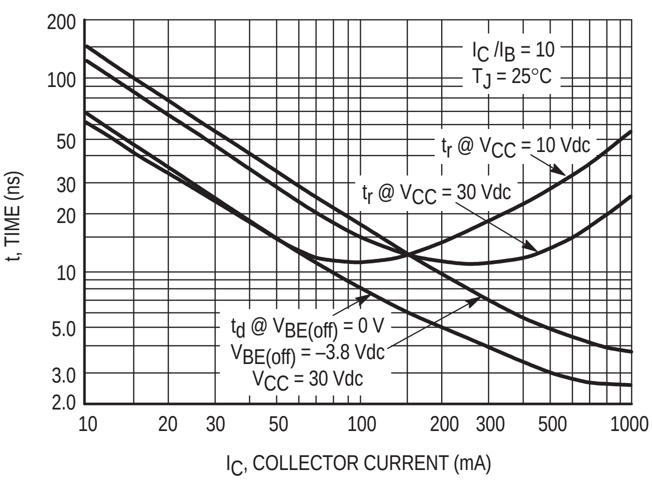


Figure 9. Turn–On Time

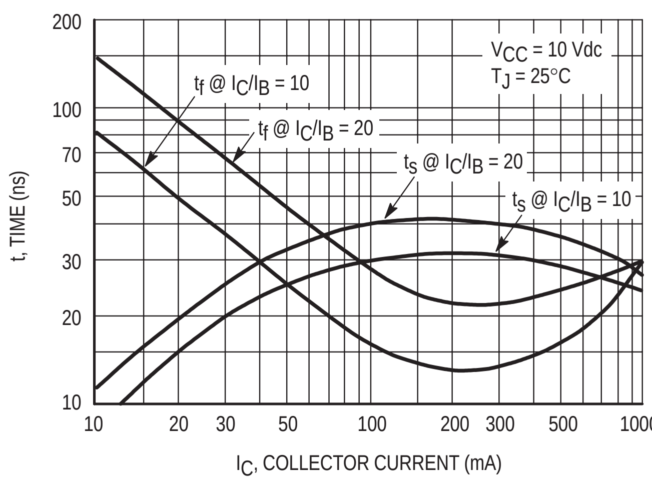


Figure 10. Turn–Off Time

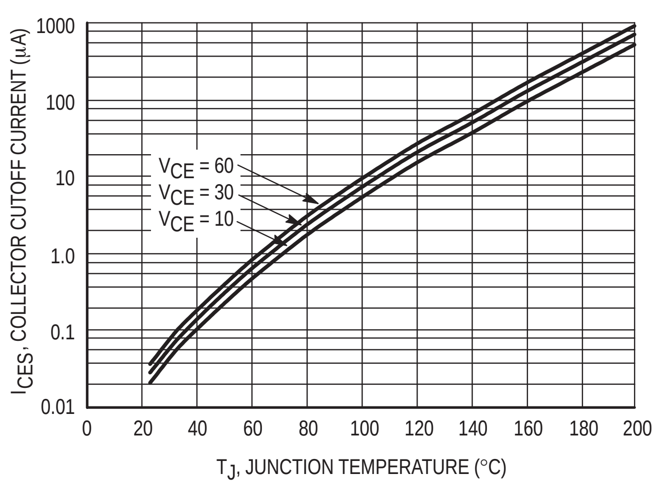
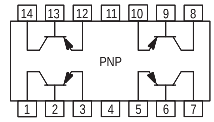


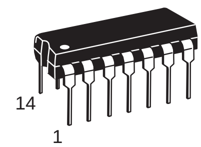
Figure 11. Collector Cutoff Current

Quad Memory Driver Transistor

PNP Silicon

MPQ3762





CASE 646–06, STYLE 1
TO–116

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 Effective, 4 Die	100 39	167 73.5	°C/W °C/W
Coupling Factors	Q1–Q4 or Q2–Q3 Q1–Q2 or Q3–Q4	46 5.0	56 10	% %

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

Characteristic	Symbol	Min	Typ	Max	Unit
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

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%.

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

Characteristic	Symbol	Min	Typ	Max	Unit
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%.

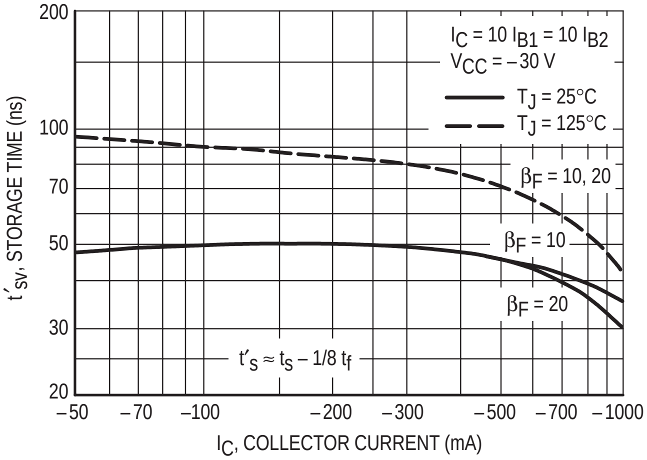


Figure 1. Storage Time Variation with Temperature

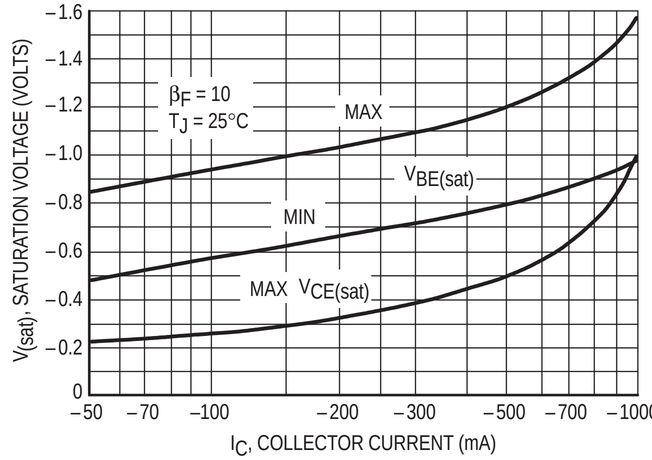


Figure 2. Limits of Saturation Voltage

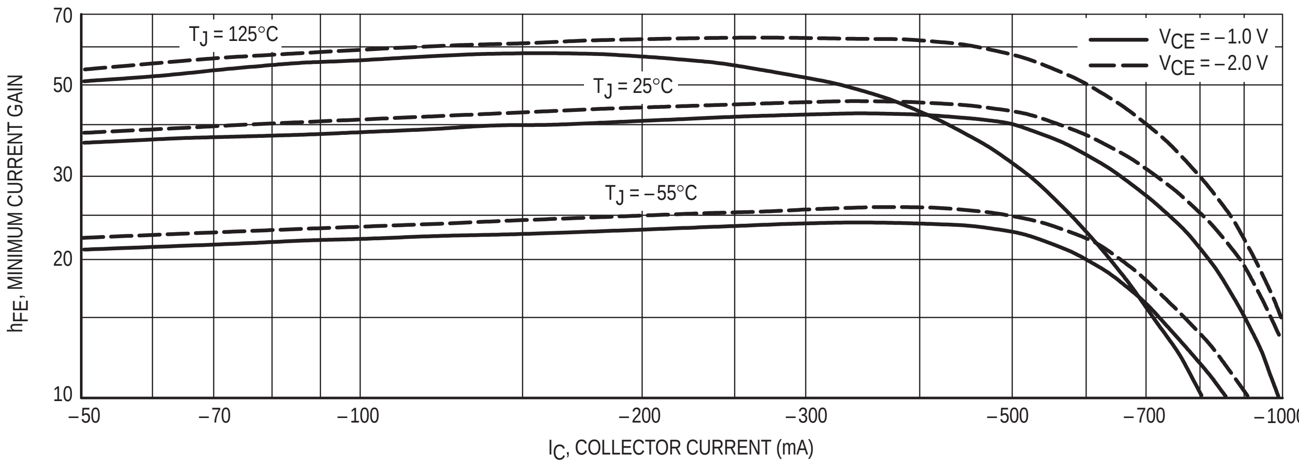


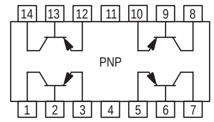
Figure 3. Minimum Current Gain Characteristics

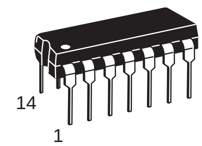
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Quad Amplifier Transistors
PNP Silicon

MPQ3798
MPQ3799*

*Motorola Preferred Device





CASE 646–06, STYLE 1
TO–116

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	Watts 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

THERMAL CHARACTERISTICS

Characteristic		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1–Q4 or Q2–Q3 Q1–Q2 or Q3–Q4	34 2.0	70 26	% %

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(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

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%.

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

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = –10 μAdc, V_{CE} = –5.0 Vdc)	MPQ3798		100	—	—	
	MPQ3799		225	—	—	
(I_C = –100 μAdc, V_{CE} = –5.0 Vdc)	MPQ3798		150	—	—	
	MPQ3799		300	—	—	
(I_C = –500 μAdc, V_{CE} = –5.0 Vdc)	MPQ3798		150	—	—	
	MPQ3799		300	—	—	
(I_C = –10 mAdc, V_{CE} = –5.0 Vdc)	MPQ3798		125	—	—	
	MPQ3799		250	—	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = –100 μAdc, I_B = –10 μAdc)			—	–0.12	–0.2	
(I_C = –1.0 mAdc, I_B = –100 μAdc)			—	–0.07	–0.25	
Base–Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = –100 μAdc, I_B = –10 μAdc)			—	–0.62	–0.7	
(I_C = –1.0 mAdc, I_B = –100 μAdc)			—	–0.68	–0.8	
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		NF				dB
(I_C = –100 μAdc, V_{CE} = –10 Vdc, R_S = 3.0 k ohms,	MPQ3798		—	2.5	—	
f = 1.0 kHz)	MPQ3799		—	1.5	—	

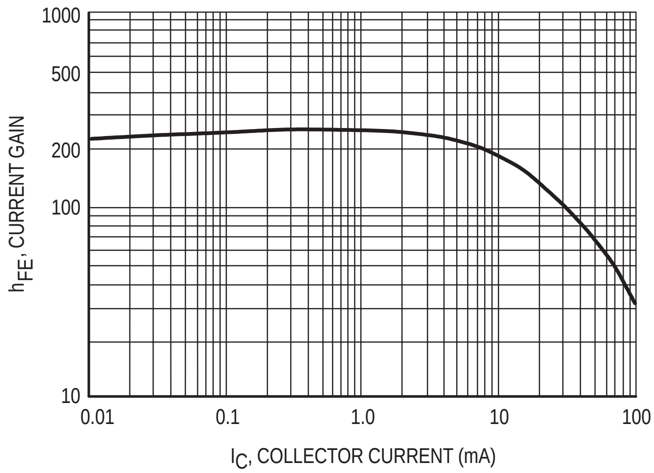


Figure 1. DC Current Gain versus Collector Current

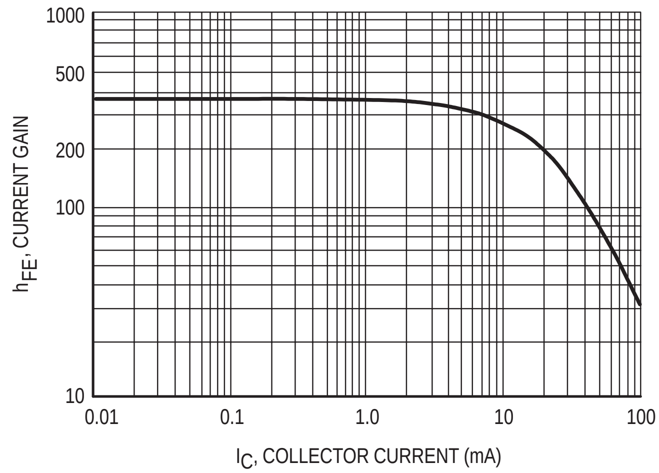


Figure 2. DC Current Gain versus Collector Current

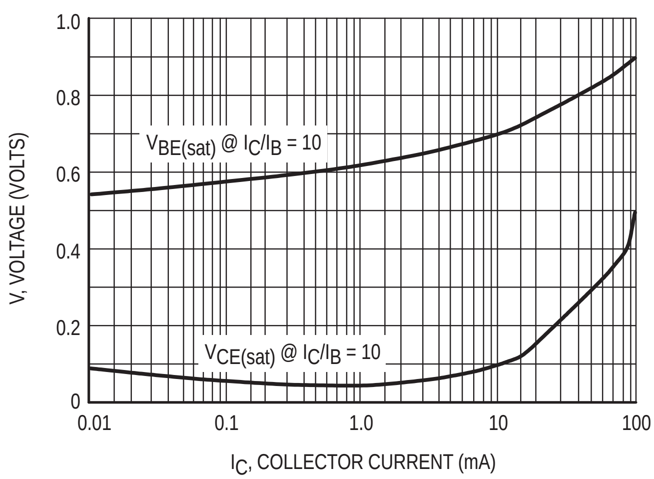


Figure 3. “ON” Voltages

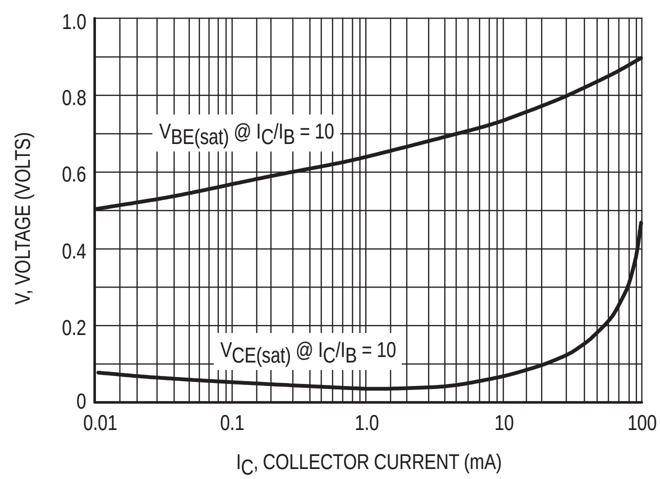


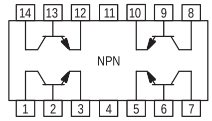
Figure 4. “ON” Voltages

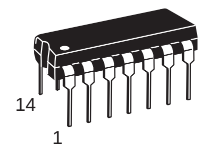
Quad Amplifier Switching Transistor

NPN Silicon

MPQ3904

Motorola Preferred Device





CASE 646–06, STYLE 1
TO–116

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector–Emitter Voltage	V_{CEO}	40		Vdc
Collector–Base Voltage	V_{CBO}	60		Vdc
Emitter–Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 825 6.7	 2.4 19.2	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1–Q4 or Q2–Q3 Q1–Q2 or Q3–Q4	34 2.0	70 26	% %

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 40 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc

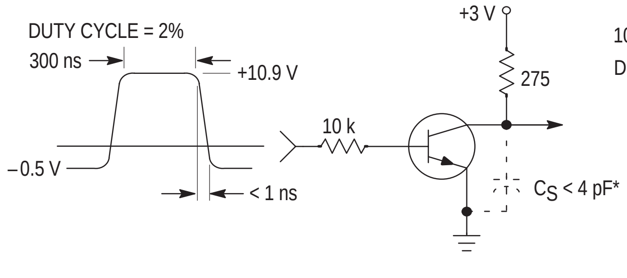
1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

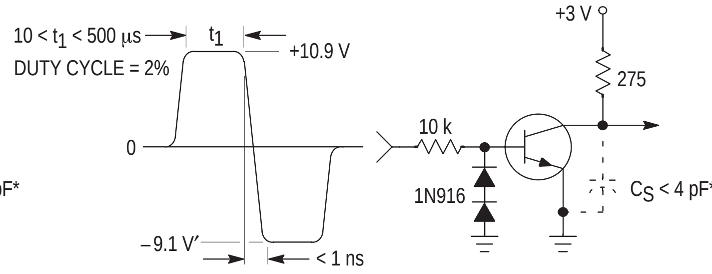
Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic	Symbol	Min	Typ	Max	Unit
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%.





* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

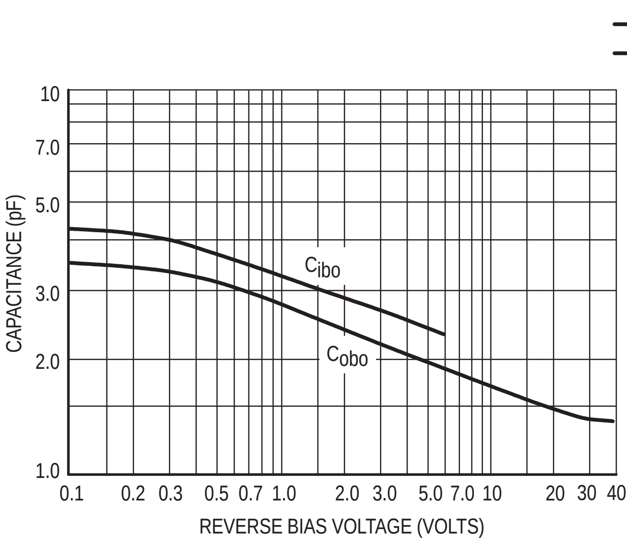


Figure 3. Capacitance

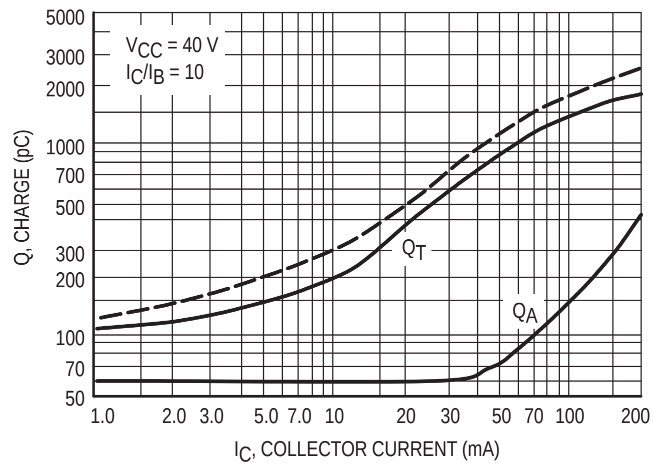


Figure 4. Charge Data

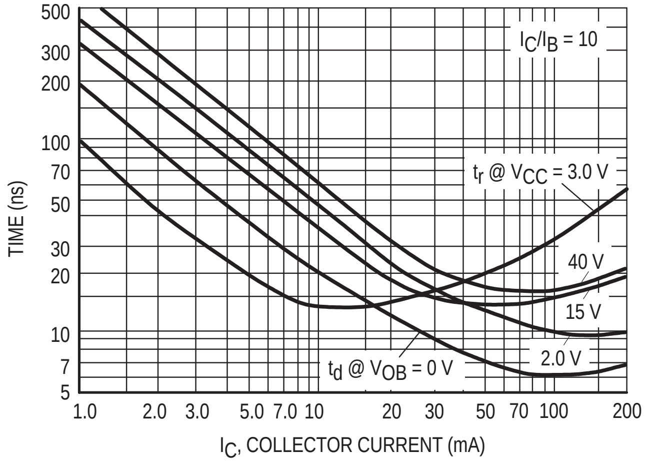


Figure 5. Turn–On Time

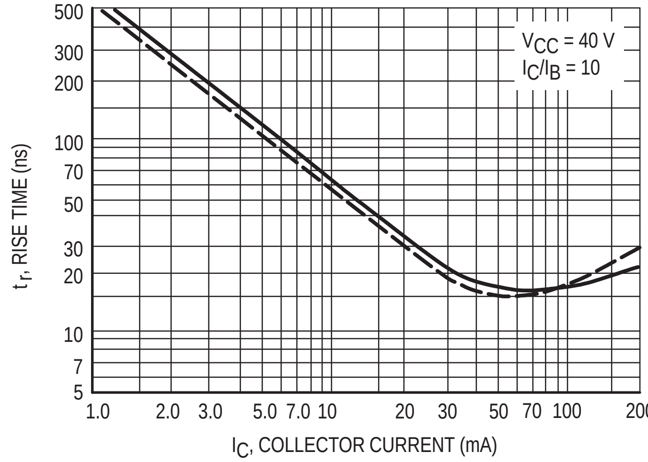


Figure 6. Rise Time

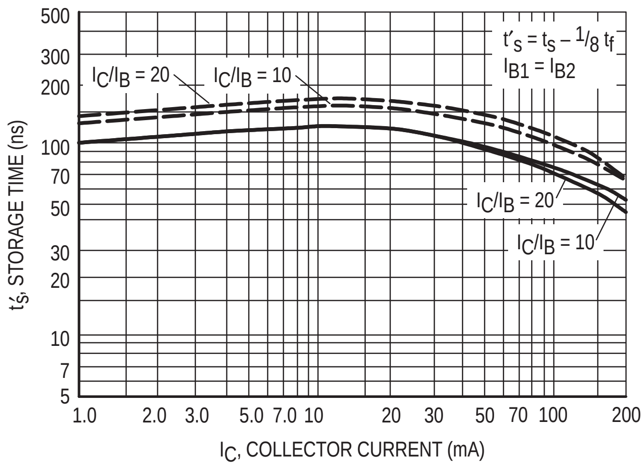


Figure 7. Storage Time

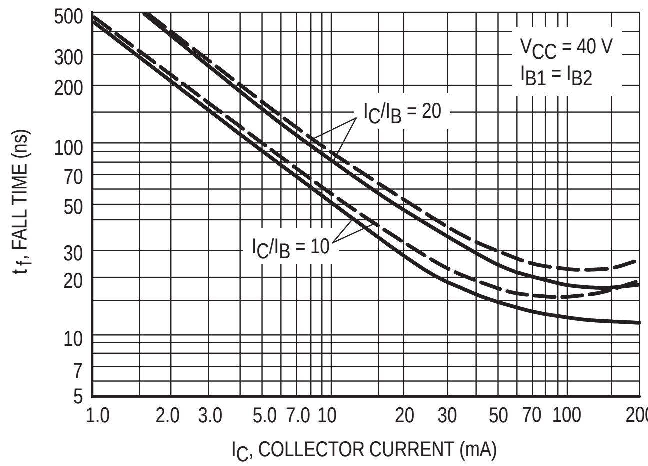


Figure 8. Fall Time

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS NOISE FIGURE VARIATIONS

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

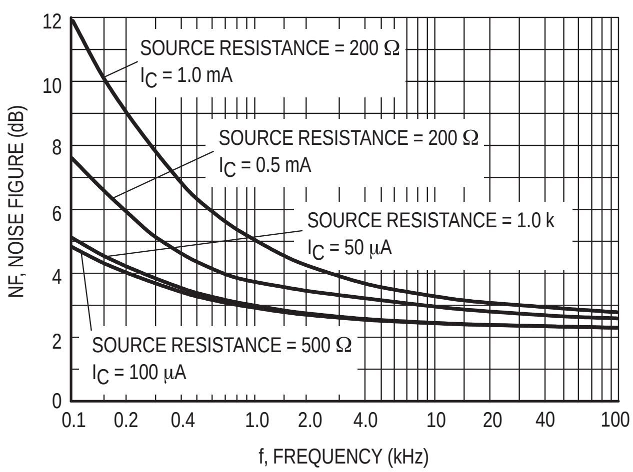


Figure 9.

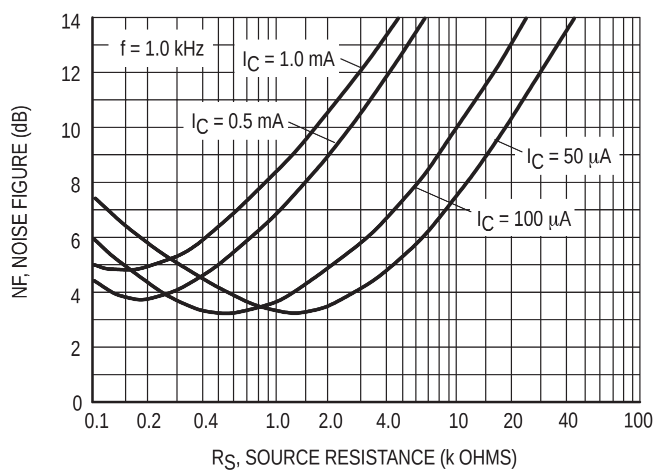


Figure 10.

h PARAMETERS

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

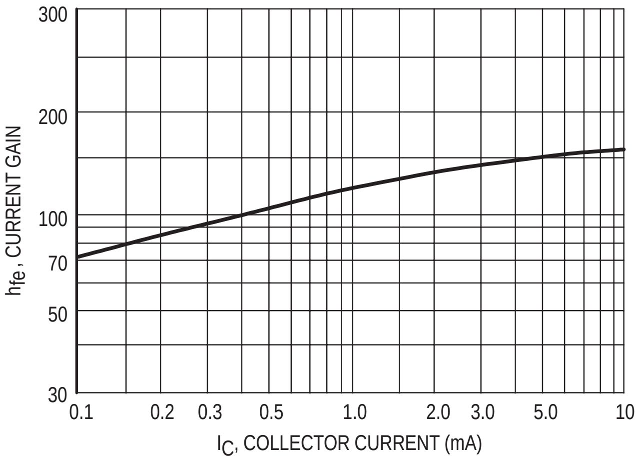


Figure 11. Current Gain

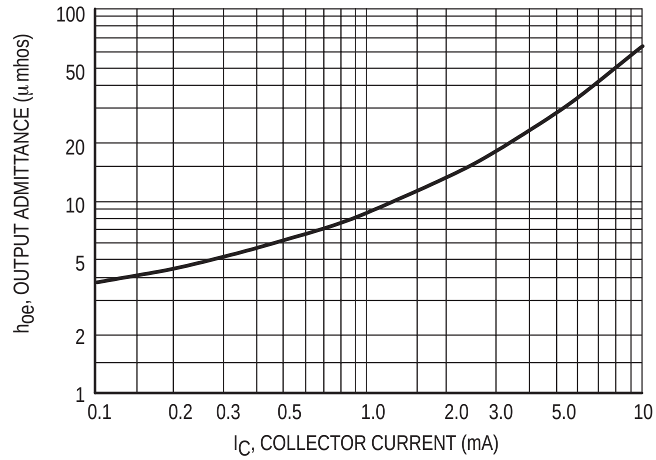


Figure 12. Output Admittance

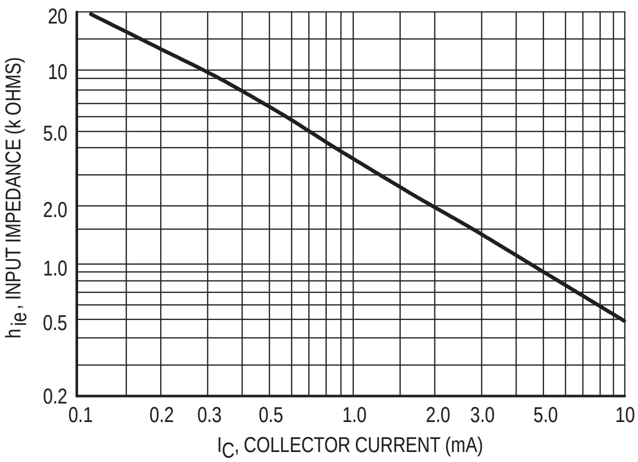


Figure 13. Input Impedance

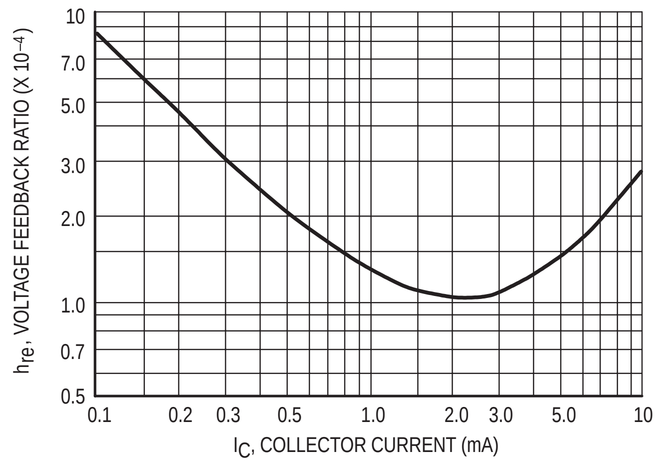


Figure 14. Voltage Feedback Ratio

TYPICAL STATIC CHARACTERISTICS

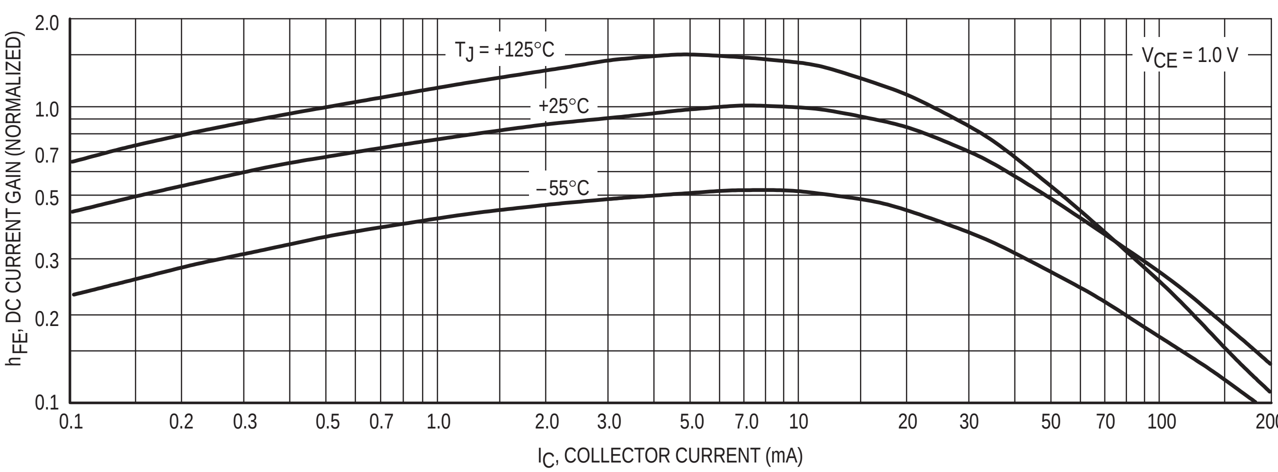


Figure 15. DC Current Gain

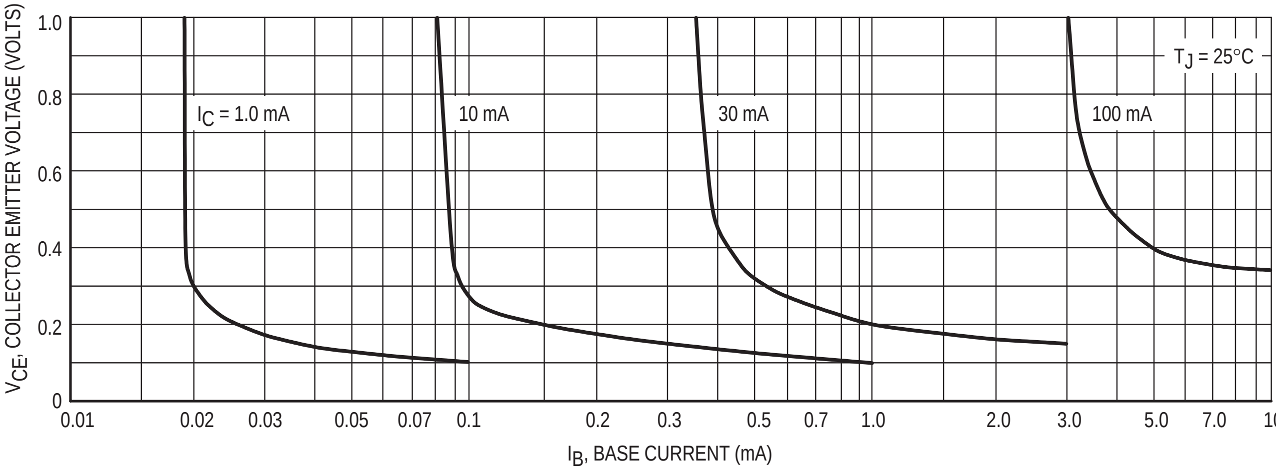


Figure 16. Collector Saturation Region

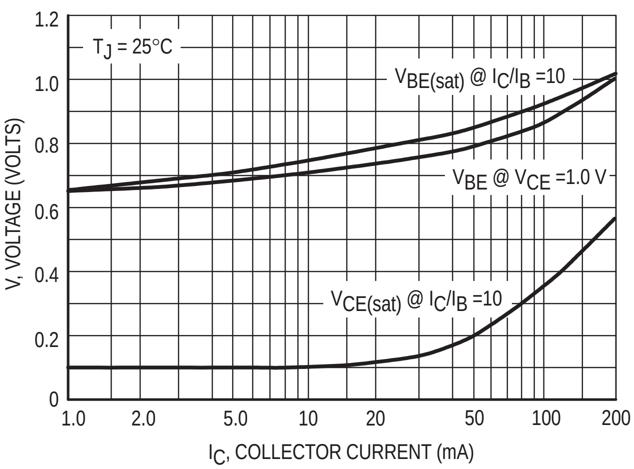


Figure 17. “ON” Voltages

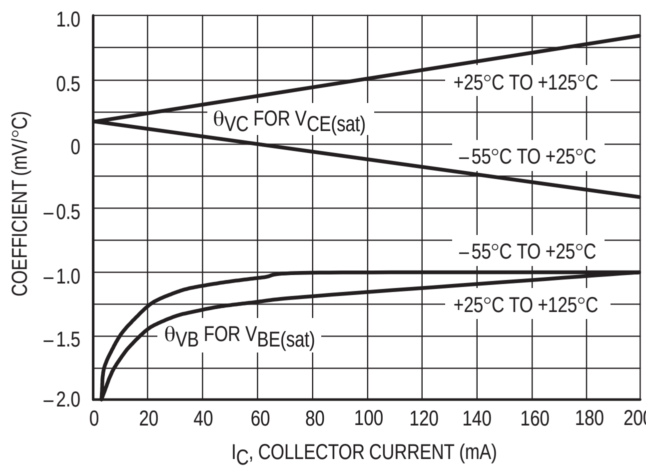
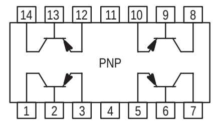


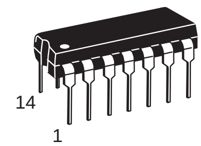
Figure 18. Temperature Coefficients

Quad Amplifier Switching Transistor
PNP Silicon

MPQ3906

Motorola Preferred Device





CASE 646–06, STYLE 1
TO–116

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

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1–Q4 or Q2–Q3 Q1–Q2 or Q3–Q4	34 2.0	70 26	% %

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(1) (I_C = –1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	–40	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = –10 μAdc, I_E = 0)	$V_{(BR)CBO}$	–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

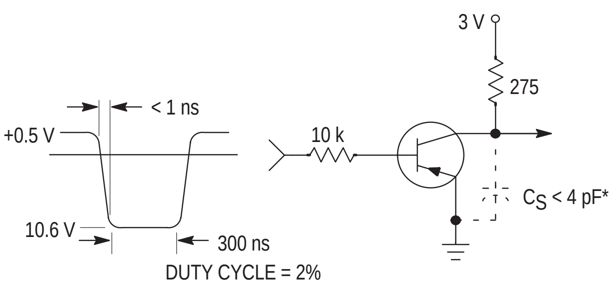
1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

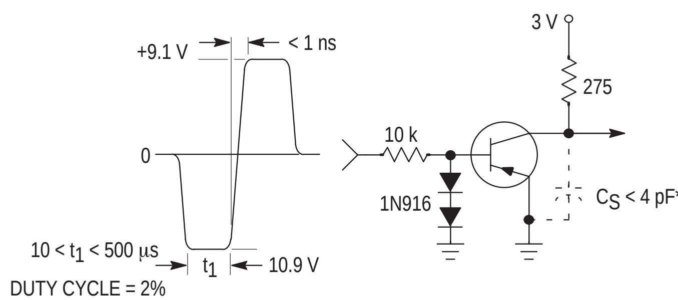
Preferred devices are Motorola recommended choices for future use and best overall value.

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				—
(I_C = –0.1 mAdc, V_{CE} = –1.0 Vdc)		40	160	—	
(I_C = –1.0 mAdc, V_{CE} = –1.0 Vdc)		60	180	—	
(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	–0.25	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%.



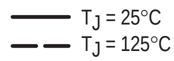


* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS



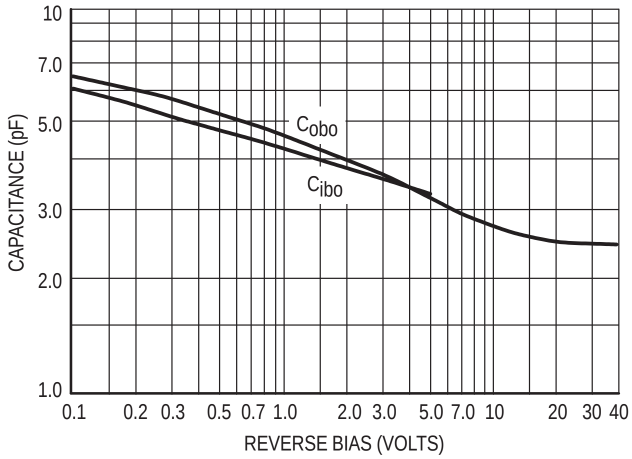


Figure 3. Capacitance

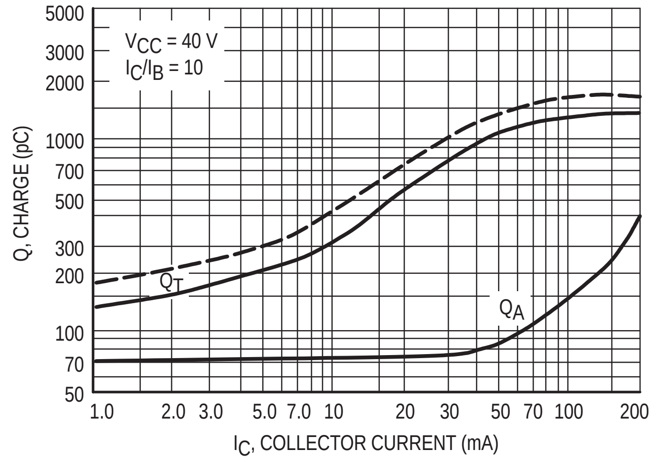


Figure 4. Charge Data

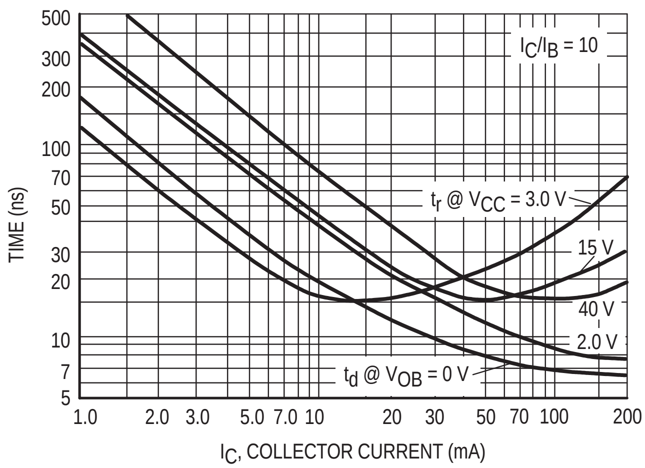


Figure 5. Turn–On Time

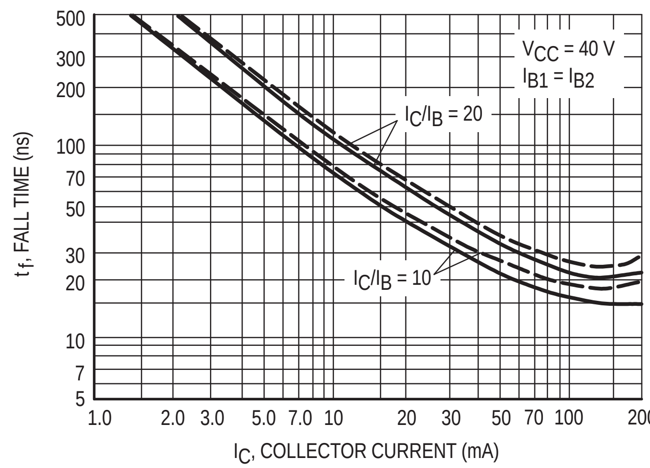


Figure 6. Fall Time

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

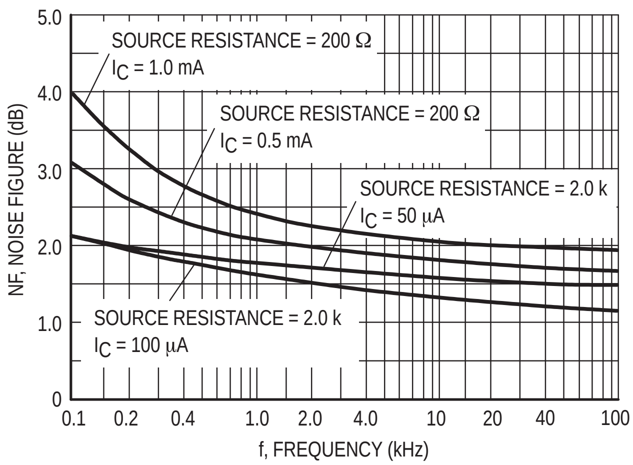


Figure 7.

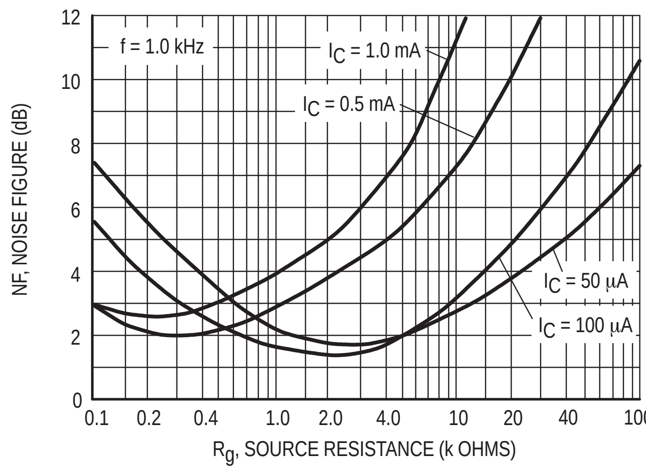


Figure 8.

h PARAMETERS

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

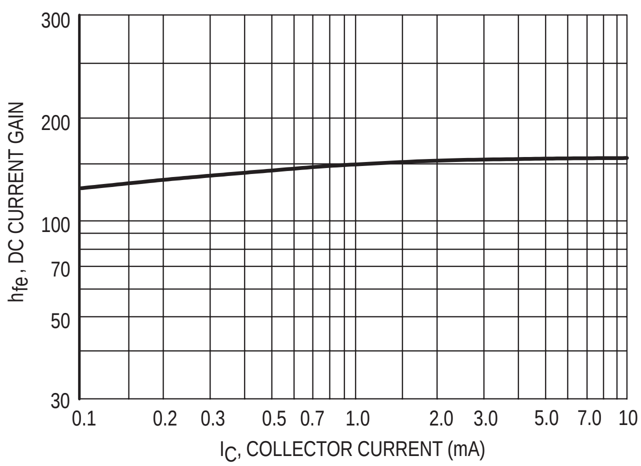


Figure 9. Current Gain

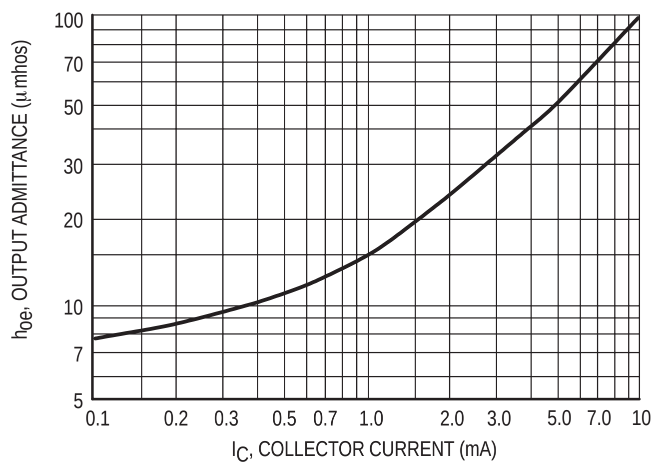


Figure 10. Output Admittance

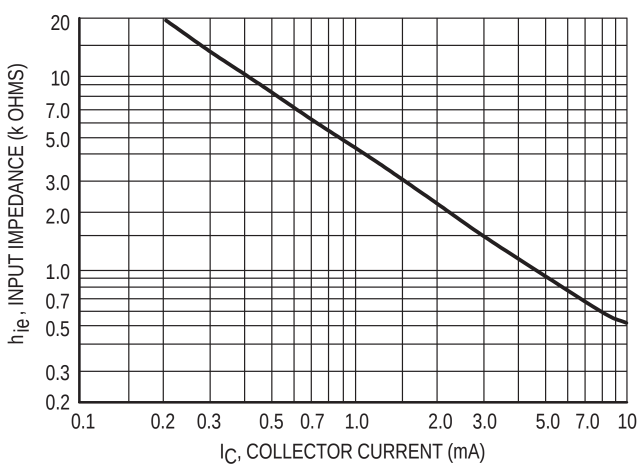


Figure 11. Input Impedance

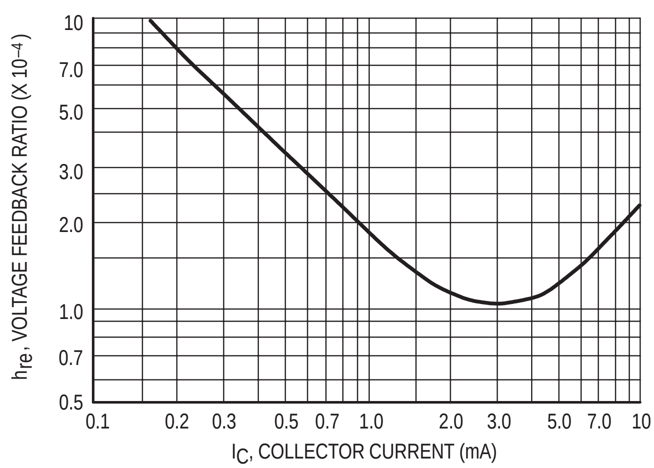


Figure 12. Voltage Feedback Ratio

TYPICAL STATIC CHARACTERISTICS

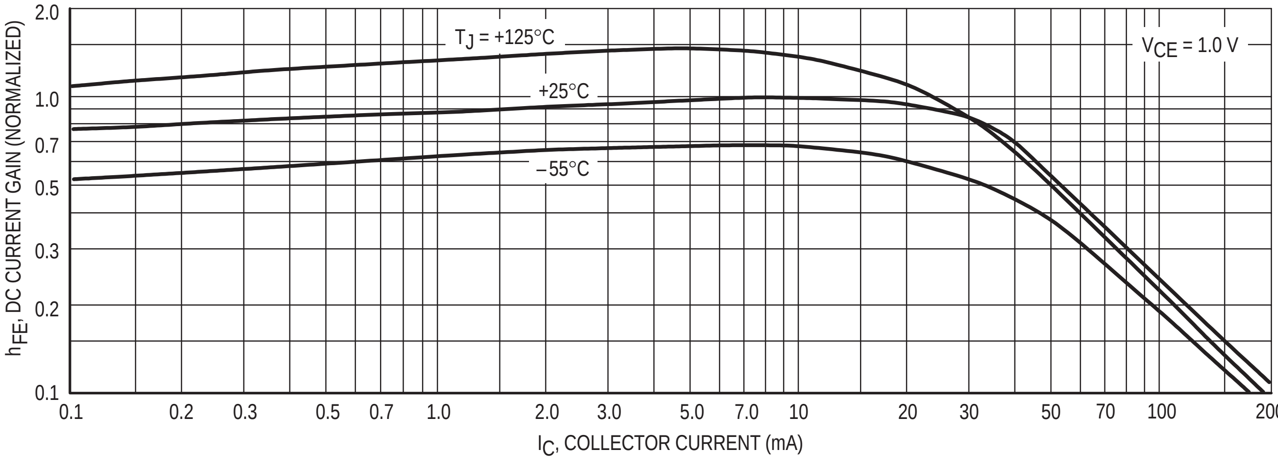


Figure 13. DC Current Gain

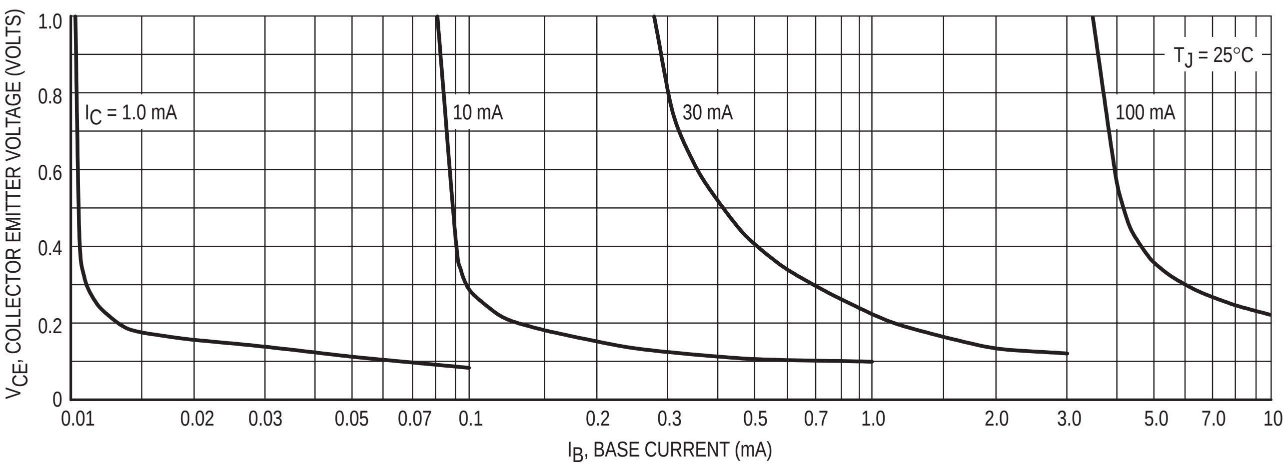


Figure 14. Collector Saturation Region

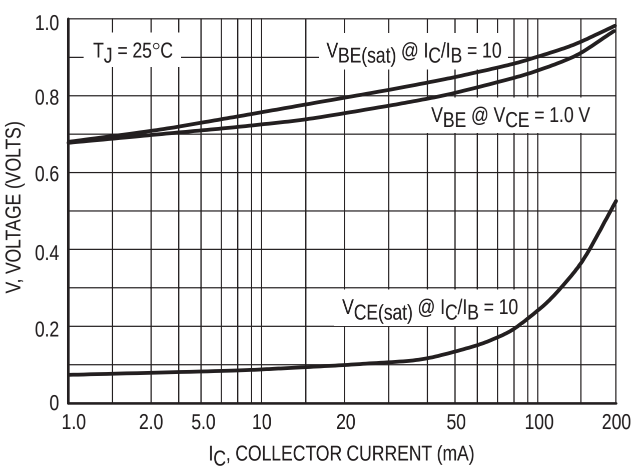


Figure 15. "ON" Voltages

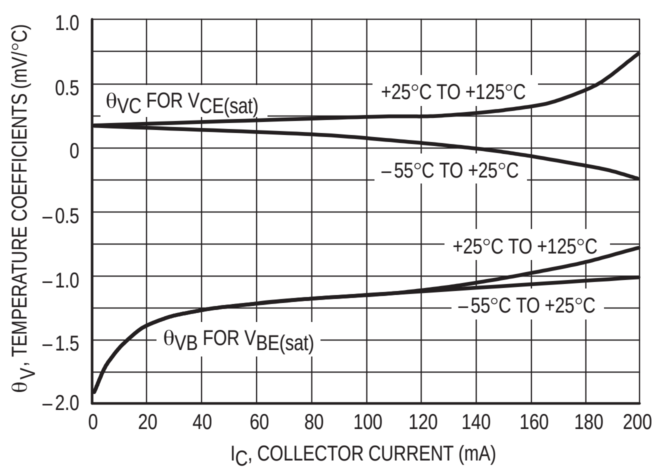


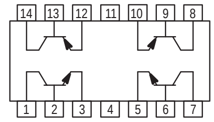
Figure 16. Temperature Coefficients

Quad Complementary Pair Transistors

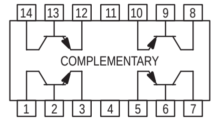
NPN/PNP Silicon

MPQ6001
MPQ6002
MPQ6502

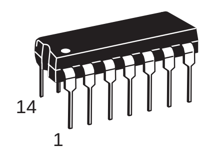
Voltage and current are negative for PNP transistors



MPQ6001, MPQ6002
TYPE A



MPQ6502
TYPE B



CASE 646–06, STYLE 1
TO–116

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, MPQ6502 Derate above 25°C MPQ6001, MPQ6002, MPQ6502	P_D	 0.65 5.18	 1.25 10	Watts mW/°C
Total Device Dissipation @ T_C = 25°C MPQ6001, MPQ6002, MPQ6502 Derate above 25°C MPQ6001, MPQ6002, MPQ6502	P_D	 1.0 8.0	 3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance				°C/W
Each Die	MPQ6001, MPQ6002, MPQ6502	125	193	
Effective, 4 Die	MPQ6001, MPQ6002, MPQ6502	41.6	100	
Coupling Factors				%
Q1–Q4 or Q2–Q3	MPQ6001, MPQ6002, MPQ6502	30	60	
Q1–Q2 or Q3–Q4	MPQ6001, MPQ6002, MPQ6502	20	24	

1. Voltage and Current are negative for PNP devices.

REV 3

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		25	—	—	
	MPQ6002, MPQ6502		50	—	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPQ6001		35	—	—	
	MPQ6002, MPQ6502		75	—	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MPQ6001		40	—	—	
	MPQ6002, MPQ6502		100	—	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MPQ6001		20	—	—	
	MPQ6002, MPQ6502		30	—	—	
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

2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

NPN DATA

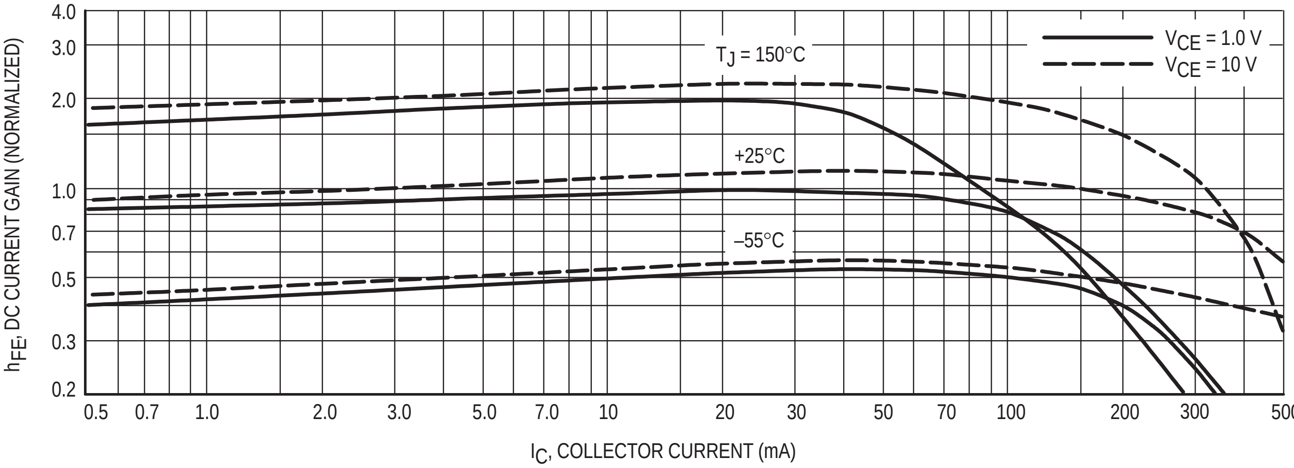


Figure 1. Normalized DC Current Gain

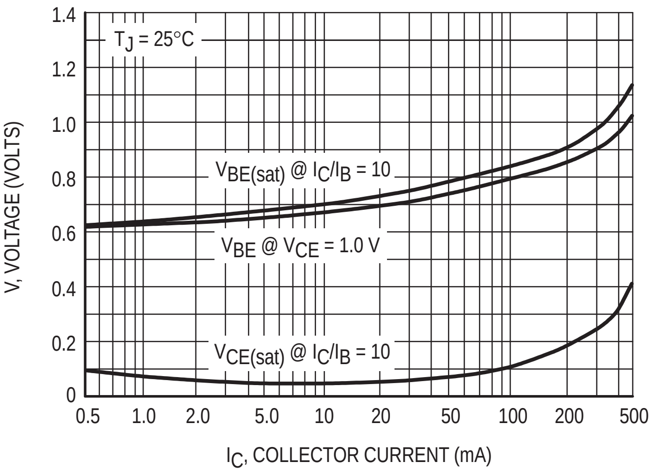


Figure 2. "ON" Voltages

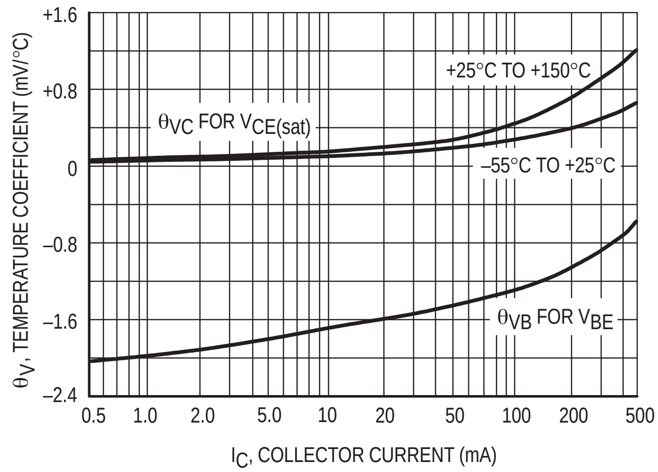


Figure 3. Temperature Coefficients

NOISE FIGURE

(V_{CE} = 10 Vdc, T_A = 25°C)

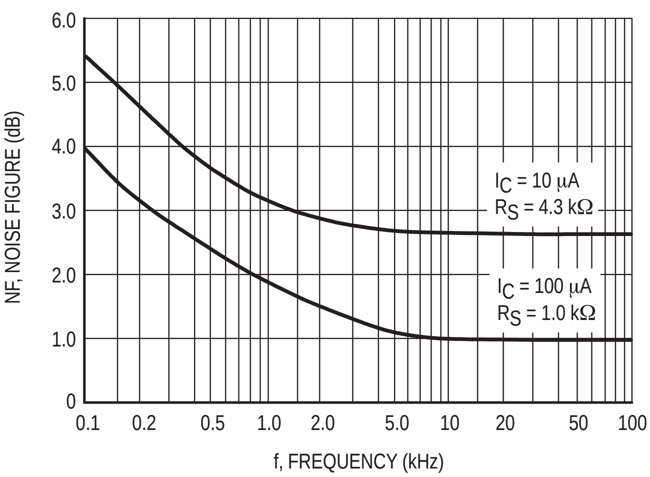


Figure 4. Frequency Effects

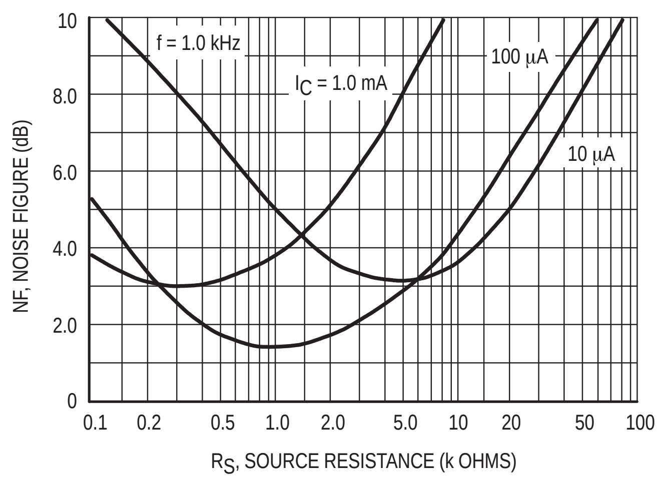
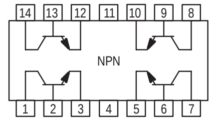


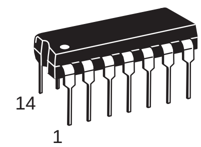
Figure 5. Source Resistance Effects

Quad Darlington Transistor

NPN Silicon

MPQ6426





CASE 646–06, STYLE 1
TO–116

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

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1–Q4 or Q2–Q3 Q1–Q2 or Q3–Q4	34 2.0	70 26	% %

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

Characteristic	Symbol	Min	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

1. Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.
2. Pulse Test: Pulse Width $\leq$ 300 μs; Duty Cycle $\leq$ 2.0%.

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS(2)				
DC Current Gain	h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		5000	—	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		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 $\leq$ 300 μs; Duty Cycle $\leq$ 2.0%.

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

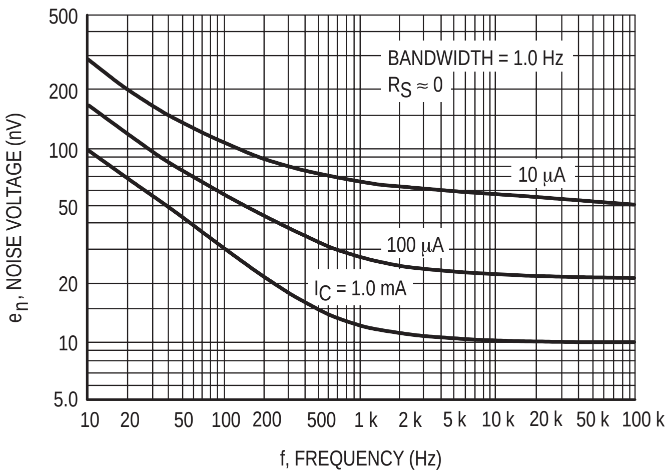


Figure 1. Noise Voltage

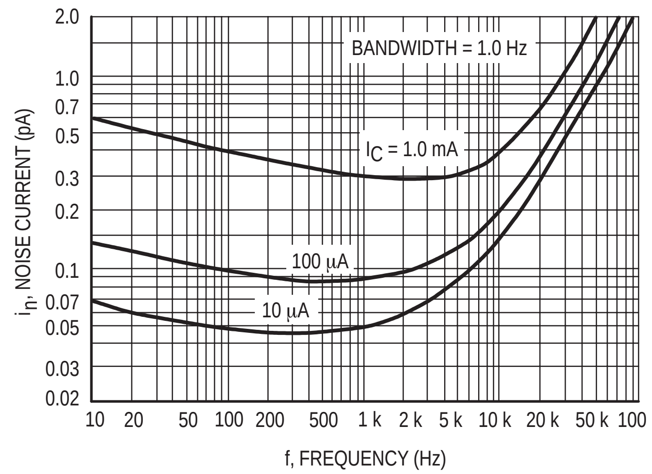


Figure 2. Noise Current

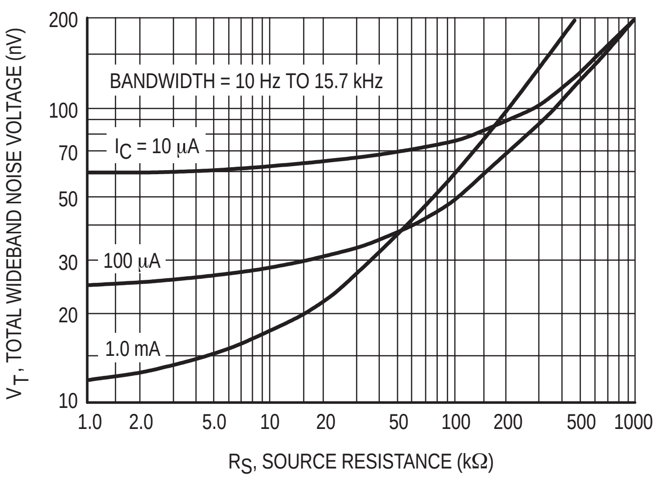


Figure 3. Total Wideband Noise Voltage

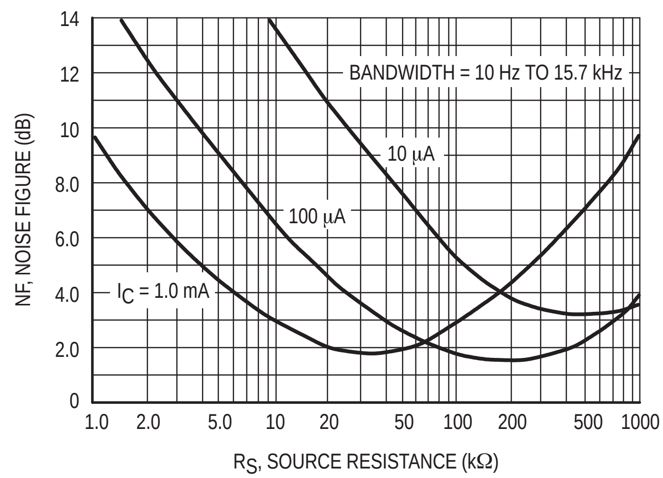


Figure 4. Wideband Noise Figure

DYNAMIC CHARACTERISTICS

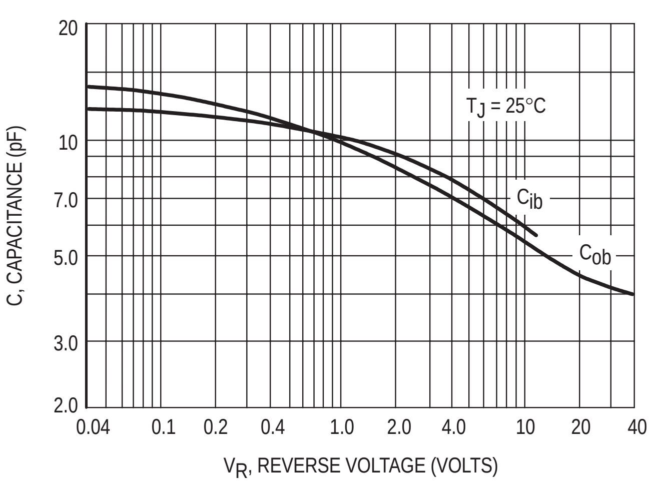


Figure 5. Capacitance

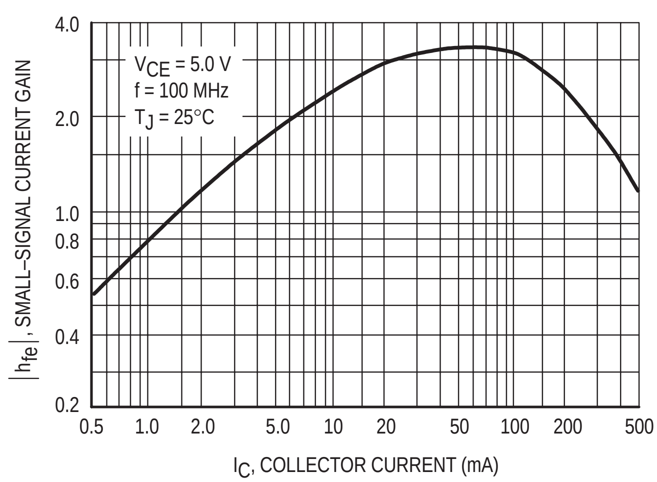
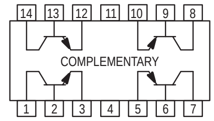


Figure 6. High Frequency Current Gain

Quad Complementary Pair Transistor
NPN/PNP Silicon



TYPE B

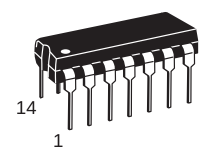
MPQ6700

MPQ6502
For Specifications,
See MPQ6001 Data

MPQ6600A1
For Specifications,
See MPQ6100A Data

Voltage and current are negative for PNP transistors

Motorola Preferred Device



CASE 646–06, STYLE 1
TO–116
TYPE B

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

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)	$V_{(BR)CEO}$	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

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%.

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

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS(2)				
DC Current Gain	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		30	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		50	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		70	—	
Collector–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL–SIGNAL CHARACTERISTICS				
Current–Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f =1.0 MHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) PNP	C_{ibo}	—	10	pF
NPN		—	8.0	

2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

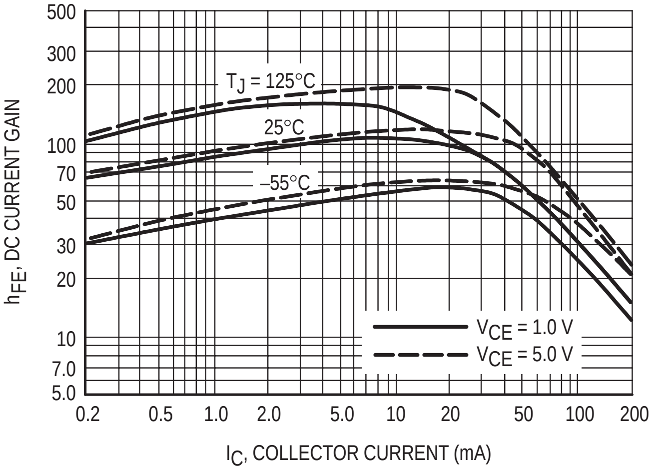


Figure 1. DC Current Gain

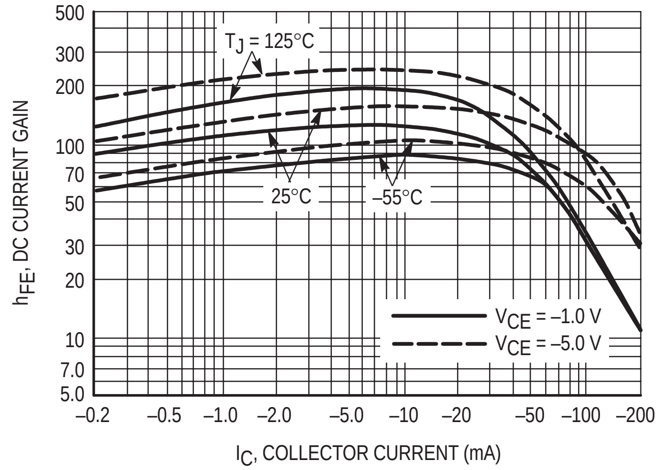


Figure 2. DC Current Gain

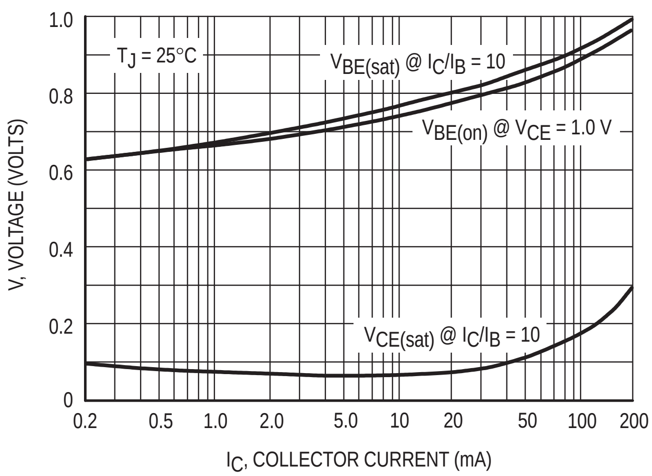


Figure 3. "ON" Voltage

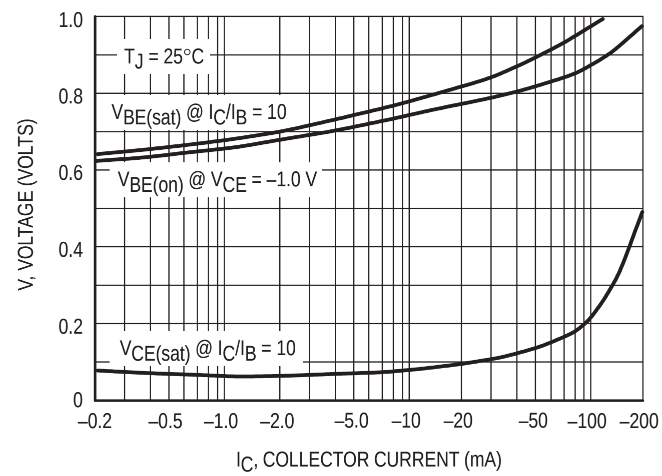


Figure 4. "ON" Voltage

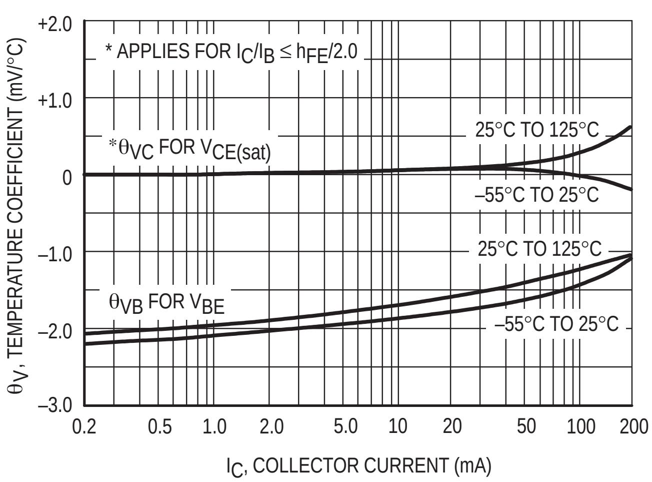


Figure 5. Temperature Coefficients

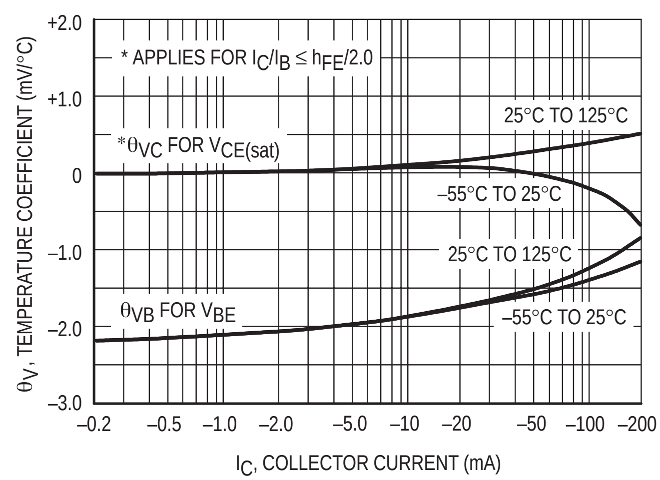


Figure 6. Temperature Coefficients

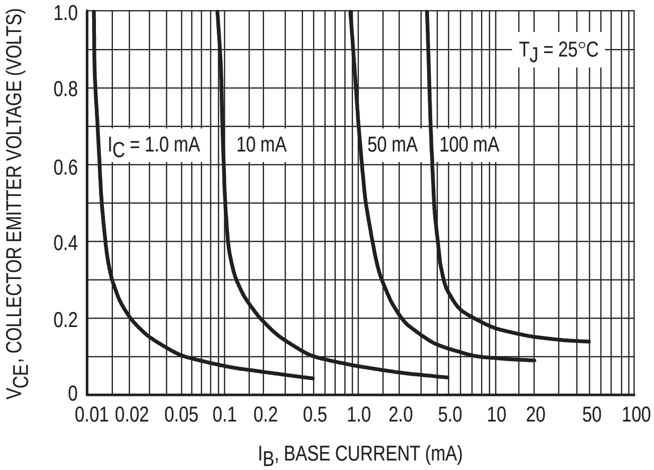


Figure 7. Collector Saturation Region

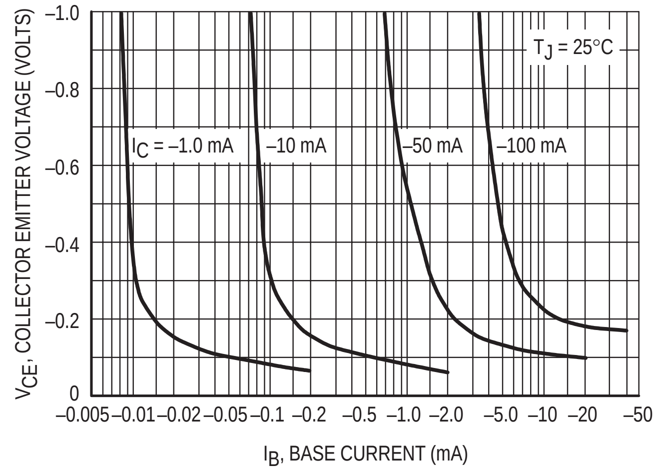


Figure 8. Collector Saturation Region

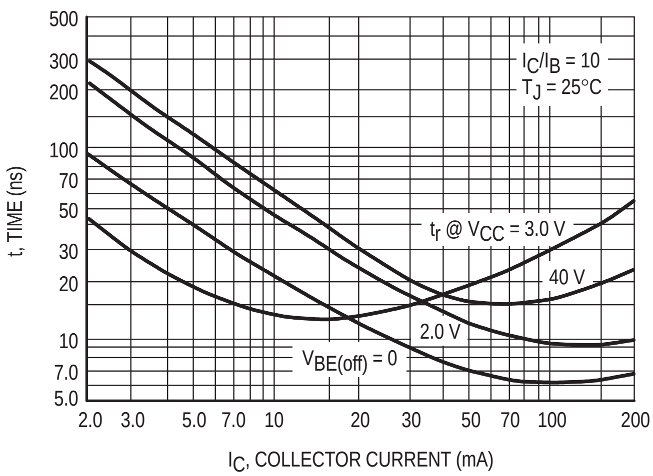


Figure 9. Turn–On Time

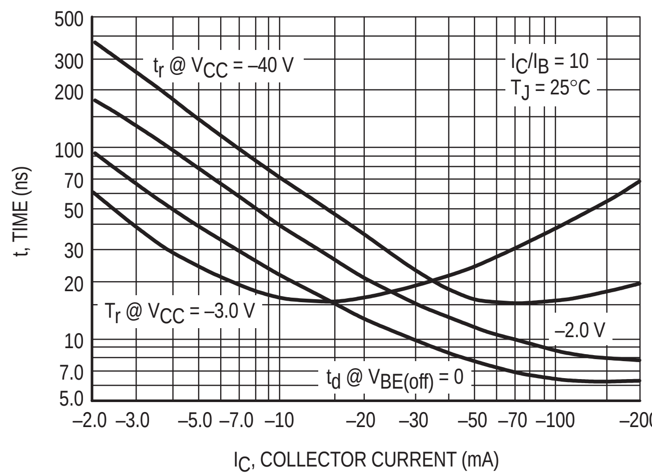


Figure 10. Turn–On Time

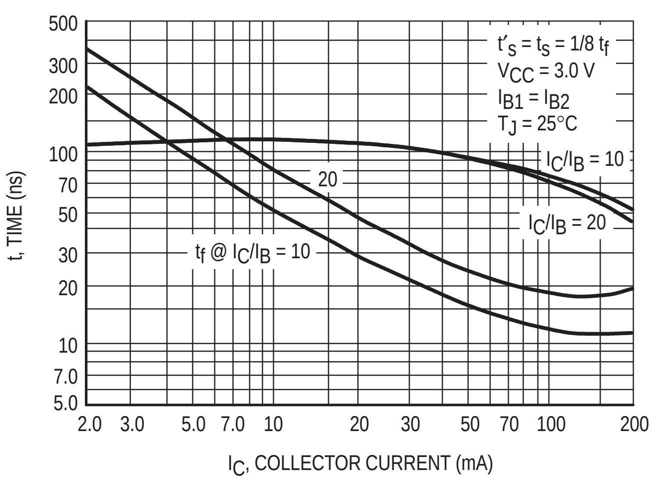


Figure 11. Turn–Off Time

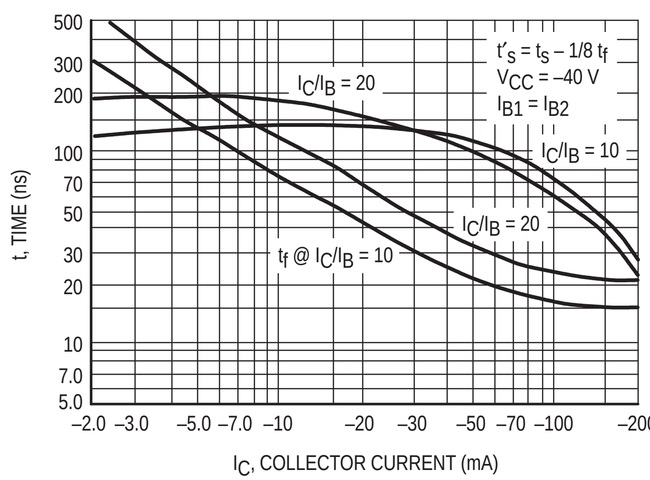


Figure 12. Turn–Off Time

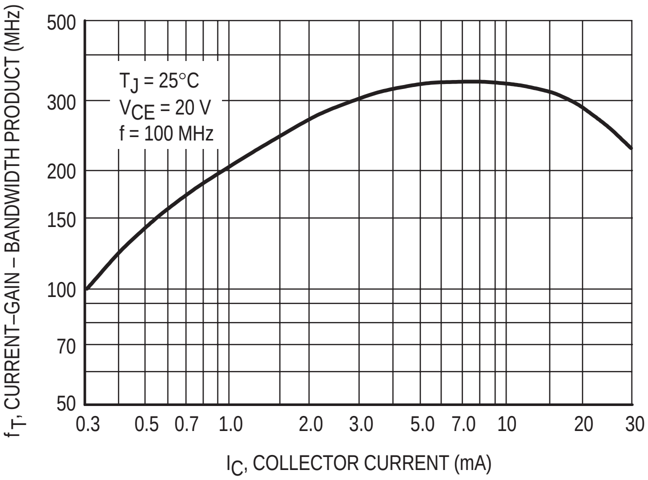


Figure 13. Current–Gain — Bandwidth Product

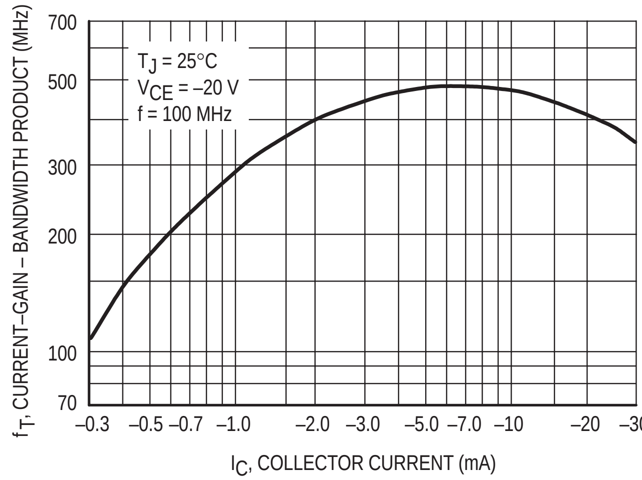


Figure 14. Current–Gain — Bandwidth Product

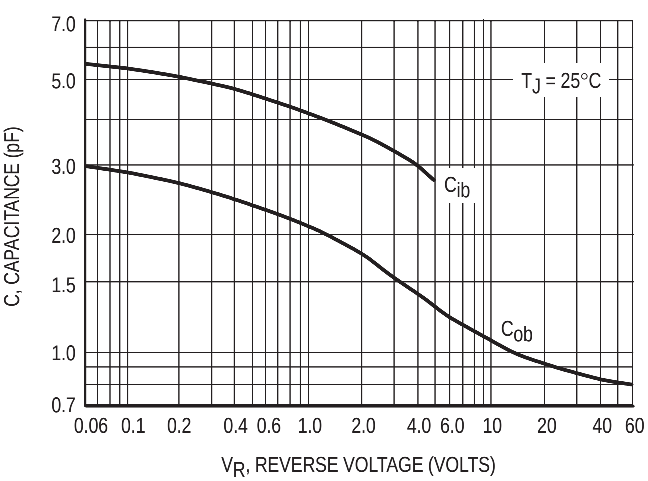


Figure 15. Capacitance

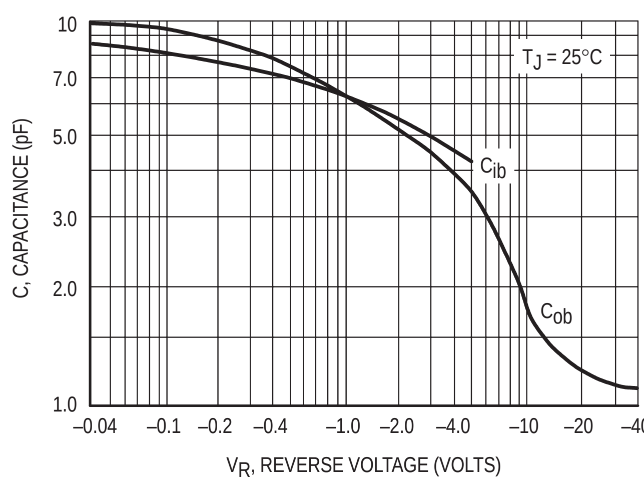
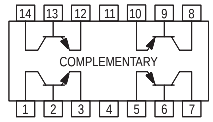


Figure 16. Capacitance

Quad Complementary Pair Transistor

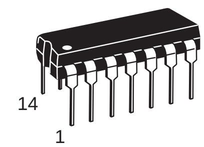
NPN/PNP Silicon



TYPE B

MPQ6842

Voltage and current are negative for PNP transistors



CASE 646–06, STYLE 1
TO–116
TYPE B

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

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1–Q4 or Q2–Q3 Q1–Q2 or Q3–Q4	34 2.0	70 26	% %

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	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_E = 0)	I_{EBO}	—	—	50	nAdc

1. Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.
2. Pulse Test: Pulse Width $\leq$ 300 μs; Duty Cycle $\leq$ 2.0%.

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
(I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc)		30	—	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		50	—	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		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(2) (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	C_{ibo}				pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) PNP		—	5.0	10	
NPN		—	4.0	8.0	
SWITCHING CHARACTERISTICS (T_A = 25°C, V_{CC} = 5.0 Vdc)					
Propagation Delay Time					ns
(50% Points TP1 to TP3)	t_{PLH}	—	15	25	
(50% Points TP2 to TP4)	t_{PHL}	—	6.0	15	
Rise Time (0.3 V to 4.7 V, TP3 or TP4)	t_r	5.0	25	35	ns
Fall Time (4.7 V to 0.3 V, TP3 or TP4)	t_f	5.0	10	20	ns

2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

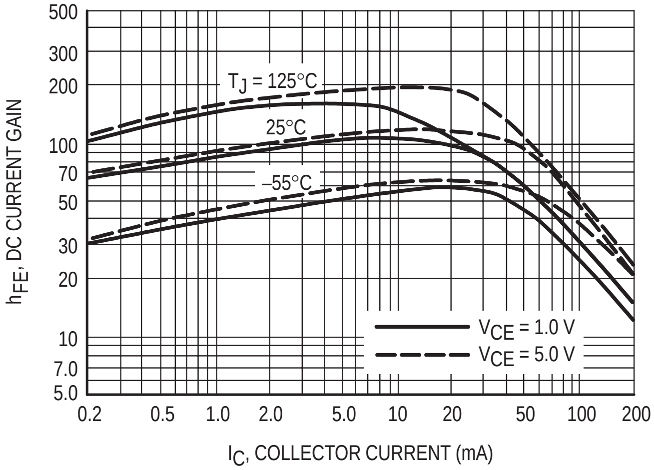


Figure 1. DC Current Gain

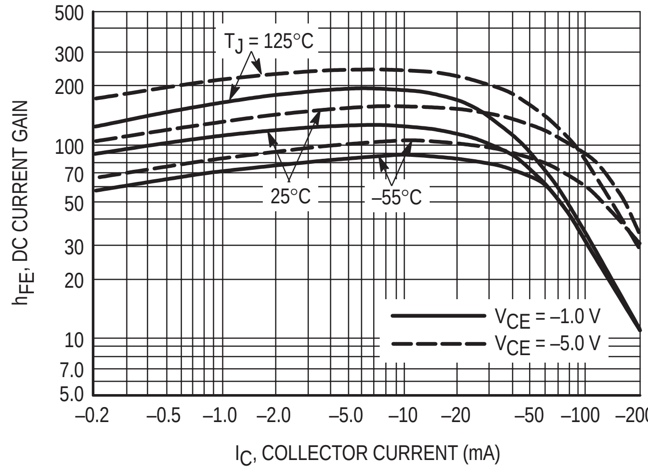


Figure 2. DC Current Gain

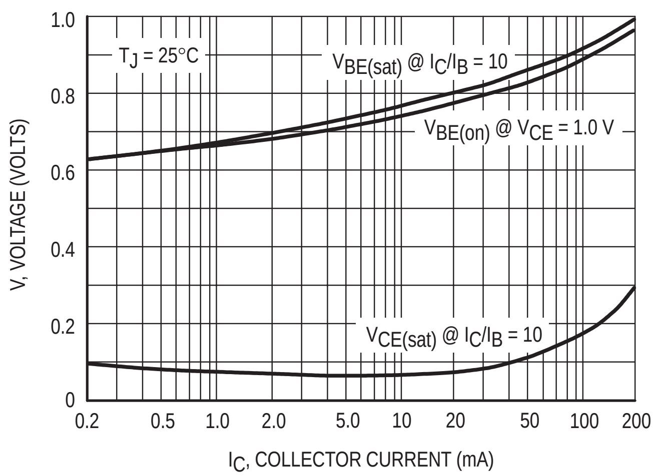


Figure 3. "ON" Voltage

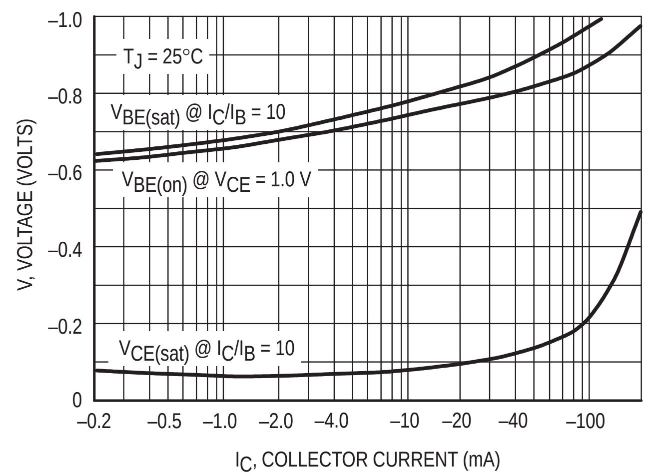


Figure 4. "ON" Voltage

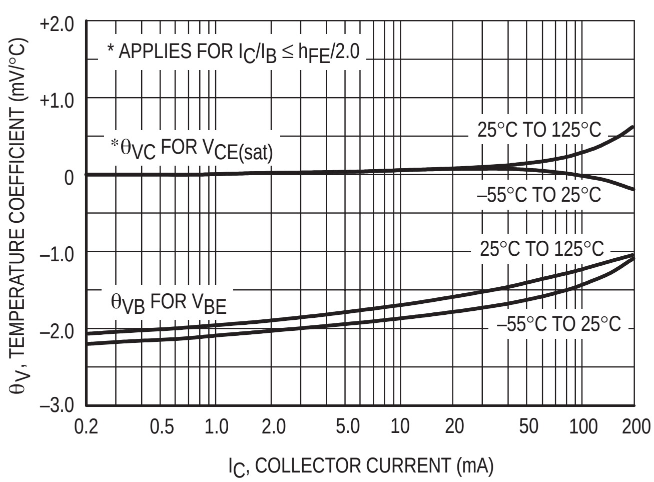


Figure 5. Temperature Coefficients

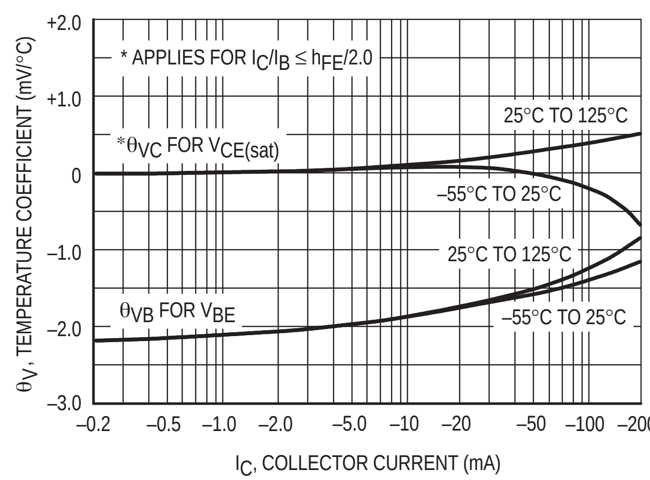


Figure 6. Temperature Coefficients

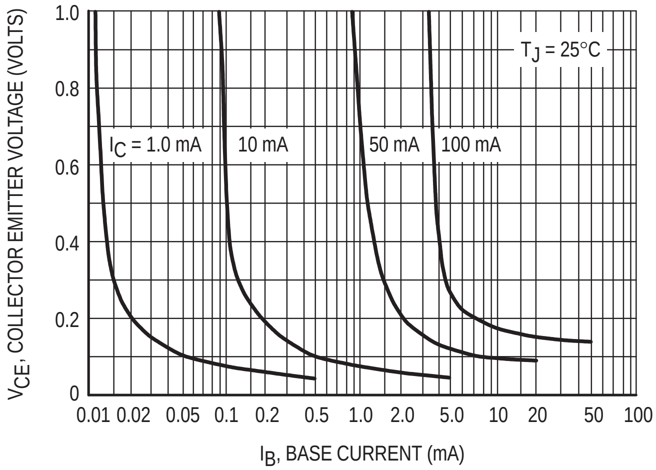


Figure 7. Collector Saturation Region

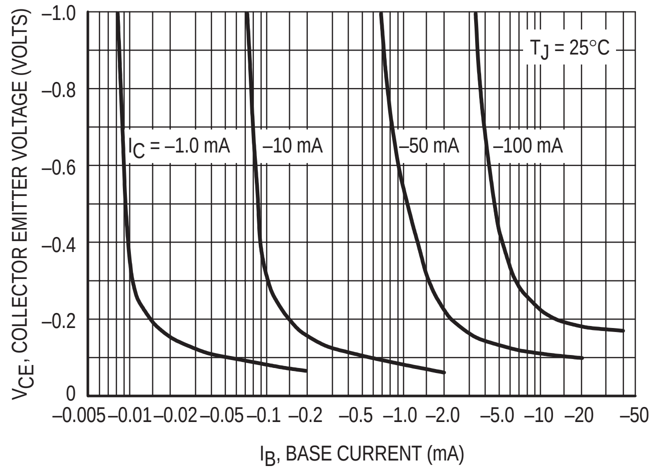
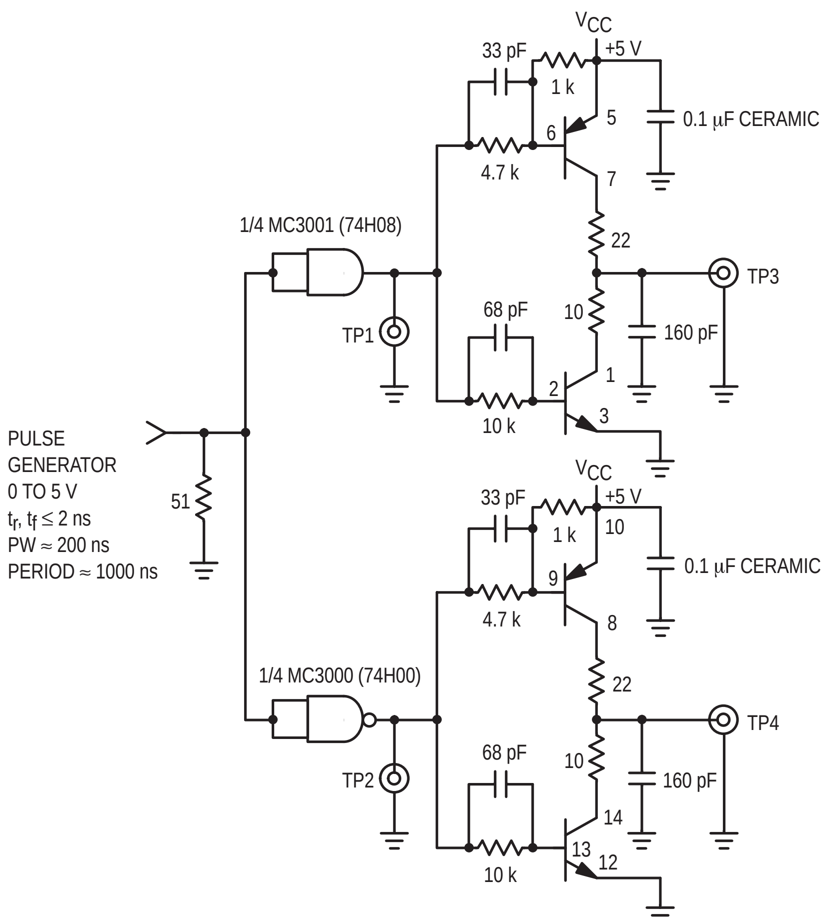


Figure 8. Collector Saturation Region



NOTES:
1. Unless otherwise noted, all resistors carbon composition $^1/_4$ W ±5%, all capacitors dipped mica ±2%.
2. Use short interconnect wiring with good power and ground buses.
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.

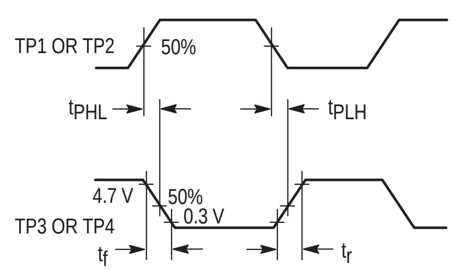
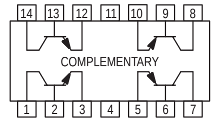


Figure 9. Switching Times Test Circuit and Waveforms

Quad Amplifier Transistors

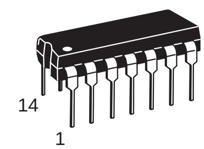
NPN Silicon



TYPE B

MPQ7041
MPQ7042
MPQ7043*

*Motorola Preferred Device



CASE 646–06, STYLE 1
TO–116

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_C = 25°C Derate above 25°C	P_D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	100 39	167 73.5	°C/W °C/W
Coupling Factors	Q1–Q4 or Q2–Q3 Q1–Q2 or Q3–Q4	46 5.0	56 10	% %

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

Characteristic		Symbol	Min	Typ	Max	Unit
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

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

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

Characteristic	Symbol	Min	Max	Max	Unit
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		25	45	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		40	60	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		40	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

DC CHARACTERISTICS

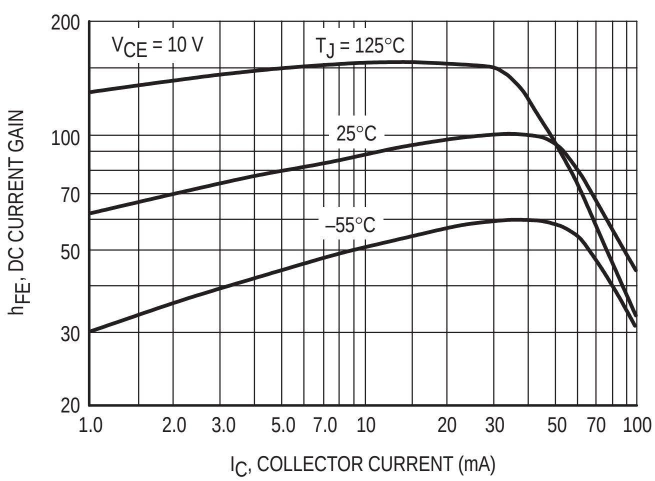


Figure 1. DC Current Gain

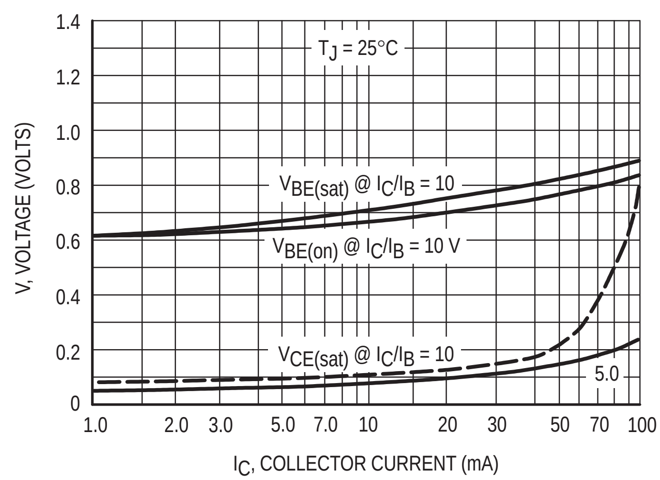


Figure 2. "ON" Voltages

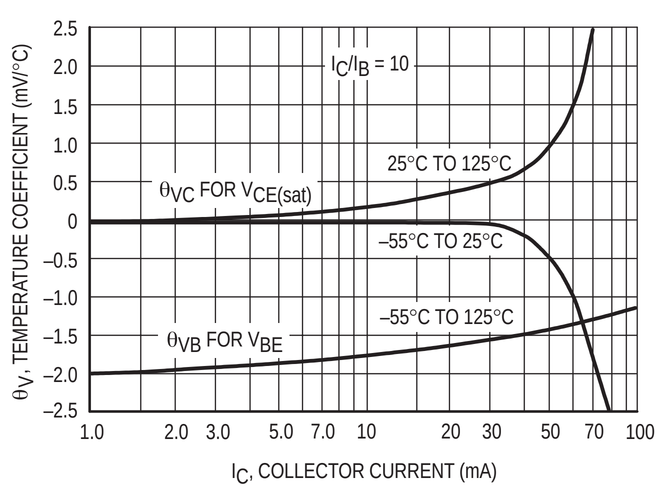
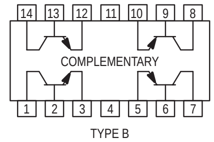


Figure 3. Temperature Coefficients

Quad Complementary Pair Transistor

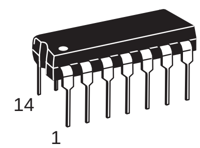
NPN/PNP Silicon



MPQ7051

Voltage and current are negative for PNP transistors

Motorola Preferred Device



CASE 646–06, STYLE 1
TO–116
TYPE B

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_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc

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

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

Characteristic	Symbol	Min	Max	Unit
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)		35	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		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	C_{ibo}	—	50	pF
PNP		—	75	

DC CHARACTERISTICS

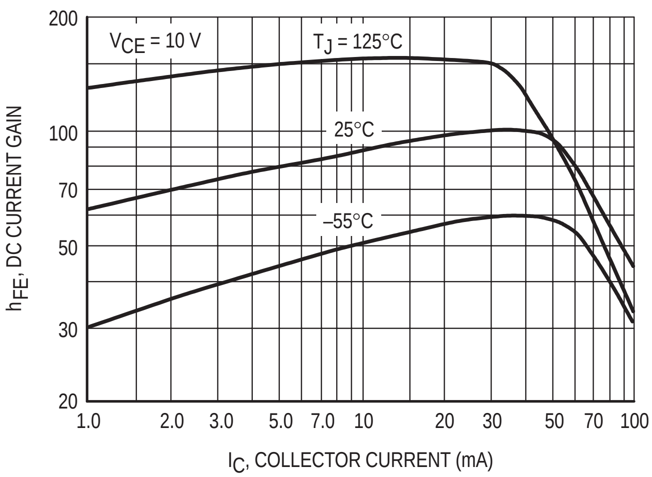


Figure 1. DC Current Gain

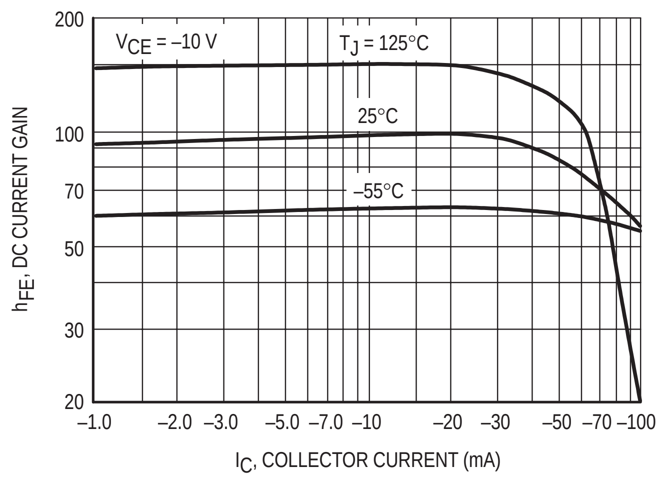


Figure 2. DC Current Gain

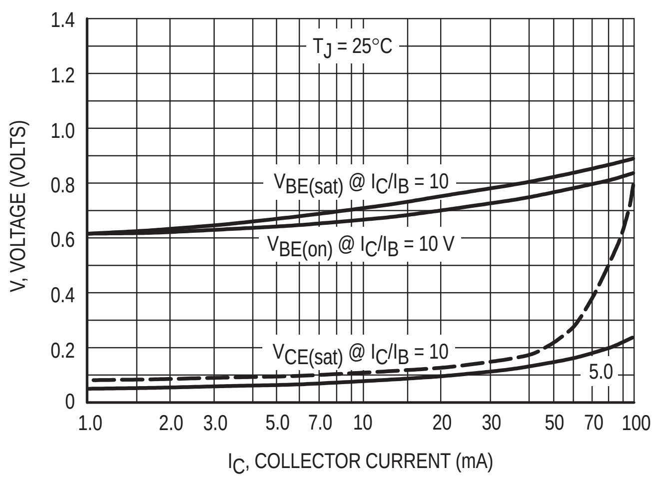


Figure 3. "ON" Voltages

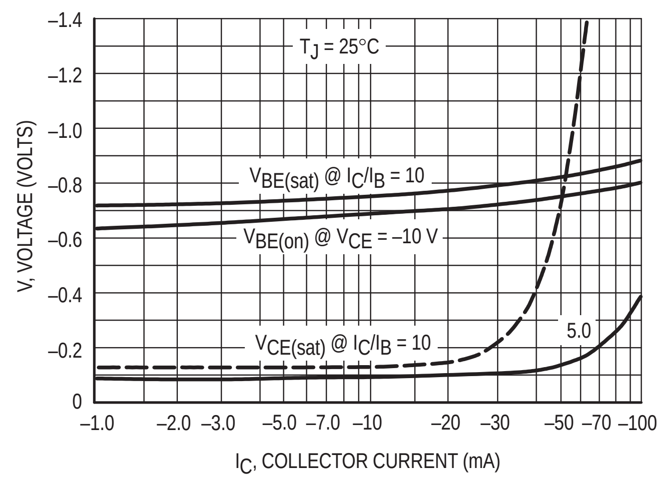


Figure 4. "ON" Voltages

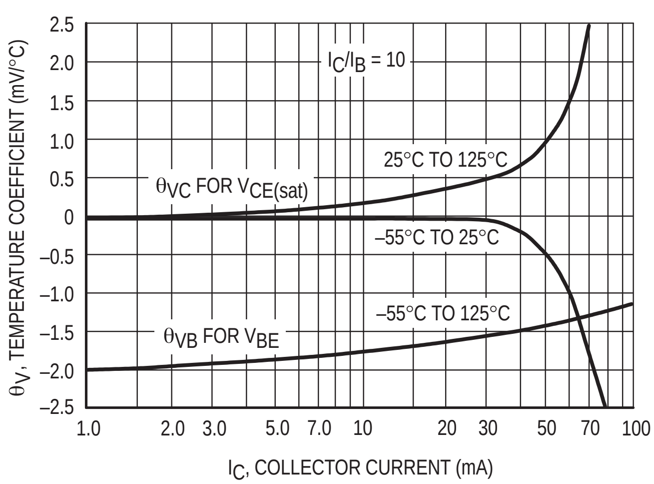


Figure 5. Temperature Coefficients

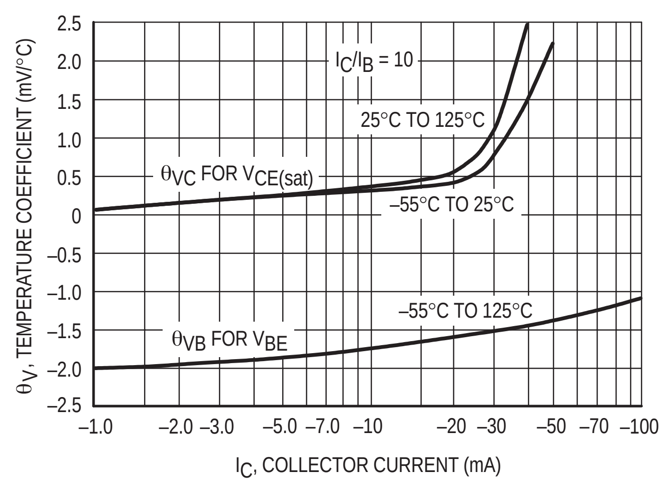
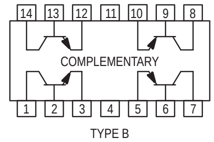


Figure 6. Temperature Coefficients

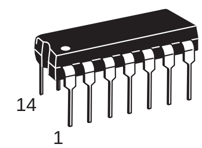
Quad Amplifier Transistors

PNP Silicon



MPQ7091
MPQ7093*

*Motorola Preferred Device



CASE 646–06, STYLE 1
TO–116

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 Effective, 4 Die	100 39	167 73.5	°C/W °C/W
Coupling Factors	Q1–Q4 or Q2–Q3 Q1–Q2 or Q3–Q4	46 5.0	56 10	% %

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

Characteristic		Symbol	Min	Typ	Max	Unit
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

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

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

Characteristic	Symbol	Min	Max	Max	Unit
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
(I_C = –1.0 mAdc, V_{CE} = –10 Vdc)		25	40	—	
(I_C = –10 mAdc, V_{CE} = –10 Vdc)		35	55	—	
(I_C = –30 mAdc, V_{CE} = –10 Vdc)		25	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

DC CHARACTERISTICS

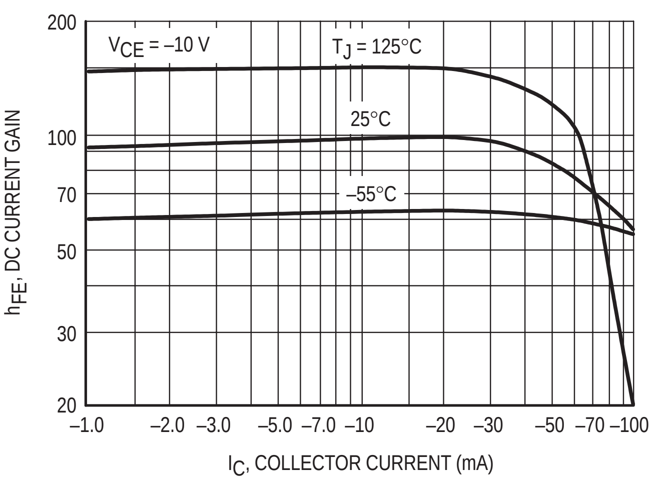


Figure 1. DC Current Gain

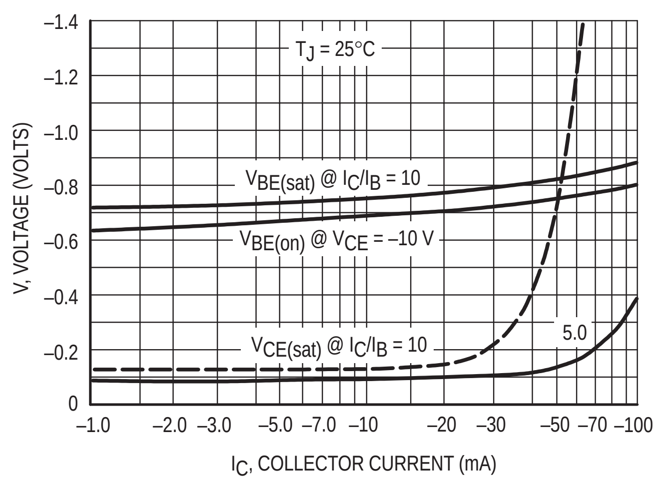


Figure 2. "ON" Voltages

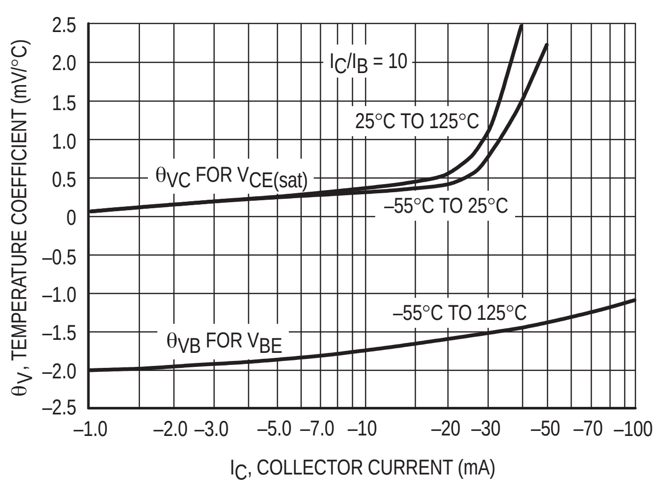
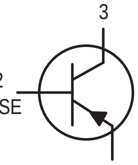


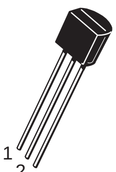
Figure 3. Temperature Coefficients

Chopper Transistor
PNP Silicon

MPS404A

Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

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

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

Characteristic	Symbol	Min	Max	Unit
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 –0.2	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

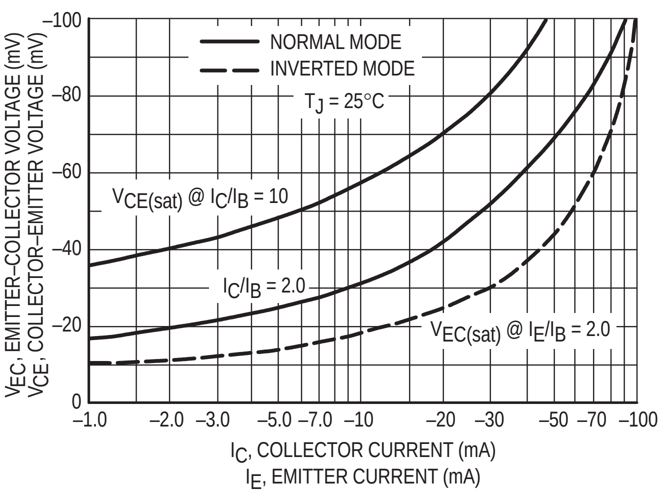


Figure 1. Collector–Emitter Voltage

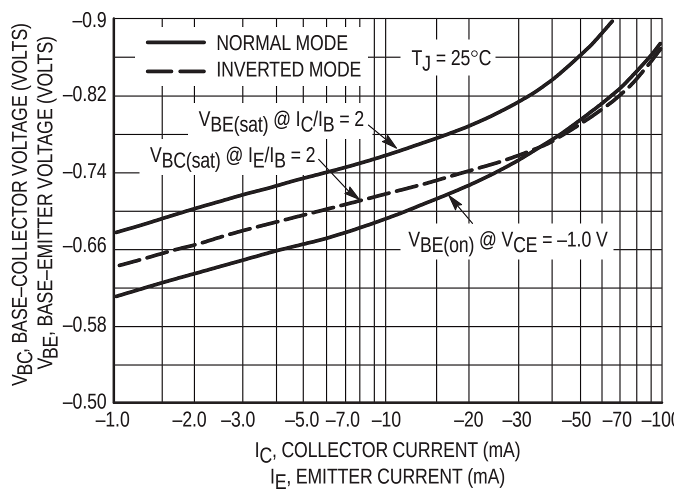


Figure 2. Base "On" Voltage

NORMAL MODE

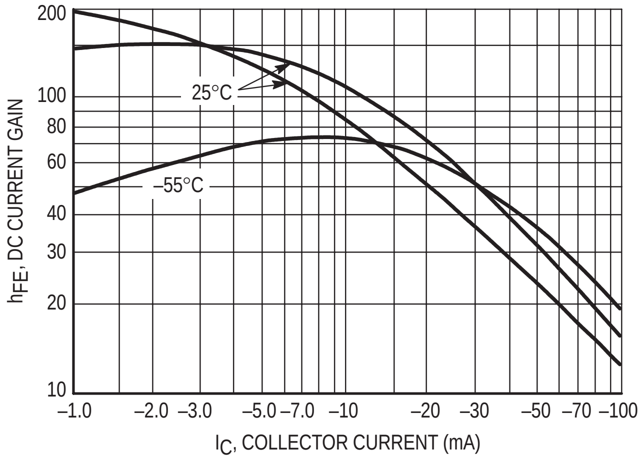


Figure 3. DC Current Gain @ V_{CE} = –0.15 Vdc

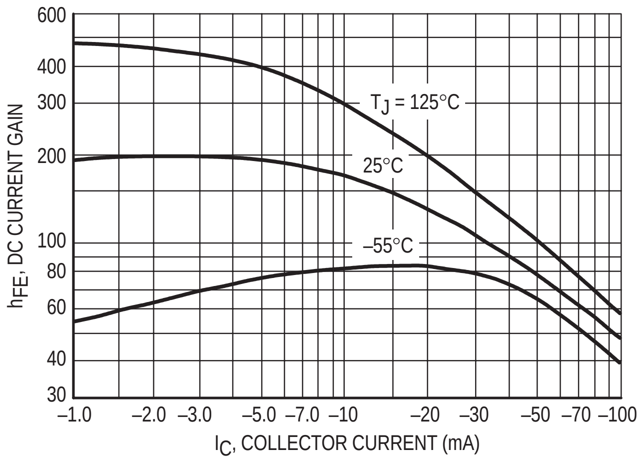


Figure 5. DC Current Gain @ V_{CE} = –1.0 Vdc

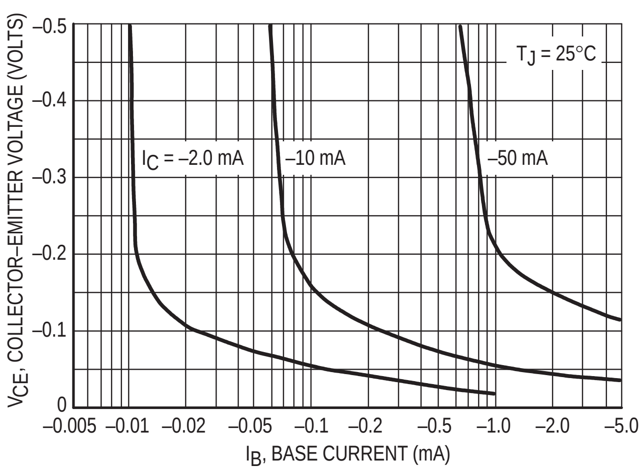


Figure 7. Collector Saturation Region

INVERTED MODE

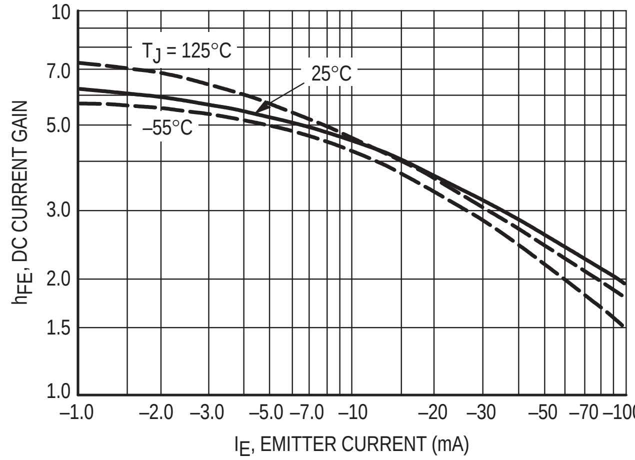


Figure 4. DC Current Gain @ V_{EC} = –0.15 Vdc

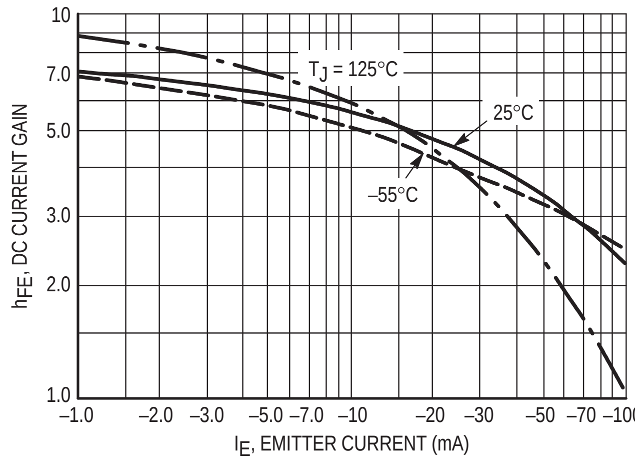


Figure 6. DC Current Gain @ V_{EC} = –1.0 Vdc

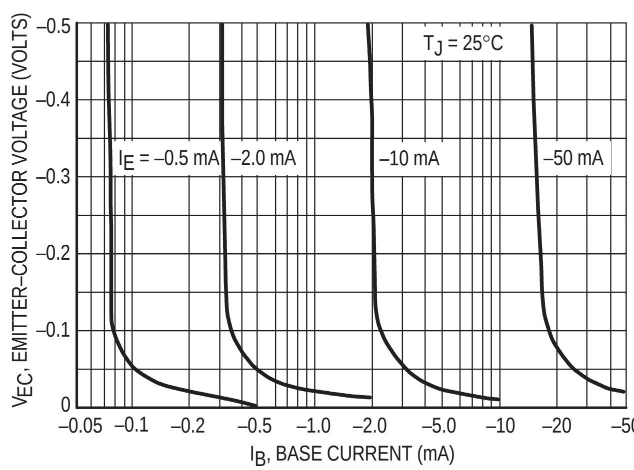


Figure 8. Emitter Saturation Region

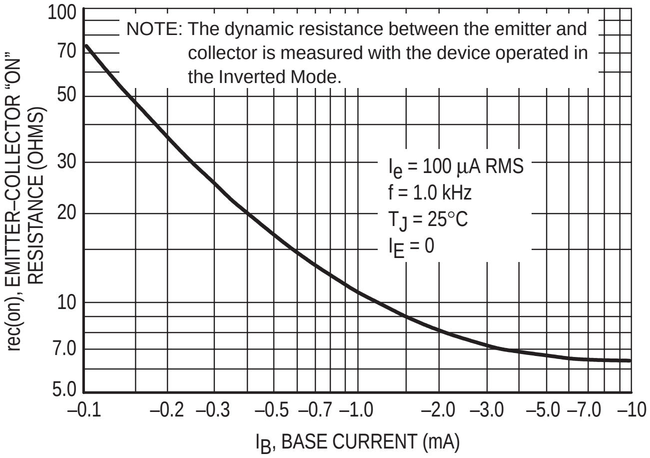


Figure 9. Emitter–Collector “On” Resistance

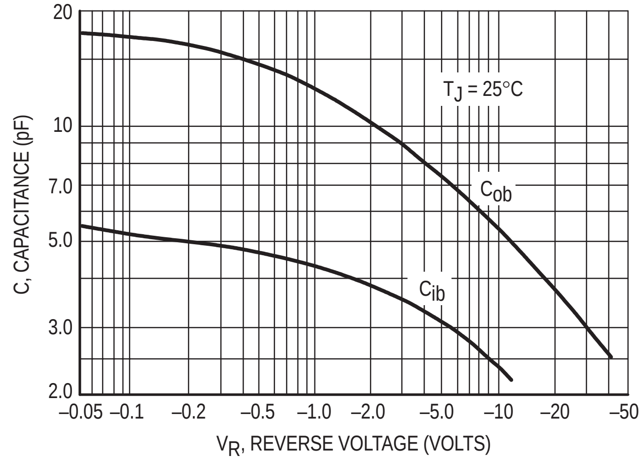


Figure 10. Capacitance

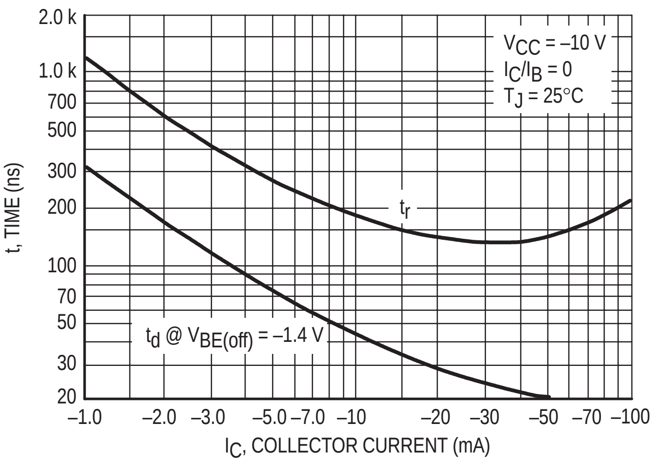


Figure 11. Turn–On Time

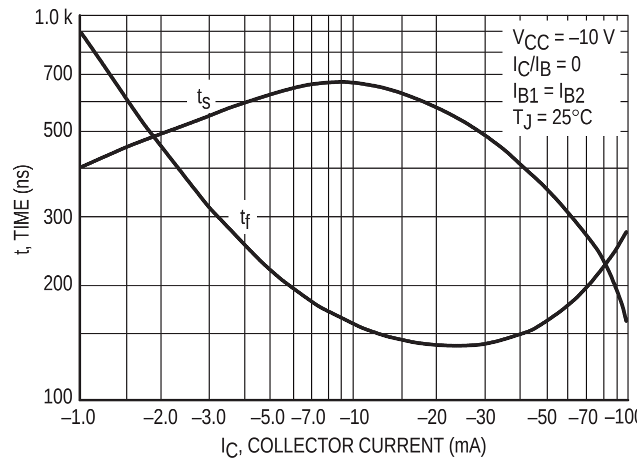
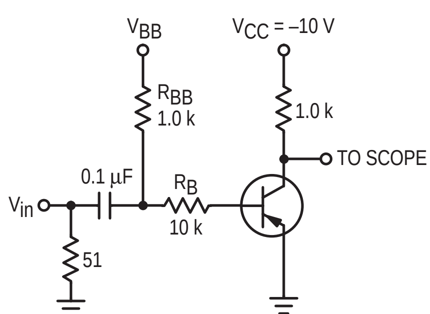


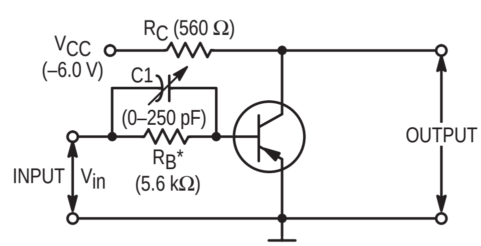
Figure 12. Turn–Off Time



	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 13. Switching Time 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.

VOLTAGE WAVEFORMS

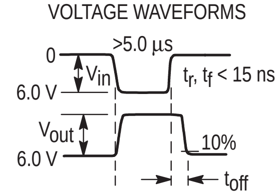


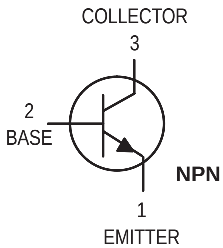
Figure 14. Stored Base Charge Test Circuit

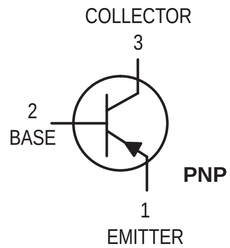
Amplifier Transistors

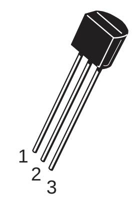
NPN
MPS650
MPS651*
PNP
MPS750
MPS751*

Voltage and current are negative for PNP transistors

***Motorola Preferred Devices**







CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

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

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

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS(1)				
DC Current Gain	h_{FE}			—
(I_C = 50 mA, V_{CE} = 2.0 V)		75	—	
(I_C = 500 mA, V_{CE} = 2.0 V)		75	—	
(I_C = 1.0 A, V_{CE} = 2.0 V)		75	—	
(I_C = 2.0 A, V_{CE} = 2.0 V)		40	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 2.0 A, I_B = 200 mA)		—	0.5	
(I_C = 1.0 A, I_B = 100 mA)		—	0.3	
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.

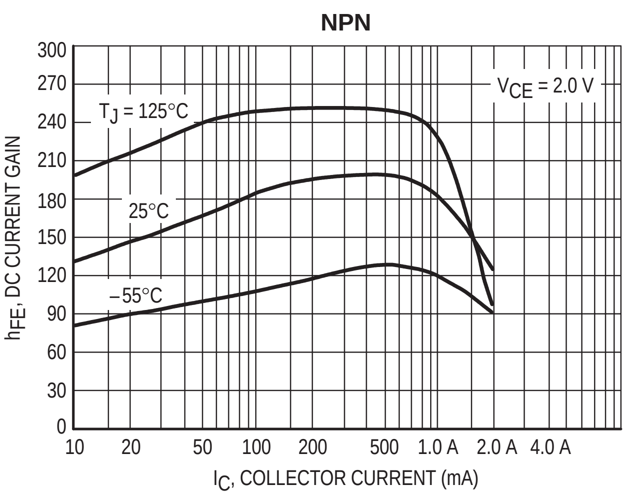


Figure 1. MPS650, MPS651 Typical DC Current Gain

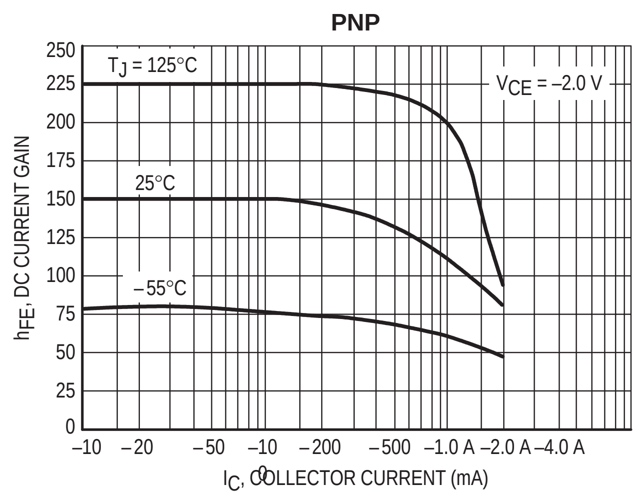


Figure 2. MPS750, MPS751 Typical DC Current Gain

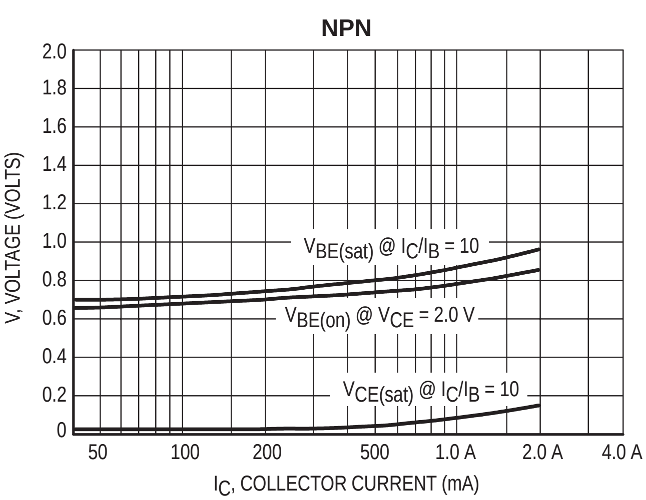


Figure 3. MPS650, MPS651 On Voltages

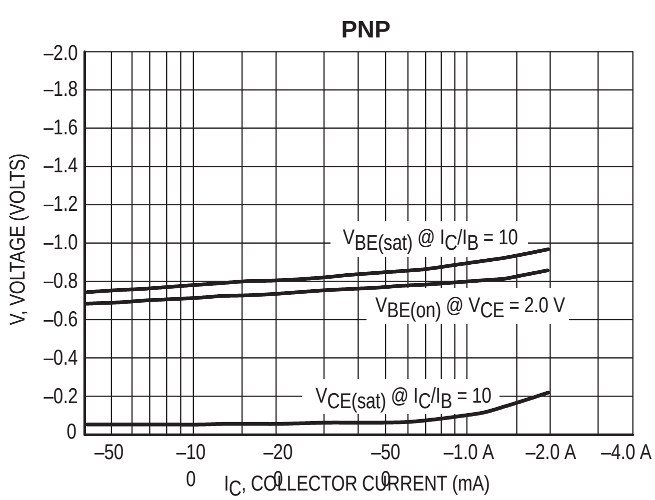


Figure 4. MPS750, MPS751 On Voltages

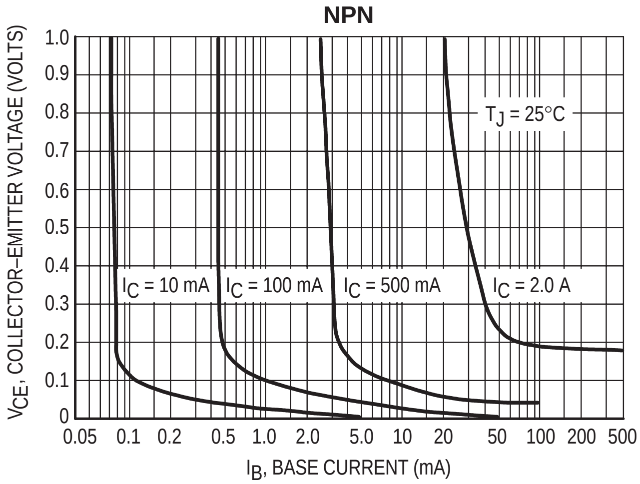


Figure 5. MPS650, MPS651 Collector Saturation Region

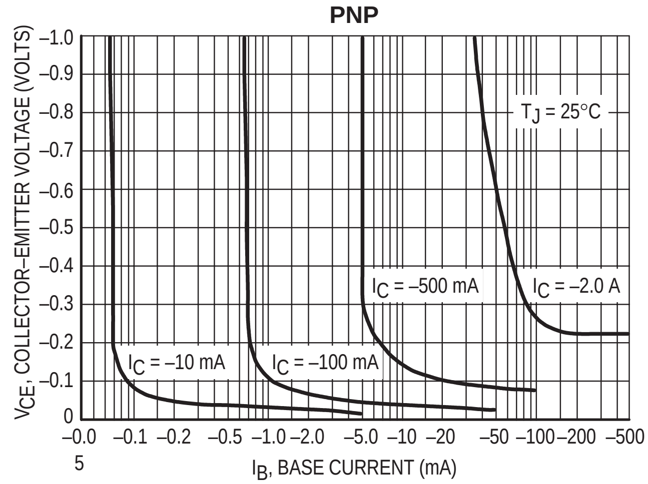


Figure 6. MPS750, MPS751 Collector Saturation Region

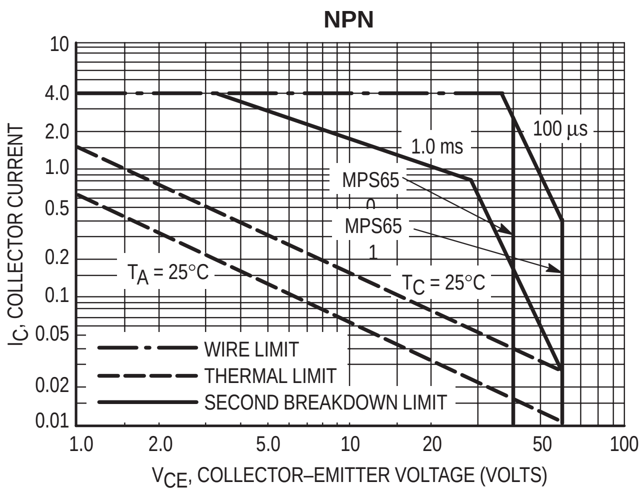


Figure 7. MPS650, MPS651 SOA, Safe Operating Area

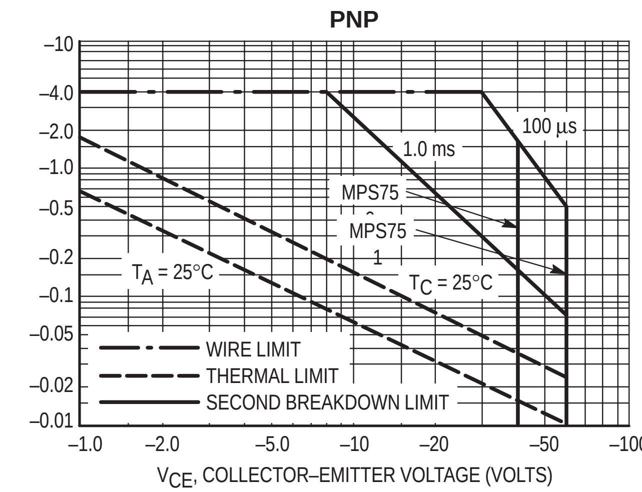
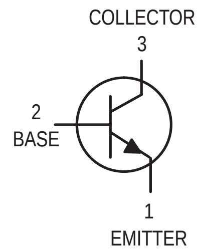


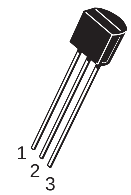
Figure 8. MPS750, MPS751 SOA, Safe Operating Area

Amplifier Transistors
NPN Silicon

MPS918*
MPS3563

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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		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)	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)		$V_{(BR)CEO}$			Vdc
(I_C = 3.0 mAdc, I_B = 0)	MPS918		15	—	
	MPS3563		12	—	
Collector–Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 1.0 μAdc, I_E = 0)	MPS918		30	—	
(I_C = 100 μAdc, I_E = 0)	MPS3563		30	—	
Emitter–Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)	MPS918		3.0	—	
	MPS3563		2.0	—	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 15 Vdc, I_E = 0)	MPS918		—	10	
	MPS3563		—	50	

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%.

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

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

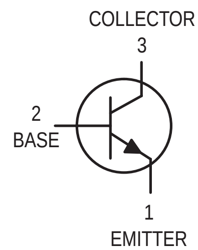
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain[2]		h_{FE}			—
(I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	MPS918		20	—	
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	MPS3563		20	200	
Collector–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS918	$V_{CE(sat)}$	—	0.4	Vdc
Base–Emitter 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]		f_T			MHz
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS918		600	—	
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS3563		600	1500	
Output Capacitance		C_{obo}			pF
(V_{CB} = 0 Vdc, I_E = 0, f = 1.0 MHz)	MPS918		—	3.0	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MPS918		—	1.7	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MPS3563		—	1.7	
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 kΩ, f = 60 MHz)	MPS918	NF	—	6.0	dB
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	—	%

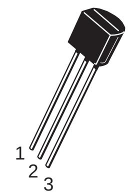
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 1.0%.

General Purpose Transistors
NPN Silicon

MPS2222
MPS2222A*

*Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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}	—	100	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MPS2222A	I_{BL}	—	20	nAdc

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

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

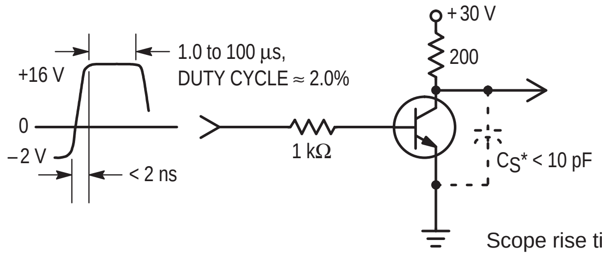
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)			35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			75	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = –55°C)	MPS2222A only		35	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)			100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)			50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	MPS2222		30	—	
	MPS2222A		40	—	
Collector–Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MPS2222		—	0.4	
	MPS2222A		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	MPS2222		—	1.6	
	MPS2222A		—	1.0	
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

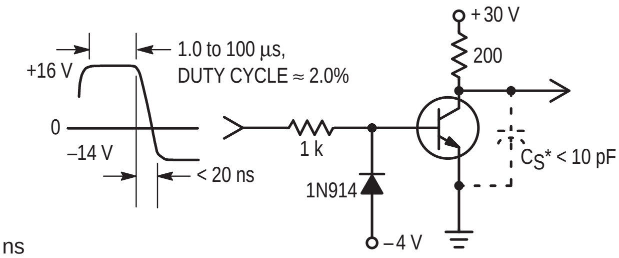
SWITCHING CHARACTERISTICS   MPS2222A only

Characteristic	Conditions	Symbol	Min	Max	Unit
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





Scope rise time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

Figure 1. Turn–On Time **Figure 2. Turn–Off Time**

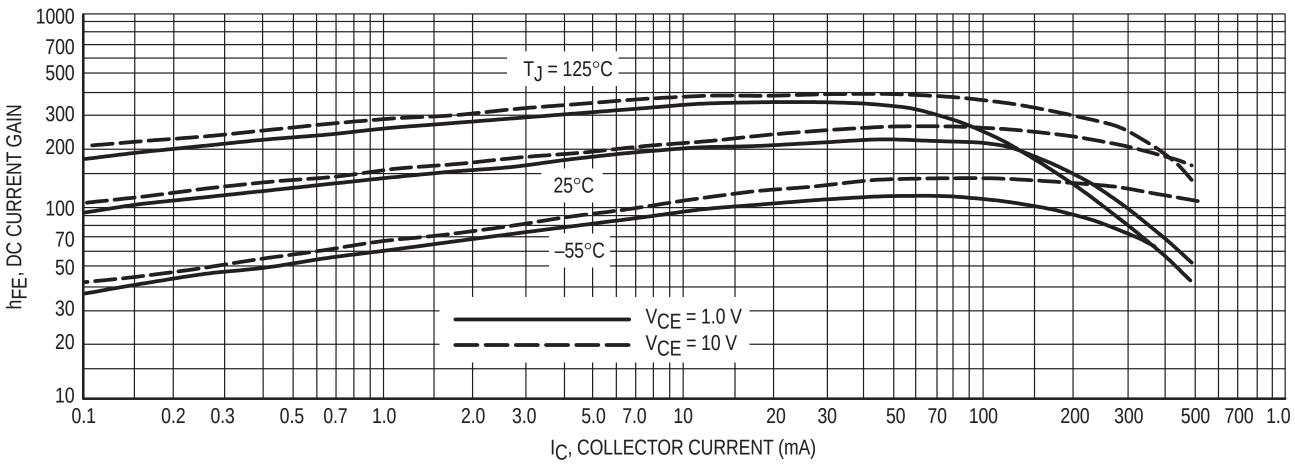


Figure 3. DC Current Gain

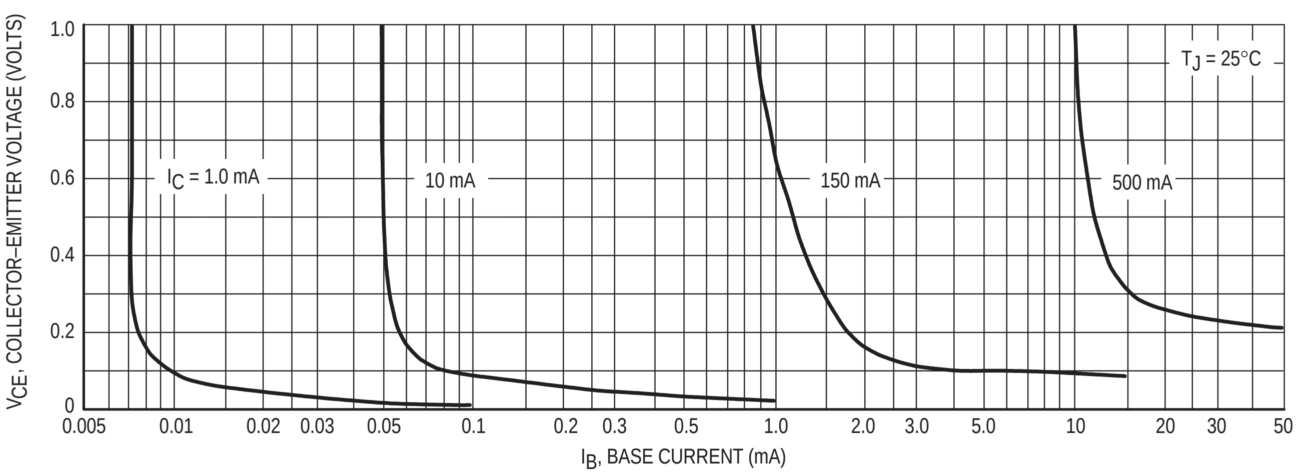


Figure 4. Collector Saturation Region

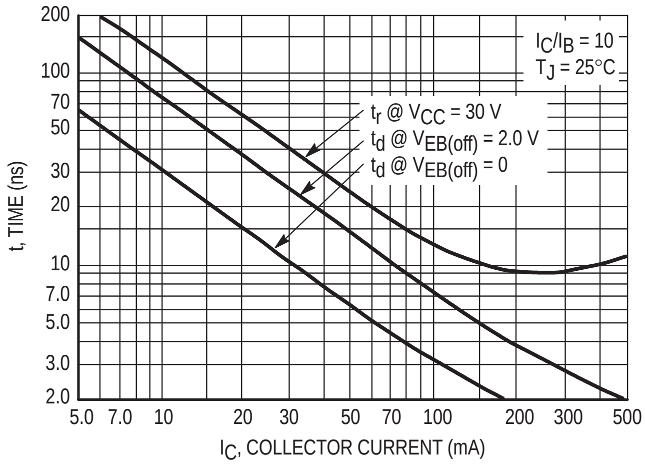


Figure 5. Turn–On Time

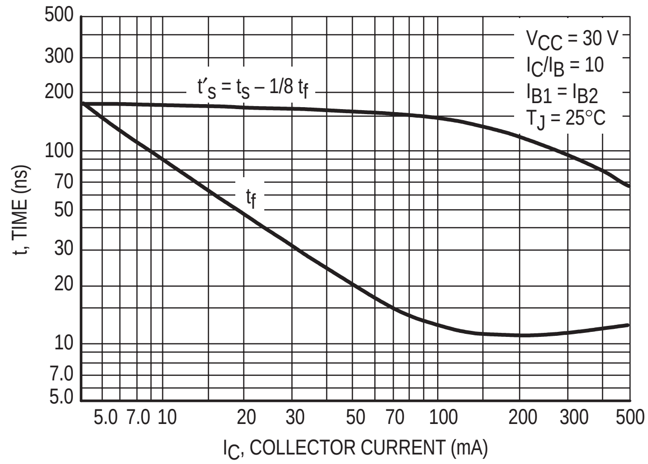


Figure 6. Turn–Off Time

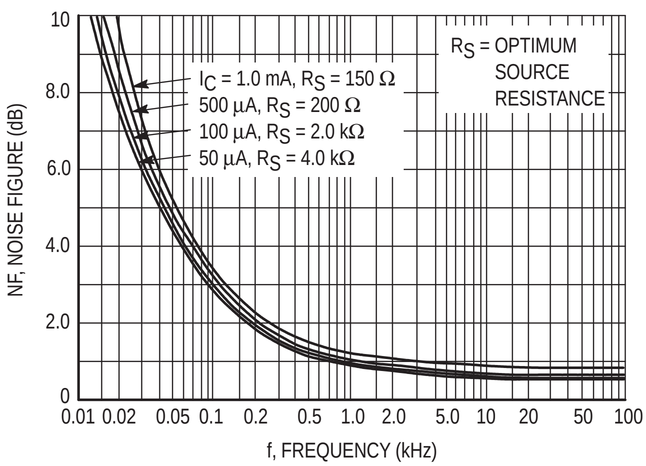


Figure 7. Frequency Effects

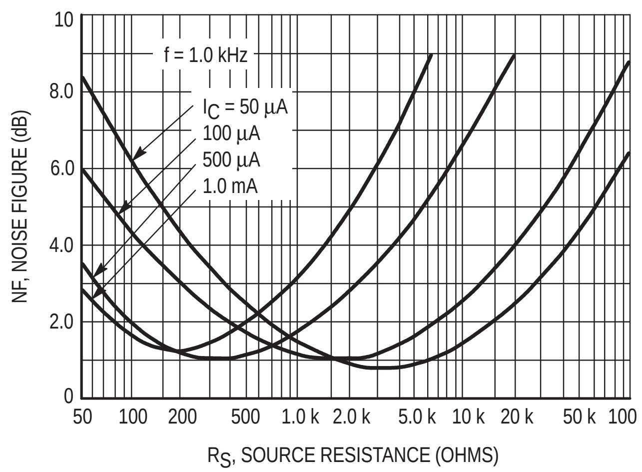


Figure 8. Source Resistance Effects

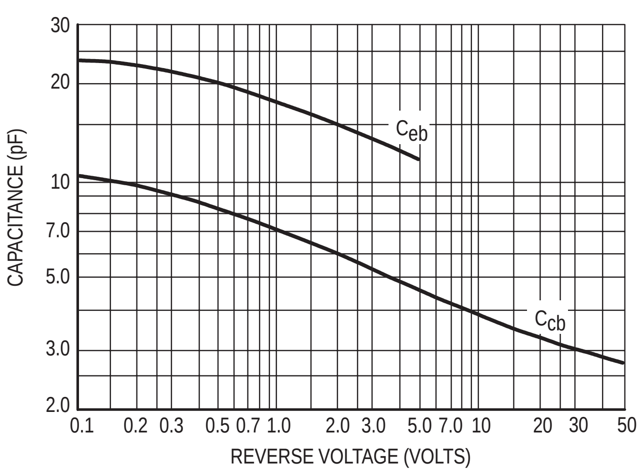


Figure 9. Capacitances

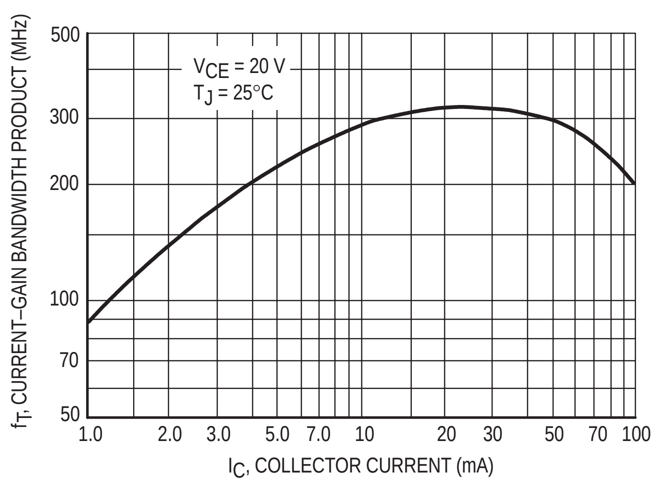


Figure 10. Current–Gain Bandwidth Product

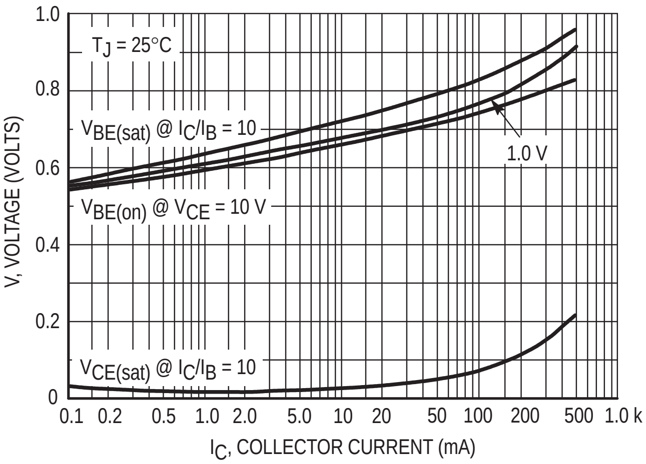


Figure 11. "On" Voltages

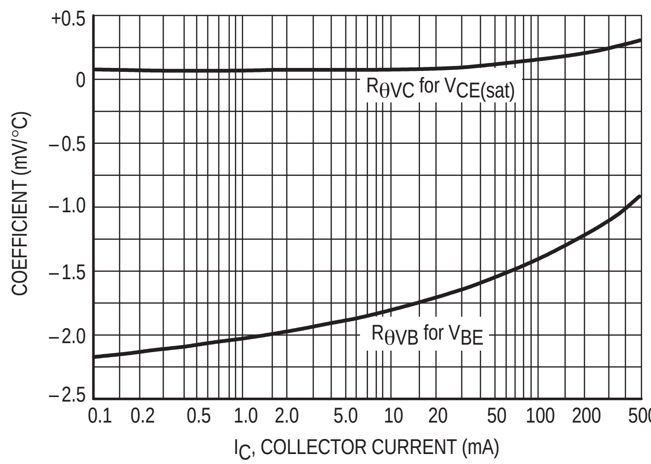
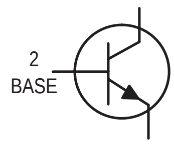


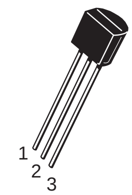
Figure 12. Temperature Coefficients

Switching Transistors
NPN Silicon

MPS2369
MPS2369A*

*Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

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

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	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	
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

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

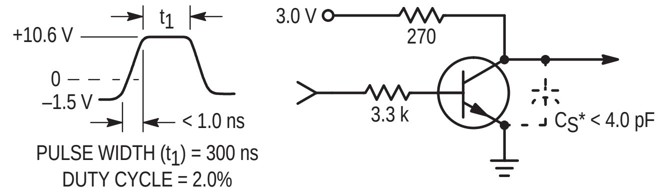


Figure 1. t_{on} Circuit

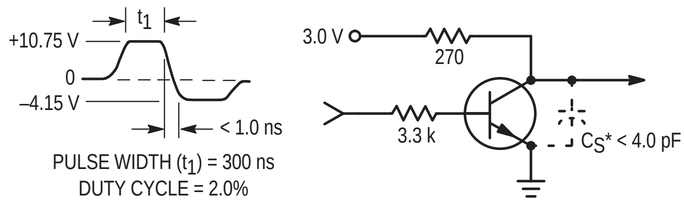


Figure 2. t_{off} Circuit

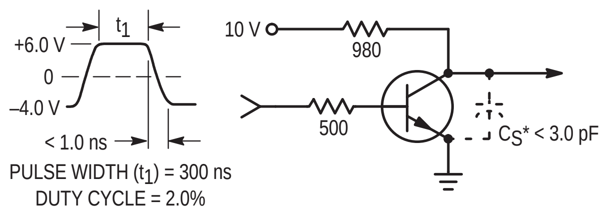


Figure 3. Storage Test Circuit

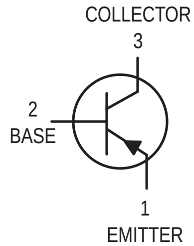
* Total shunt capacitance of test jig and connectors.

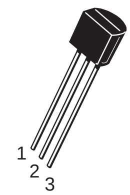
General Purpose Transistors

PNP Silicon

MPS2907
MPS2907A*

*Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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}	— — — —	–0.02 –0.01 –20 –10	μAdc
Base Current (V_{CE} = –30 Vdc, $V_{EB(off)}$ = –0.5 Vdc)		I_B	—	–50	nAdc

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

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = –0.1 mAdc, V_{CE} = –10 Vdc)	MPS2907		35	—	
	MPS2907A		75	—	
(I_C = –1.0 mAdc, V_{CE} = –10 Vdc)	MPS2907		50	—	
	MPS2907A		100	—	
(I_C = –10 mAdc, V_{CE} = –10 Vdc)	MPS2907		75	—	
	MPS2907A		100	—	
(I_C = –150 mAdc, V_{CE} = –10 Vdc)(1)	MPS2907, MPS2907A		100	300	
(I_C = –500 mAdc, V_{CE} = –10 Vdc)(1)	MPS2907		30	—	
	MPS2907A		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(1)		$V_{BE(sat)}$			Vdc
(I_C = –150 mAdc, I_B = –15 mAdc)			—	–1.3	
(I_C = –500 mAdc, I_B = –50 mAdc)			—	–2.6	
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.

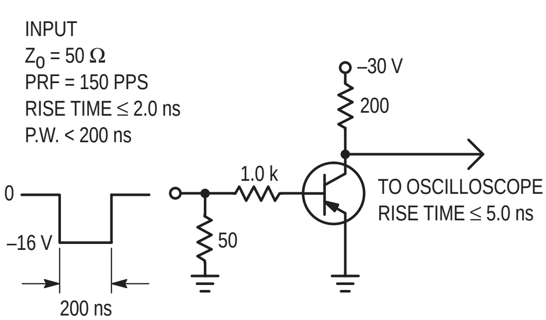


Figure 1. Delay and Rise Time Test Circuit

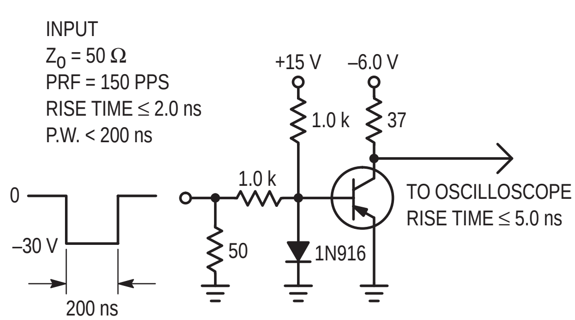


Figure 2. Storage and Fall Time Test Circuit

TYPICAL CHARACTERISTICS

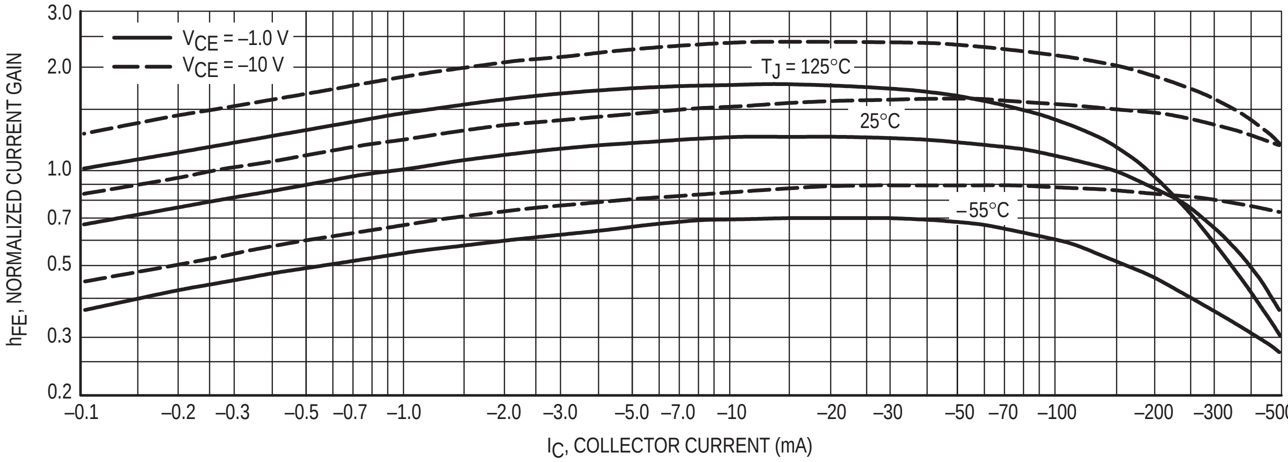


Figure 3. DC Current Gain

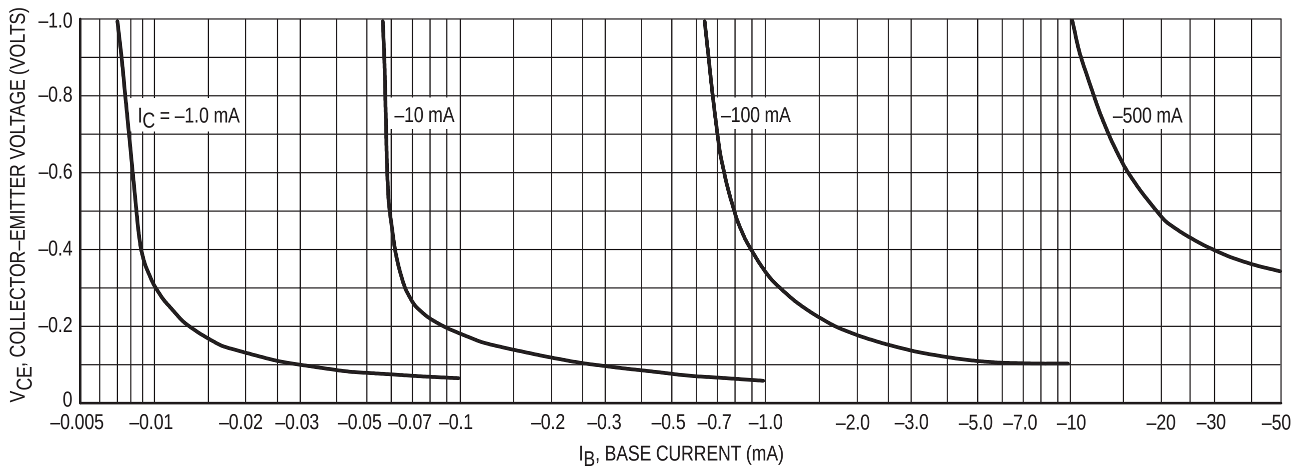


Figure 4. Collector Saturation Region

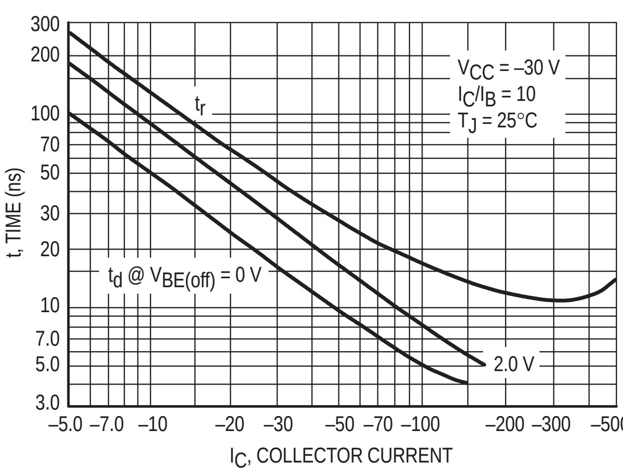


Figure 5. Turn–On Time

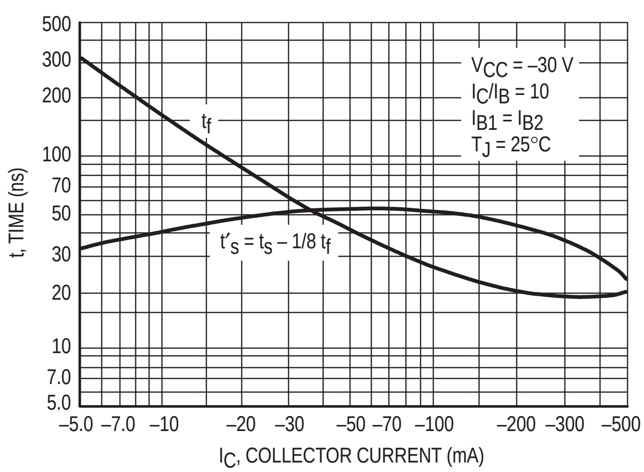


Figure 6. Turn–Off Time

TYPICAL SMALL–SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

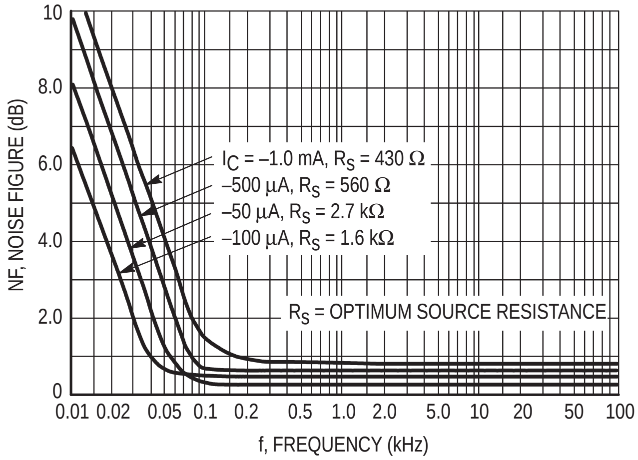


Figure 7. Frequency Effects

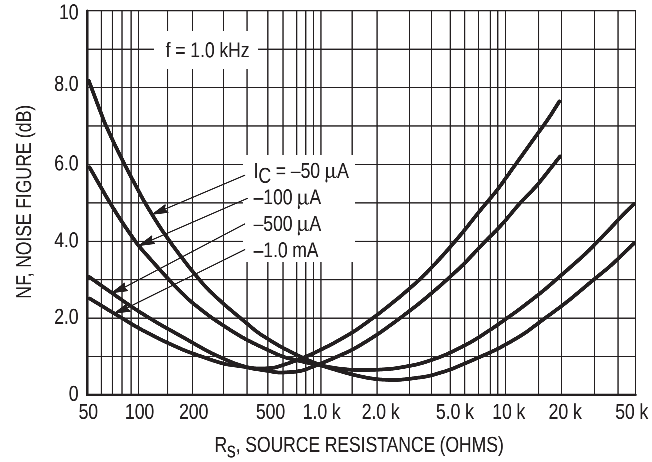


Figure 8. Source Resistance Effects

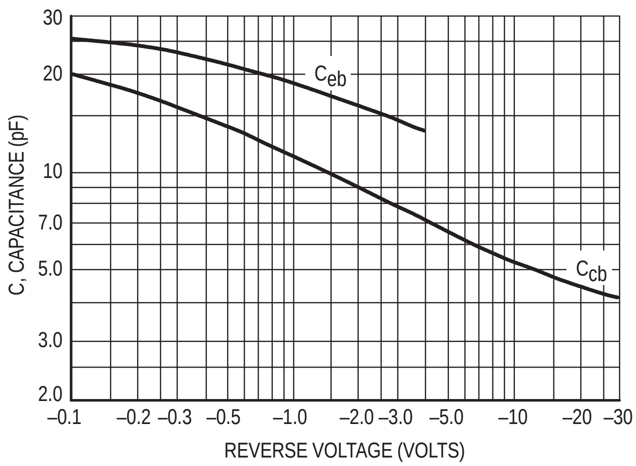


Figure 9. Capacitances

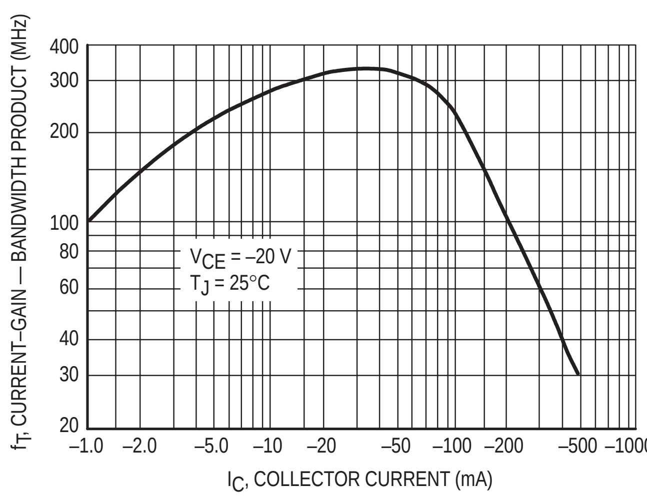


Figure 10. Current–Gain — Bandwidth Product

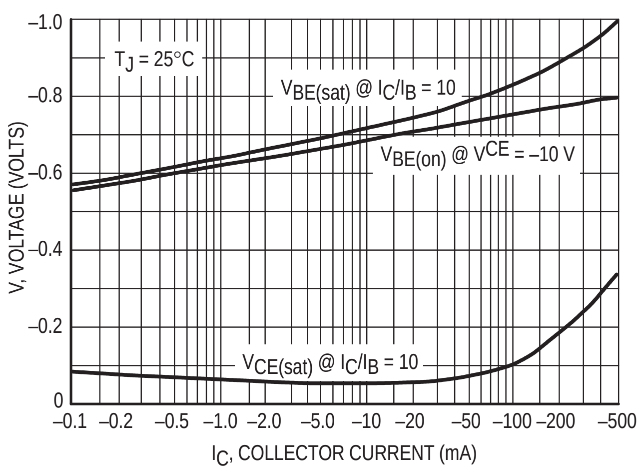


Figure 11. “On” Voltage

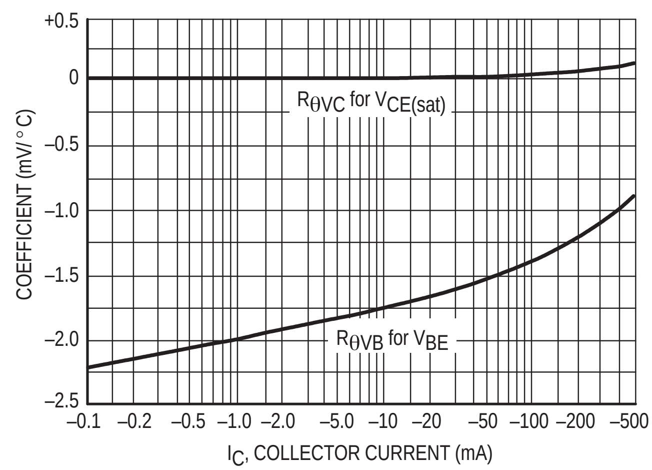
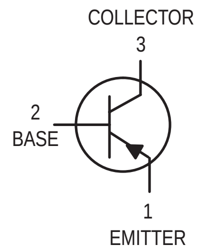
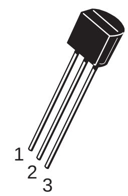


Figure 12. Temperature Coefficients

Switching Transistor
PNP Silicon



MPS3638A



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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(2) (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

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%.

(Replaces MPS3638/D)

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

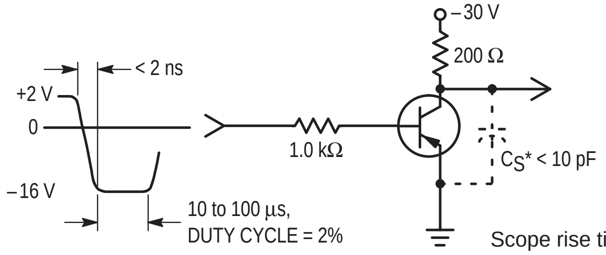
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS(2)				
DC Current Gain	h_{FE}			—
(I_C = –1.0 mAdc, V_{CE} = –10 Vdc)		80	—	
(I_C = –10 mAdc, V_{CE} = –10 Vdc)		100	—	
(I_C = –50 mAdc, V_{CE} = –1.0 Vdc)		100	—	
(I_C = –300 mAdc, V_{CE} = –2.0 Vdc)		20	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = –50 mAdc, I_B = –2.5 mAdc)		—	–0.25	
(I_C = –300 mAdc, I_B = –30 mAdc)		—	–1.0	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = –50 mAdc, I_B = –2.5 mAdc)		—	–1.1	
(I_C = –300 mAdc, I_B = –30 mAdc)		–0.80	–2.0	
SMALL–SIGNAL CHARACTERISTICS				
Current–Gain — Bandwidth Product (V_{CE} = –3.0 Vdc, I_C = –50 mAdc, f = 100 MHz)	f_T	150	—	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}	—	25	pF
Input Impedance (I_C = –10 mAdc, V_{CE} = –10 Vdc, f = 1.0 kHz)	h_{ie}	—	2000	kΩ
Voltage Feedback Ratio (I_C = –10 mAdc, V_{CE} = –10 Vdc, f = 1.0 kHz)	h_{re}	—	15	X 10^{-4}
Small–Signal Current Gain (I_C = –10 mAdc, V_{CE} = –10 Vdc, f = 1.0 kHz)	h_{fe}	100	—	—
Output Admittance (I_C = –10 mAdc, V_{CE} = –10 Vdc, f = 1.0 kHz)	h_{oe}	—	1.2	mmhos

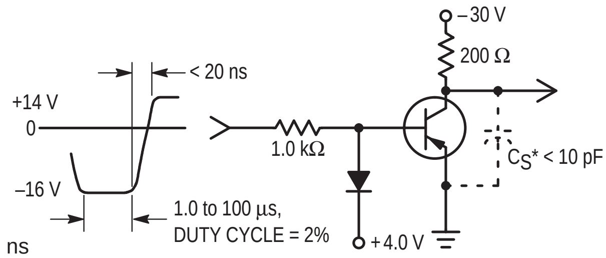
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
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

2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUIT





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

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

TRANSIENT CHARACTERISTICS

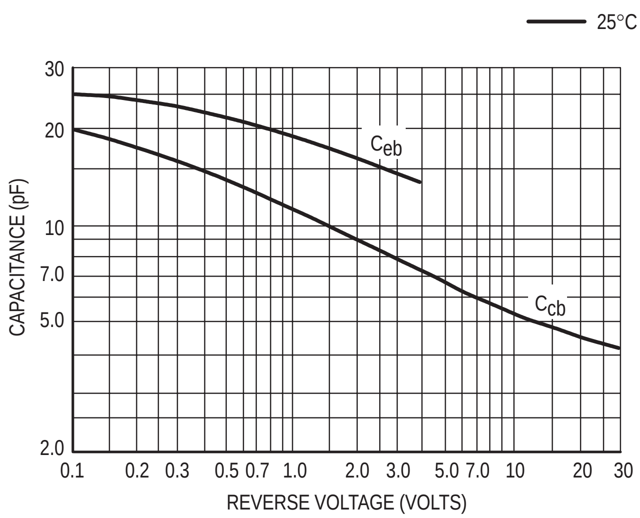


Figure 3. Capacitances

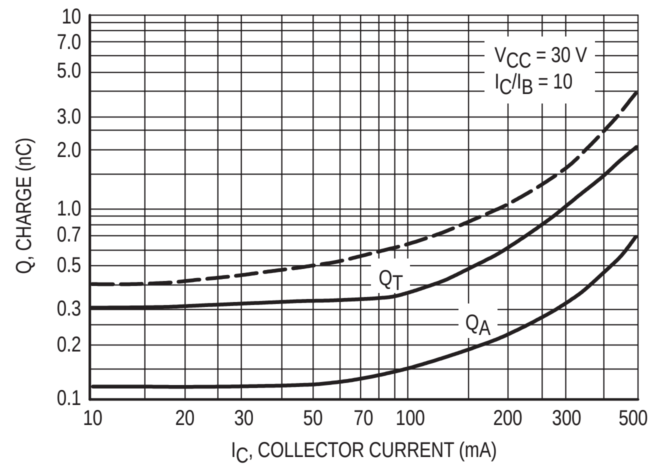


Figure 4. Charge Data

TRANSIENT CHARACTERISTICS (Continued)

25°C — 100°C

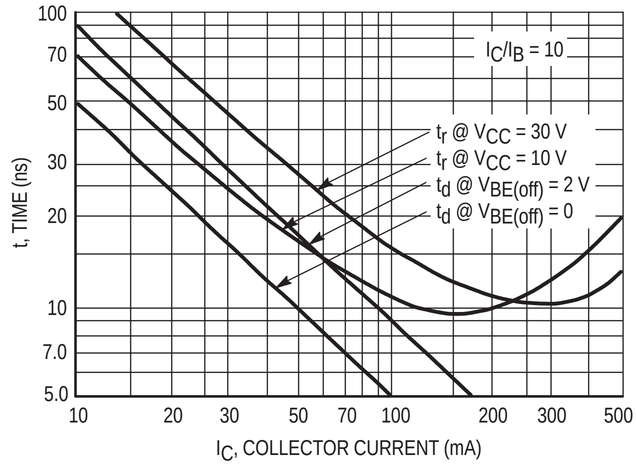


Figure 5. Turn–On Time

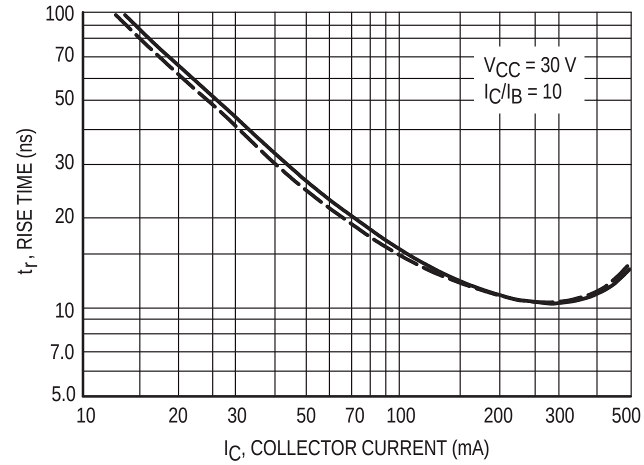


Figure 6. Rise Time

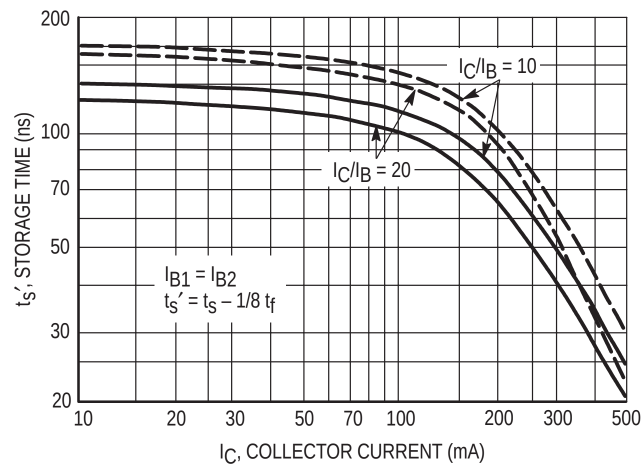


Figure 7. Storage Time

SMALL–SIGNAL CHARACTERISTICS

NOISE FIGURE

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

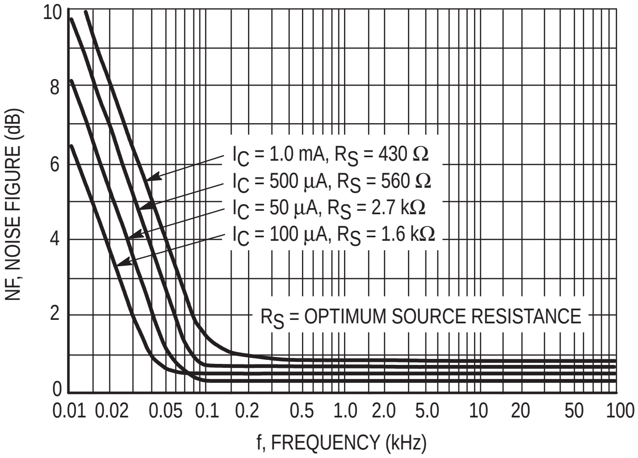


Figure 8. Frequency Effects

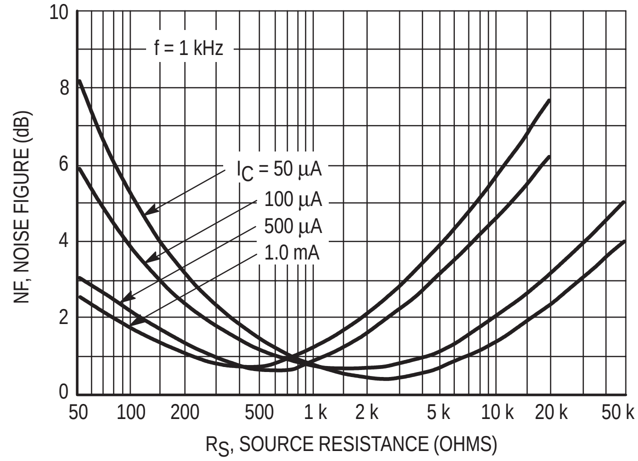


Figure 9. Source Resistance Effects

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 the 2N4402 line, and the same units were used to develop the correspondingly–numbered curves on each graph.

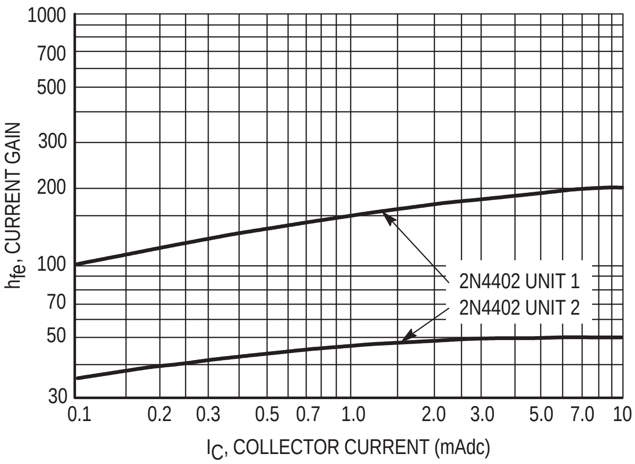


Figure 10. Current Gain

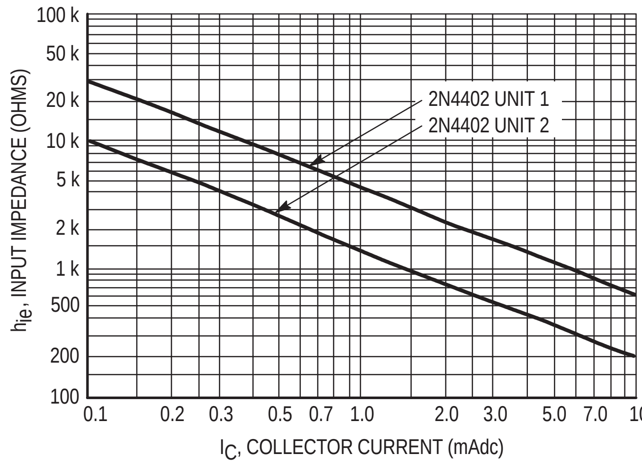


Figure 11. Input Impedance

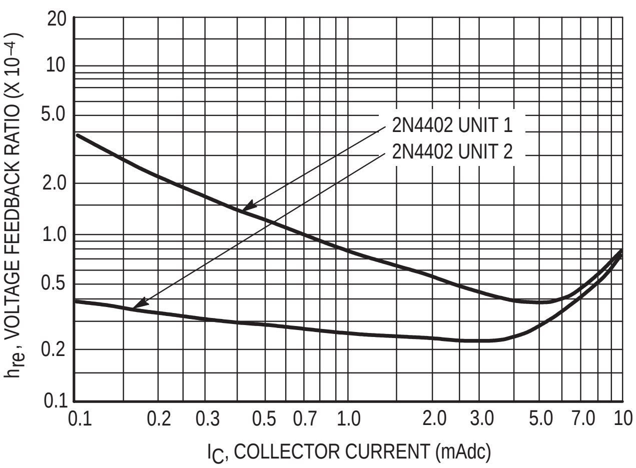


Figure 12. Voltage Feedback Ratio

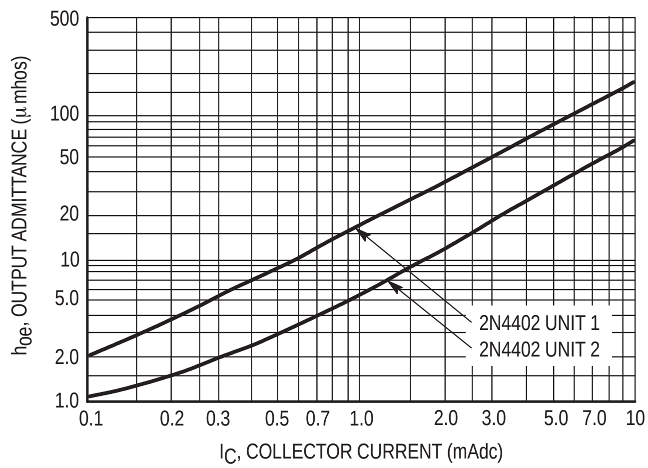


Figure 13. Output Admittance

STATIC CHARACTERISTICS

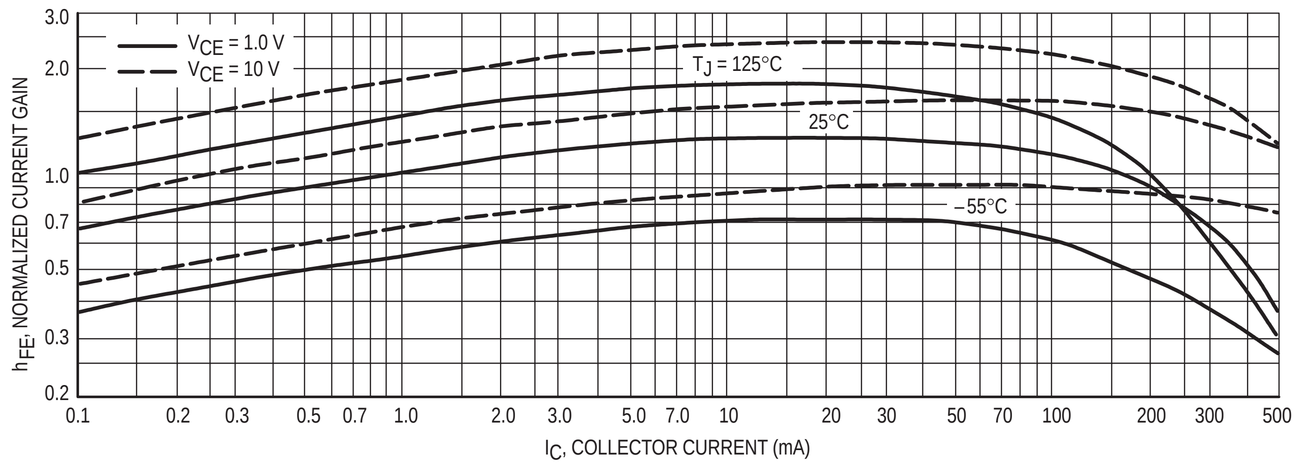


Figure 14. DC Current Gain

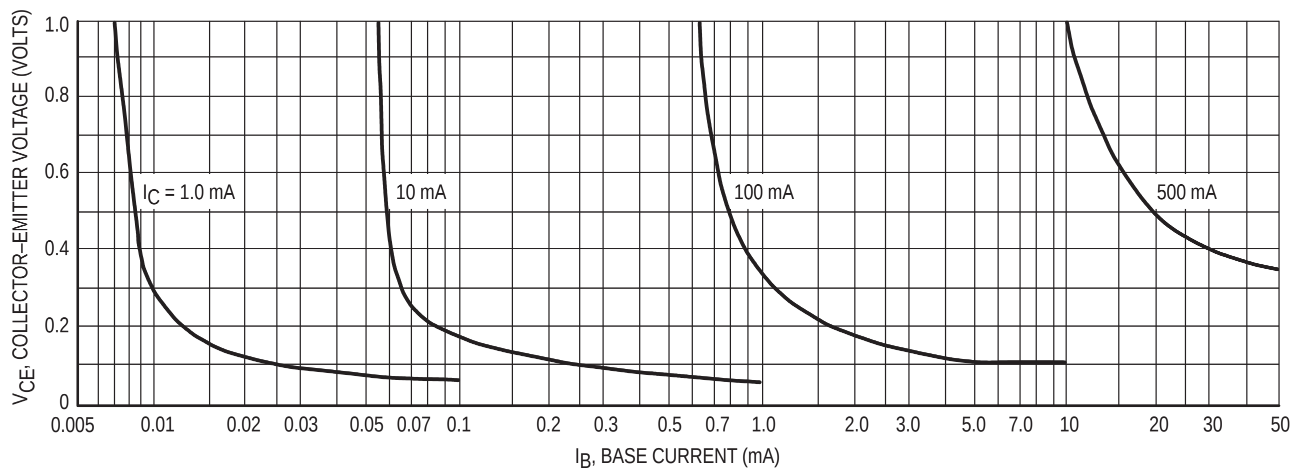


Figure 15. Collector Saturation Region

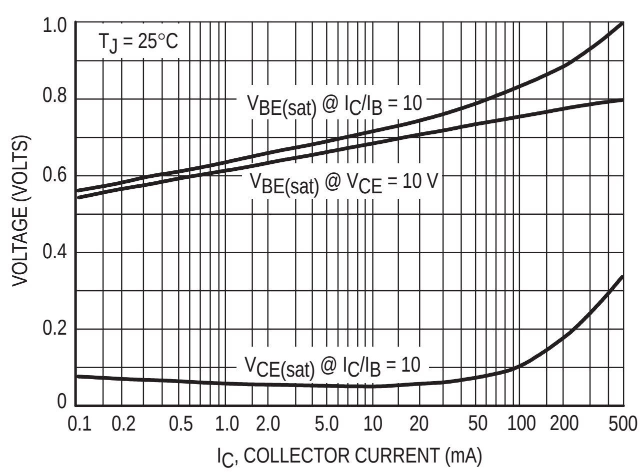


Figure 16. “On” Voltages

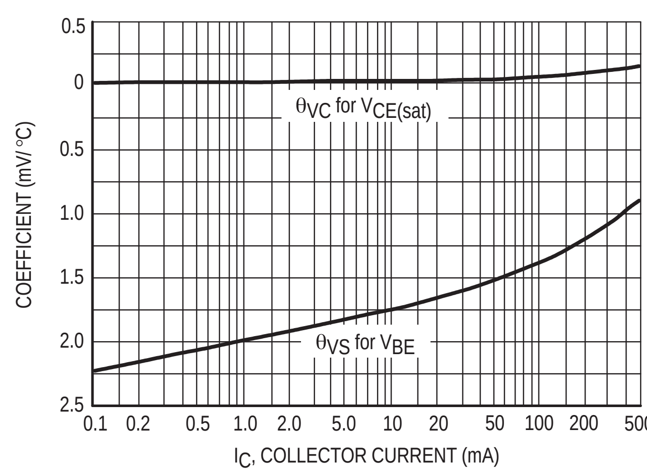
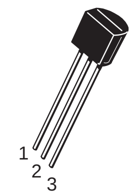


Figure 17. Temperature Coefficients

Switching Transistor
PNP Silicon

MPS3640



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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 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)

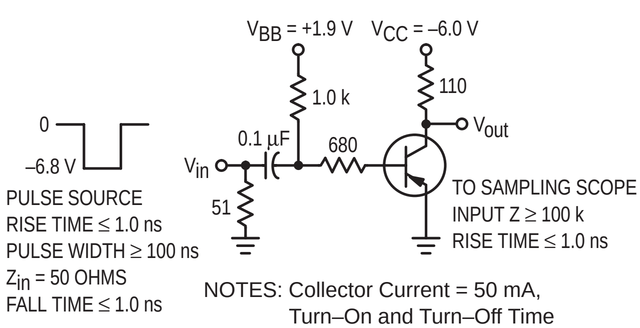
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = –100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	–12	—	Vdc
Collector–Emitter Sustaining Voltage(1) (I_C = –10 mAdc, I_B = 0)	$V_{CEO(sus)}$	–12	—	Vdc
Collector–Base Breakdown Voltage (I_C = –100 μAdc, I_E = 0)	$V_{(BR)CBO}$	–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

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

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

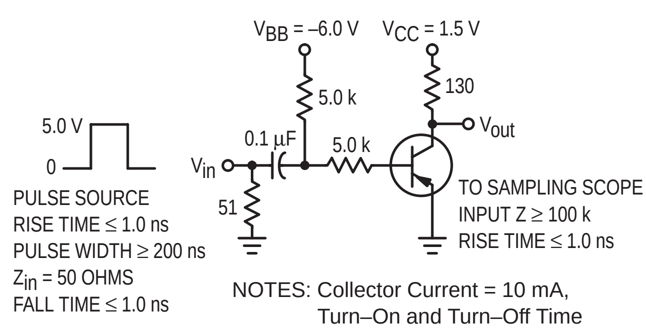
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = –10 mAdc, V_{CE} = –0.3 Vdc) (I_C = –50 mAdc, V_{CE} = –1.0 Vdc)		h_{FE}	 30 20	 120 —	—
Collector–Emitter Saturation Voltage (I_C = –10 mAdc, I_B = –1.0 mAdc) (I_C = –50 mAdc, I_B = –5.0 mAdc) (I_C = –10 mAdc, I_B = –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		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, 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%.



NOTES: Collector Current = 50 mA,
Turn–On and Turn–Off Time
Base Currents = 5.0 mA.

Figure 1.



NOTES: Collector Current = 10 mA,
Turn–On and Turn–Off Time
Base Currents = 0.5 mA.

Figure 2.

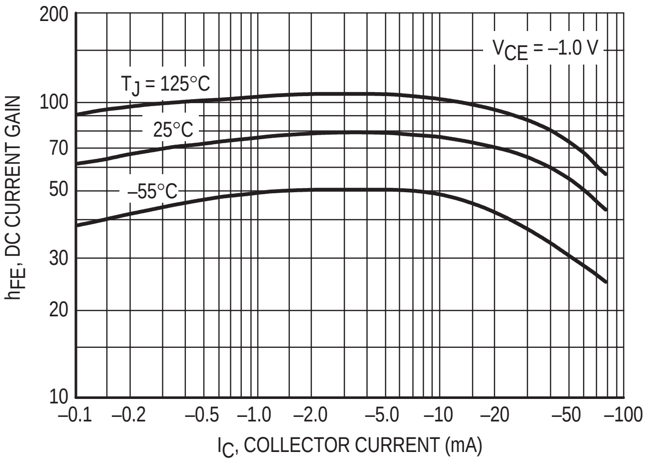


Figure 3. DC Current Gain

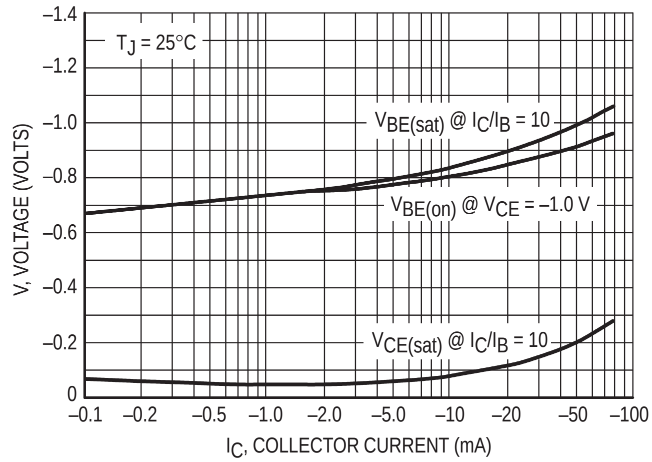


Figure 4. "On" Voltages

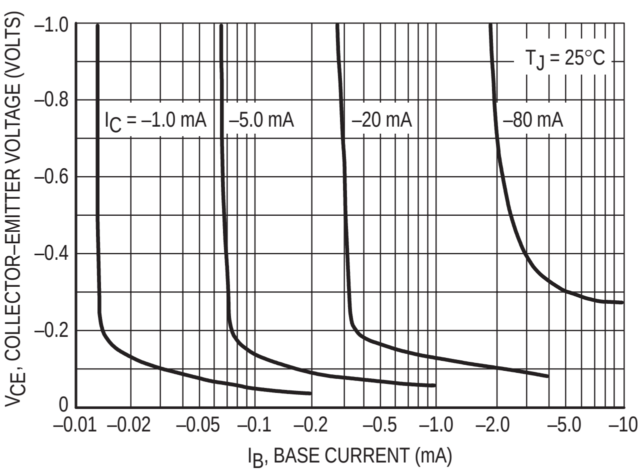


Figure 5. Collector Saturation Region

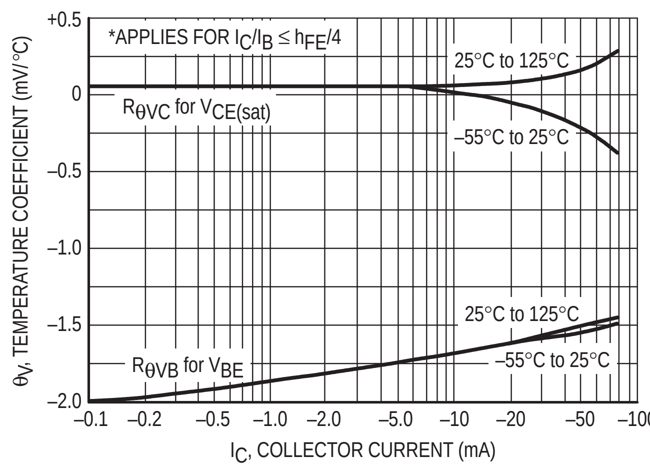


Figure 6. Temperature Coefficients

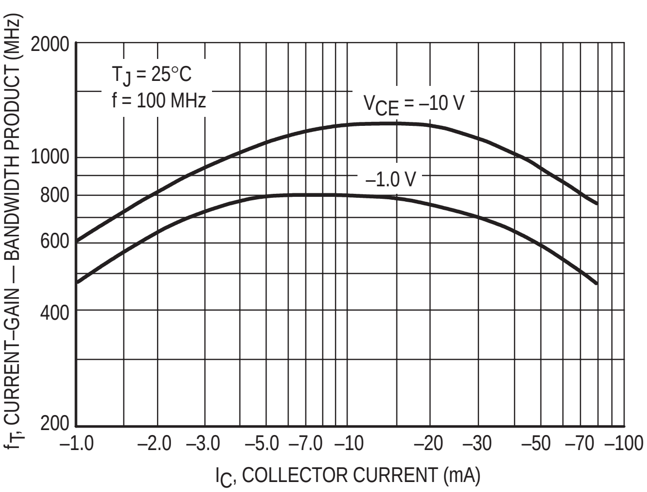


Figure 7. Current–Gain — Bandwidth Product

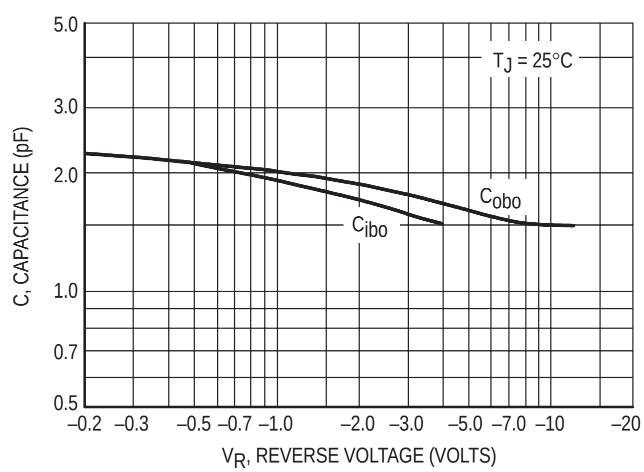
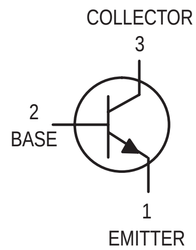


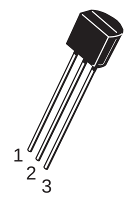
Figure 8. Capacitance

Switching Transistor
NPN Silicon

MPS3646

Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

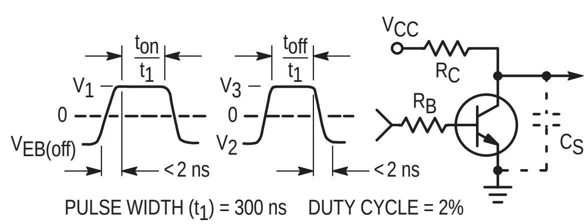
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Max	Unit
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 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

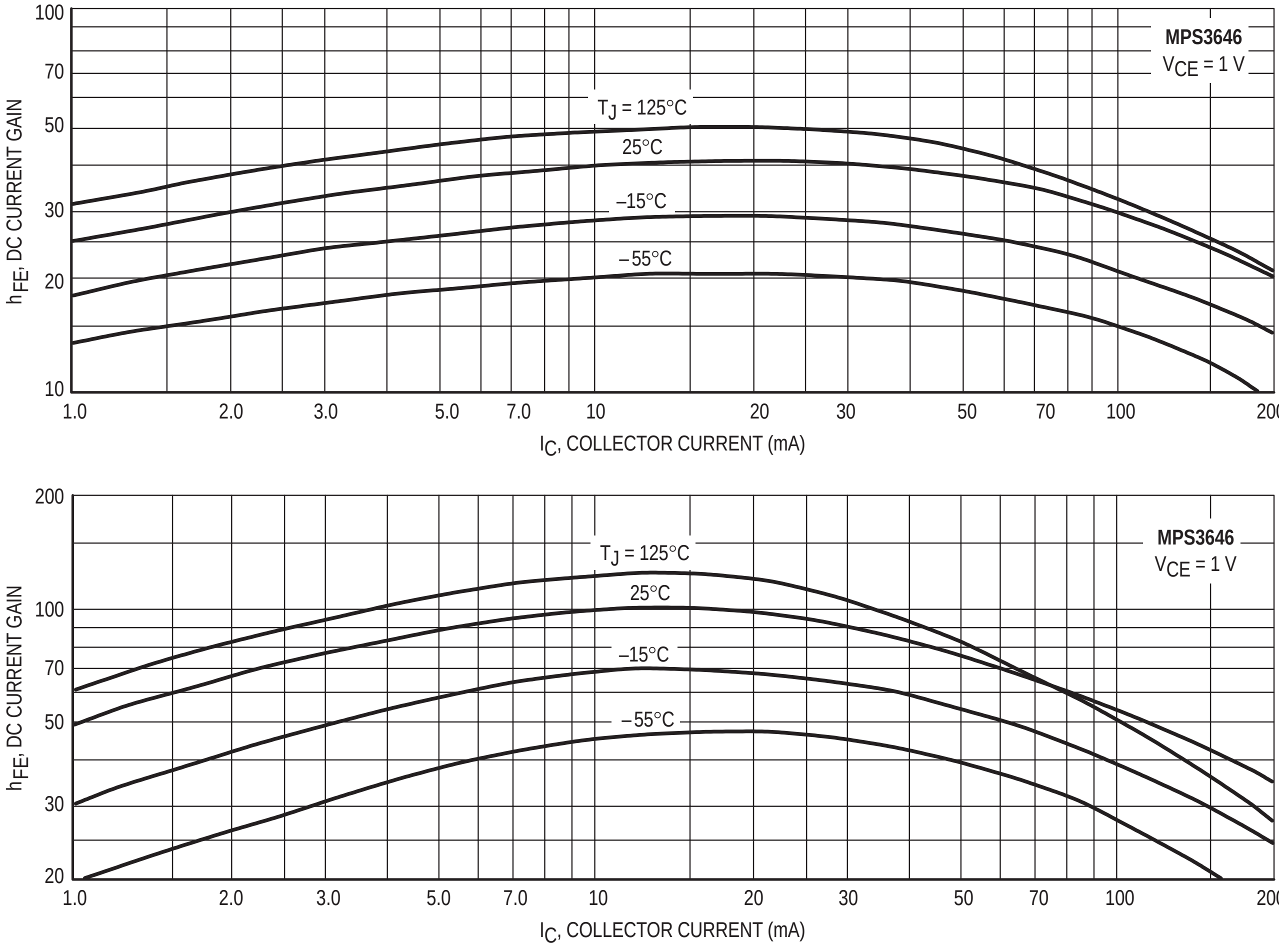


Figure 2. Minimum Current Gain

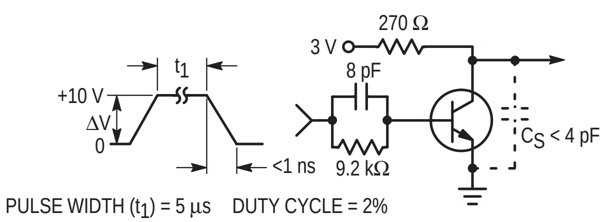


Figure 3. Q_T Test Circuit

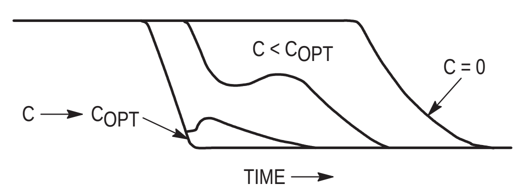


Figure 4. Turn–Off Waveform

NOTE 1

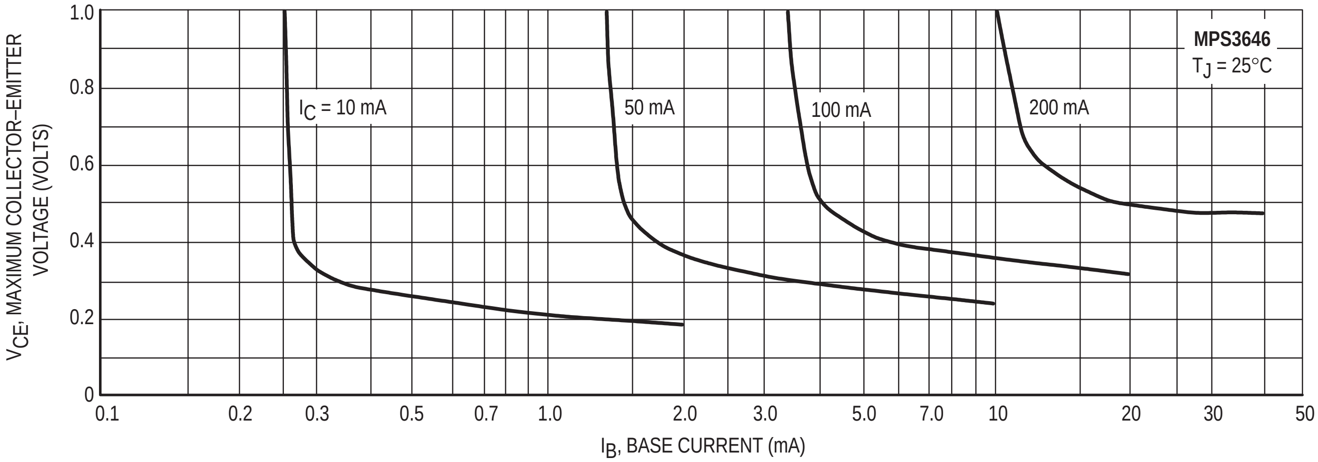
When a transistor is held in a conductive state by a base current, I_B, a charge, Q_S, is developed or “stored” in the transistor. Q_S may be written: $Q_S = Q_1 + Q_V + Q_X$.

Q_1 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_1 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: $C = Q_T/\Delta V$, where ΔV is defined in Figure 3.

"ON" CONDITION CHARACTERISTICS



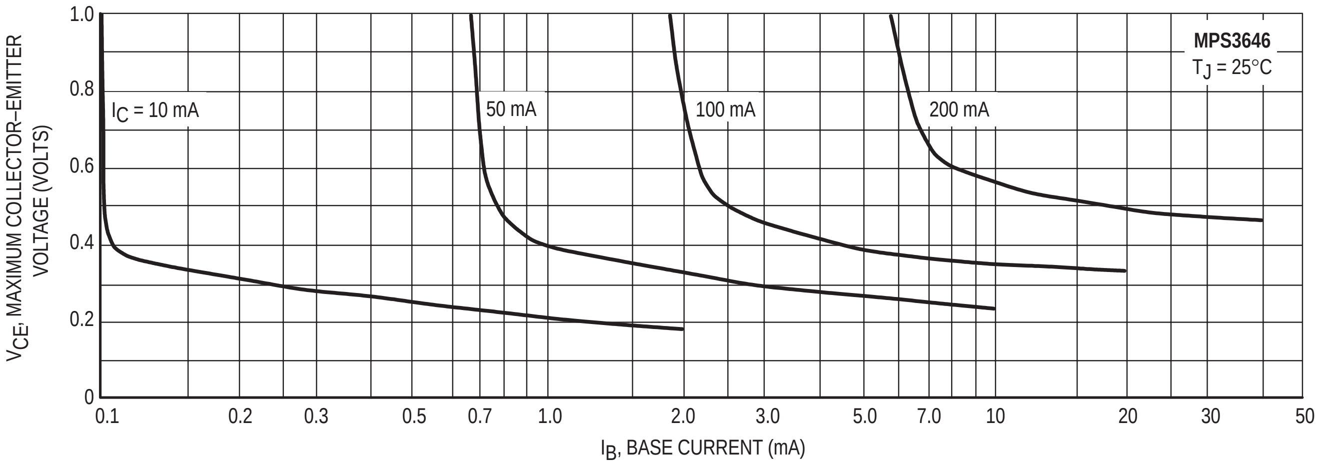


Figure 5. Collector Saturation Region

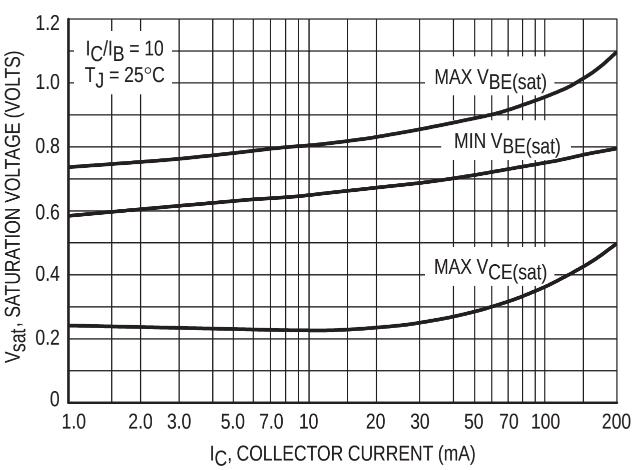


Figure 6. Saturation Voltage Limits

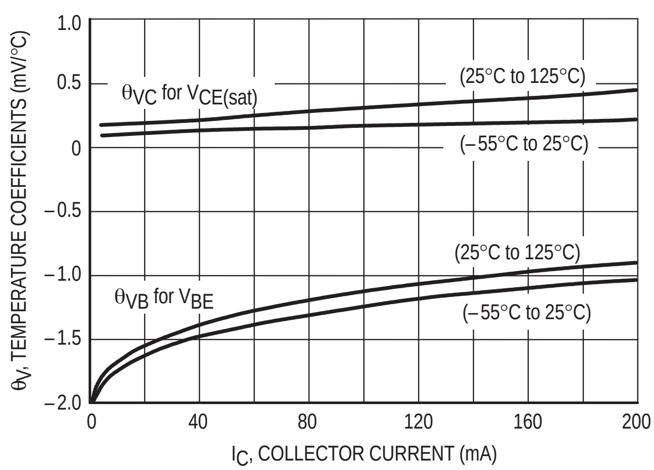


Figure 7. Temperature Coefficients

DYNAMIC CHARACTERISTICS

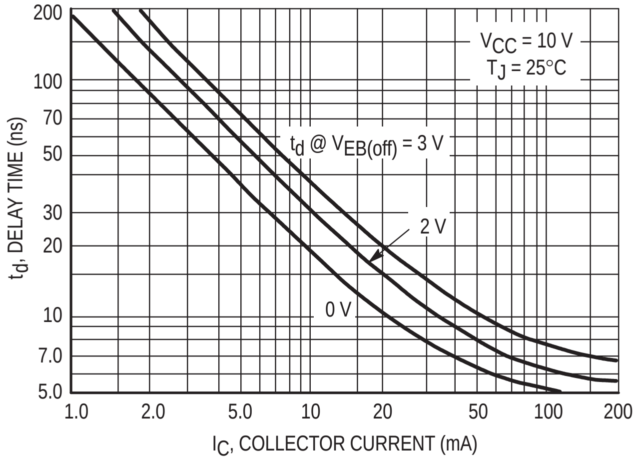


Figure 8. Delay Time

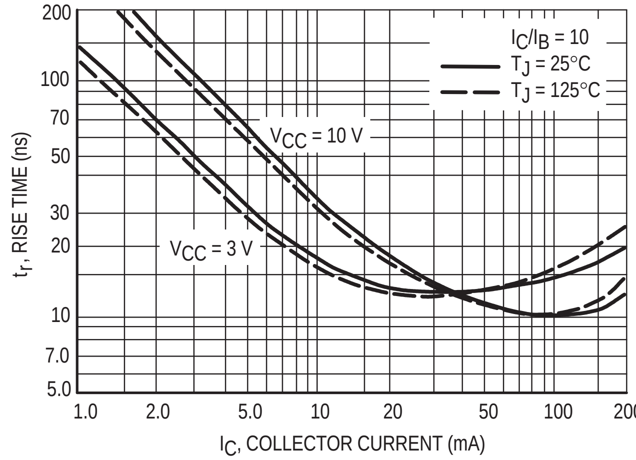


Figure 9. Rise Time

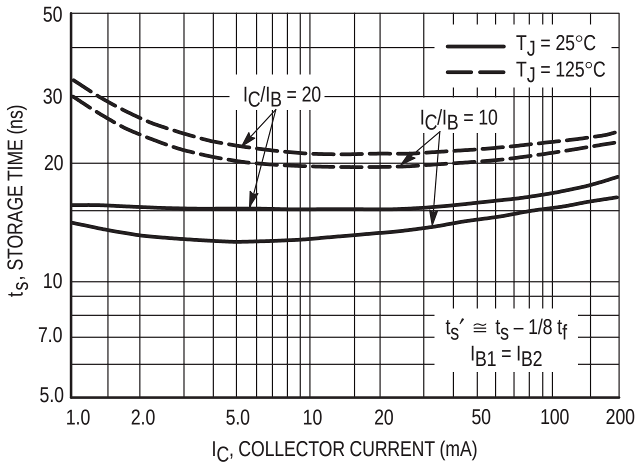


Figure 10. Storage Time

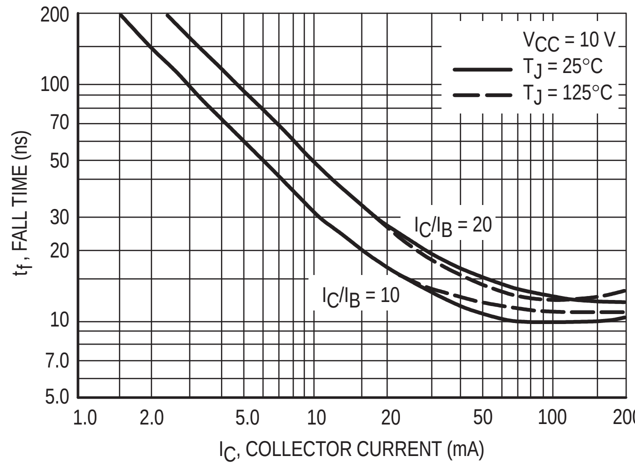


Figure 11. Fall Time

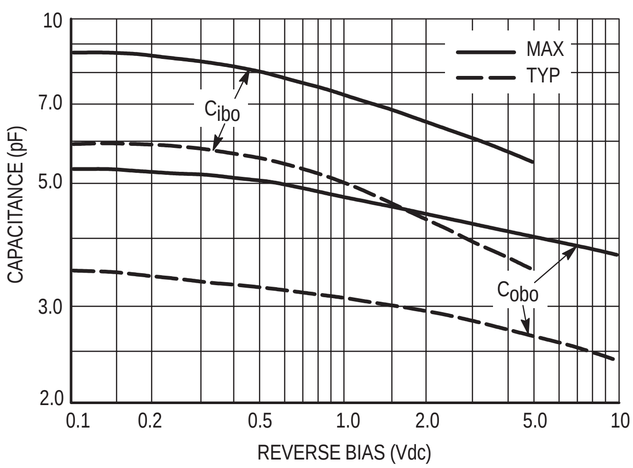


Figure 12. Junction Capacitance

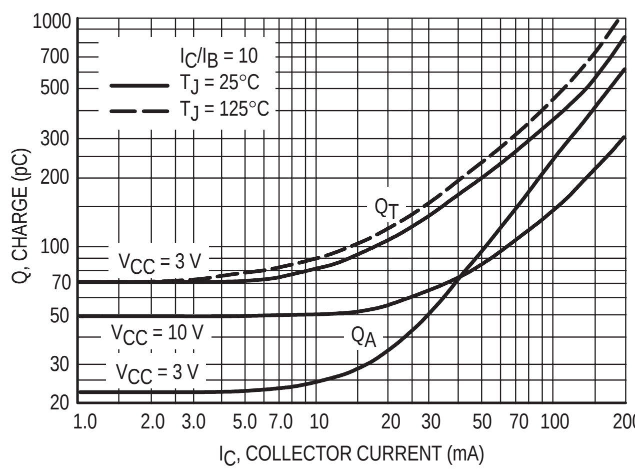
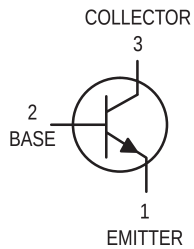
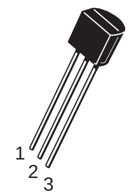


Figure 13. Maximum Charge Data

General Purpose Transistor
NPN Silicon

MPS3904





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

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

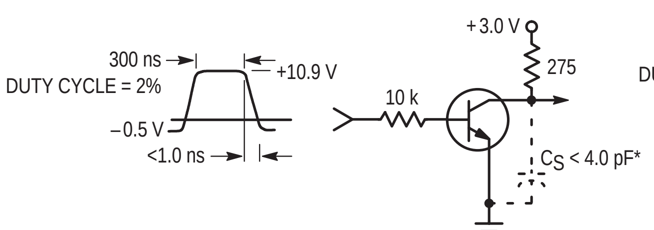
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]				
DC Current Gain	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		40	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		70	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		60	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		30	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	0.3	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	1.1	
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	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

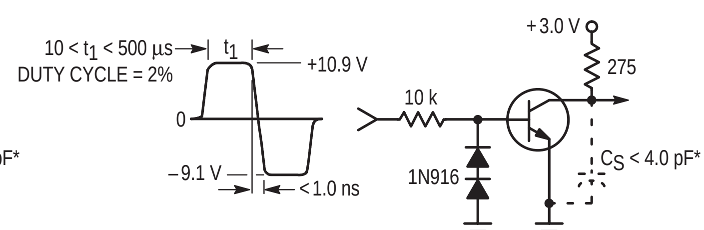
SWITCHING CHARACTERISTICS

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





*Total shunt capacitance of test jig and connectors

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

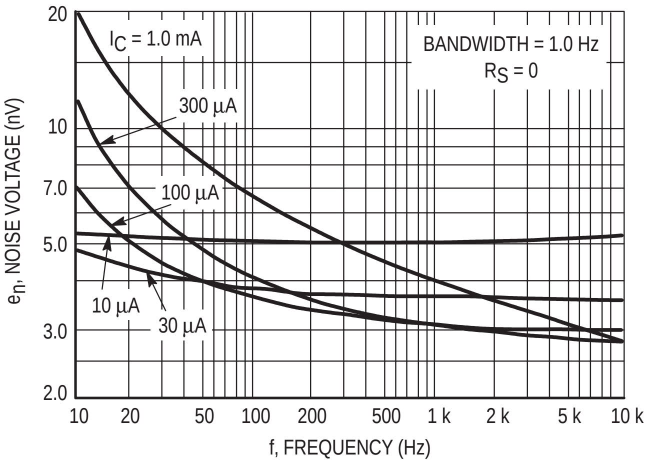


Figure 3. Noise Voltage

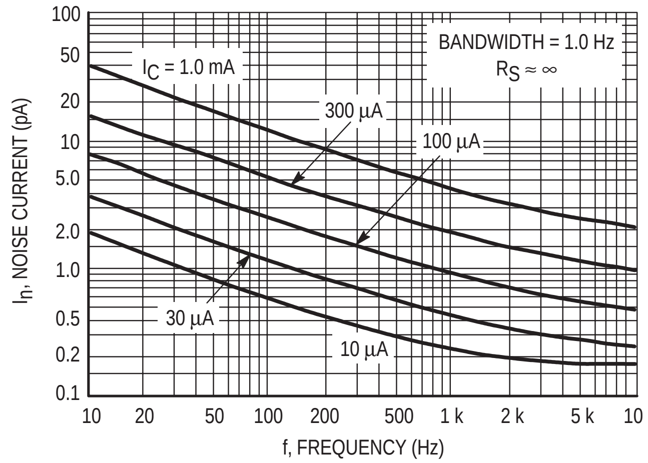


Figure 4. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

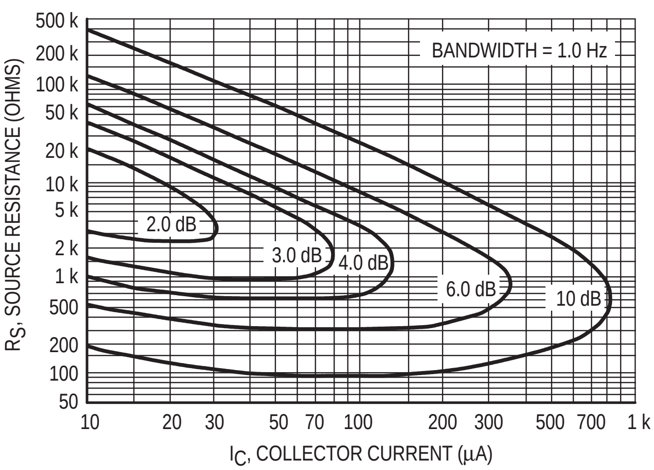


Figure 5. Narrow Band, 100 Hz

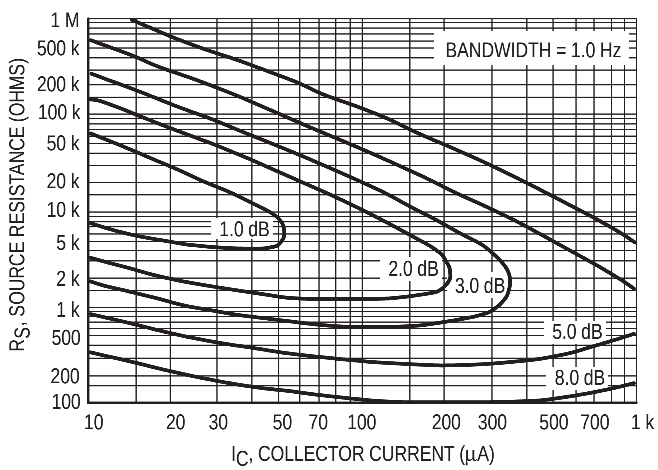


Figure 6. Narrow Band, 1.0 kHz

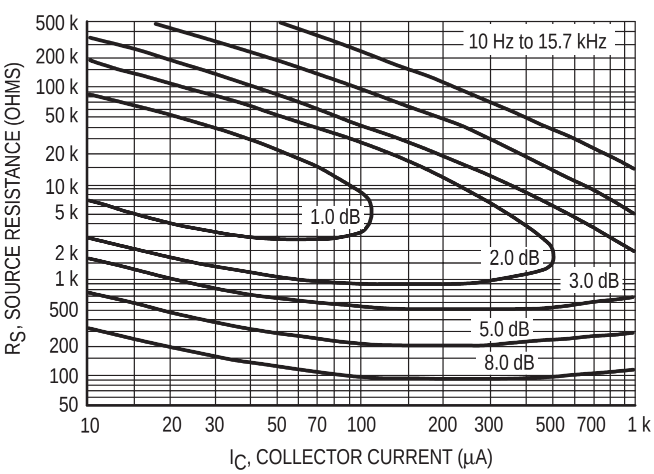


Figure 7. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

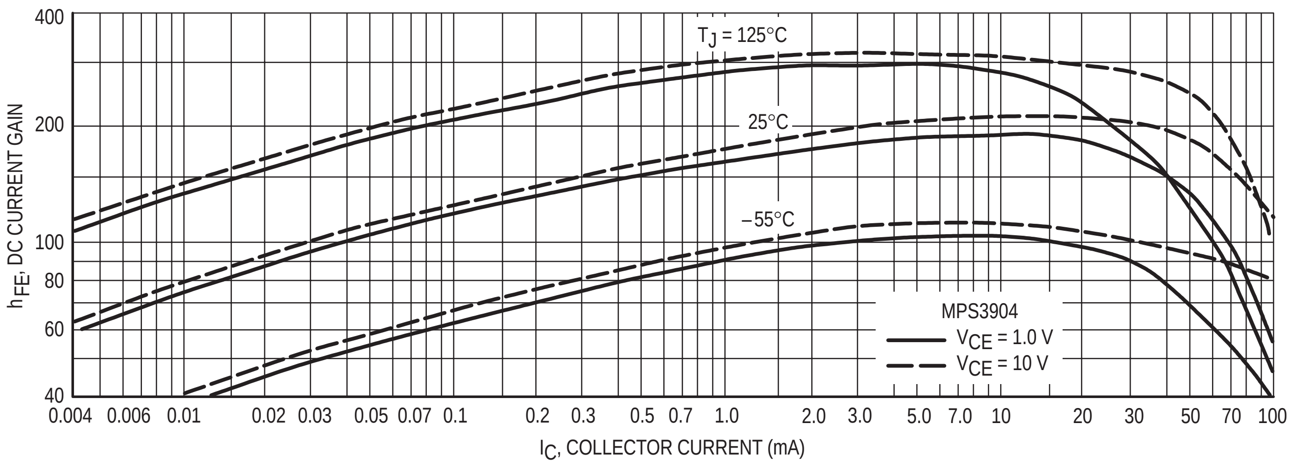


Figure 8. DC Current Gain

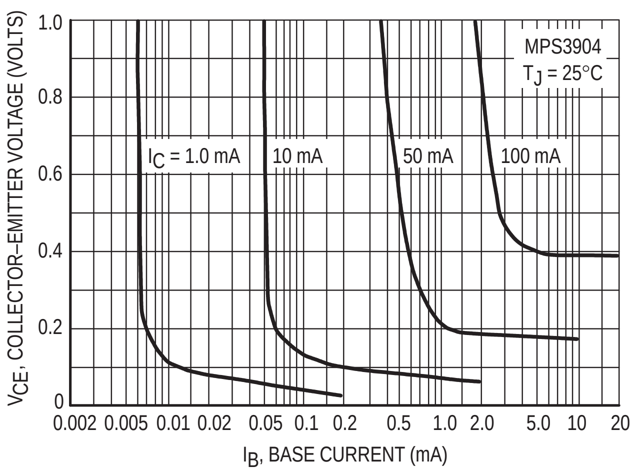


Figure 9. Collector Saturation Region

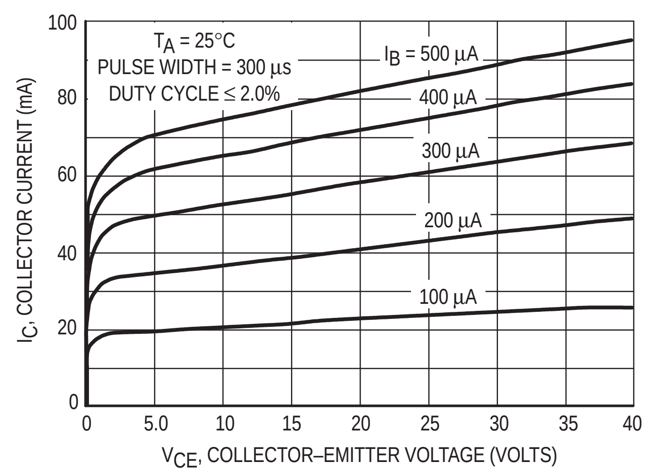


Figure 10. Collector Characteristics

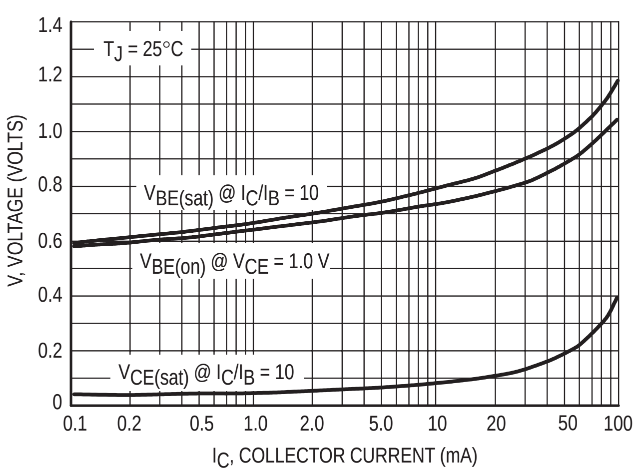


Figure 11. "On" Voltages

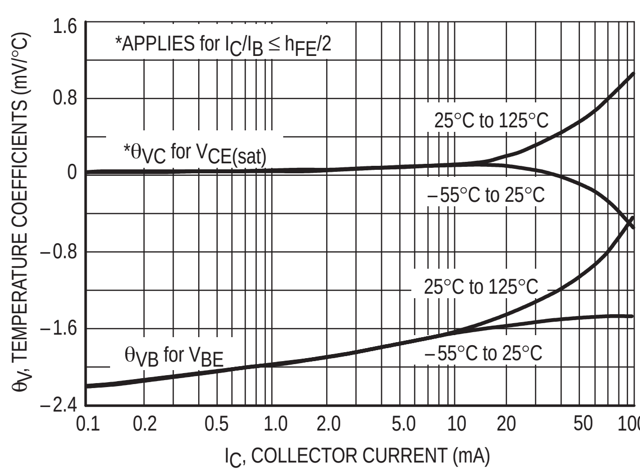


Figure 12. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

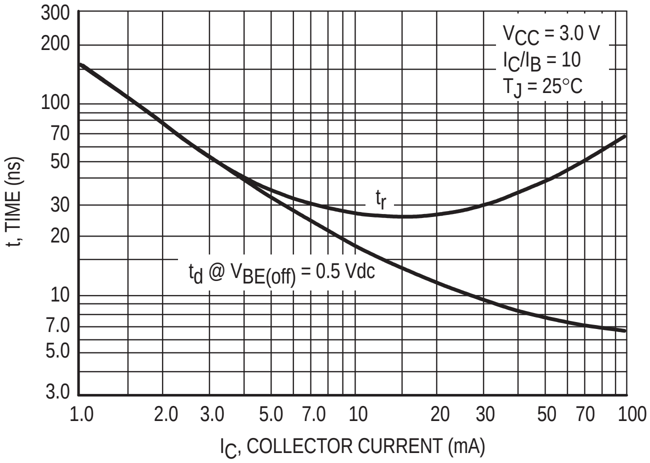


Figure 13. Turn–On Time

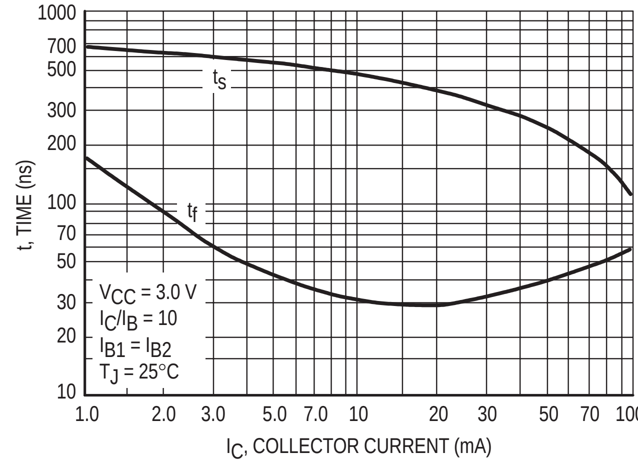


Figure 14. Turn–Off Time

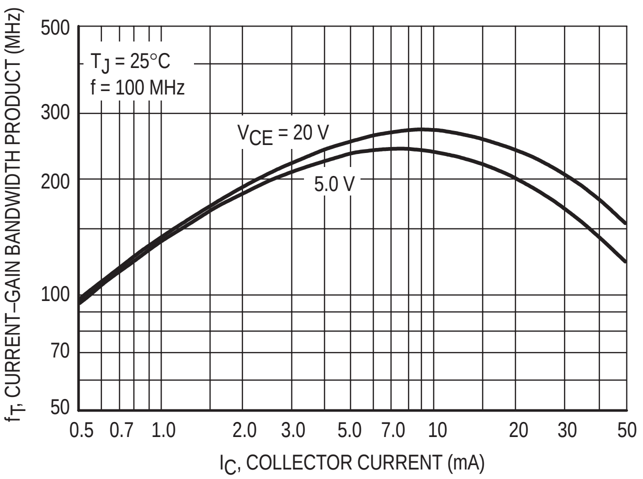


Figure 15. Current–Gain — Bandwidth Product

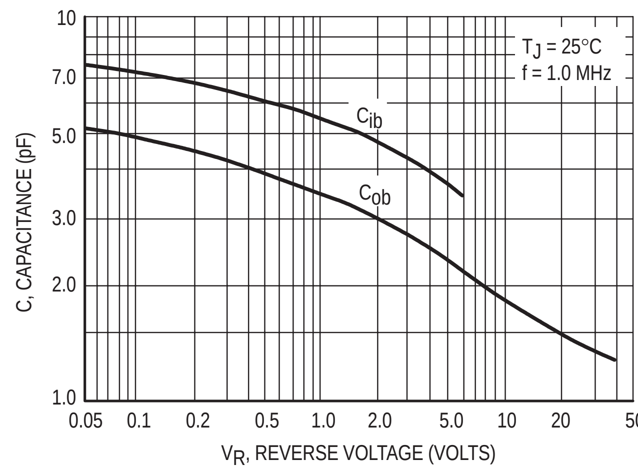


Figure 16. Capacitance

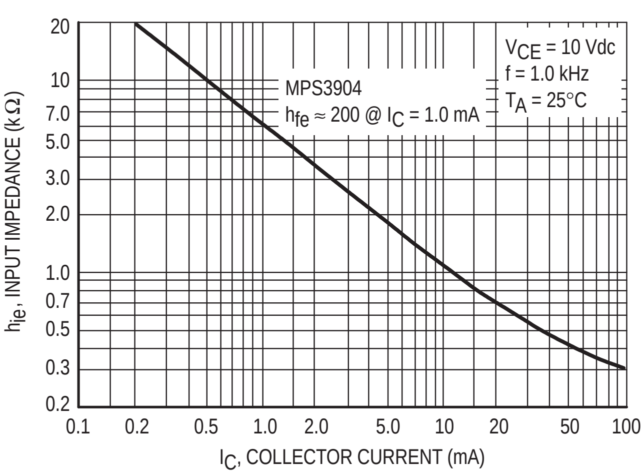


Figure 17. Input Impedance

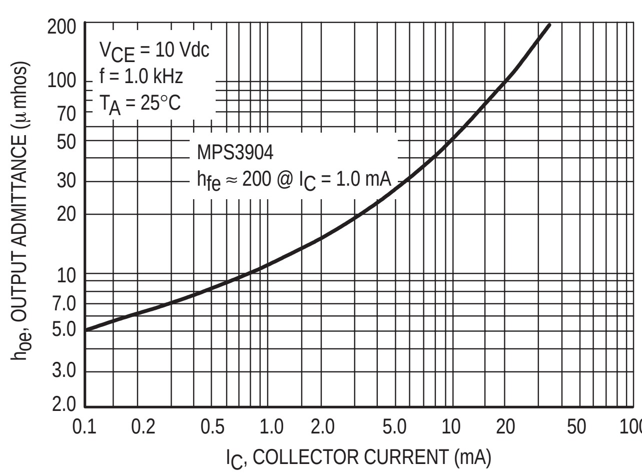


Figure 18. Output Admittance

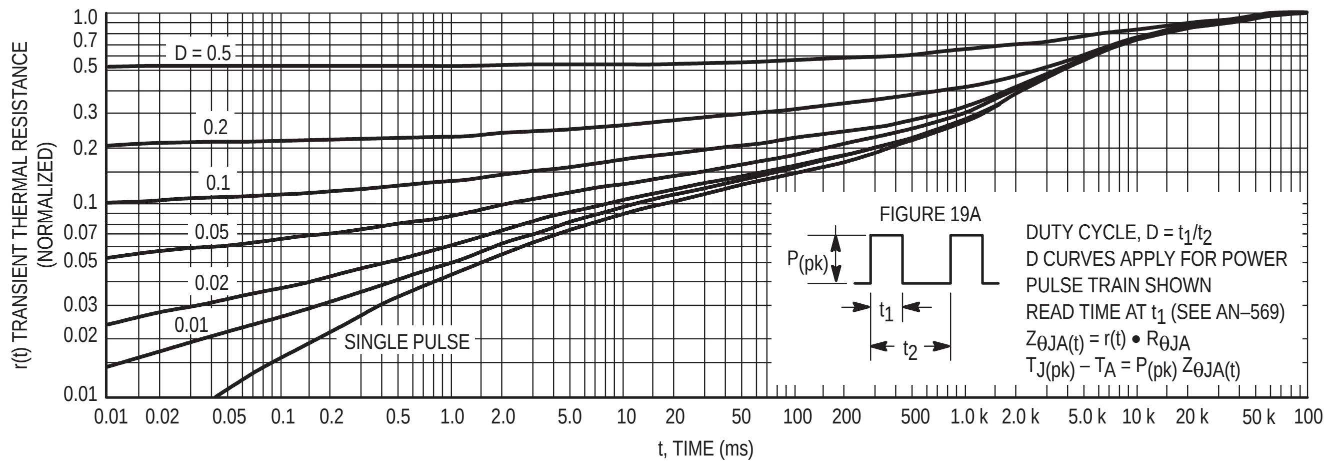


Figure 19. Thermal Response

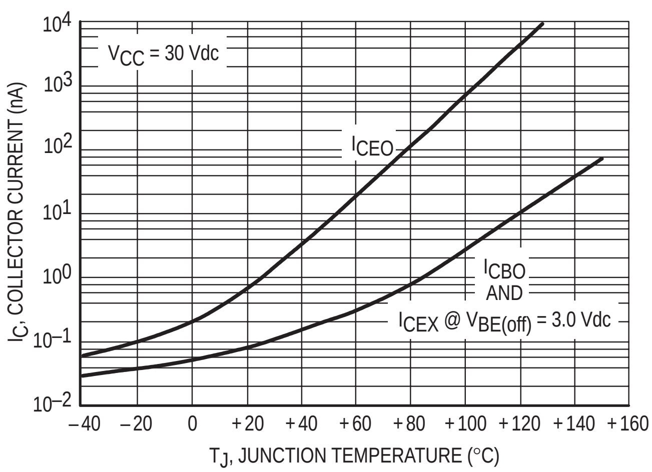


Figure 19A.

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.

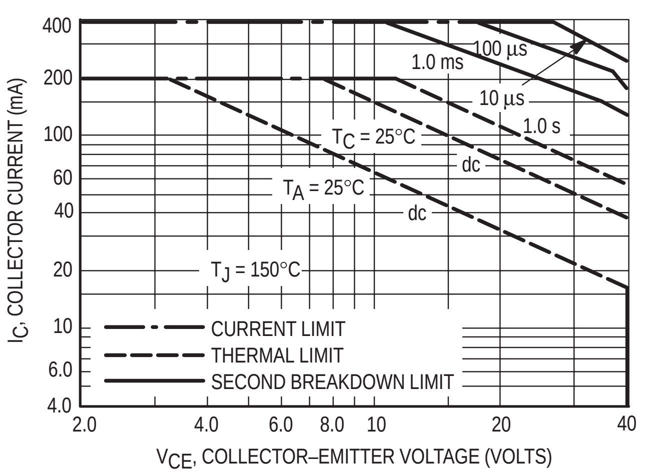


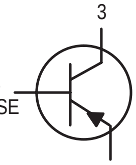
Figure 20.

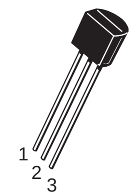
The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

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 that can be handled to values less than the limitations imposed by second breakdown.

General Purpose Transistor
PNP Silicon

MPS3906





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

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 = 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

1. Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2.0%.

REV 1

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

Characteristic		Symbol	Min	Max	Unit
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
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 Ω
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 Ω, 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%.

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

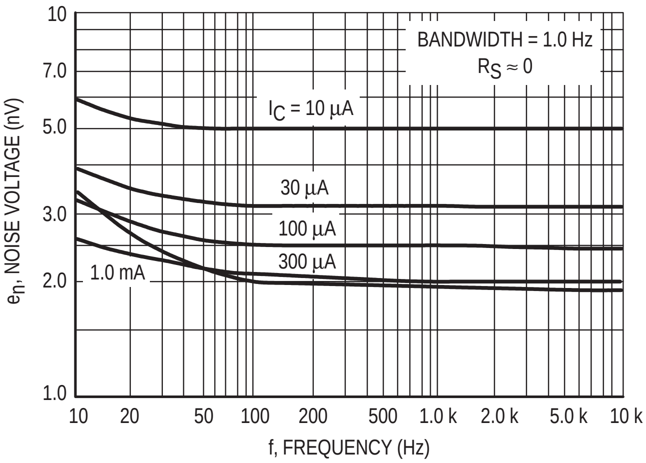


Figure 1. Noise Voltage

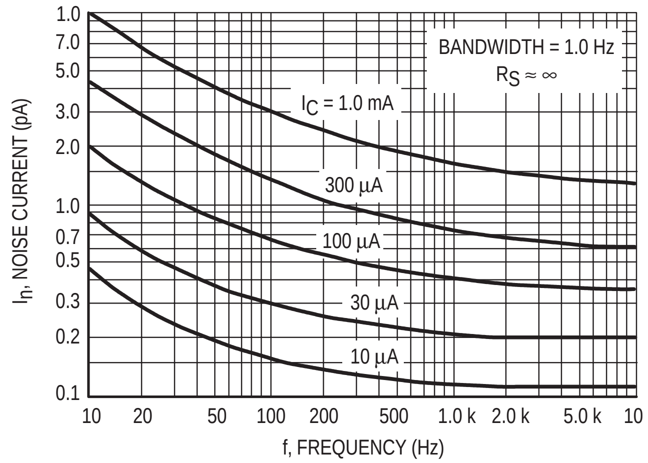


Figure 2. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

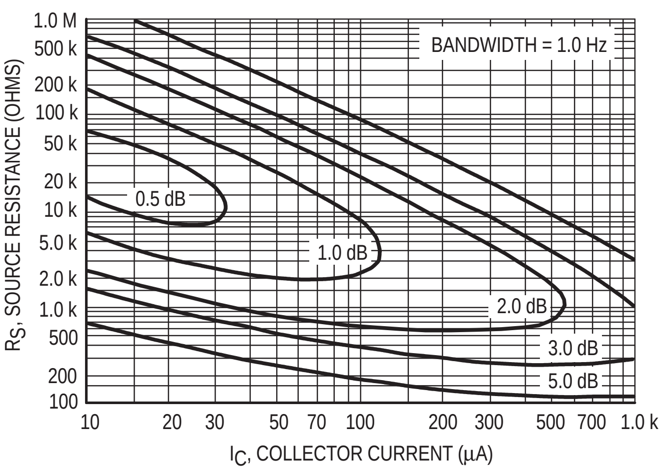


Figure 3. Narrow Band, 100 Hz

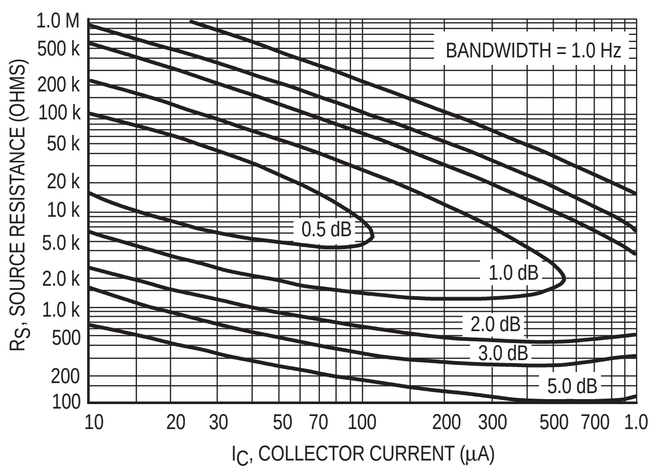


Figure 4. Narrow Band, 1.0 kHz

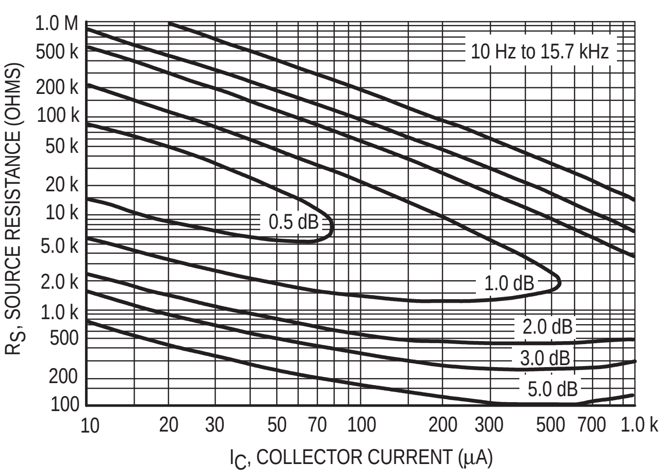


Figure 5. Wideband

Noise Figure is Defined as:

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

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

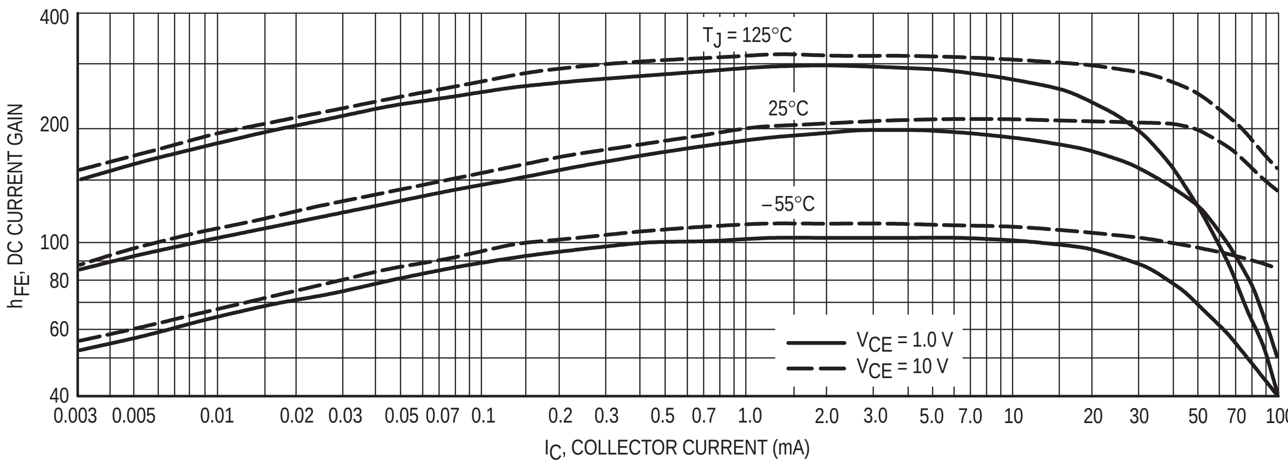


Figure 6. DC Current Gain

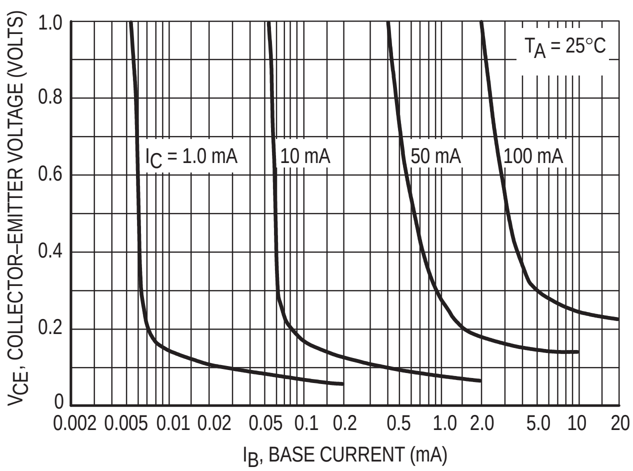


Figure 7. Collector Saturation Region

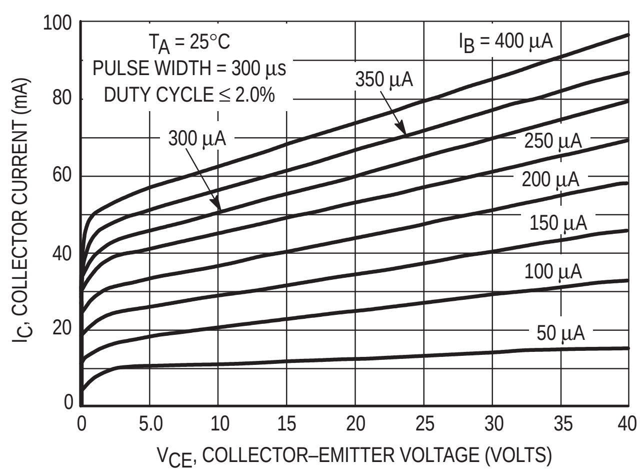


Figure 8. Collector Characteristics

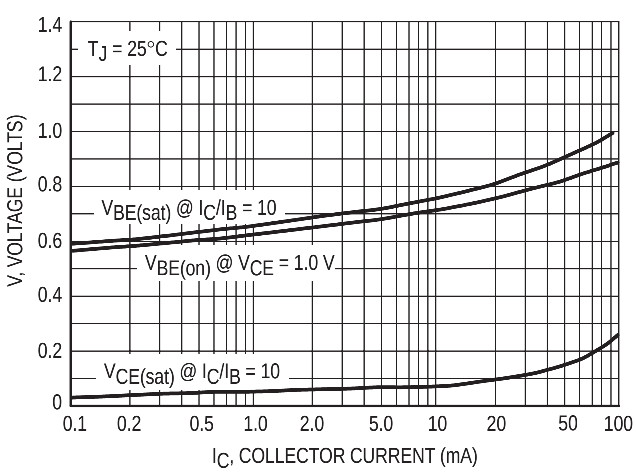


Figure 9. "On" Voltages

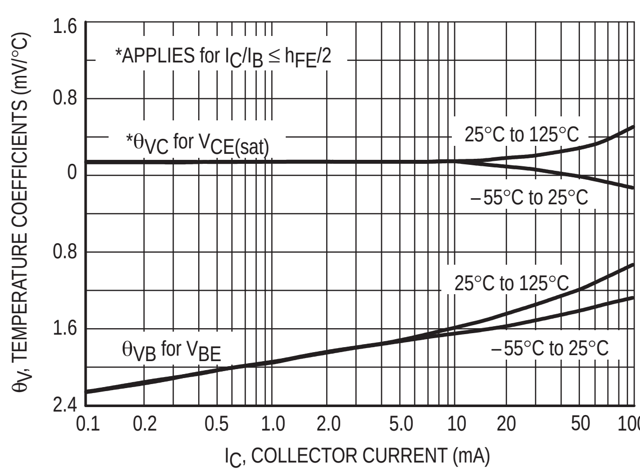


Figure 10. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

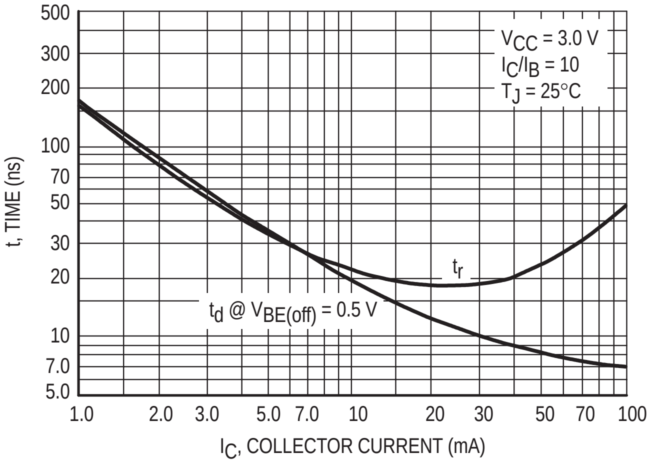


Figure 11. Turn–On Time

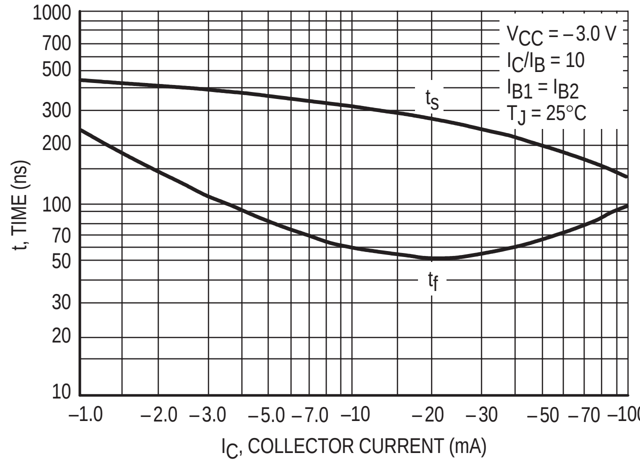


Figure 12. Turn–Off Time

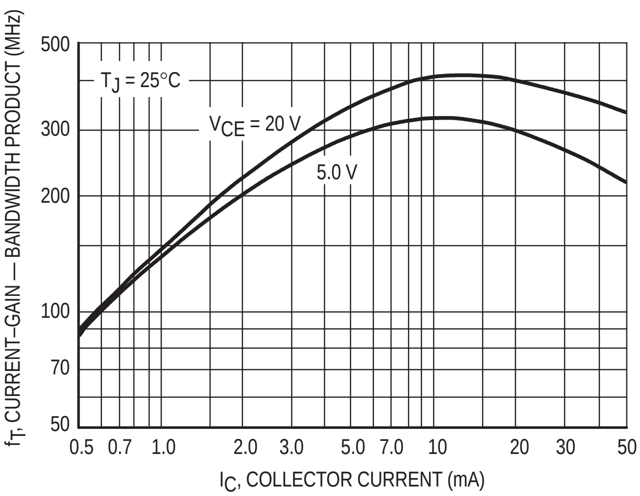


Figure 13. Current–Gain — Bandwidth Product

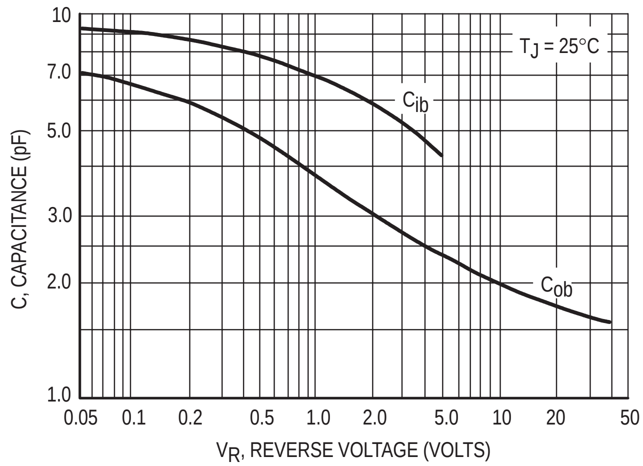


Figure 14. Capacitance

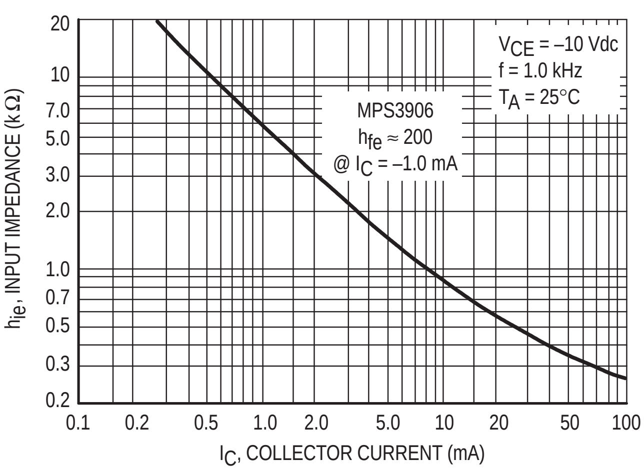


Figure 15. Input Impedance

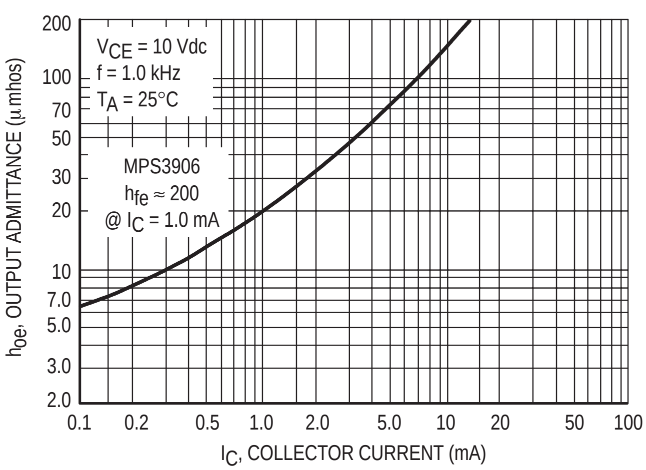


Figure 16. Output Admittance

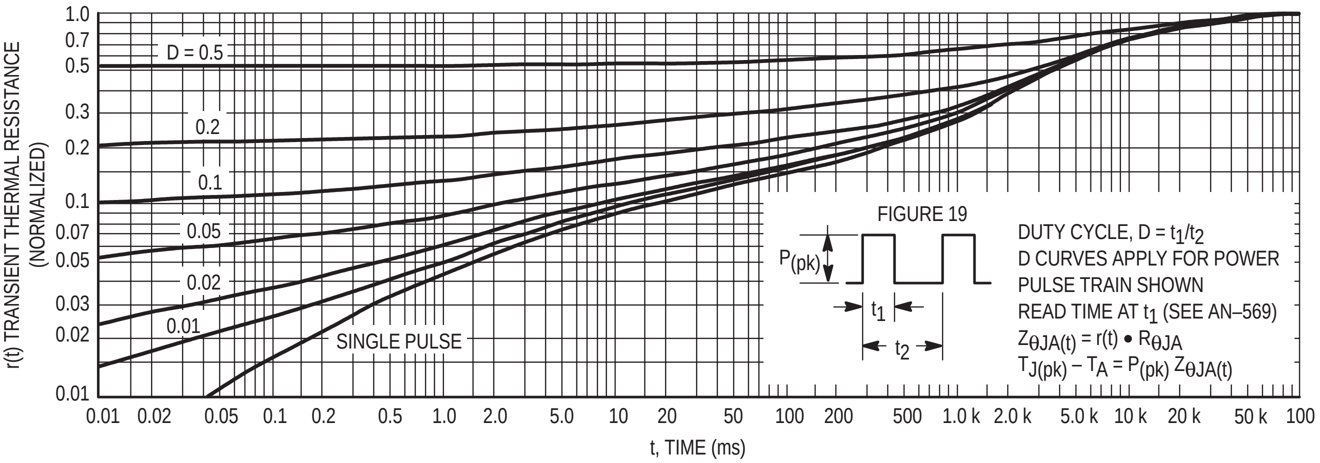


Figure 17. Thermal Response

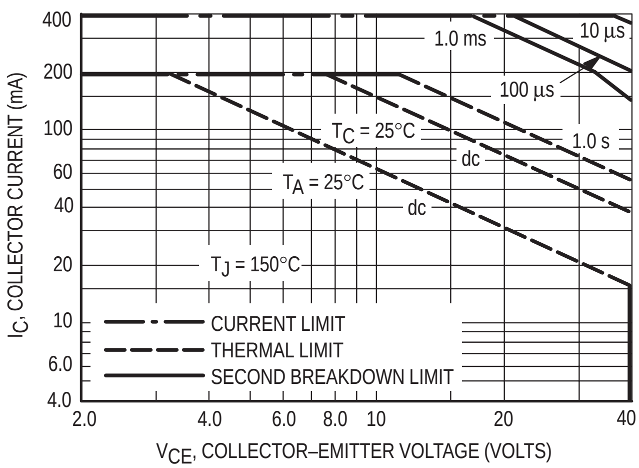


Figure 18. Active–Region Safe Operating Area

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 18 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 $T_{J(pk)} \le 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 17. 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.

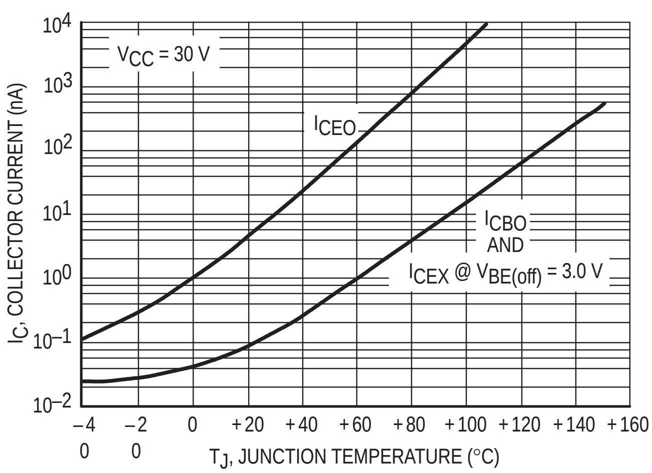


Figure 19. Typical Collector Leakage Current

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 17 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 17 by the steady state value $R_{\theta JA}$.

Example:
Dissipating 2.0 watts peak under the following conditions:

$t_1 = 1.0$ ms, $t_2 = 5.0$ ms (D = 0.2)

Using Figure 17 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

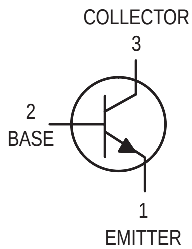
The peak rise in junction temperature is therefore

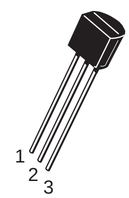
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C.$

For more information, see AN–569.

Amplifier Transistor
NPN Silicon

MPS4124





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CE}	25	Vdc
Collector–Base Voltage	V_{CB}	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_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)	$V_{(BR)CEO}$	25	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μA, I_E = 0)	$V_{(BR)CBO}$	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

(Replaces MPS4123/D)

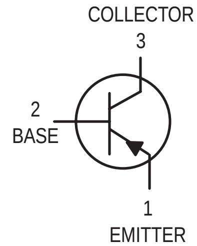
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

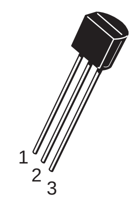
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mA, V_{CE} = 1.0 V) (I_C = 50 mA, V_{CE} = 1.0 V)	h_{FE}	 120 60	 360 —	—
Collector–Emitter Saturation Voltage (I_C = 50 mA, I_B = 5.0 mA)	$V_{CE(sat)}$	—	0.3	Vdc
Base–Emitter Saturation Voltage (I_C = 50 mA, I_B = 5.0 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)	f_T	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)	C_{ib}	—	13.5	pF
Small–Signal Current Gain (I_C = 2.0 mA, V_{CE} = 1.0 V, f = 1.0 kHz)	h_{fe}	120	480	—
Noise Figure (I_C = 100 μA, V_{CE} = 5.0 V, R_S = 1.0 kΩ, f = 1.0 kHz)	NF	—	5.0	dB

Amplifier Transistor

PNP Silicon

MPS4126





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CE}	–25	Vdc
Collector–Base Voltage	V_{CB}	–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)	$V_{(BR)CEO}$	–25	—	Vdc
Collector–Base Breakdown Voltage (I_C = –10 μA, I_E = 0)	$V_{(BR)CBO}$	–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

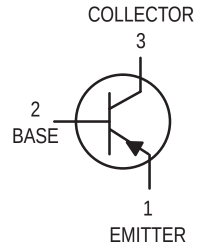
(Replaces MPS4125/D)

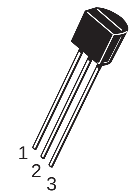
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain (I_C = –2.0 mA, V_{CE} = –1.0 V) (I_C = –50 mA, V_{CE} = –1.0 V)	h_{FE}	 120 60	 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)	f_T	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)	C_{ib}	—	11.5	pF
Small–Signal Current Gain (I_C = –2.0 mA, V_{CE} = 1.0 V, f = 1.0 kHz)	h_{fe}	120	480	—
Noise Figure (I_C = –100 μA, V_{CE} = –5.0 V, R_S = 1.0 kΩ, f = 1.0 kHz)	NF	—	4.0	dB

Transistor
PNP Silicon

MPS4250





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

1. Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2.0%.

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

Characteristic	Symbol	Min	Max	Unit
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

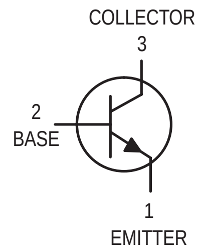
1. Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2.0%.

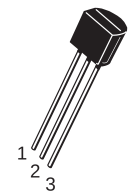
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

High Frequency Transistor
NPN Silicon

MPS5179

Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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)

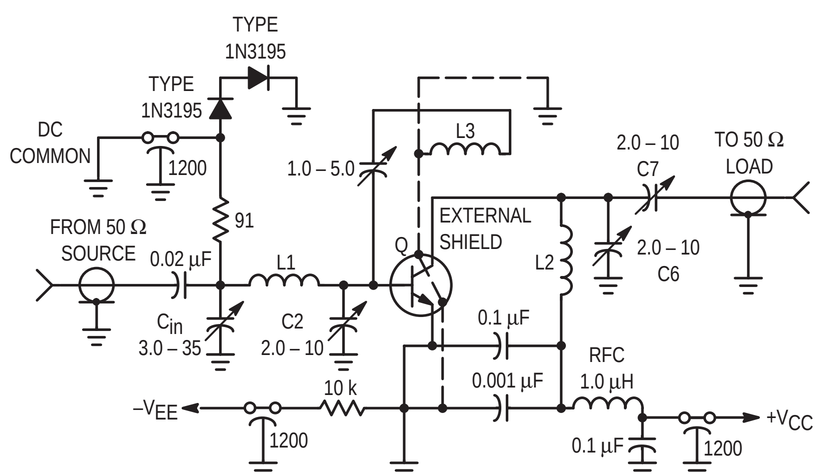
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.001 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	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

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

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

Characteristic	Symbol	Min	Max	Unit
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)	$rb'C_c$	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.



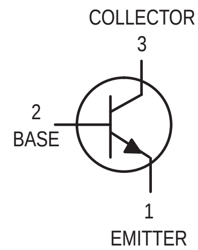
L1 1–3/4 Turns, #18 AWG, 0.5″ L, 0.5″ Diameter
L2 2 Turns, #16 AWG, 0.5″ L, 0.5″ Diameter
L3 2 Turns, #13 AWG, 0.25″ L, 0.5″ Diameter (Position 1/4″ from L2)

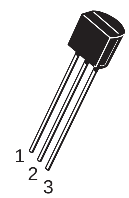
Figure 1. 200 MHz Amplifier Power Gain and Noise Figure Circuit

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Amplifier Transistor
NPN Silicon

MPS6428





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

Characteristic	Symbol	Min	Max	Unit
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
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

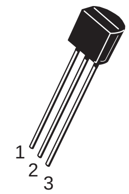
NOISE FIGURE/TOTAL NOISE VOLTAGE CHARACTERISTICS

	NF Max (1)	VT Max (1)	NF Max (2)	VT Max (2)	NF Max (3)	VT 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

Amplifier Transistor
NPN Silicon

MPS6507



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

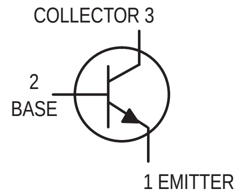
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

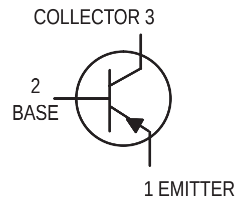
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (2) (I_C = 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	—	—	—

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%.

Amplifier Transistors

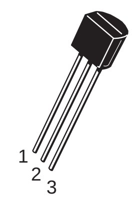




NPN MPS6521* PNP MPS6523

Voltage and current are negative for PNP transistors

***Motorola Preferred Device**



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector–Emitter Voltage MPS6521 MPS6523	V_{CEO}	 25 —	 — 25	Vdc
Collector–Base Voltage 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

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)	 MPS6521 MPS6523	I_{CBO}	 — —	 0.05 0.05	μAdc

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

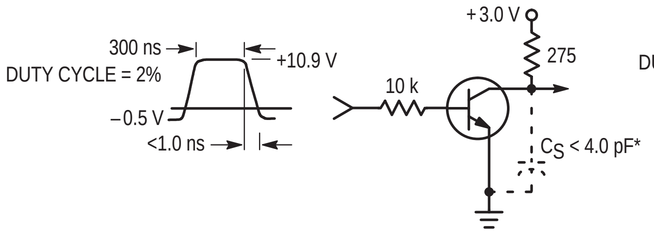
(Replaces MPS6520/D)

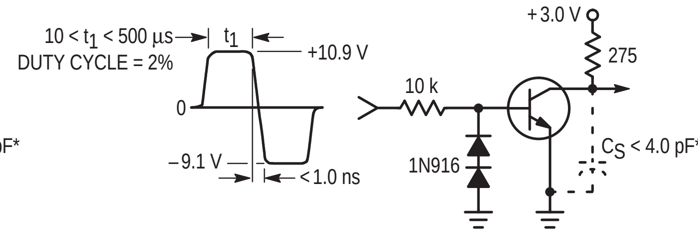
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6521		150	—	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6521		300	600	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6523		150	—	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6523		300	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 Ω, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	—	3.0	dB

NPN
MPS6521

EQUIVALENT SWITCHING TIME TEST CIRCUITS





*Total shunt capacitance of test jig and connectors

Figure 1. Turn–On Time **Figure 2. Turn–Off Time**

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

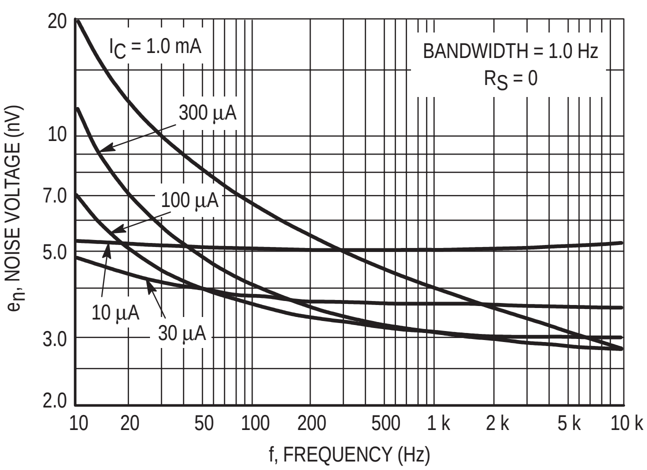


Figure 3. Noise Voltage

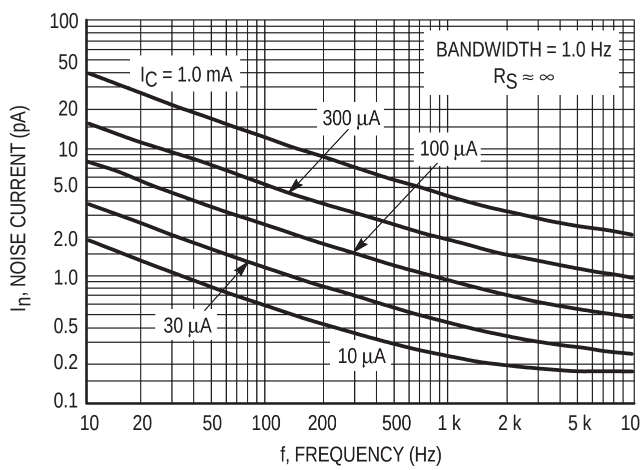


Figure 4. Noise Current

NPN
MPS6521

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

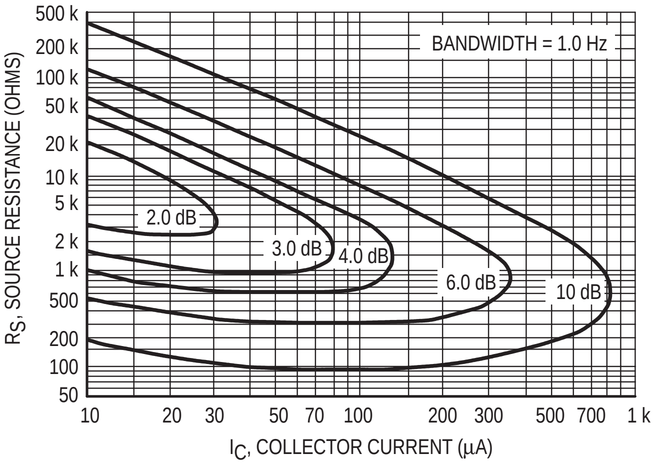


Figure 5. Narrow Band, 100 Hz

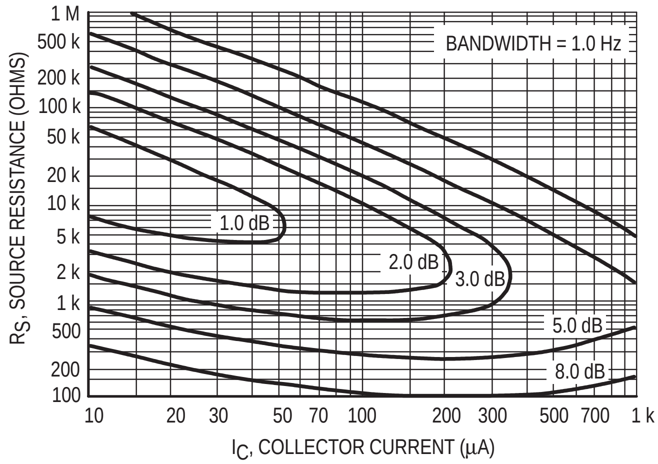


Figure 6. Narrow Band, 1.0 kHz

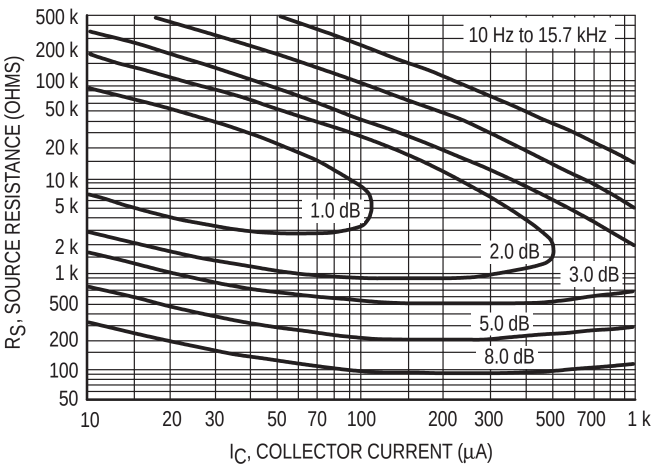


Figure 7. Wideband

Noise Figure is defined as:

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

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

NPN
MPS6521

TYPICAL STATIC CHARACTERISTICS

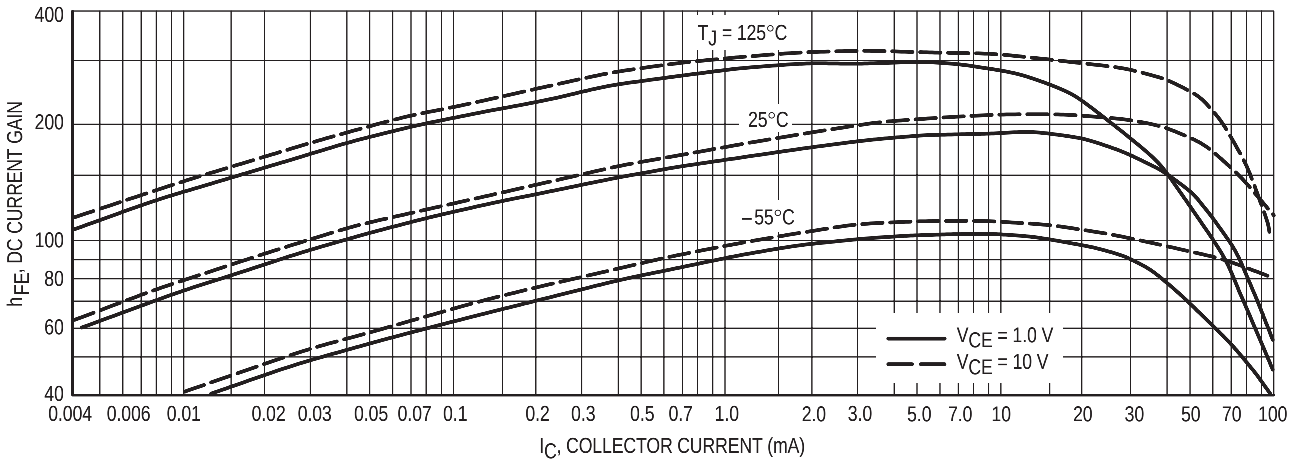


Figure 8. DC Current Gain

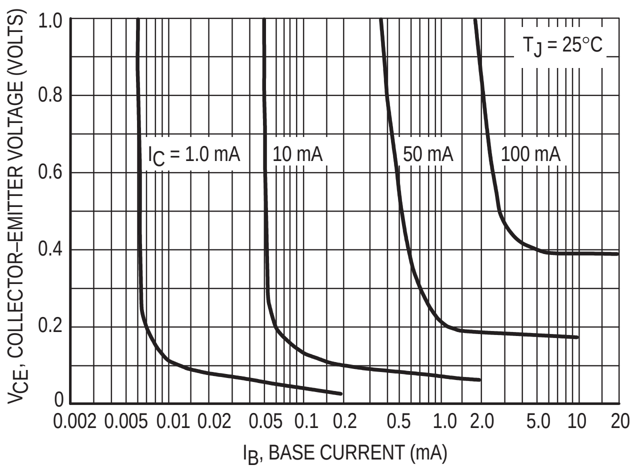


Figure 9. Collector Saturation Region

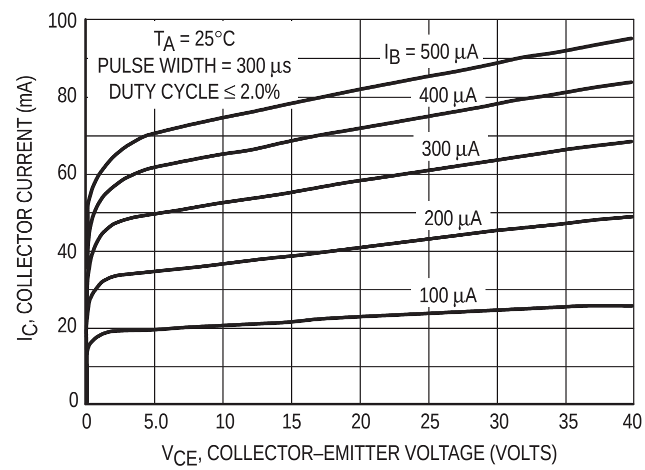


Figure 10. Collector Characteristics

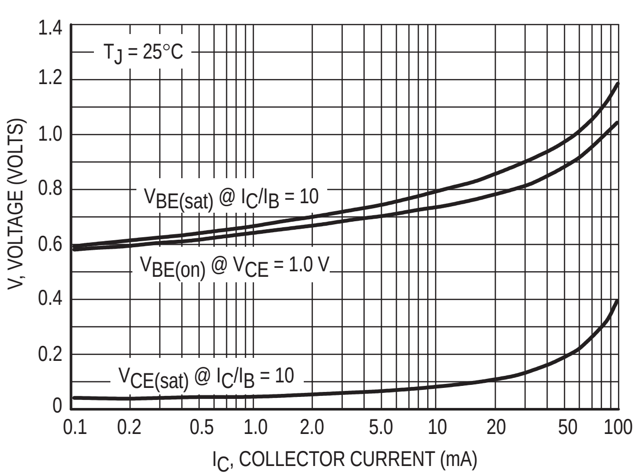


Figure 11. "On" Voltages

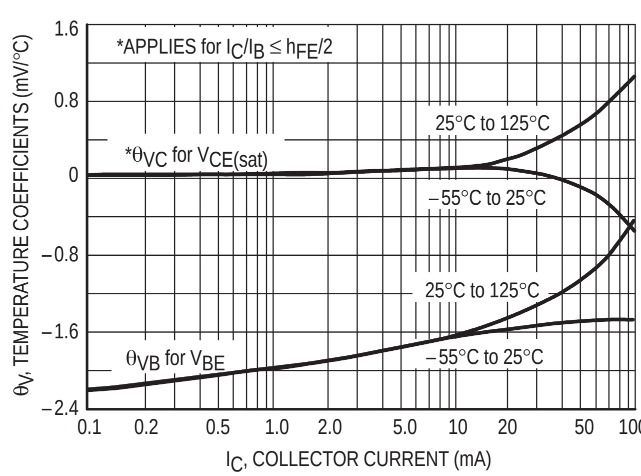


Figure 12. Temperature Coefficients

NPN
MPS6521

TYPICAL DYNAMIC CHARACTERISTICS

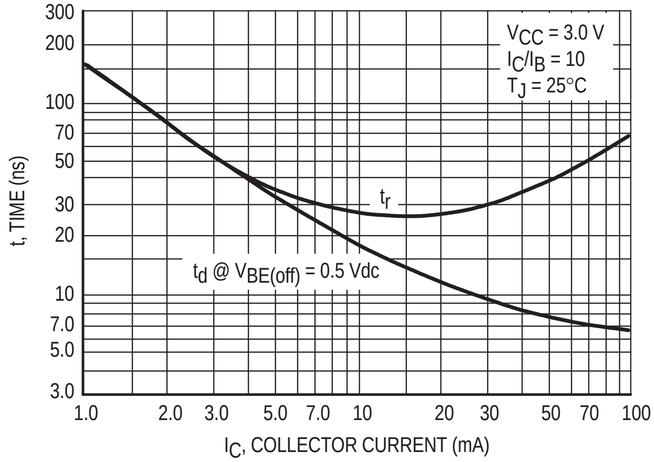


Figure 13. Turn–On Time

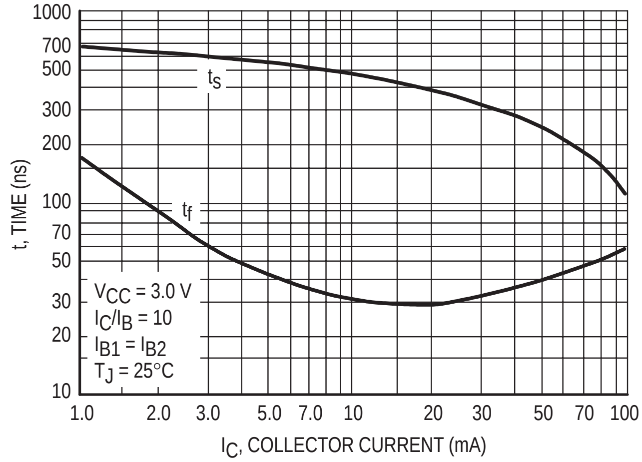


Figure 14. Turn–Off Time

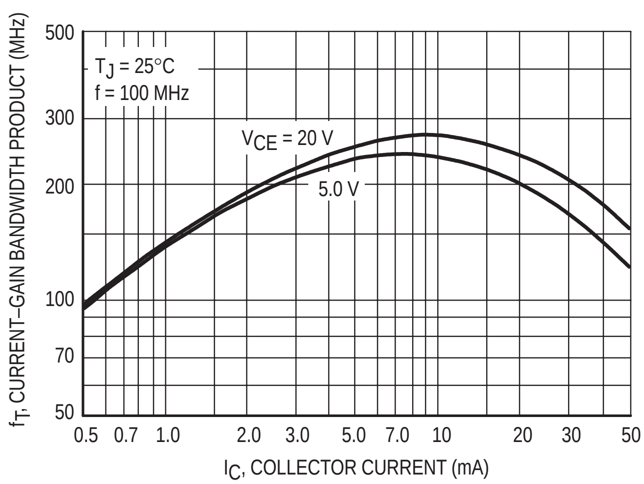


Figure 15. Current–Gain — Bandwidth Product

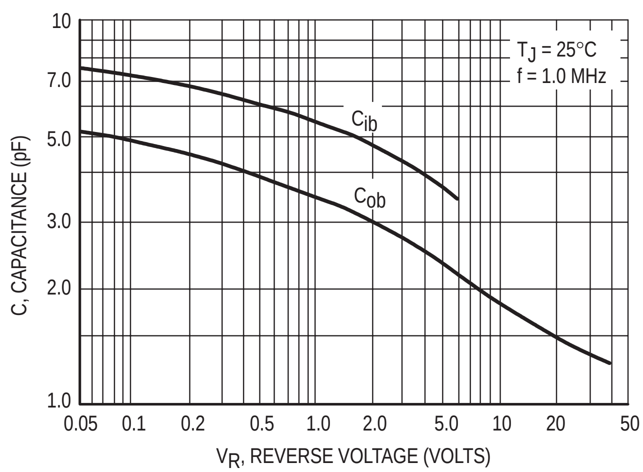


Figure 16. Capacitance

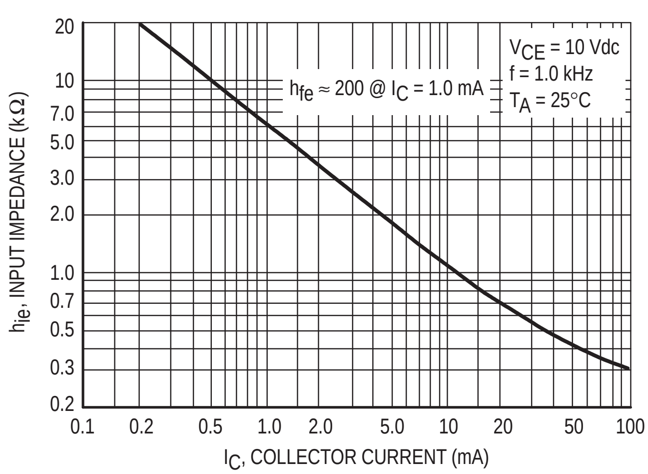


Figure 17. Input Impedance

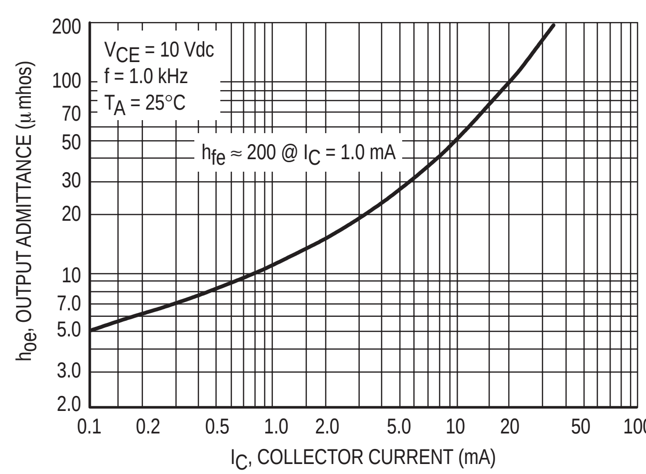


Figure 18. Output Admittance

NPN
MPS6521

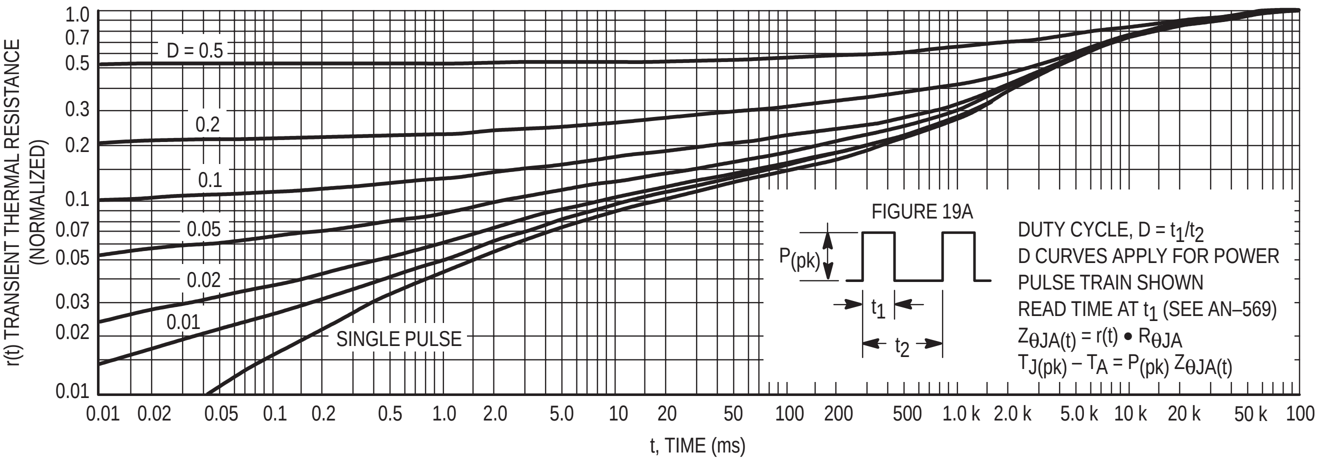


Figure 19. Thermal Response

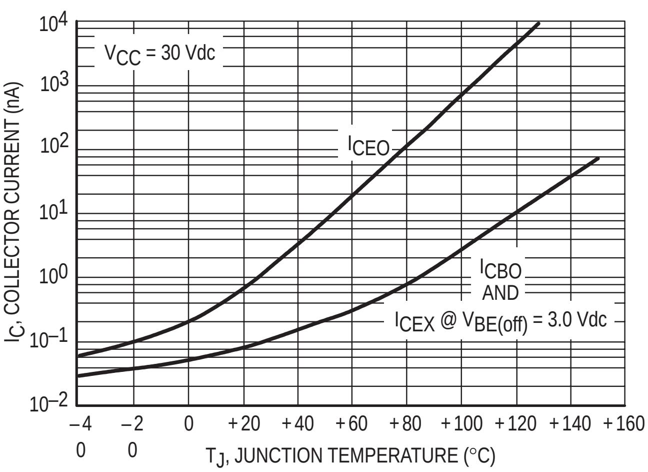


Figure 19A.

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 MPS6521 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.

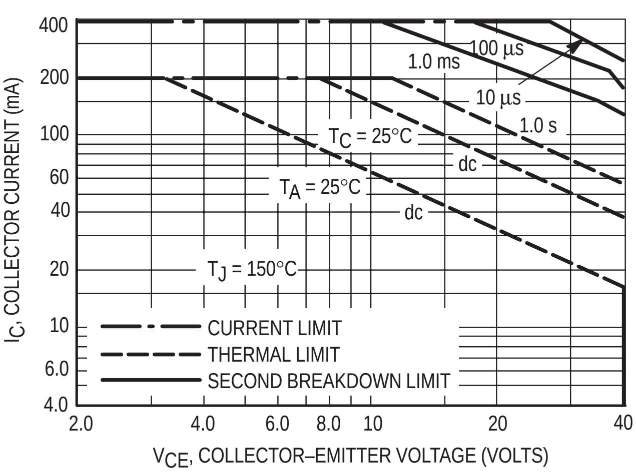


Figure 20.

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 that can be handled to values less than the limitations imposed by second breakdown.

PNP
MPS6523

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

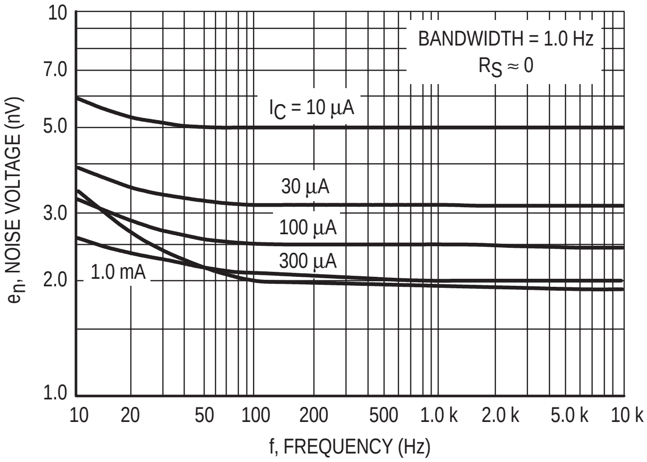


Figure 21. Noise Voltage

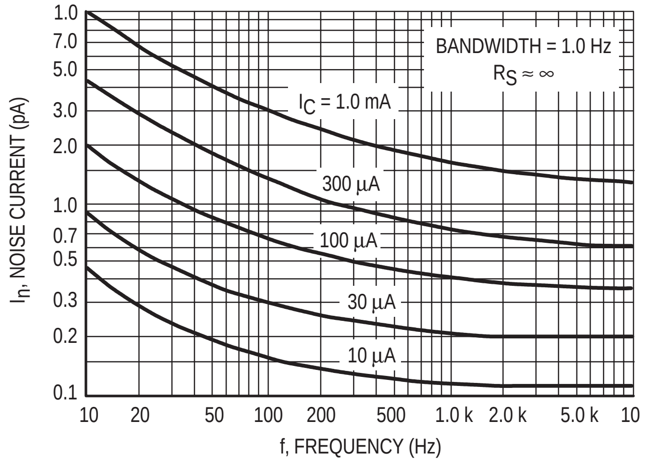


Figure 22. Noise Current

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

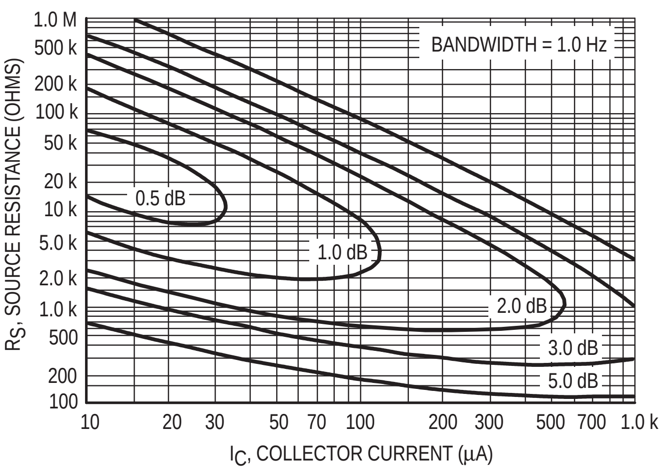


Figure 23. Narrow Band, 100 Hz

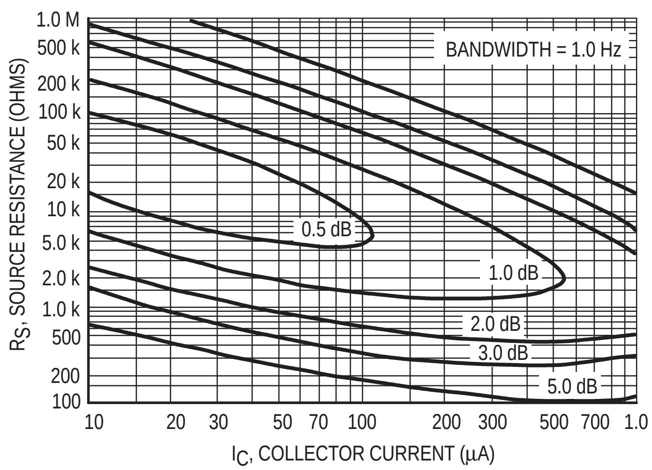


Figure 24. Narrow Band, 1.0 kHz

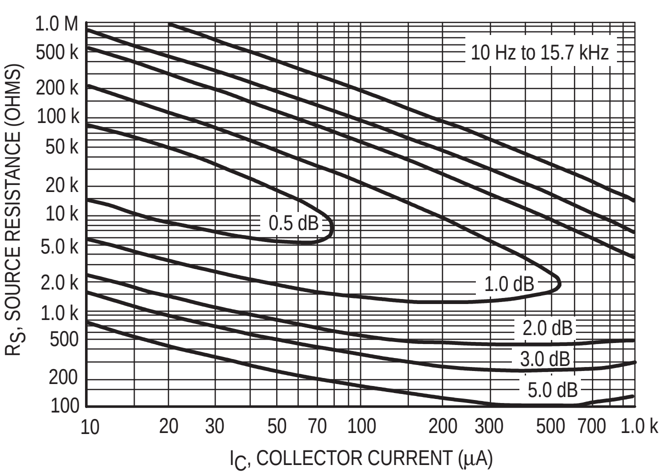


Figure 25. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

PNP
MPS6523

TYPICAL STATIC CHARACTERISTICS

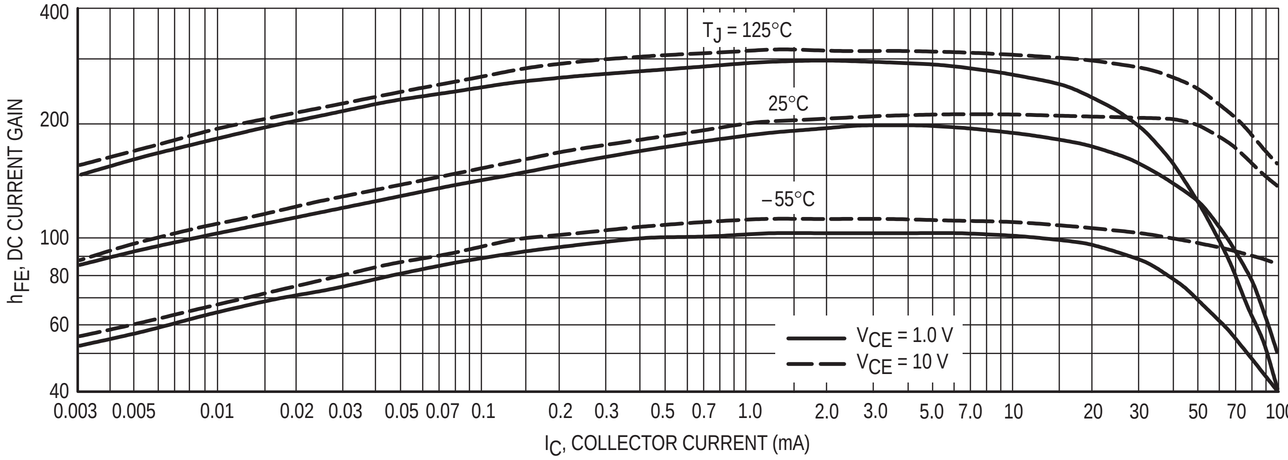


Figure 26. DC Current Gain

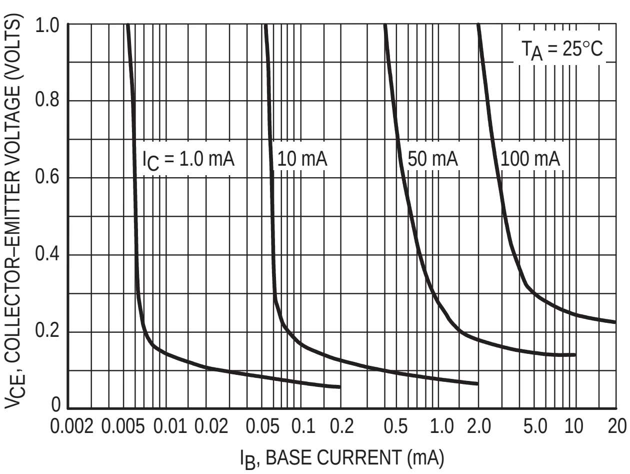


Figure 27. Collector Saturation Region

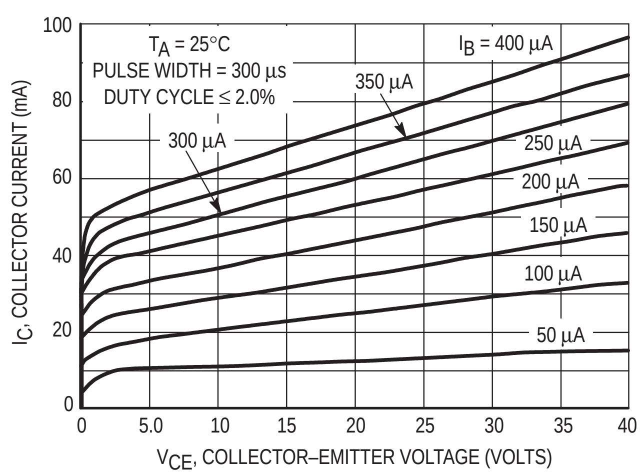


Figure 28. Collector Characteristics

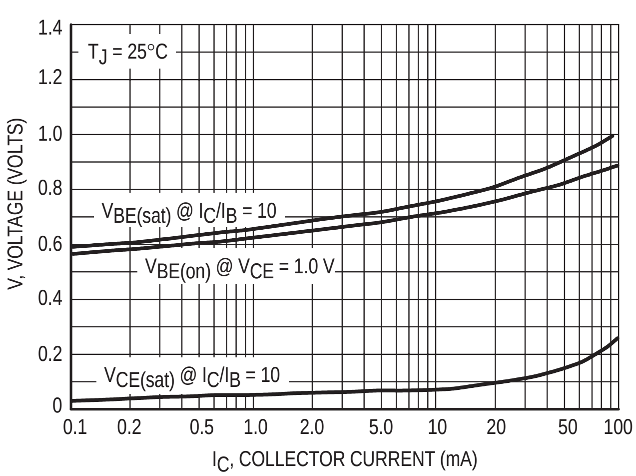


Figure 29. “On” Voltages

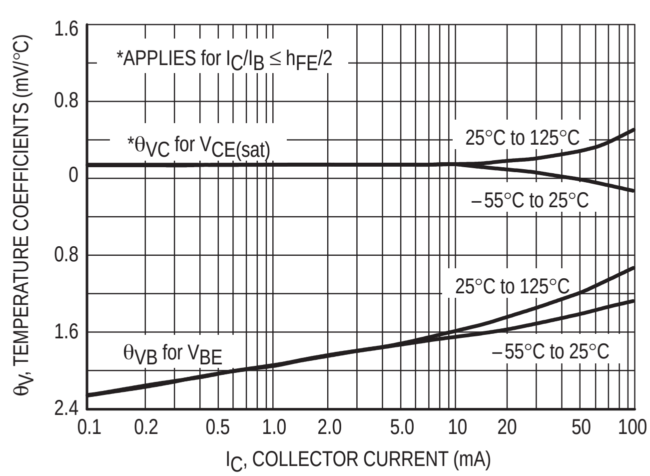


Figure 30. Temperature Coefficients

PNP
MPS6523

TYPICAL DYNAMIC CHARACTERISTICS

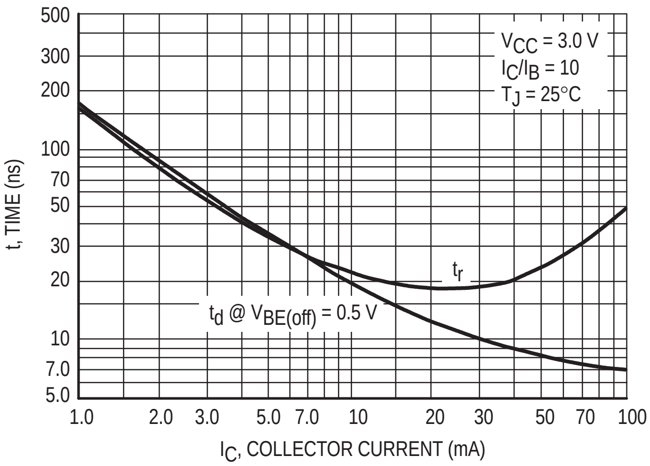


Figure 31. Turn–On Time

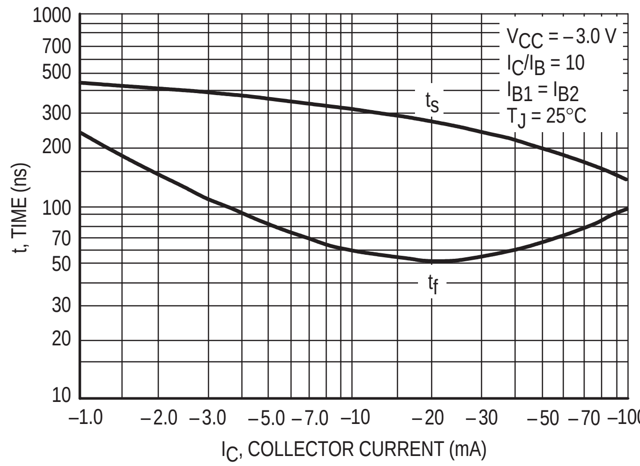


Figure 32. Turn–Off Time

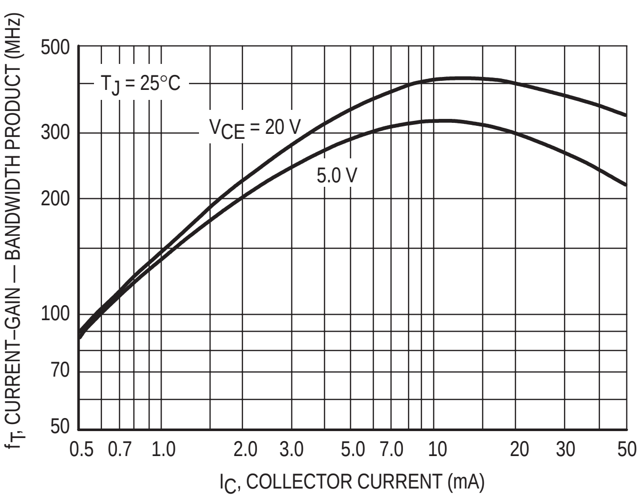


Figure 33. Current–Gain — Bandwidth Product

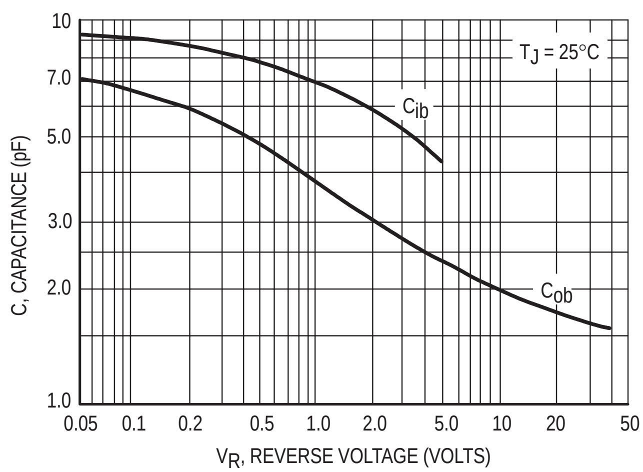


Figure 34. Capacitance

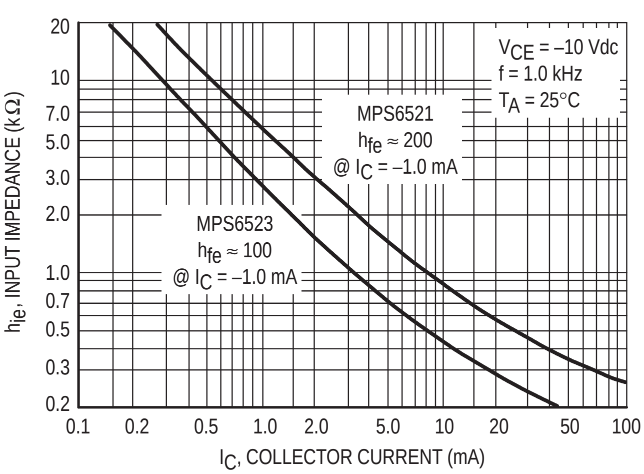


Figure 35. Input Impedance

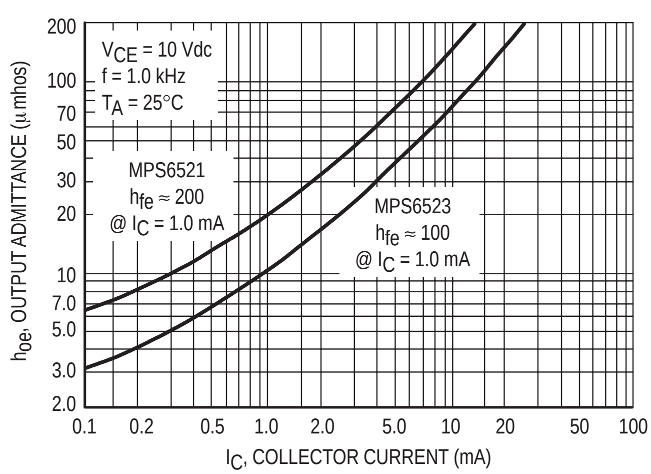


Figure 36. Output Admittance

PNP
MPS6523

TYPICAL DYNAMIC CHARACTERISTICS

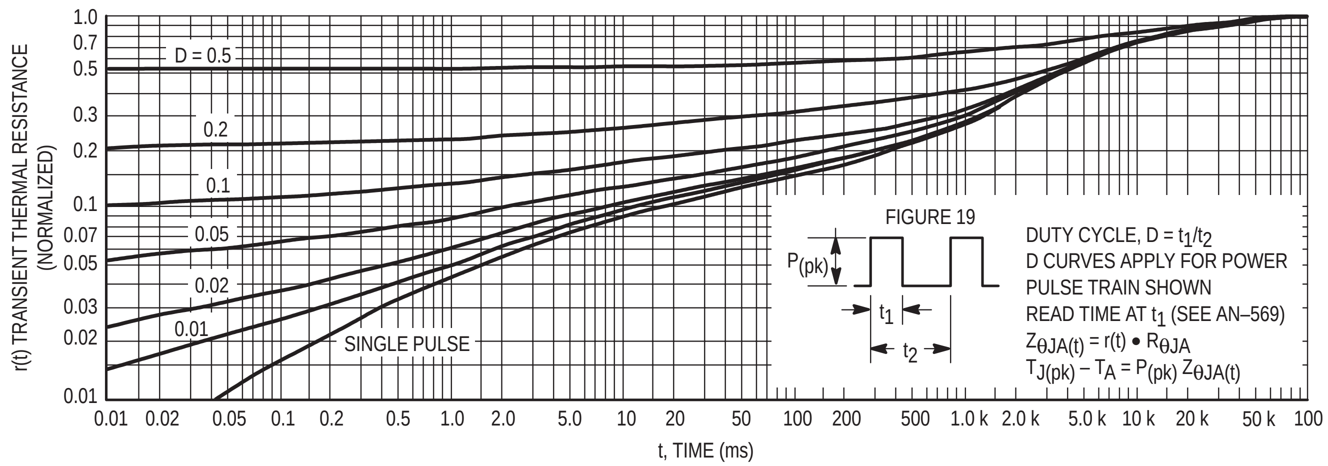


Figure 37. Thermal Response

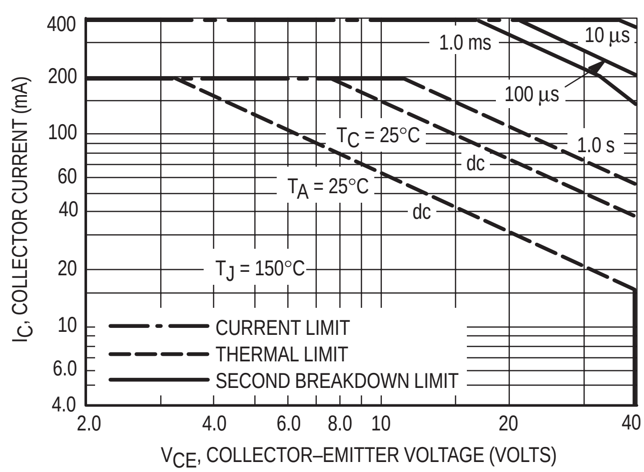


Figure 38. Active–Region Safe Operating Area

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 18 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 17. 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.

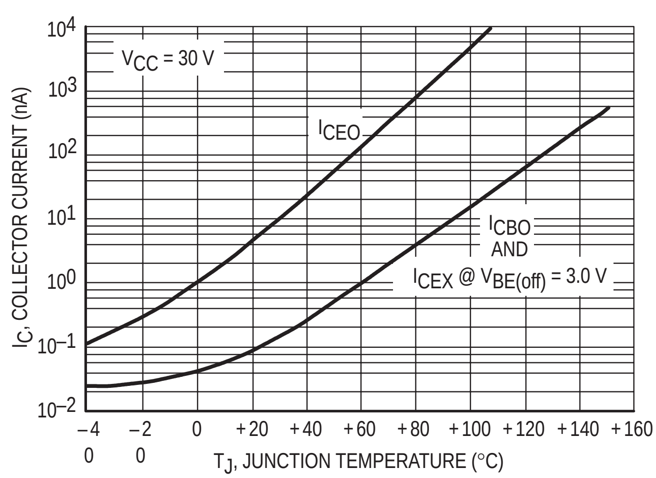


Figure 39. Typical Collector Leakage Current

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 17 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 17 by the steady state value $R_{\theta JA}$.

Example:

The MPS6523 is dissipating 2.0 watts peak under the following conditions:

$$t_1 = 1.0 \text{ ms}, t_2 = 5.0 \text{ ms} (D = 0.2)$$

Using Figure 17 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

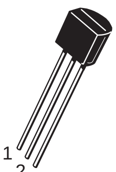
$$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C.$$

For more information, see AN–569.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Audio Transistor
NPN Silicon

MPS6560



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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)	$V_{(BR)CEO}$	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

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%.

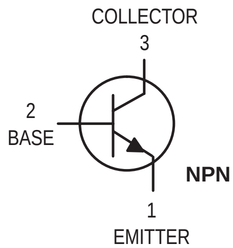
REV 1

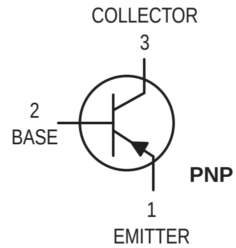
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS[2]				
DC Current Gain	h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		35	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		50	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		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

2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

Amplifier Transistors

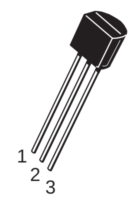




NPN
MPS6601
MPS6602*
PNP
MPS6651
MPS6652*

Voltage and current are negative for PNP transistors

***Motorola Preferred Device**



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

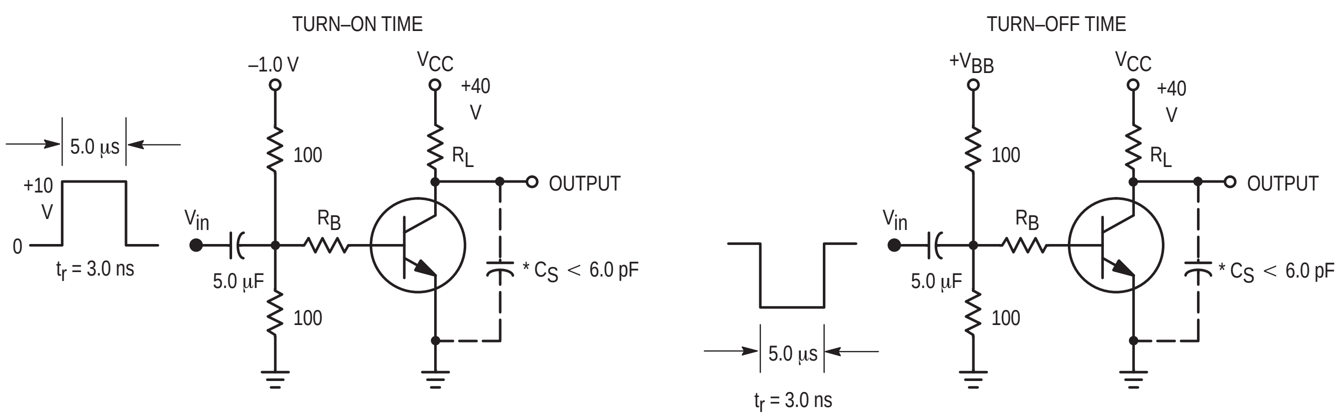
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	 MPS6601/6651 MPS6602/6652	$V_{(BR)CEO}$	 25 40	 — —	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPS6601/6651 MPS6602/6652	$V_{(BR)CBO}$	 25 40	 — —	Vdc
Emitter–Base 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

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

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			50	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			50	—	
(I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)			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 = 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}	—	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



* Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

Figure 1. Switching Time Test Circuits

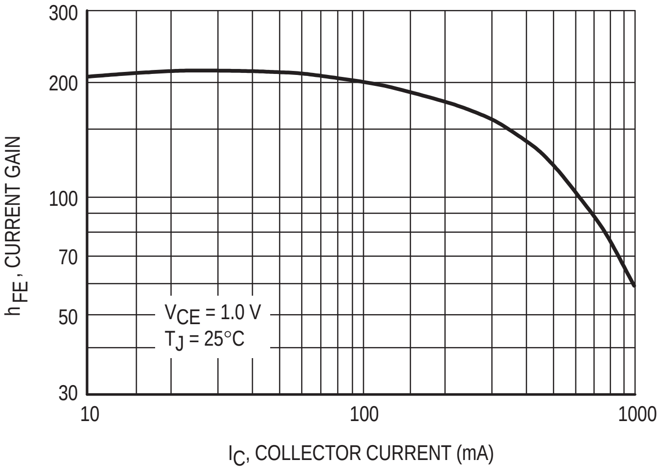


Figure 2. MPS6601/6602 DC Current Gain

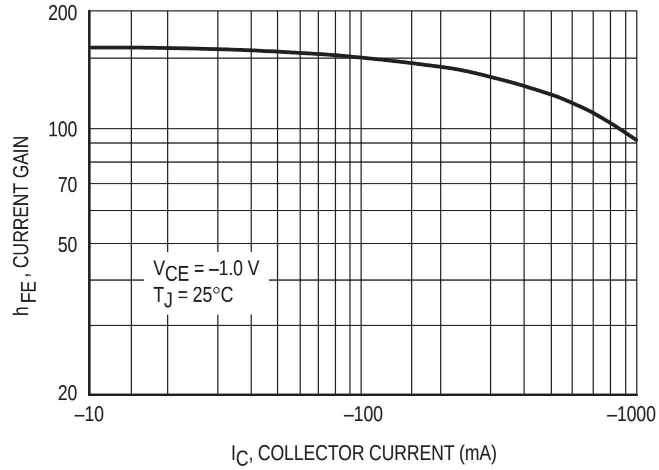


Figure 3. MPS6651/6652 DC Current Gain

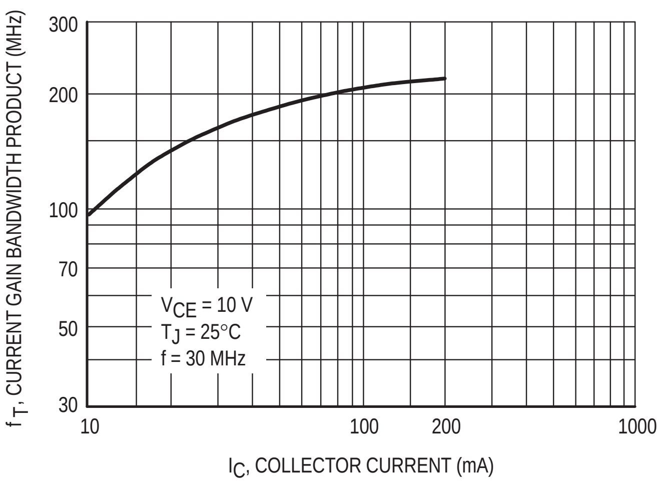


Figure 4. Current Gain Bandwidth Product

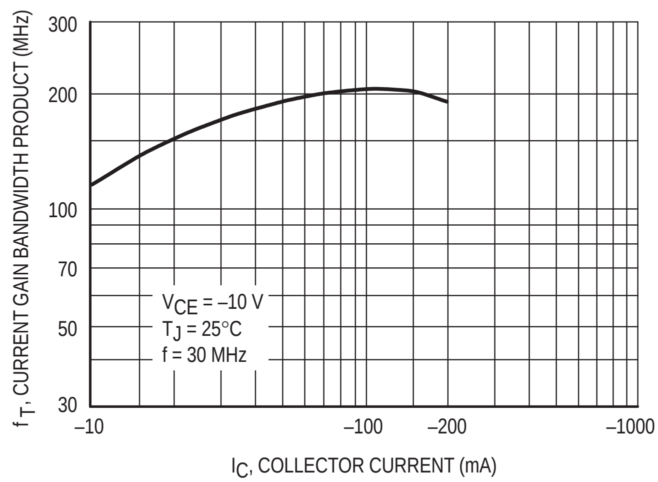


Figure 5. Current Gain Bandwidth Product

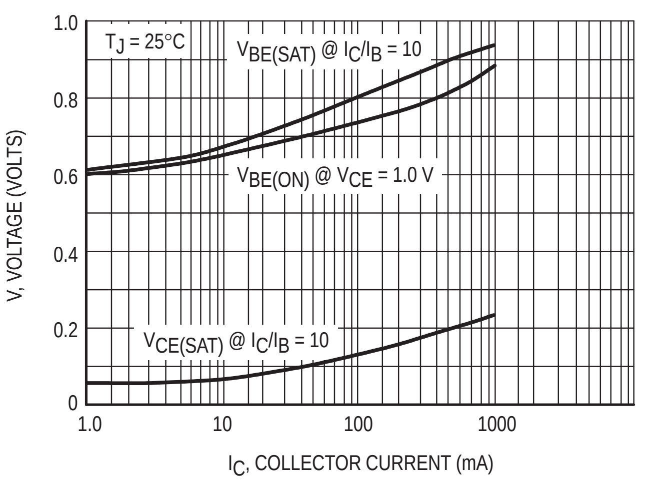


Figure 6. On Voltages

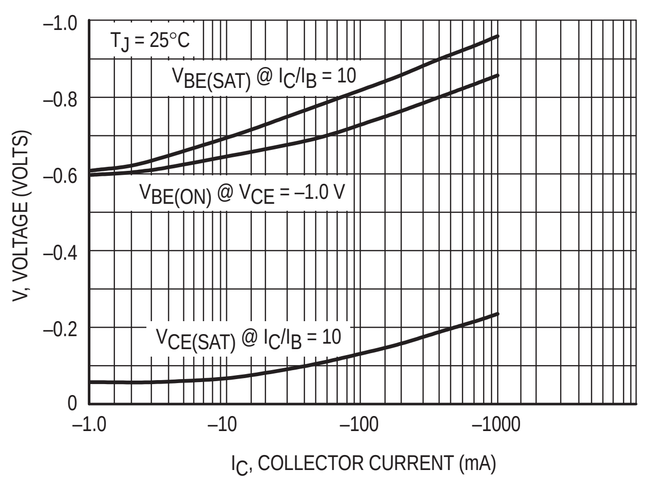


Figure 7. On Voltages

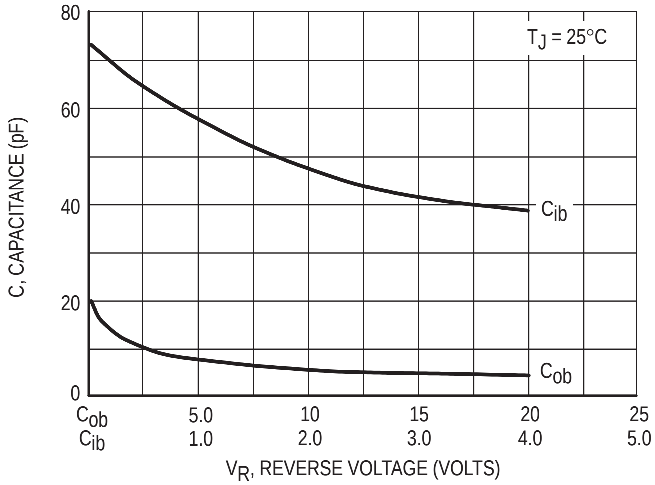


Figure 8. Capacitance

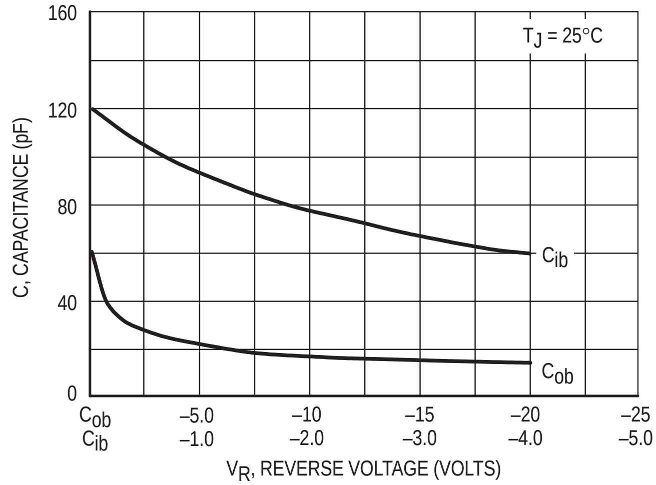


Figure 9. Capacitance

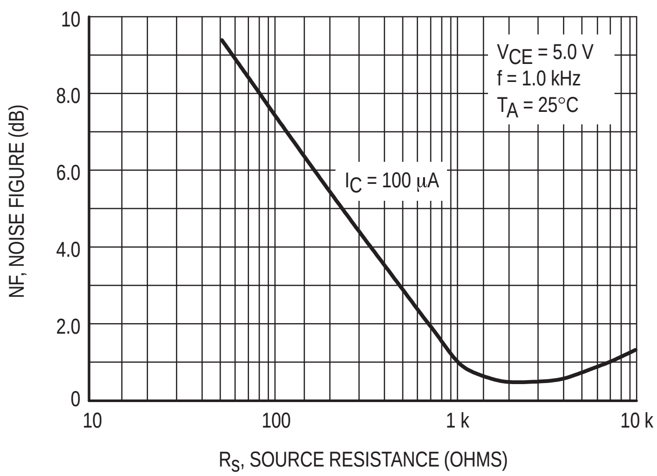


Figure 10. MPS6601/6602 Noise Figure

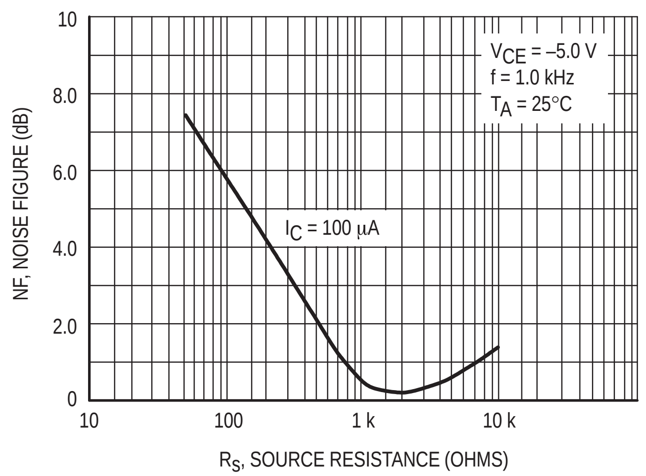


Figure 11. MPS6651/6652 Noise Figure

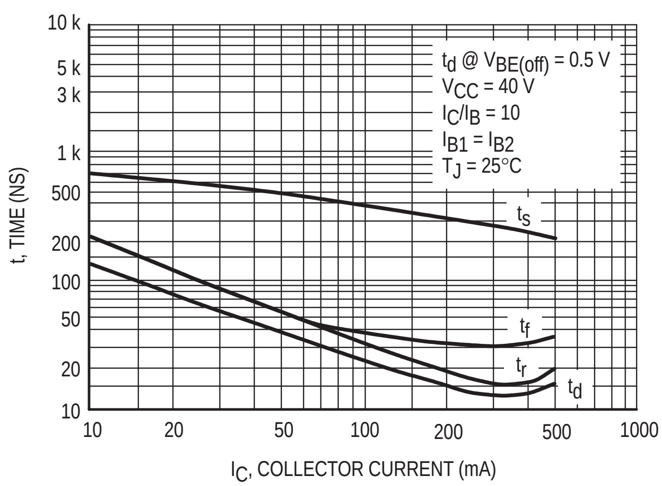


Figure 12. MPS6601/6602 Switching Times

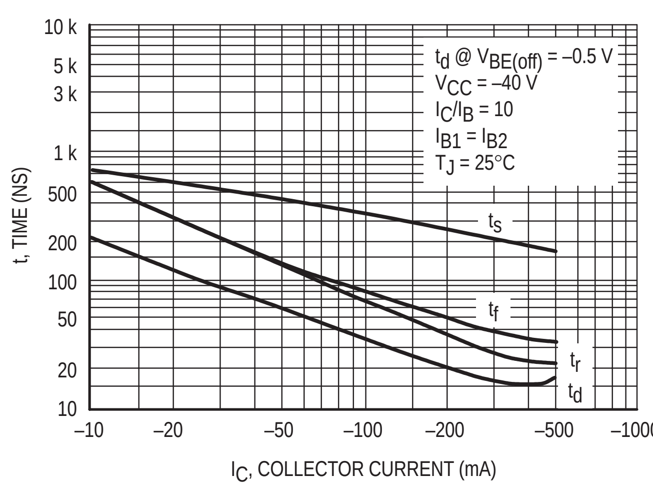


Figure 13. MPS6651/6652 Switching Times

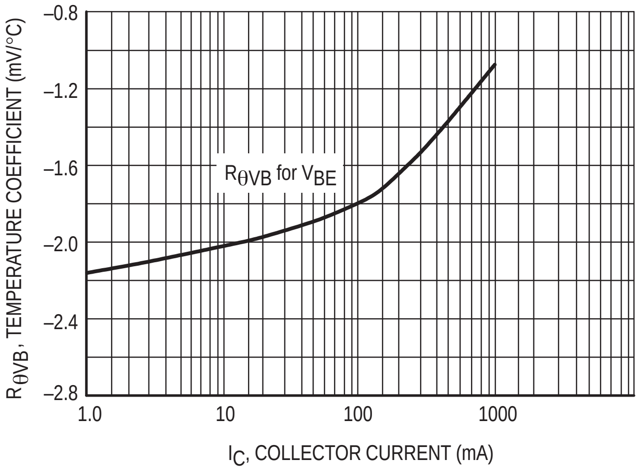


Figure 14. Base–Emitter Temperature Coefficient

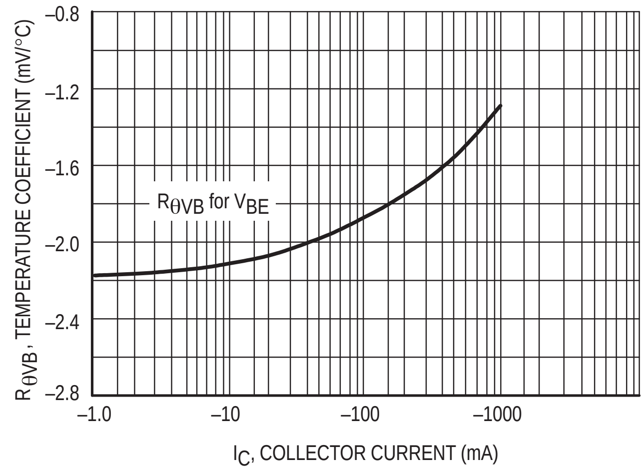


Figure 15. Base–Emitter Temperature Coefficient

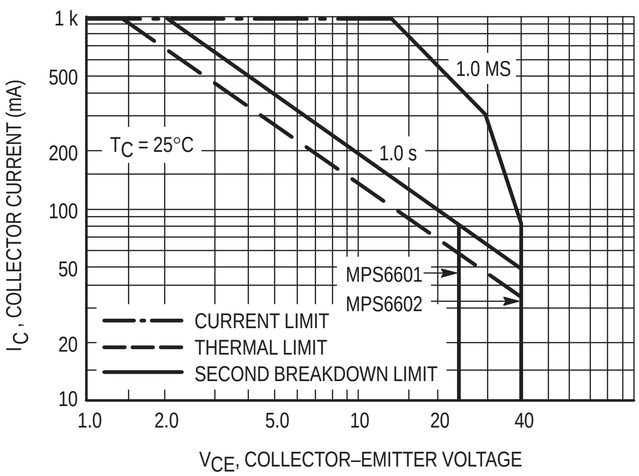


Figure 16. Safe Operating Area

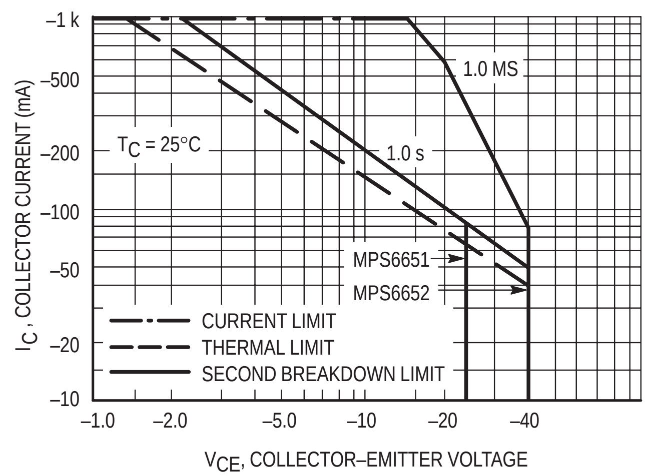


Figure 17. Safe Operating Area

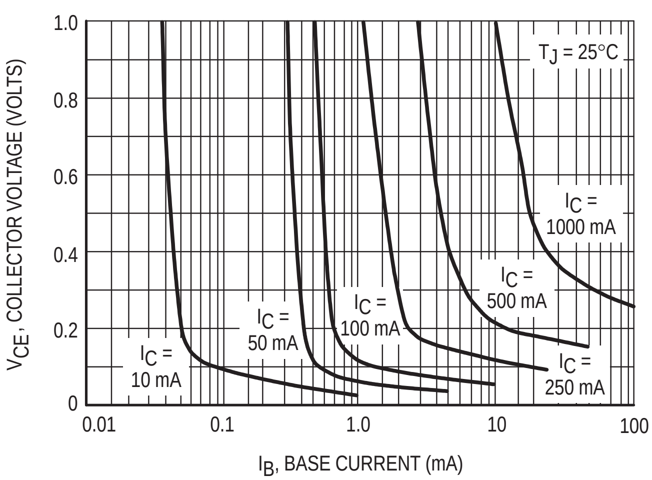


Figure 18. MPS6601/6602 Saturation Region

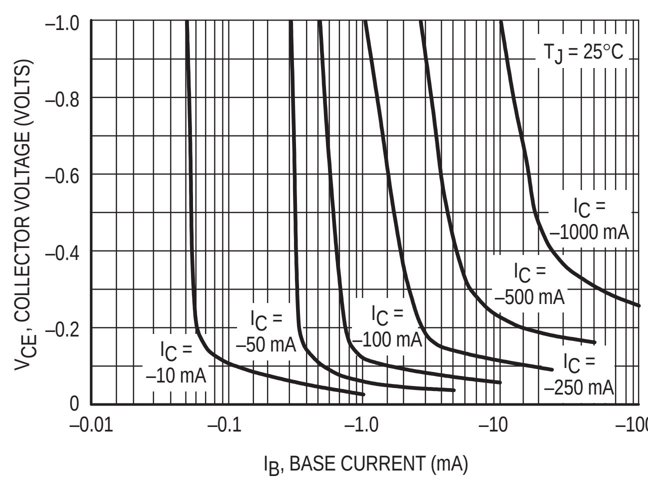


Figure 19. MPS6651/6652 Saturation Region

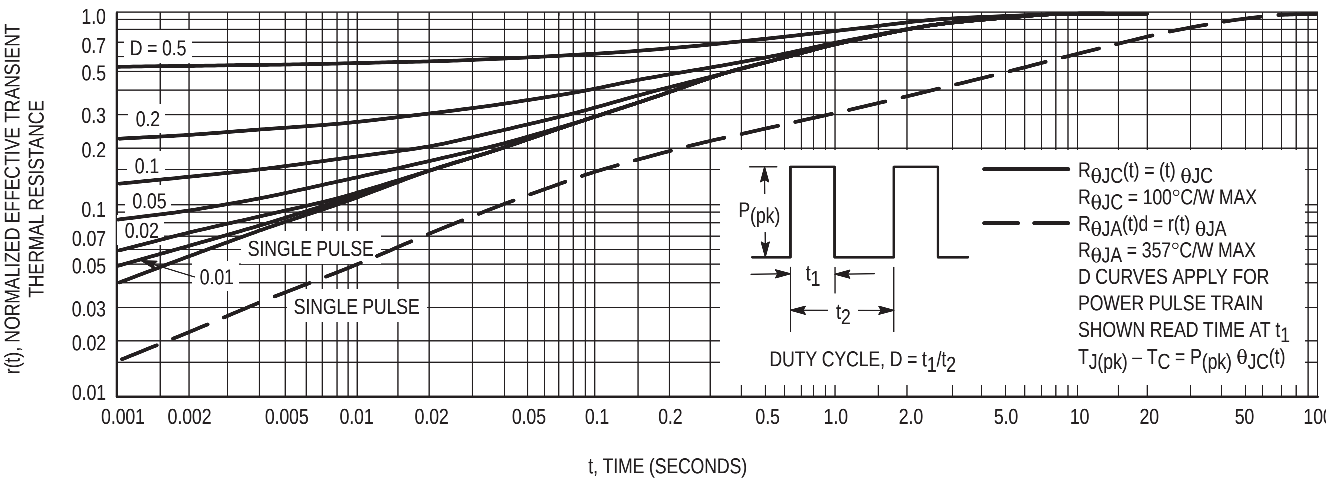
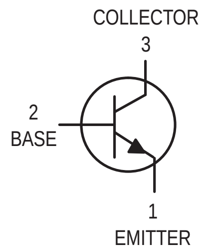


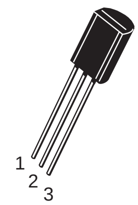
Figure 20. Thermal Response

One Watt Amplifier Transistors

NPN Silicon

MPS6714
MPS6715





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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	Watts 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 = 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

1. Pulse Test: Pulse Width ≤ 30 µs; Duty Cycle ≤ 2.0%.

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

Characteristic	Symbol	Min	Max	Unit
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%.

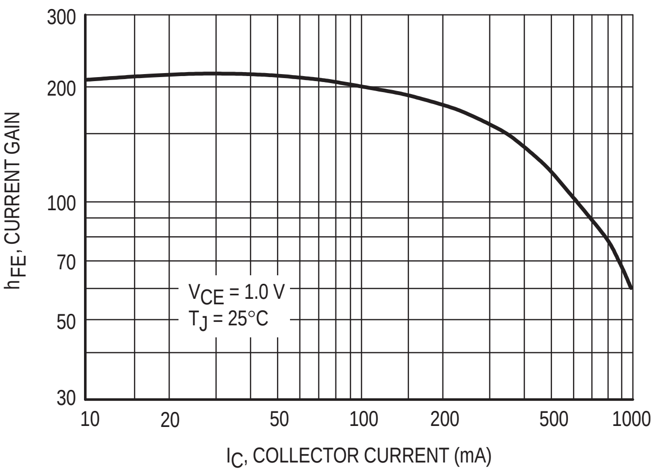


Figure 1. DC Current Gain

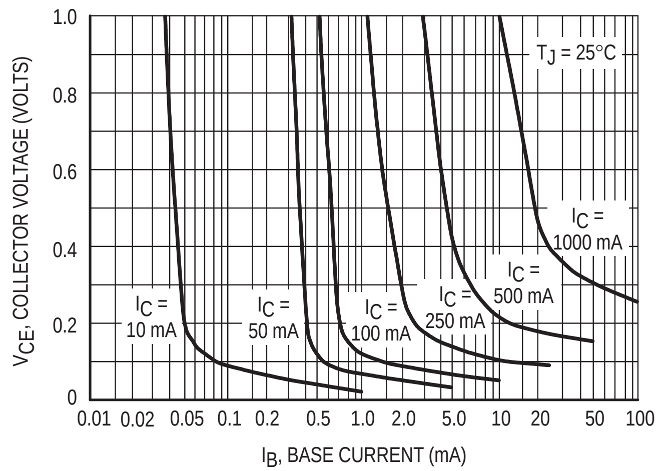


Figure 2. Collector Saturation Region

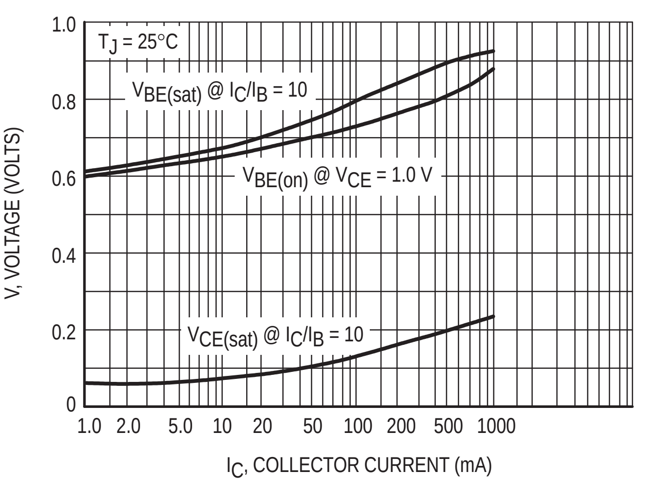


Figure 3. “ON” Voltages

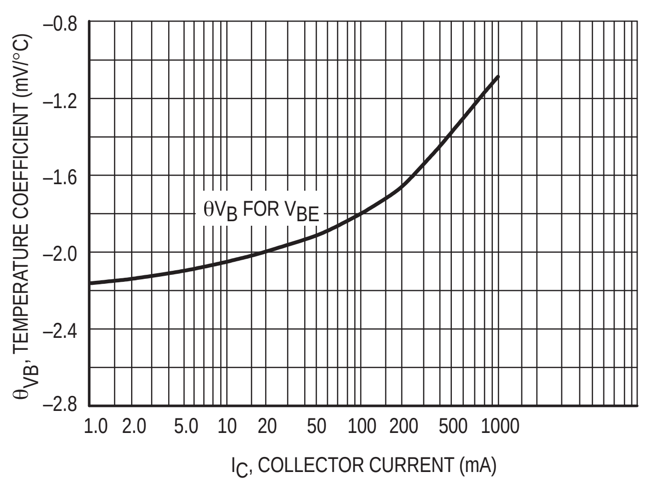


Figure 4. Temperature Coefficient

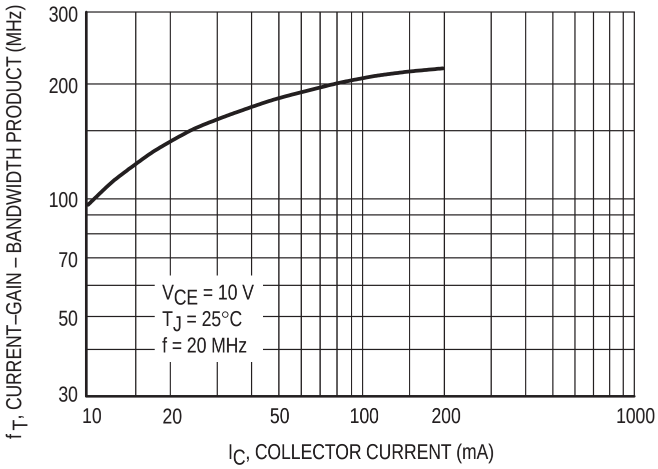


Figure 5. Current Gain — Bandwidth Product

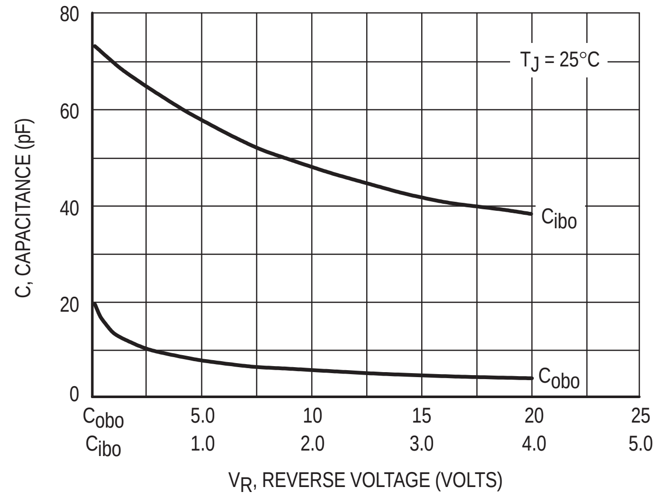


Figure 6. Capacitance

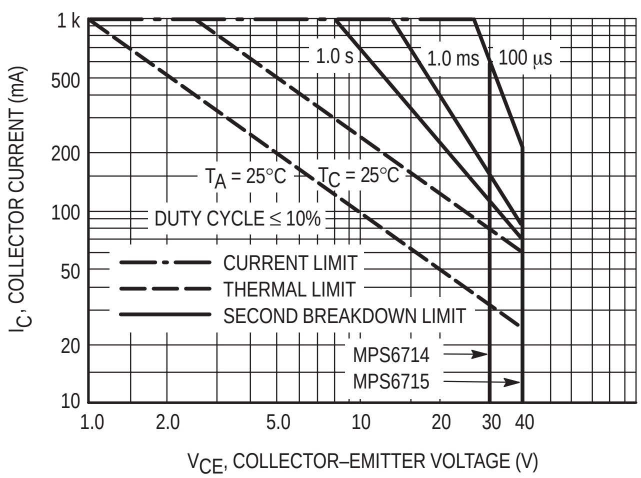
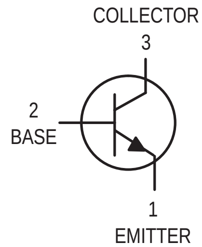


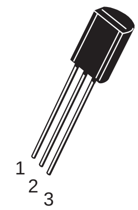
Figure 7. Active Region — Safe Operating Area

One Watt Amplifier Transistor

NPN Silicon



MPS6717



CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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	Watts 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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

Characteristic	Symbol	Min	Max	Unit
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	—

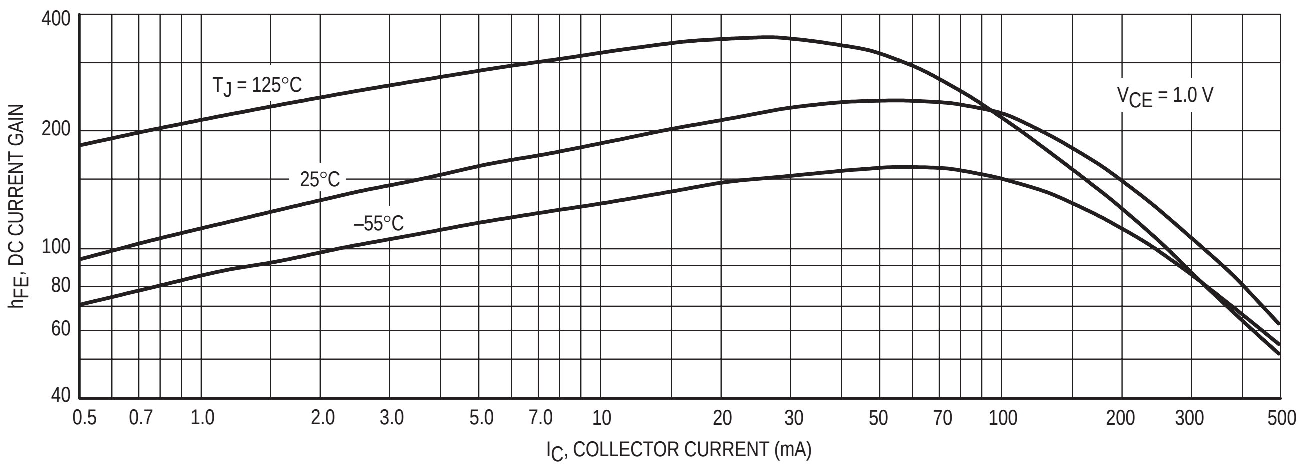


Figure 1. DC Current Gain

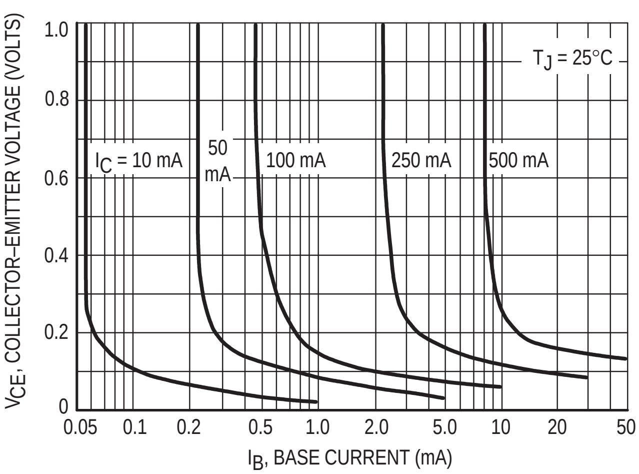


Figure 2. Collector Saturation Region

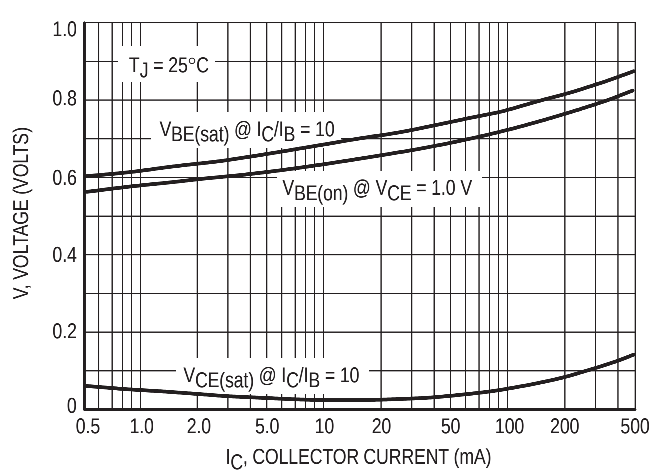


Figure 3. “On” Voltages

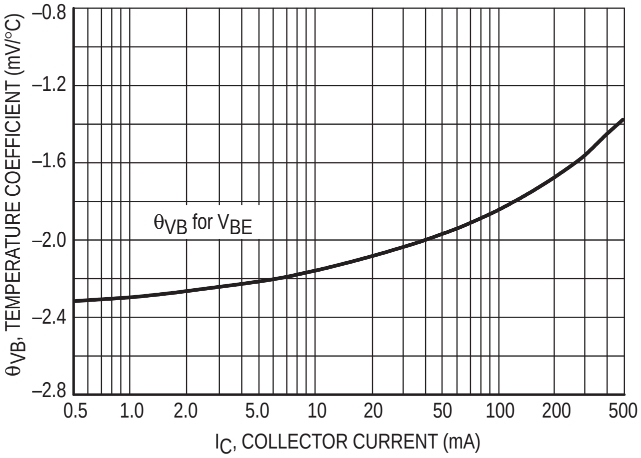


Figure 4. Base–Emitter Temperature Coefficient

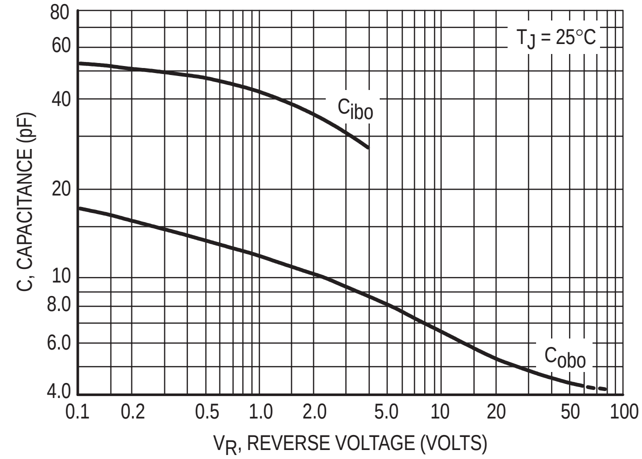


Figure 5. Capacitance

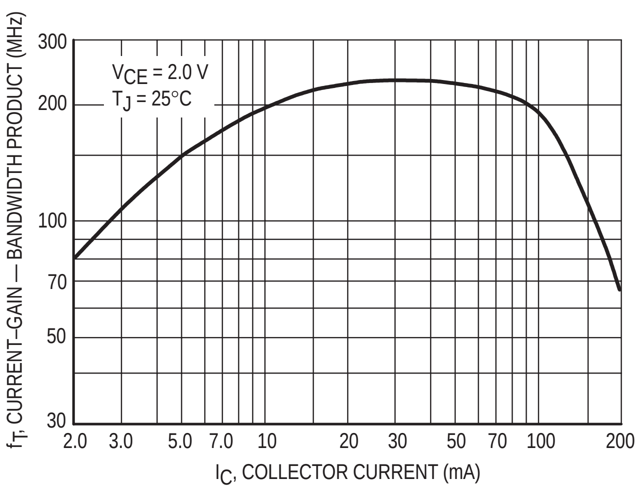


Figure 6. Current–Gain — Bandwidth Product

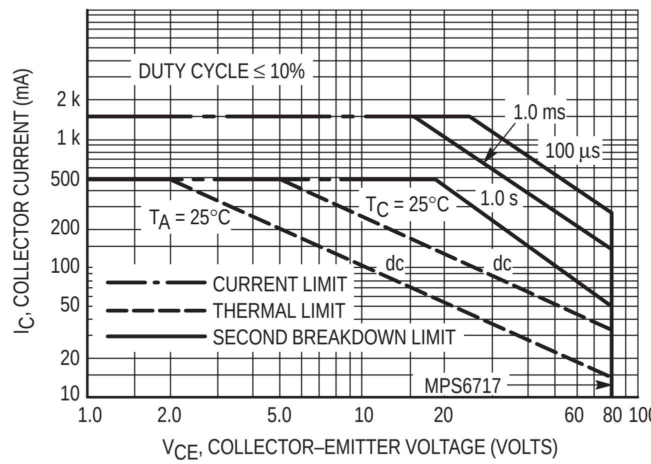
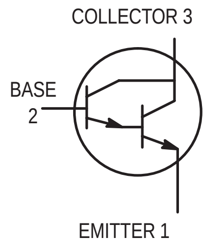


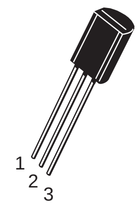
Figure 7. Active Region — Safe Operating Area

One Watt Darlington Transistors

NPN Silicon

MPS6724
MPS6725





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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		Watts 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
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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

REV 1

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

Characteristic	Symbol	Min	Max	Unit
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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

TYPICAL CHARACTERISTICS

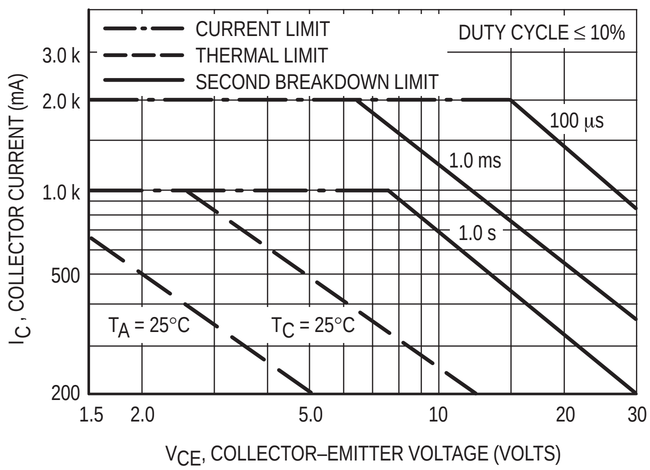


Figure 1. Active Region — Safe Operating Area

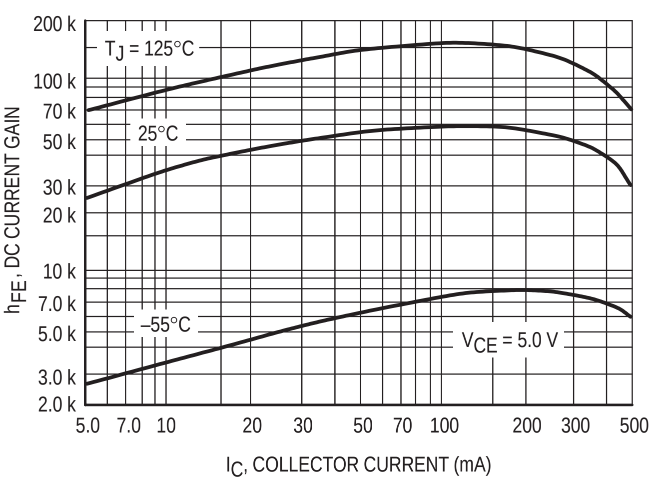


Figure 2. DC Current Gain

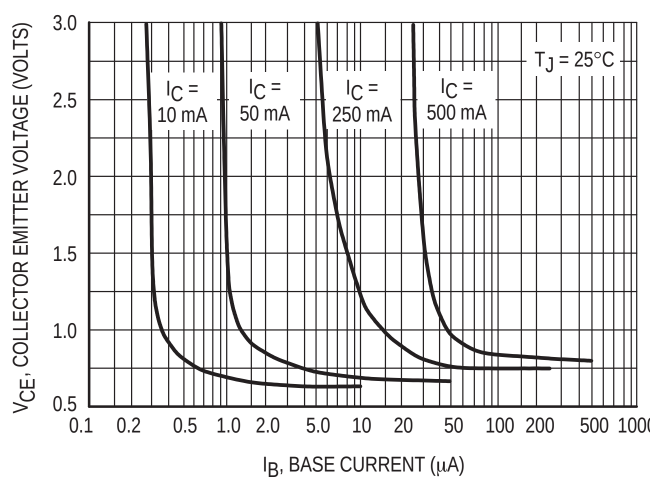


Figure 3. Collector Saturation Region

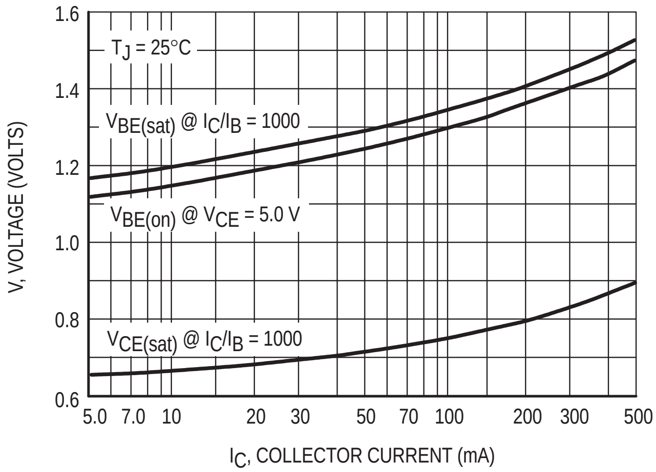


Figure 4. "ON" Voltages

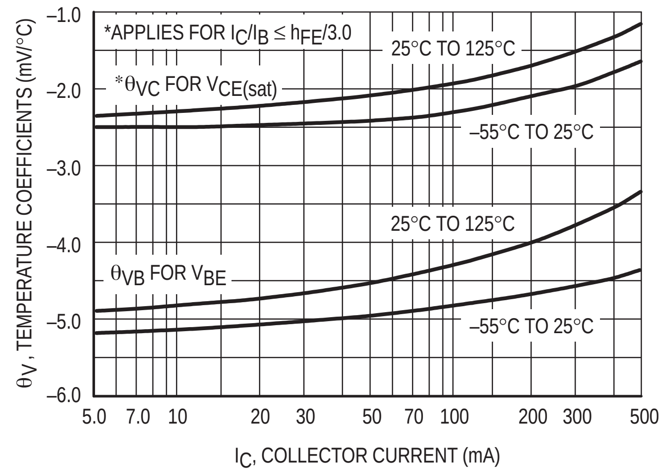


Figure 5. Temperature Coefficients

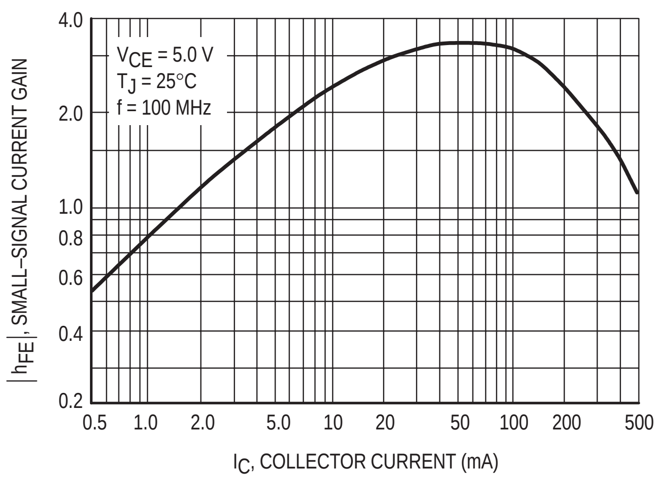


Figure 6. High Frequency Current Gain

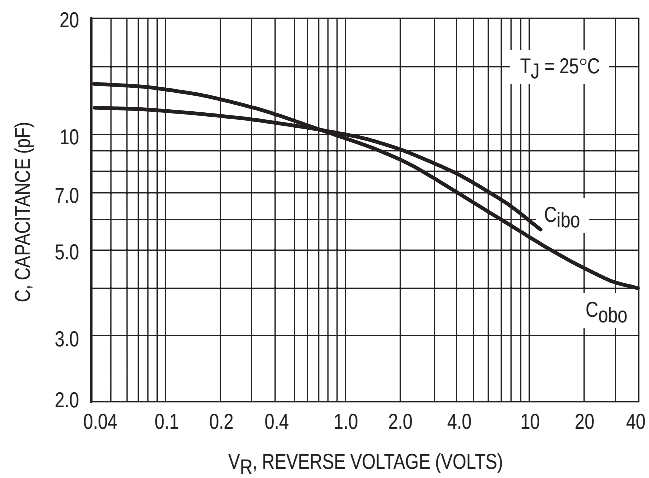
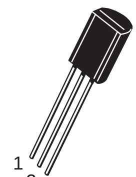


Figure 7. Capacitance

One Watt Amplifier Transistor

PNP Silicon

MPS6726
MPS6727



CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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	Watts 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

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

Characteristic	Symbol	Min	Max	Unit
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%.

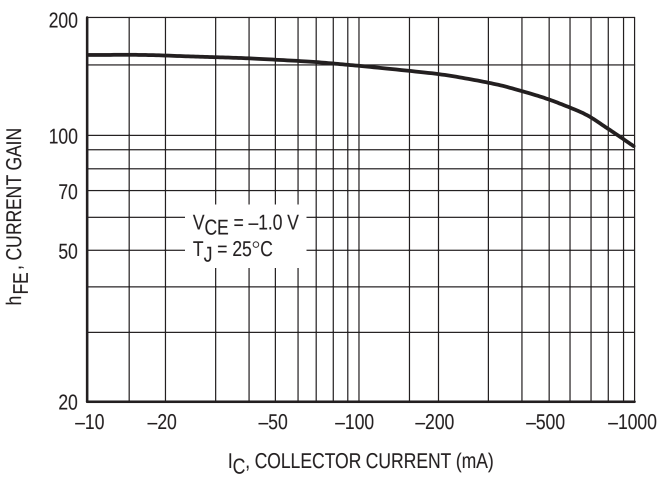


Figure 1. DC Current Gain

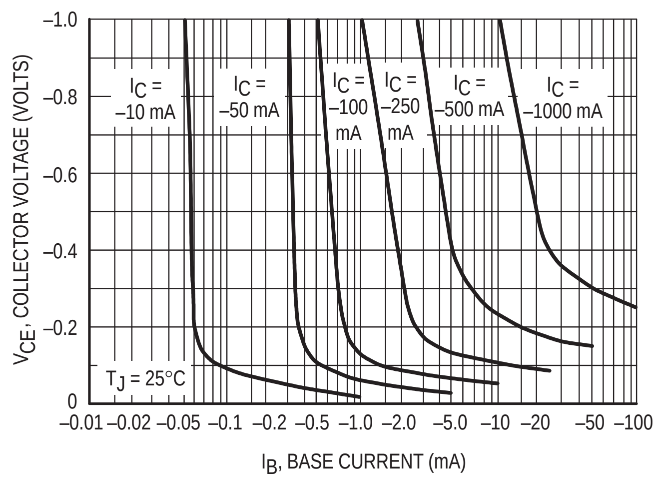


Figure 2. Collector Saturation Region

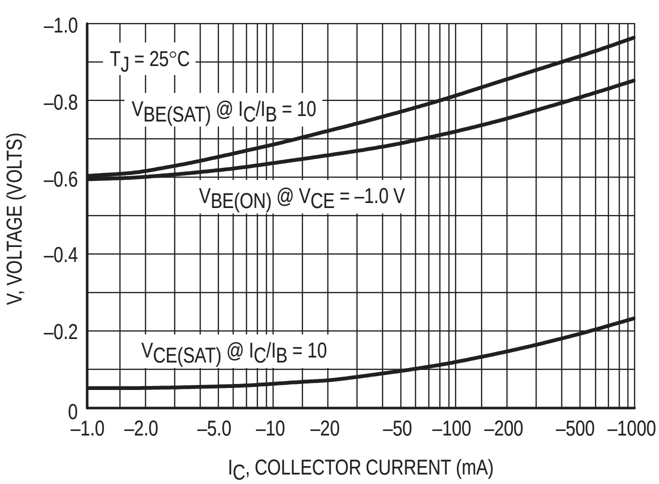


Figure 3. "ON" Voltages

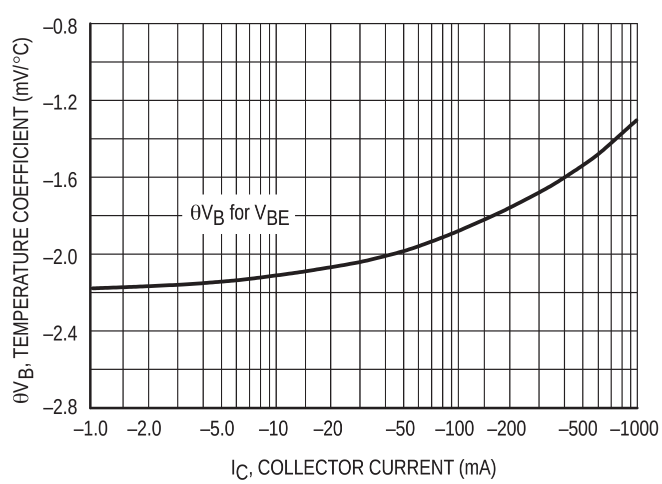


Figure 4. Temperature Coefficient

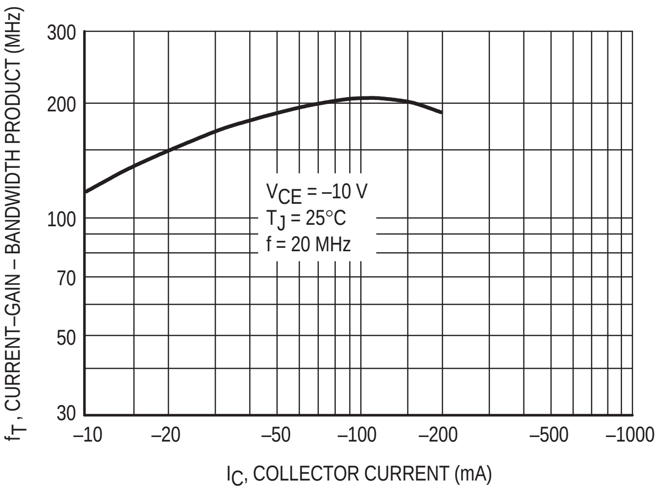


Figure 5. Current Gain — Bandwidth Product

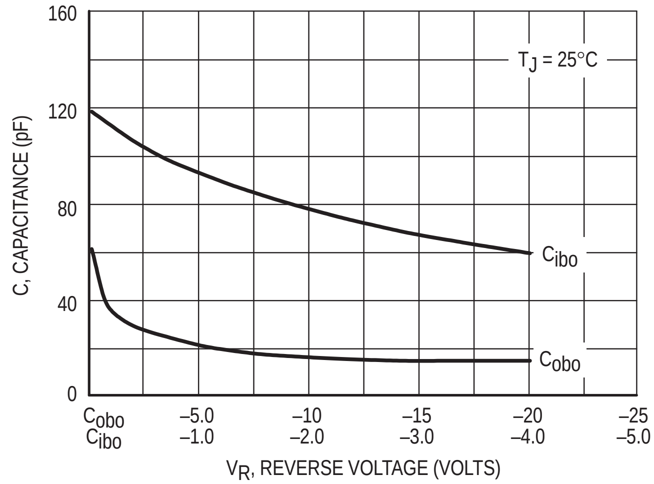


Figure 6. Capacitance

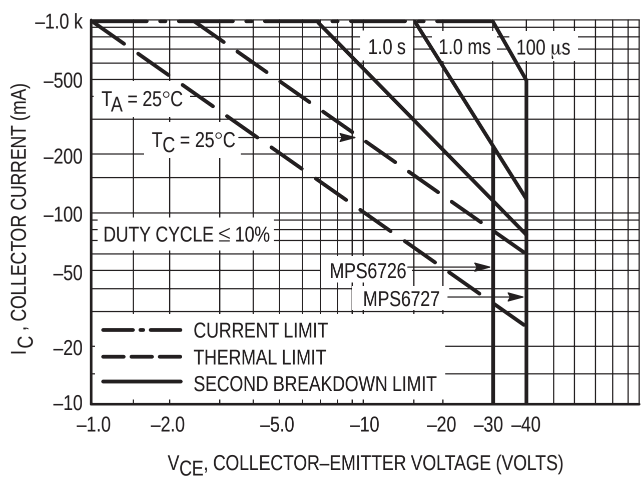
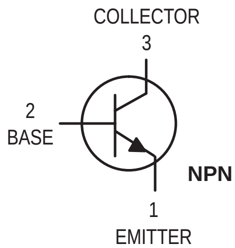
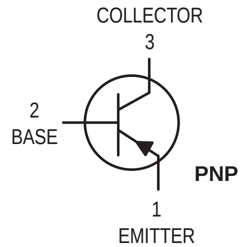


Figure 7. Active Region — Safe Operating Area

Amplifier Transistors

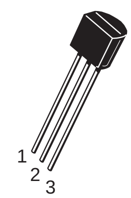




NPN
MPS8098
MPS8099*
PNP
MPS8598
MPS8599*

Voltage and current are negative for PNP transistors

***Motorola Preferred Device**



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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 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)	 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

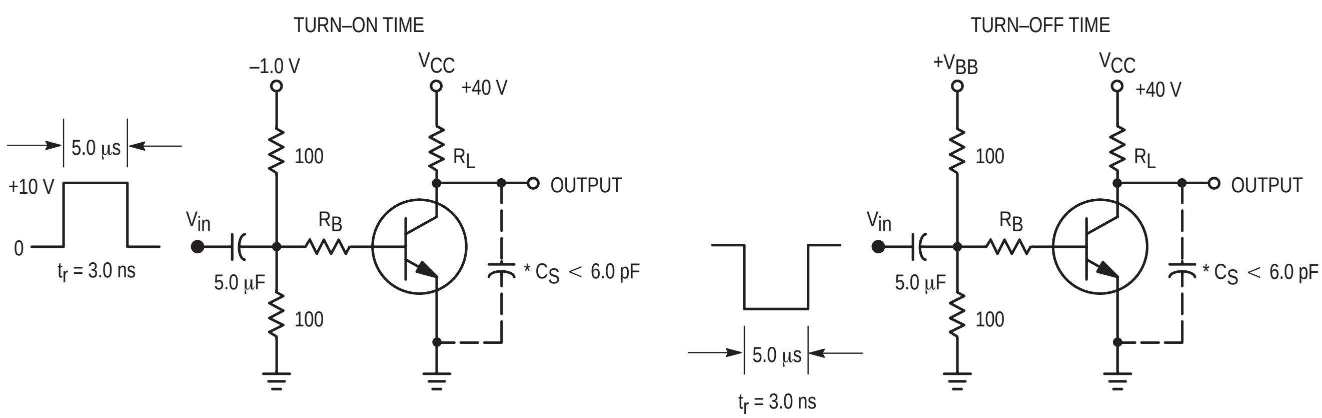
1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			100	300	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			100	—	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)			75	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 5.0 mAdc)			—	0.4	
(I_C = 100 mAdc, I_B = 10 mAdc)			—	0.3	
Base–Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPS8098, MPS8598		0.5	0.7	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPS8099, MPS8599		0.6	0.8	
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		C_{obo}			pF
(V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	MPS8098, MPS8099		—	6.0	
	MPS8598, MPS8599		—	8.0	
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS8098, MPS8099		—	25	
	MPS8598, MPS8599		—	30	

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



* Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

Figure 1. Switching Time Test Circuits

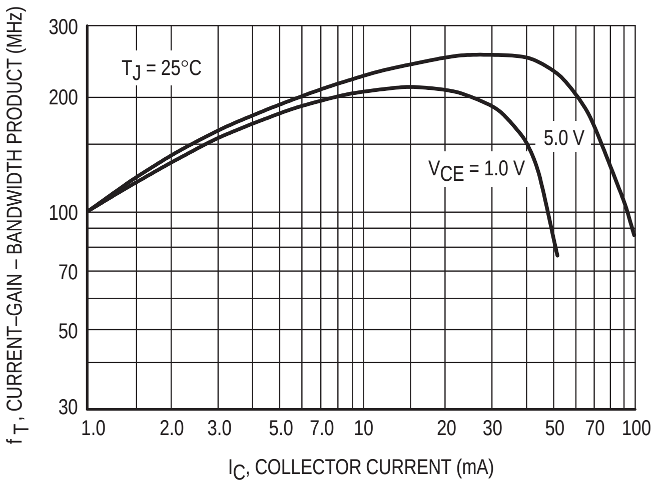


Figure 2. MPS8098/99 Current–Gain — Bandwidth Product

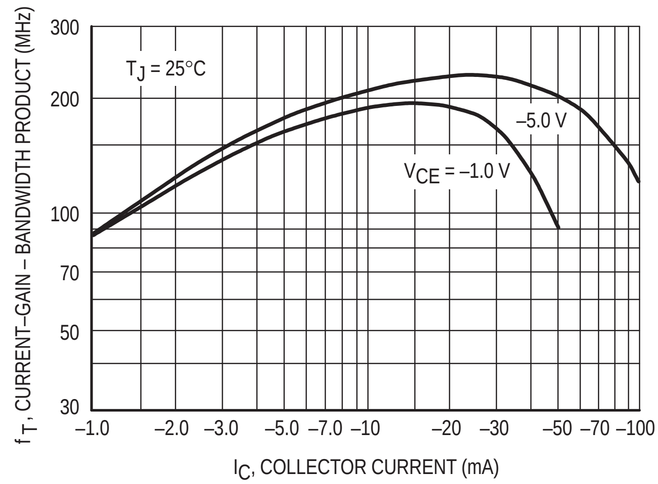


Figure 3. MPS8598/99 Current–Gain — Bandwidth Product

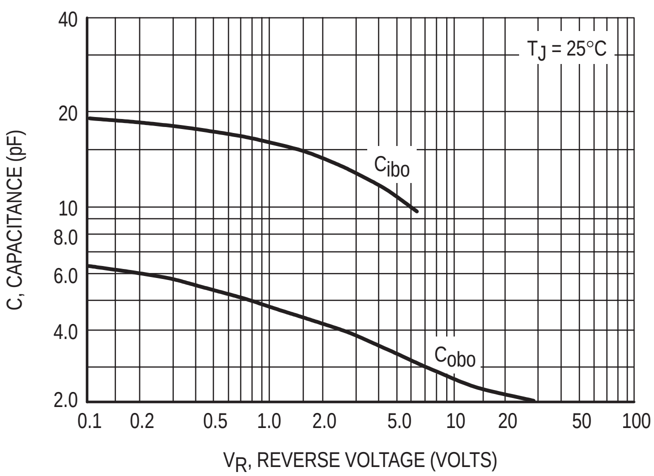


Figure 4. MPS8098/99 Capacitance

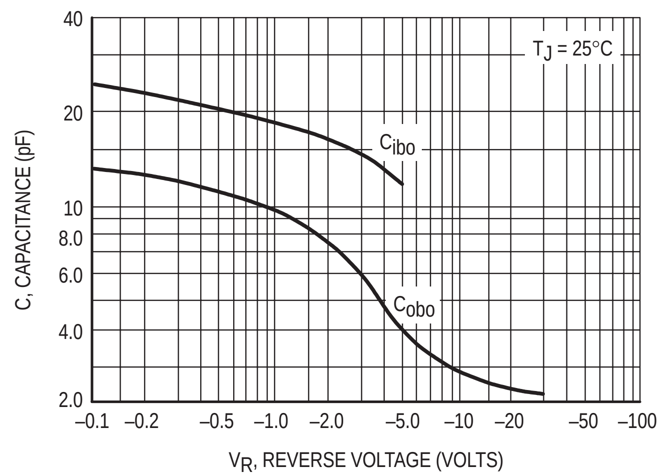


Figure 5. MPS8598/99 Capacitance

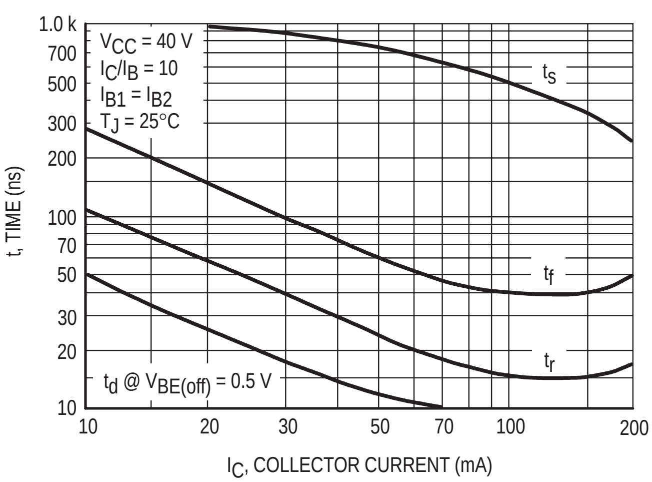


Figure 6. MPS8098/99 Switching Times

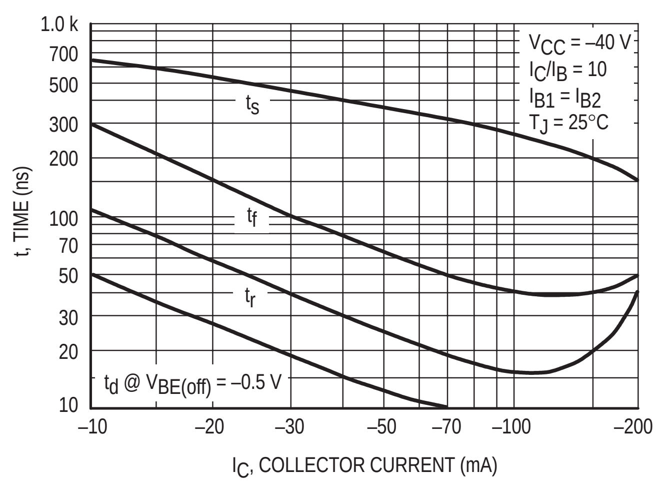


Figure 7. MPS8598/99 Switching Times

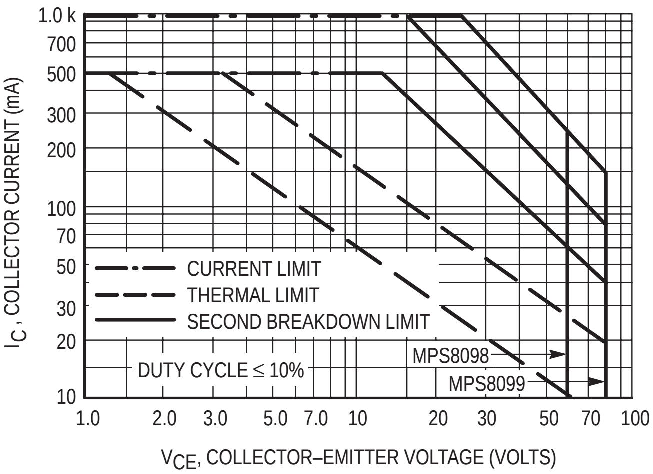


Figure 8. MPS8098/99 Active–Region Safe Operating Area

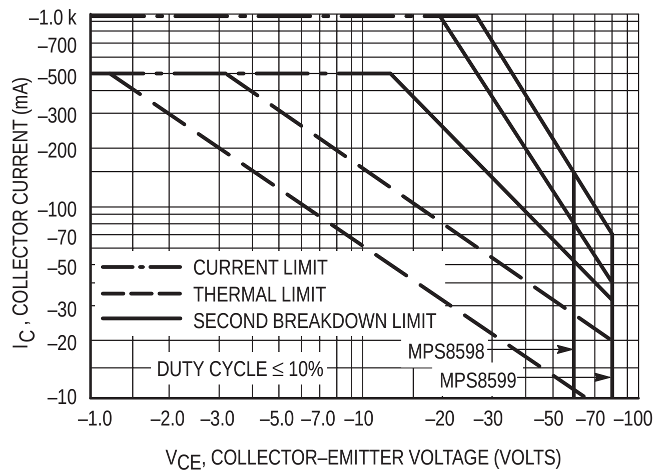


Figure 9. MPS8598/99 Active–Region Safe Operating Area

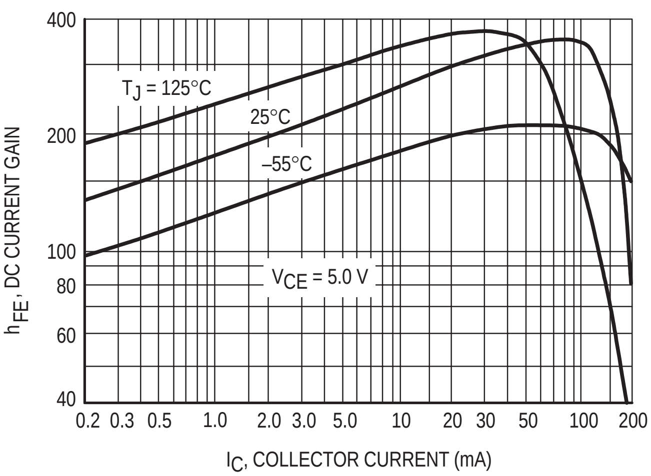


Figure 10. MPS8098/99 DC Current Gain

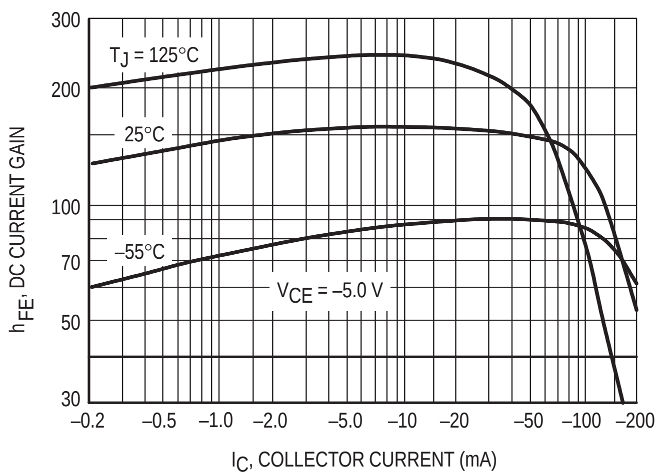


Figure 11. MPS8598/99 DC Current Gain

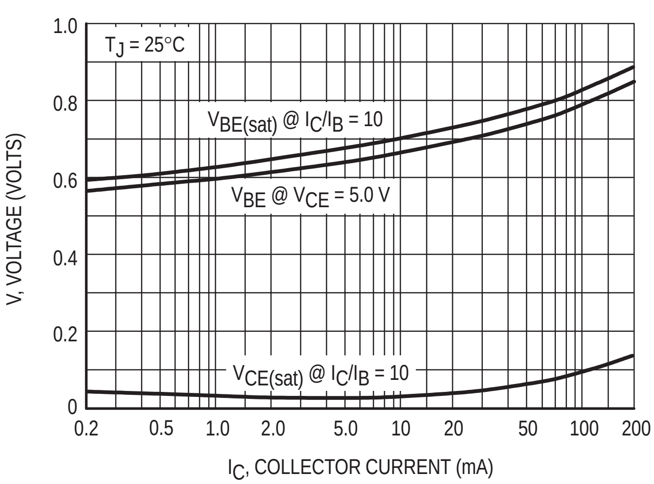


Figure 12. MPS8098/99 "ON" Voltages

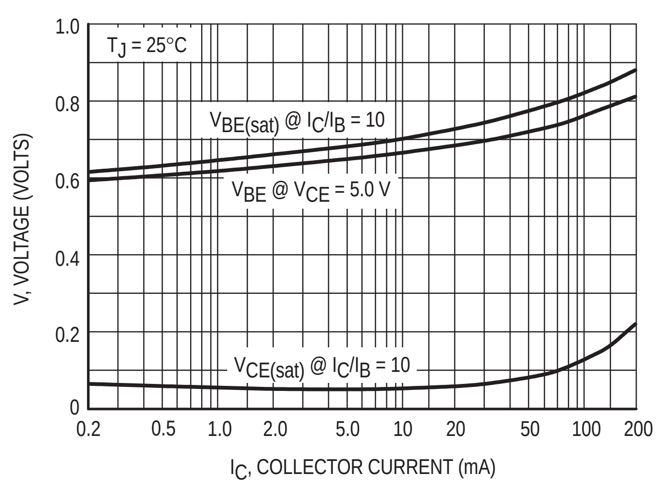


Figure 13. MPS8598/99 "ON" Voltages

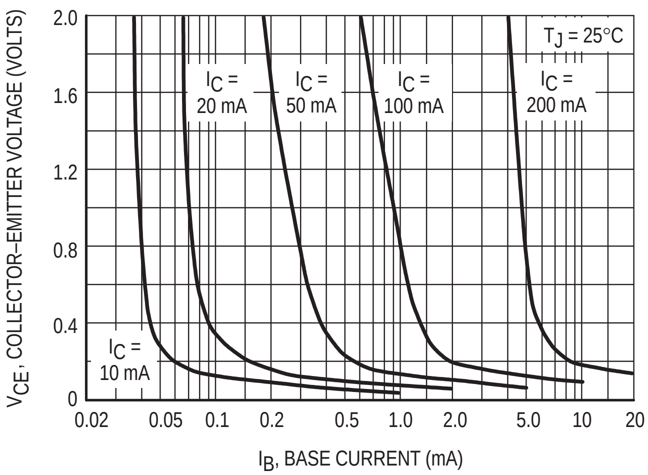


Figure 14. MPS8098/99 Collector Saturation Region

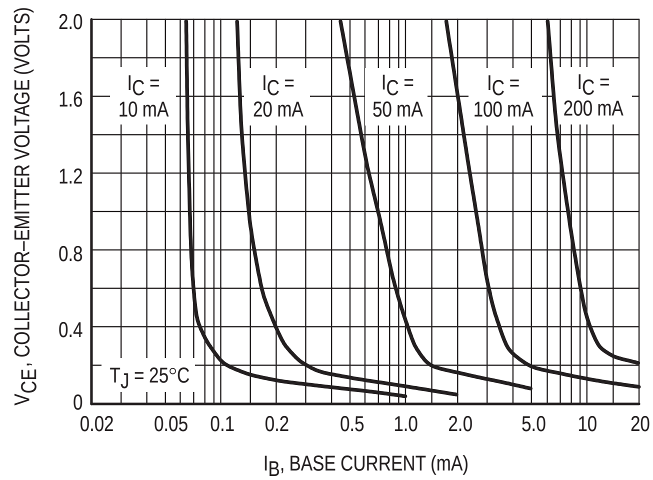


Figure 15. MPS8598/99 Collector Saturation Region

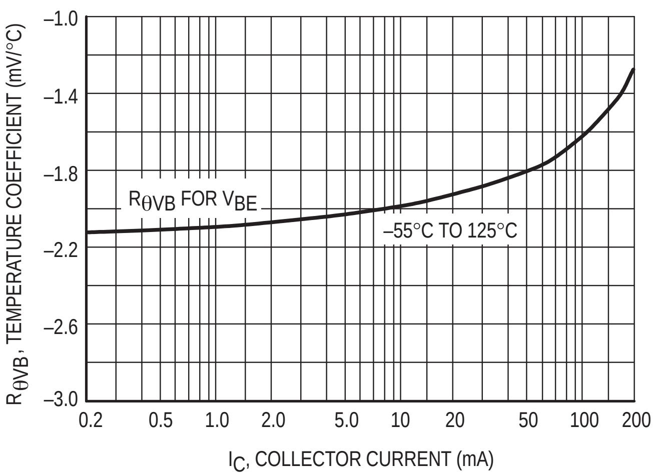


Figure 16. MPS8098/99 Base–Emitter Temperature Coefficient

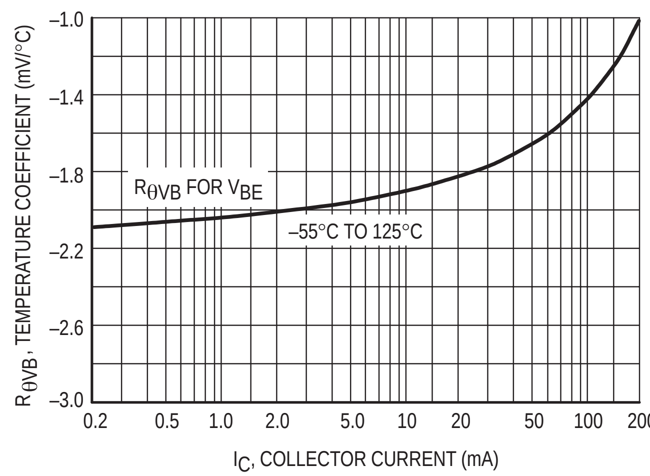


Figure 17. MPS8598/99 Base–Emitter Temperature Coefficient

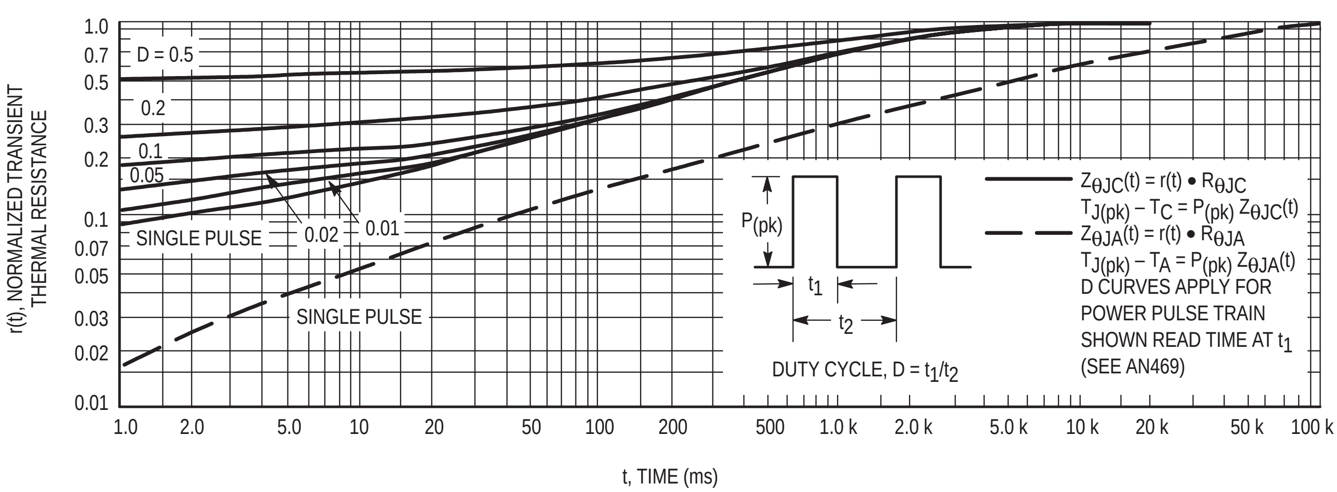
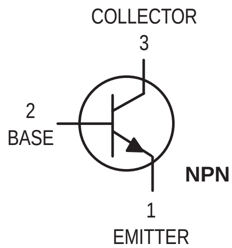
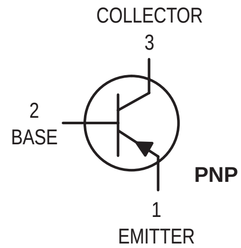


Figure 18. MPS8098, MPS8099, MPS8598 and MPS8599 Thermal Response

Amplifier Transistors

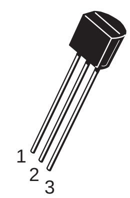




NPN
MPSA05
MPSA06*
PNP
MPSA55
MPSA56*

Voltage and current are negative for PNP transistors

***Motorola Preferred Device**



CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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)	 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

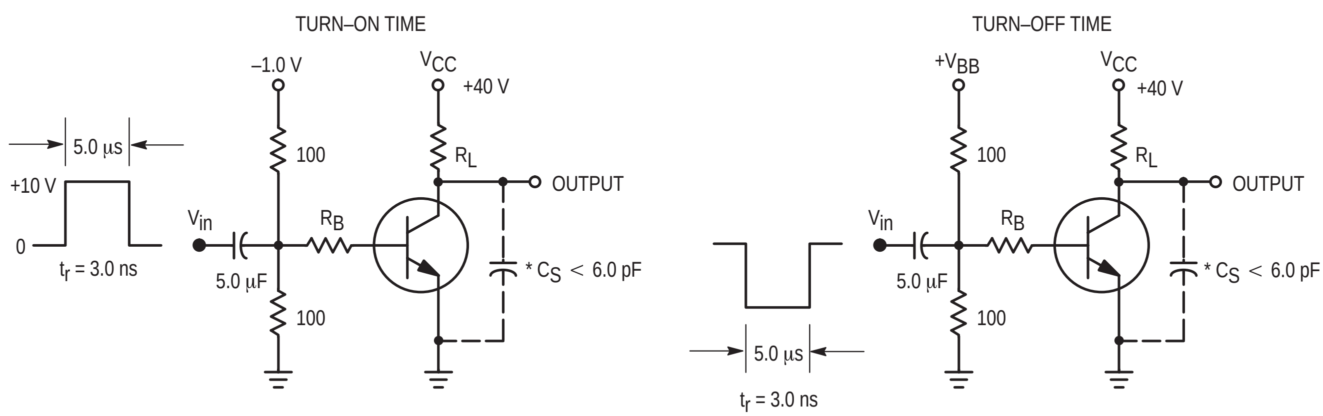
1. $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
2. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			100	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			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(3)		f_T			MHz
(I_C = 10 mA, V_{CE} = 2.0 V, f = 100 MHz)	MPSA05 MPSA06		100	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc, f = 100 MHz)	MPSA55 MPSA56		50	—	

3. f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



* Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

Figure 1. Switching Time Test Circuits

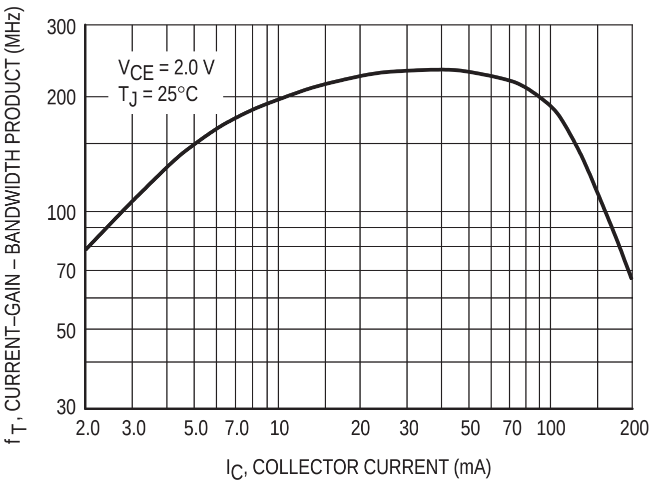


Figure 2. MPSA05/06 Current–Gain — Bandwidth Product

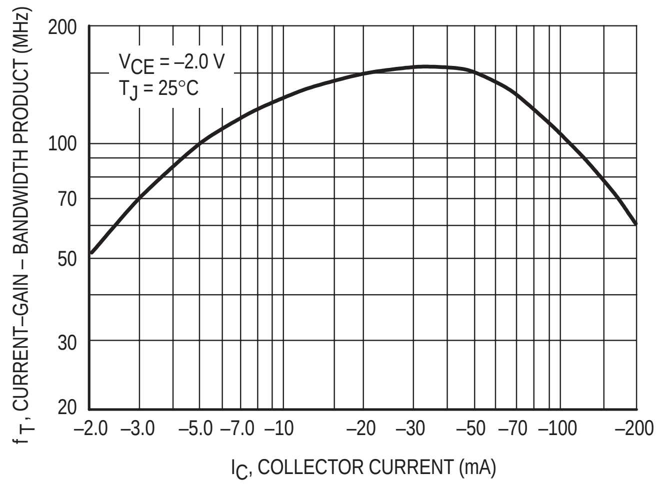


Figure 3. MPSA55/56 Current–Gain — Bandwidth Product

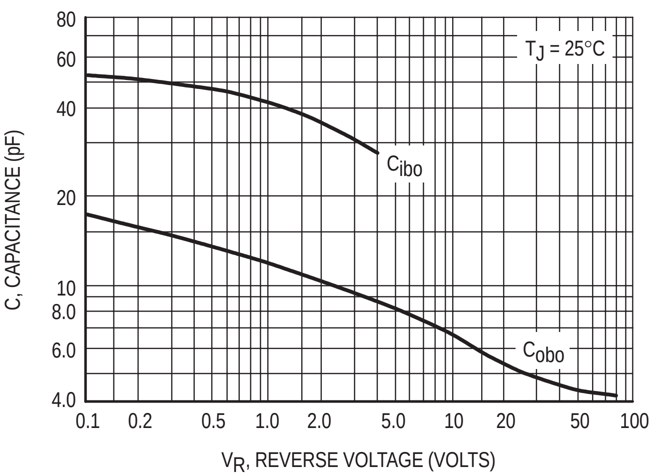


Figure 4. MPSA05/06 Capacitance

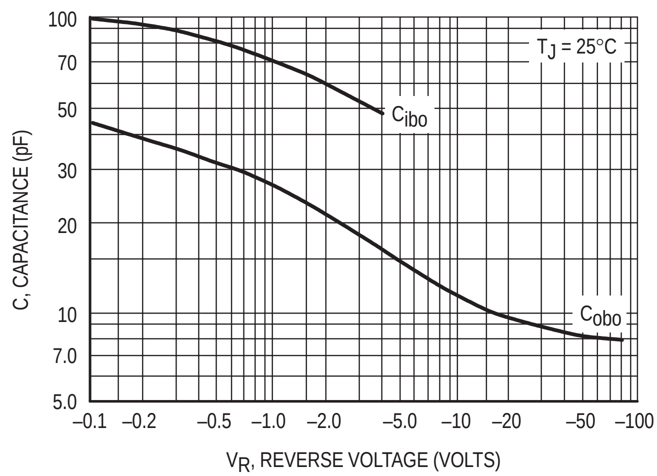


Figure 5. MPSA55/56 Capacitance

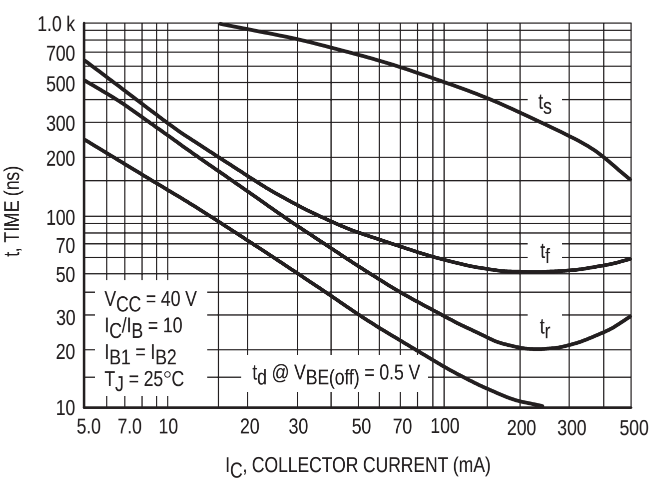


Figure 6. MPSA05/06 Switching Time

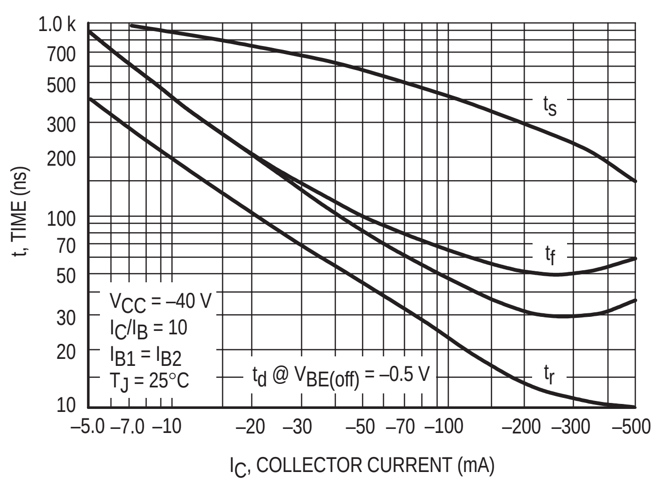


Figure 7. MPSA55/56 Switching Time

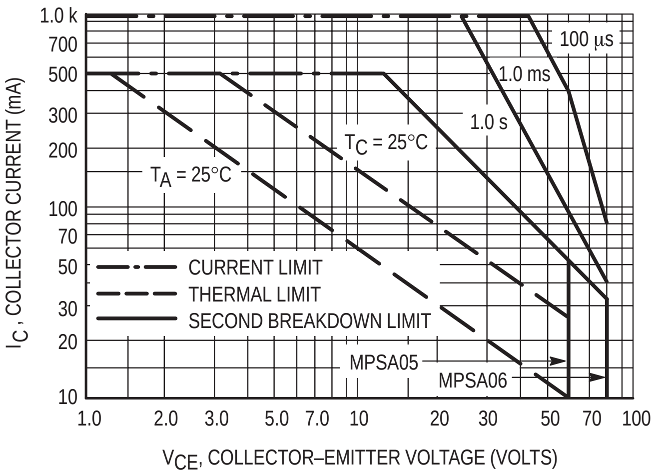


Figure 8. MPSA05/06 Active–Region Safe Operating Area

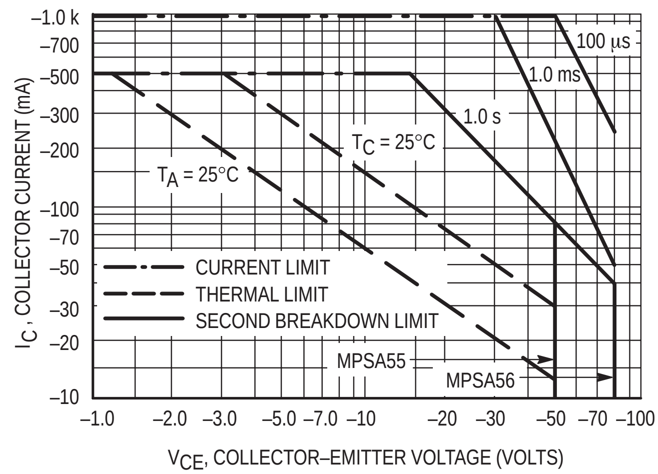


Figure 9. MPSA55/56 Active–Region Safe Operating Area

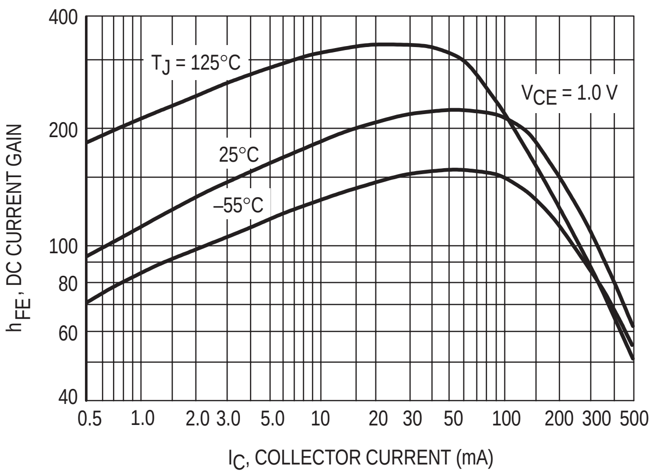


Figure 10. MPSA05/06 DC Current Gain

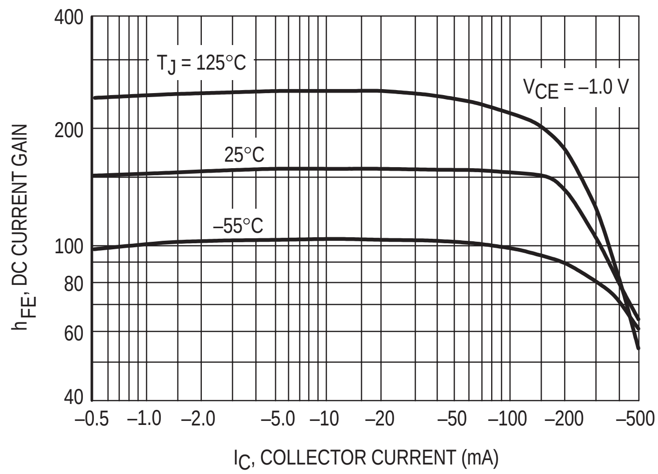


Figure 11. MPSA55/56 DC Current Gain

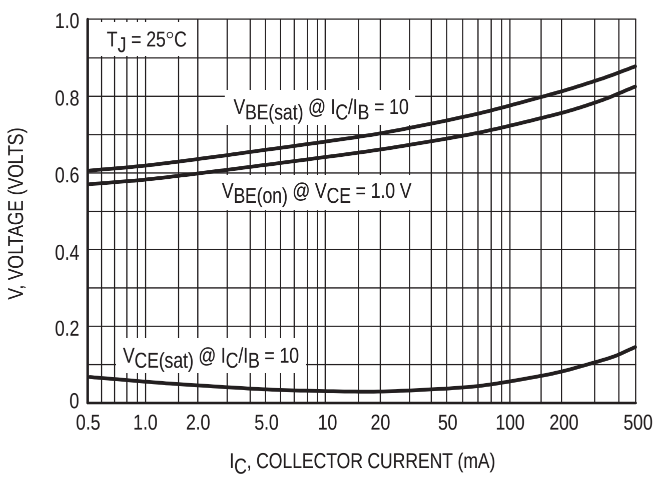


Figure 12. MPSA05/06 "ON" Voltages

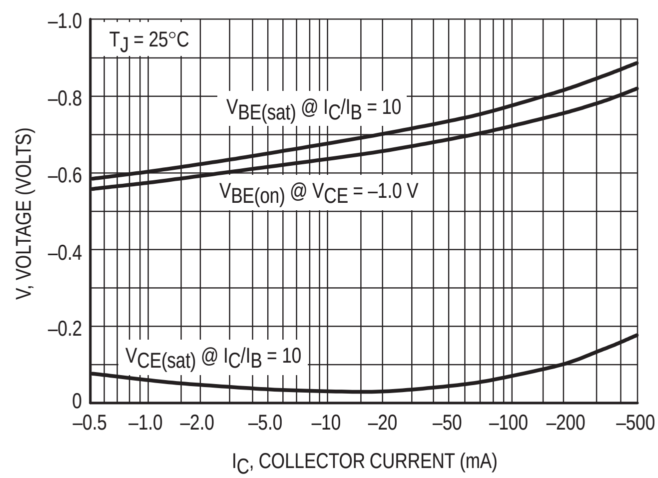


Figure 13. MPSA55/56 "ON" Voltages

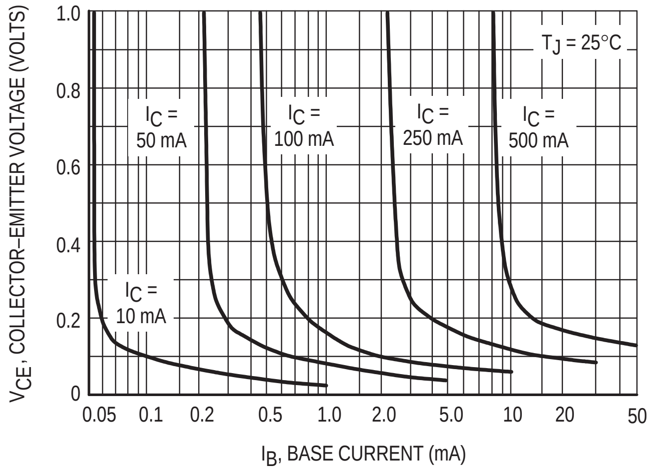


Figure 14. MPSA05/06 Collector Saturation Region

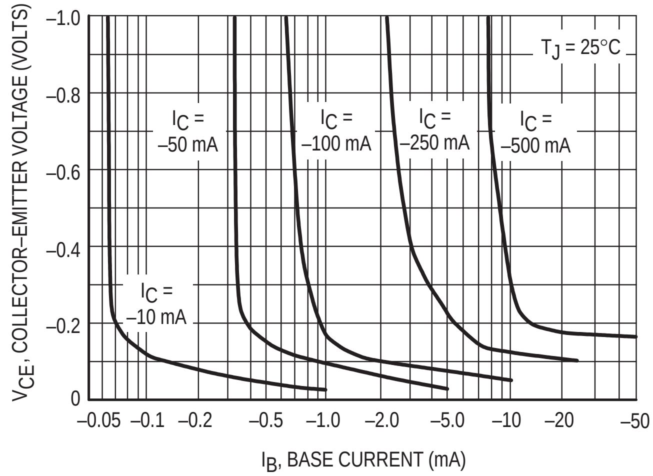


Figure 15. MPSA55/56 Collector Saturation Region

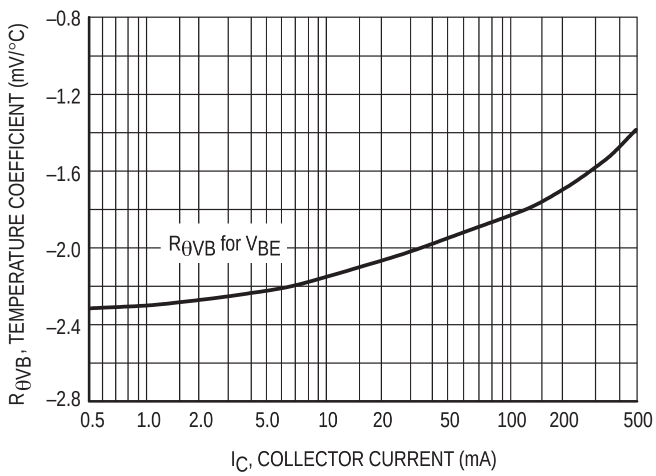


Figure 16. MPSA05/06 Base–Emitter Temperature Coefficient

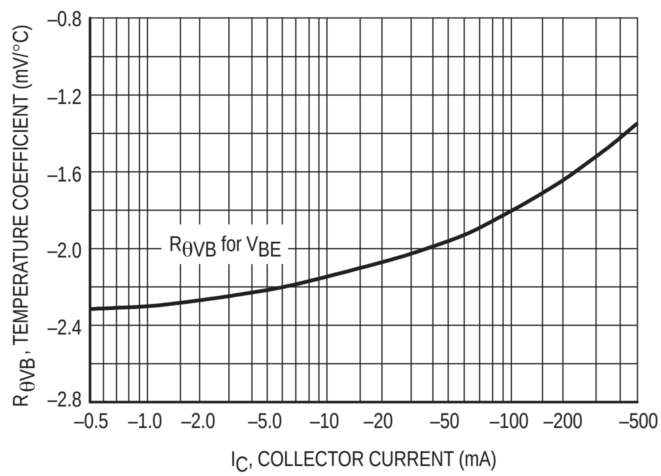


Figure 17. MPSA55/56 Base–Emitter Temperature Coefficient

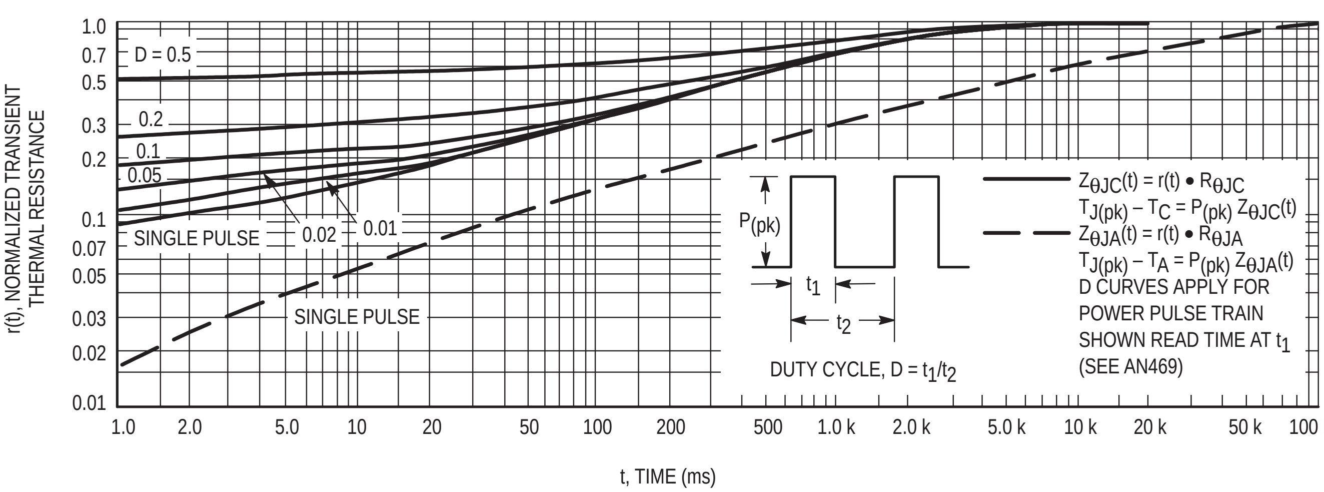
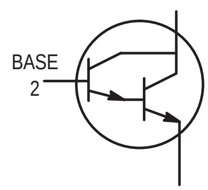


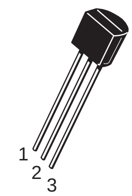
Figure 18. MPSA05, MPSA06, MPSA55 and MPSA56 Thermal Response

Darlington Transistors
NPN Silicon

MPSA13
MPSA14*

*Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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 μAdc, I_B = 0)	$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current (V_{CB}= 30 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB}= 10 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain		h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPSA13		5,000	—	
	MPSA14		10,000	—	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MPSA13		10,000	—	
	MPSA14		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. $f_T = |h_{fe}| \cdot f_{test}$.

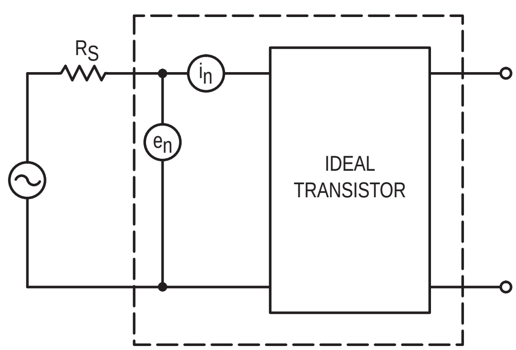


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

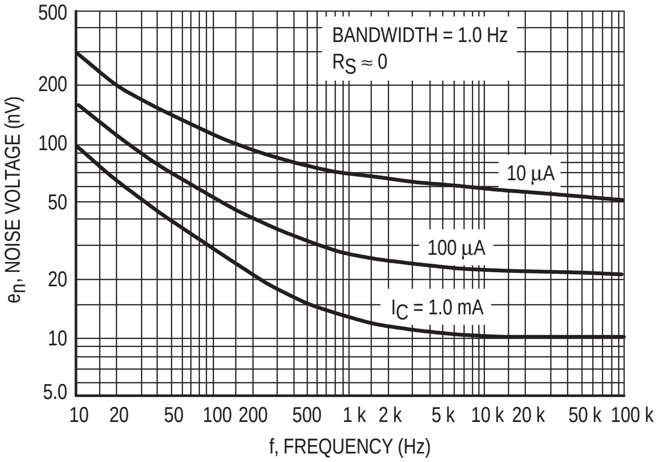


Figure 2. Noise Voltage

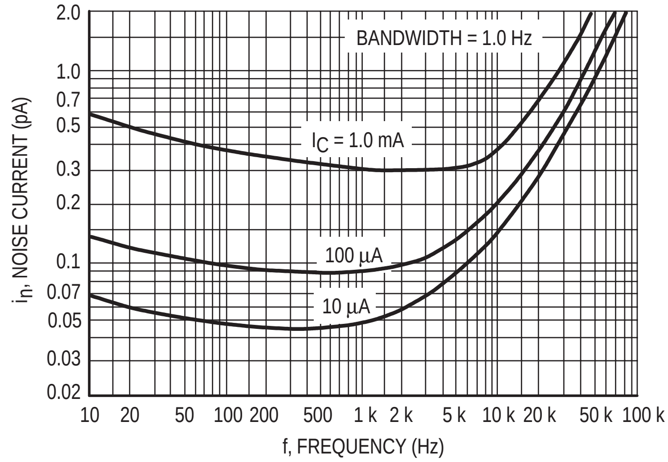


Figure 3. Noise Current

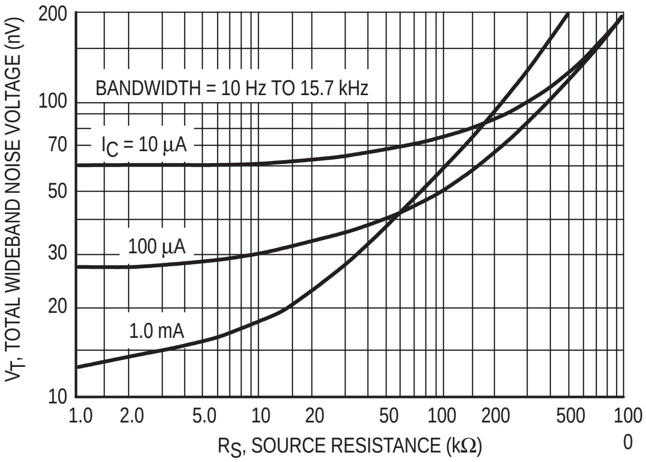


Figure 4. Total Wideband Noise Voltage

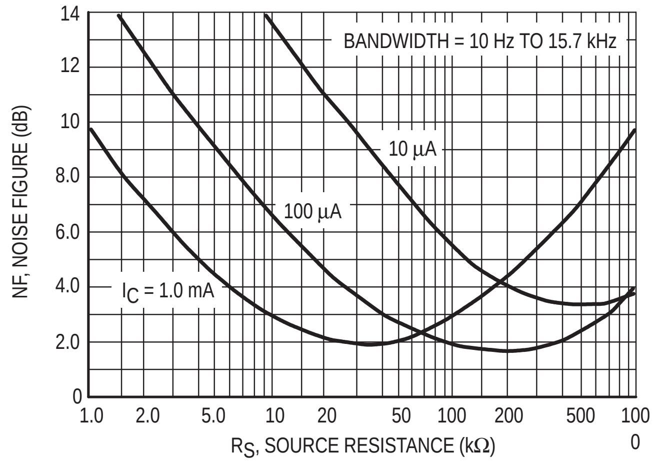


Figure 5. Wideband Noise Figure

SMALL–SIGNAL CHARACTERISTICS

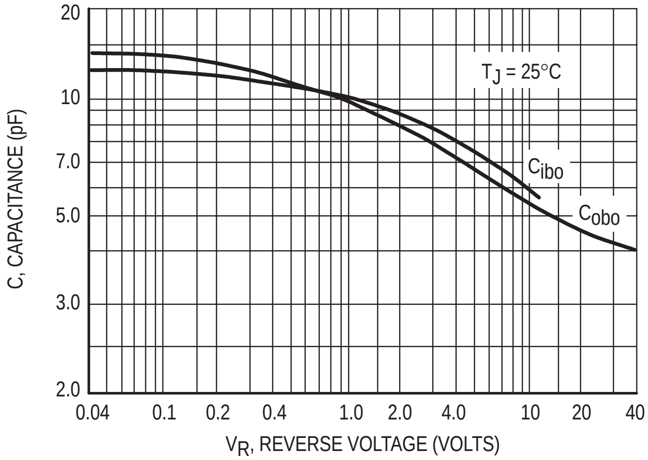


Figure 6. Capacitance

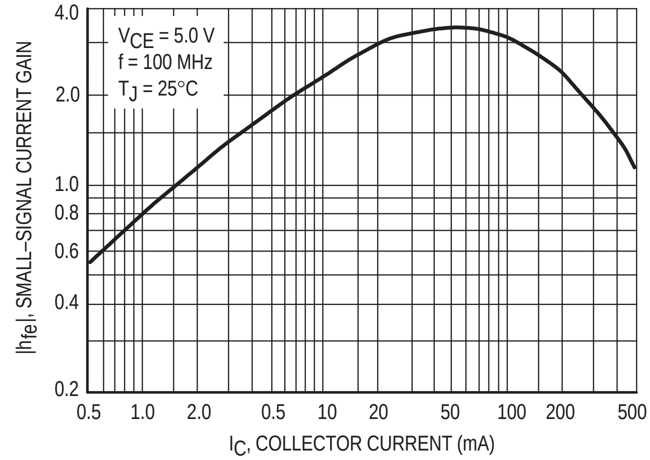


Figure 7. High Frequency Current Gain

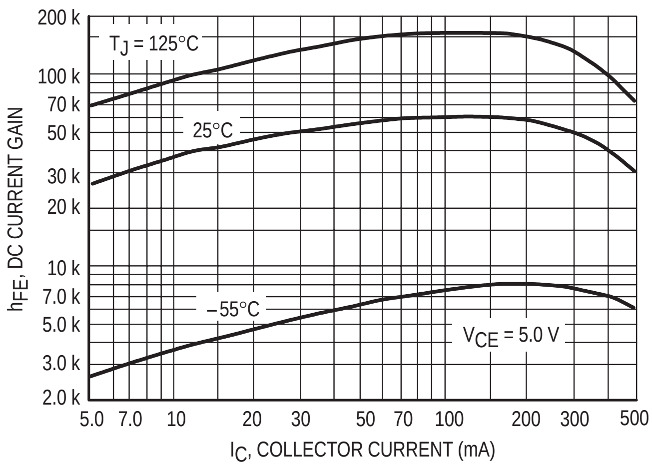


Figure 8. DC Current Gain

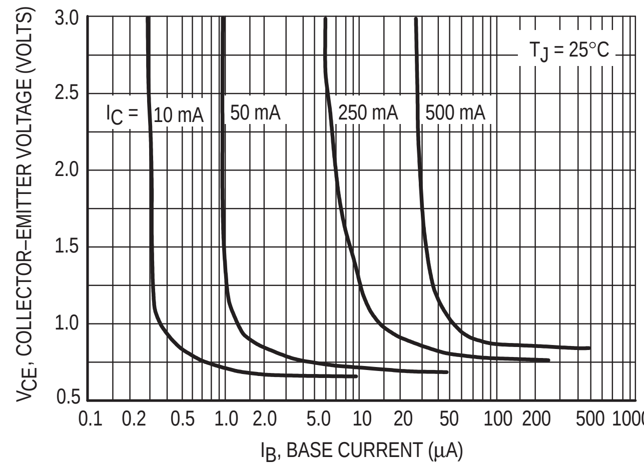


Figure 9. Collector Saturation Region

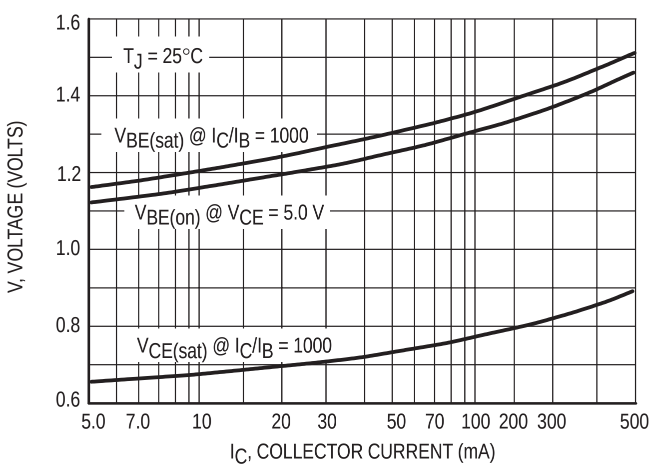


Figure 10. "On" Voltages

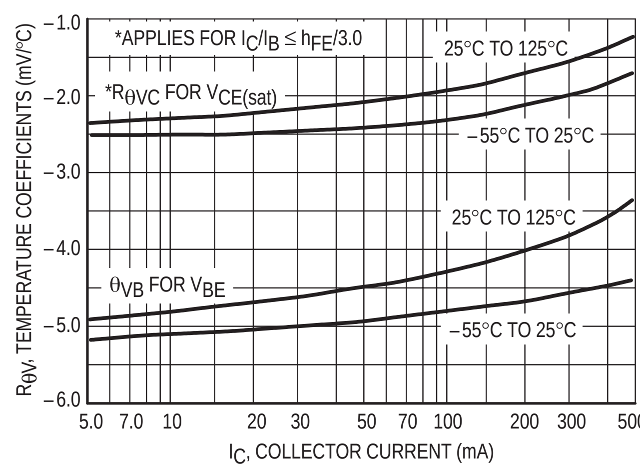


Figure 11. Temperature Coefficients

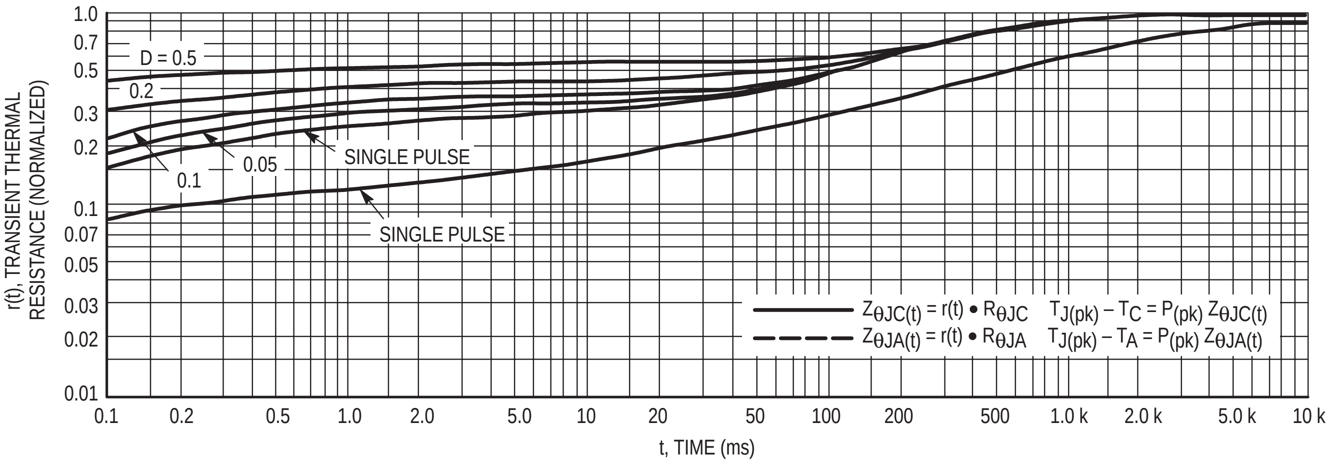


Figure 12. Thermal Response

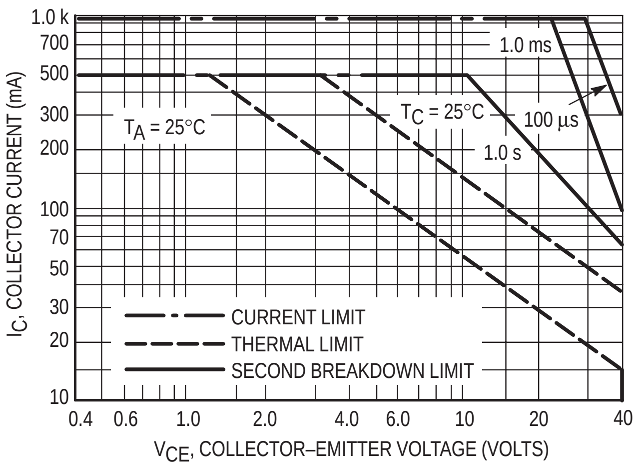
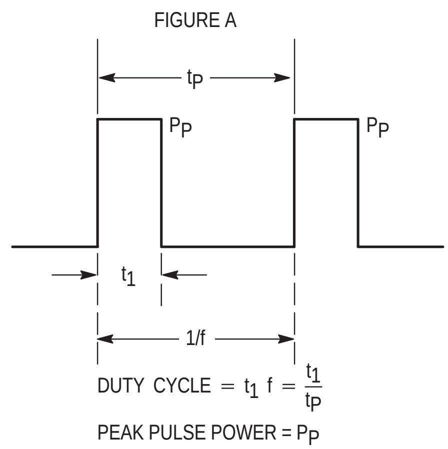


Figure 13. Active Region Safe Operating Area

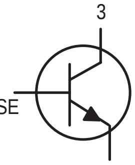


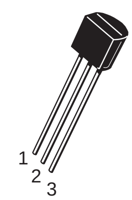
Design Note: Use of Transient Thermal Resistance Data

Chopper Transistor
NPN Silicon

MPSA17

Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	40	Vdc
Emitter–Base Voltage	V_{EBO}	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	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_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	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

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

(Replaces MPSA16/D)

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	200	600	—
Collector–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL–SIGNAL CHARACTERISTICS				
Current–Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	80	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF

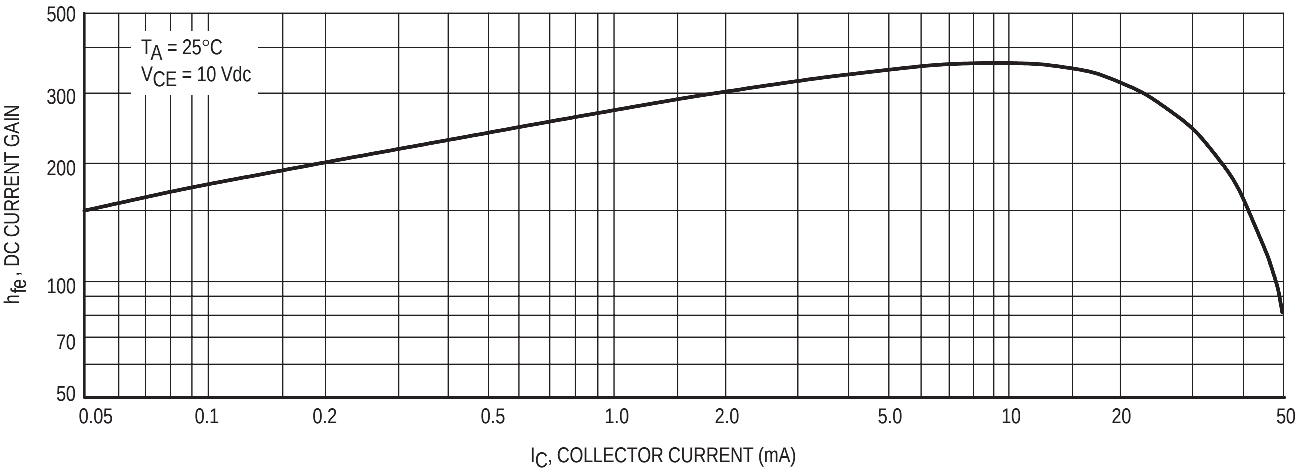


Figure 1. DC Current Gain

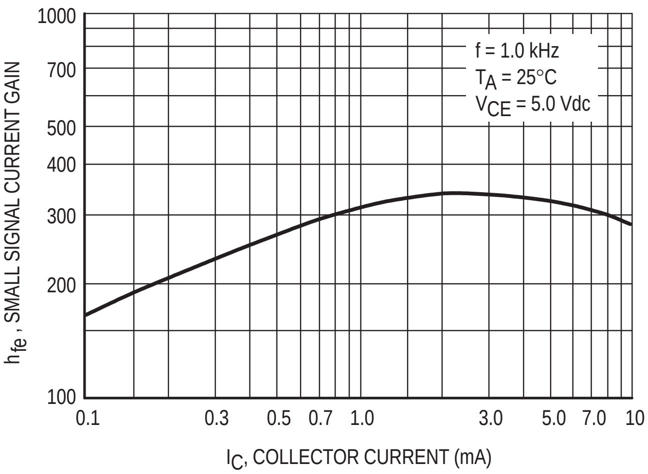


Figure 2. Small Signal Current Gain

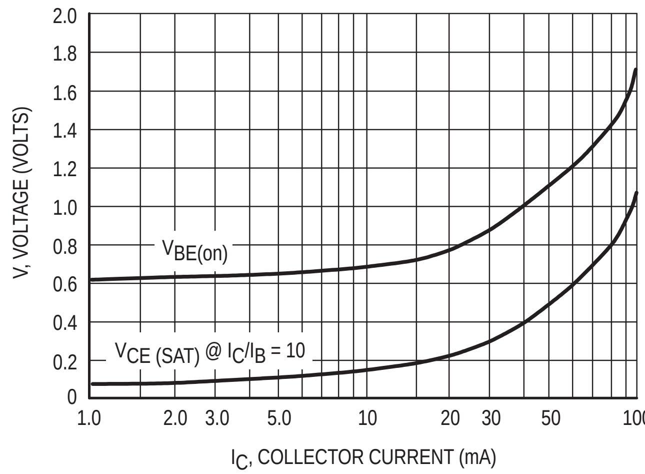


Figure 3. Saturation and On Voltages

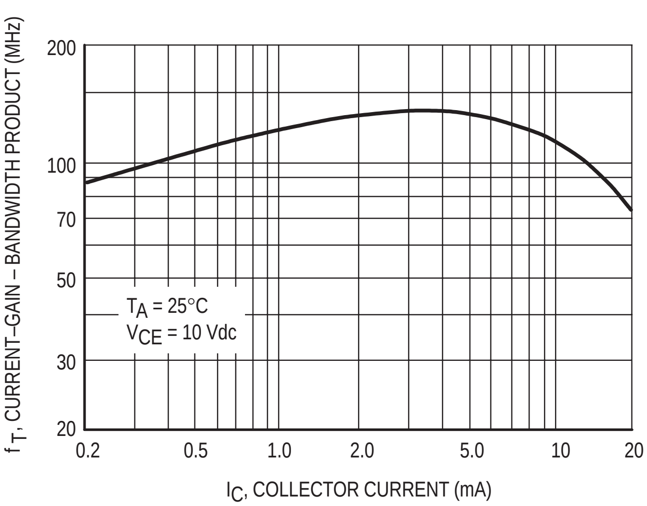


Figure 4. Current–Gain — Bandwidth Product

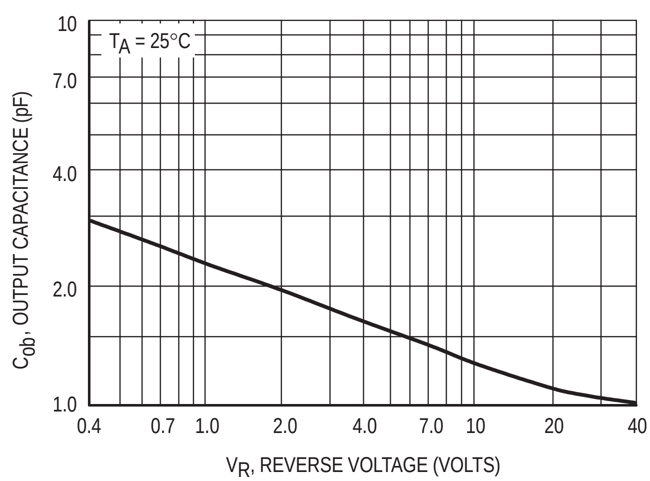


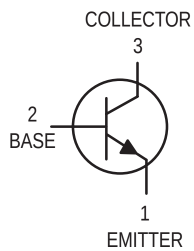
Figure 5. Output Capacitance

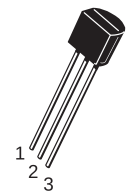
Low Noise Transistor

NPN Silicon

MPSA18

Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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%.

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS[2]					
DC Current Gain	h_{FE}				—
(I_C = 10 µAdc, V_{CE} = 5.0 Vdc)		400	580	—	
(I_C = 100 µAdc, V_{CE} = 5.0 Vdc)		500	850	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		500	1100	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		500	1150	1500	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)		—	—	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	0.08	0.3	
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	NF				dB
(I_C = 100 µAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz)		—	0.5	1.5	
(I_C = 100 µAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 100 Hz)		—	4.0	—	
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	—	$nV/\sqrt{Hz}$

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

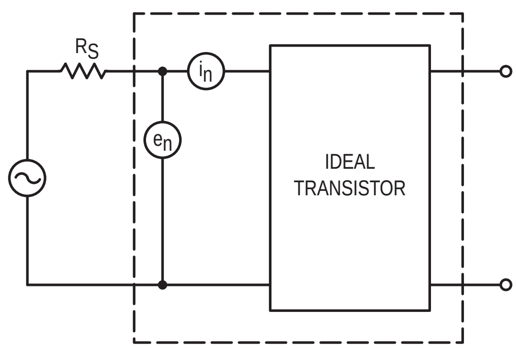


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

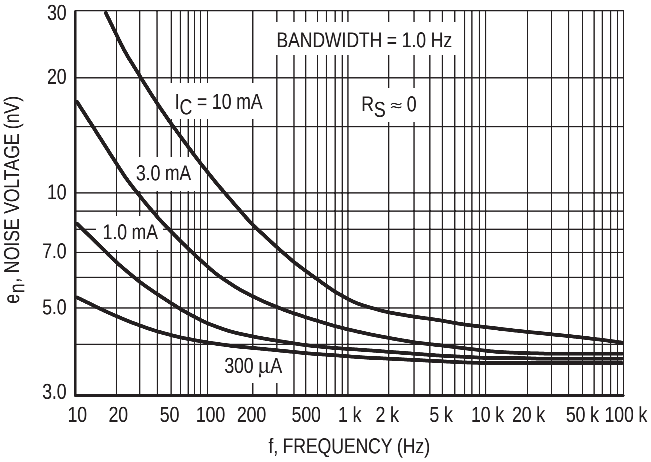


Figure 2. Effects of Frequency

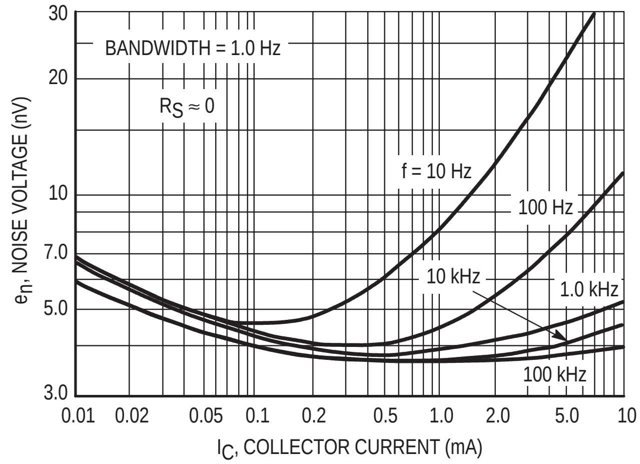


Figure 3. Effects of Collector Current

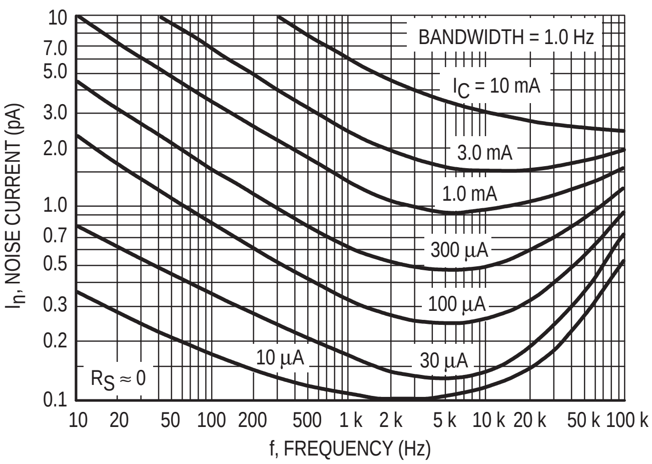


Figure 4. Noise Current

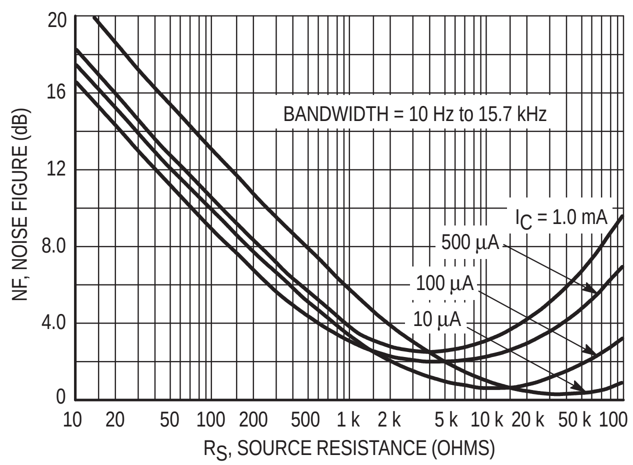


Figure 5. Wideband Noise Figure

100 Hz NOISE DATA

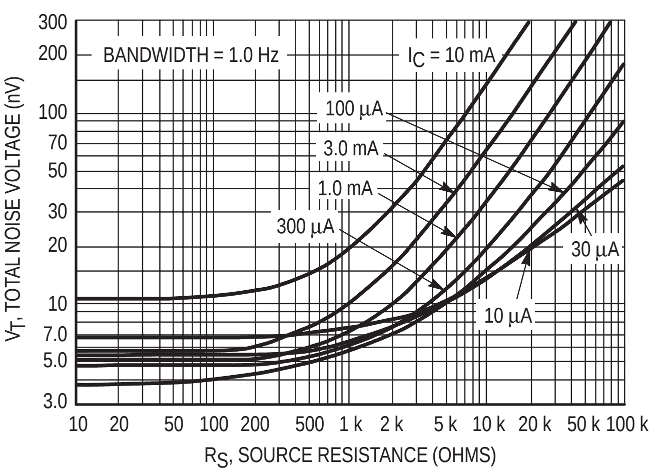


Figure 6. Total Noise Voltage

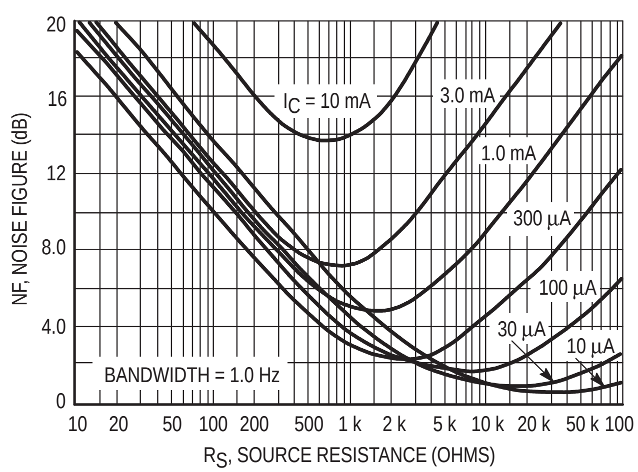


Figure 7. Noise Figure

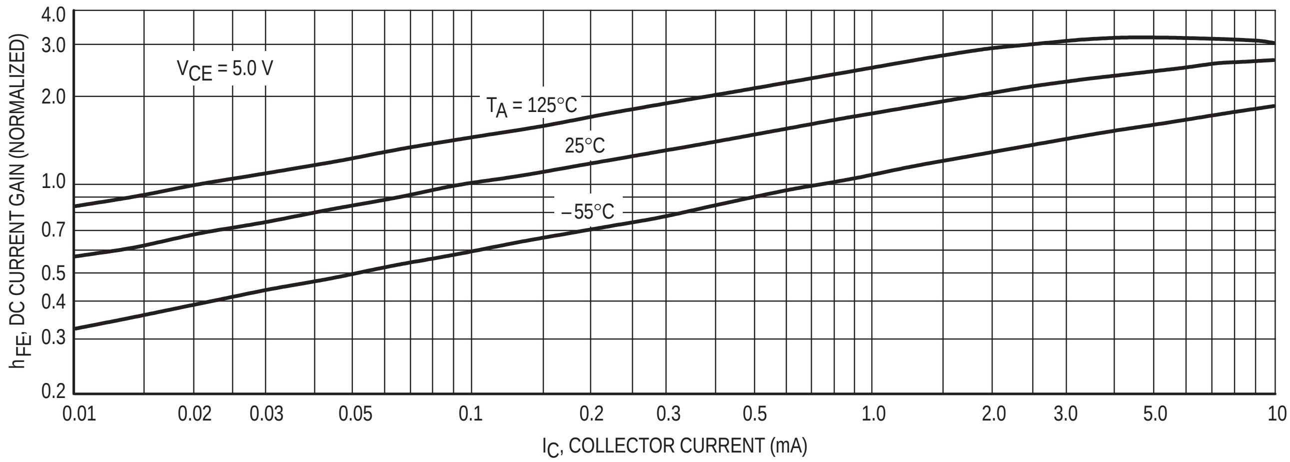


Figure 8. DC Current Gain

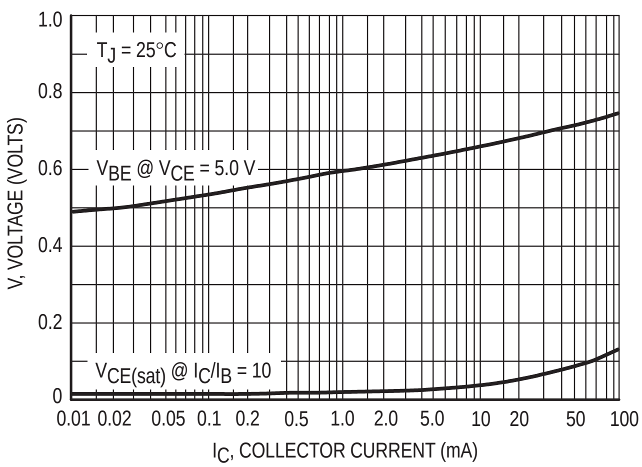


Figure 9. "On" Voltages

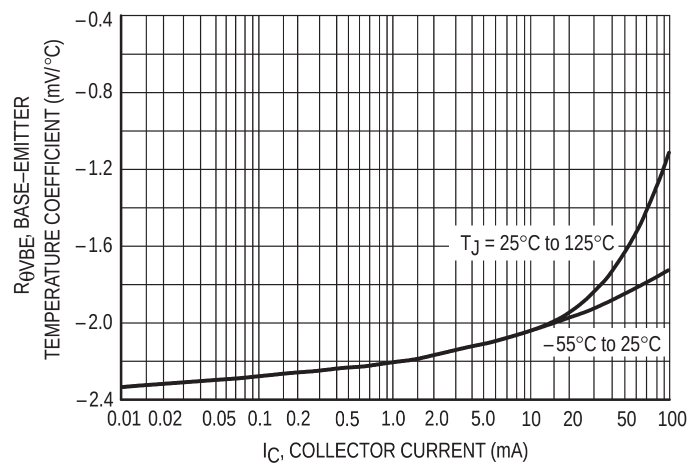


Figure 10. Temperature Coefficients

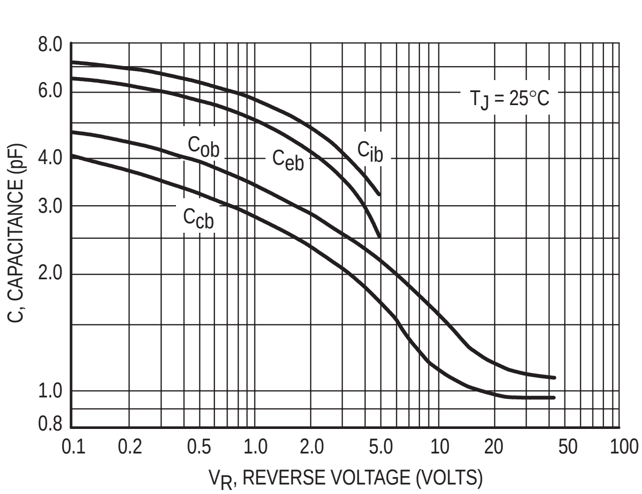


Figure 11. Capacitance

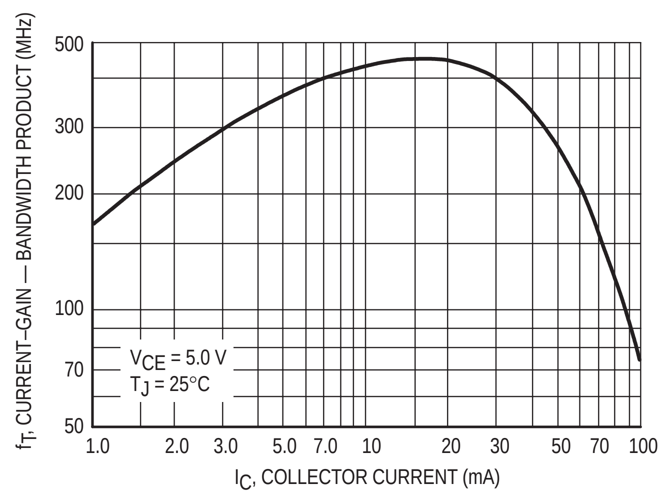
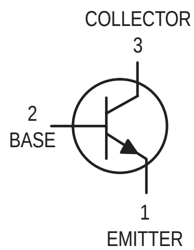
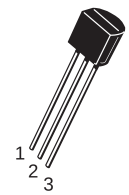


Figure 12. Current–Gain — Bandwidth Product

Amplifier Transistor
NPN Silicon

MPSA20





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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	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 = 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

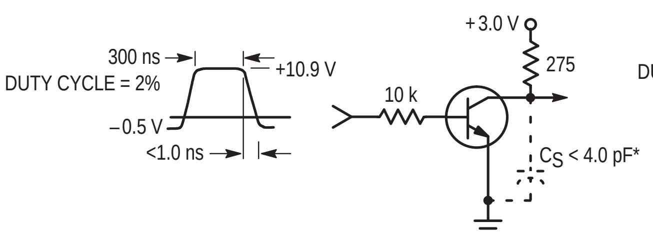
1. $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
2. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

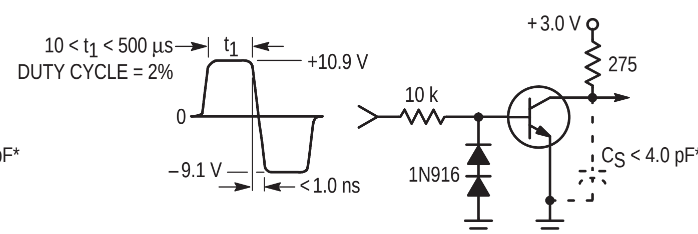
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Max	Unit
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

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

EQUIVALENT SWITCHING TIME TEST CIRCUITS





*Total shunt capacitance of test jig and connectors

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

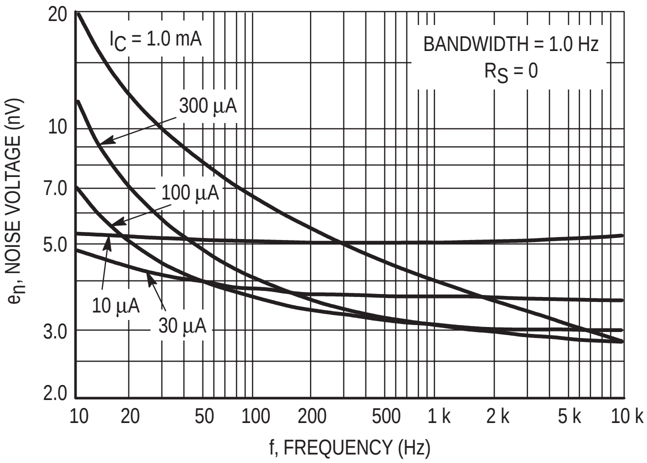


Figure 3. Noise Voltage

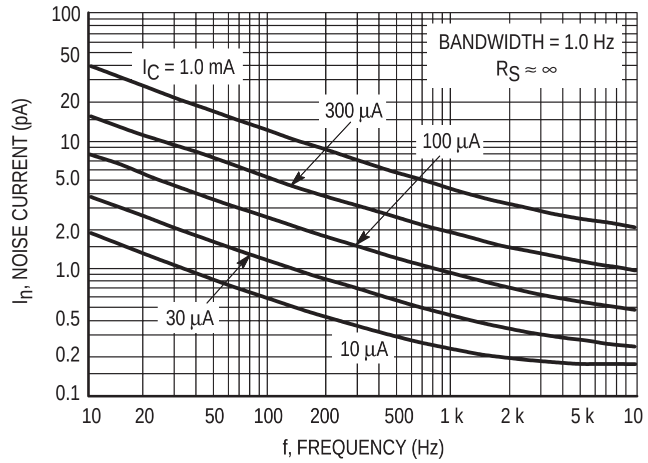


Figure 4. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

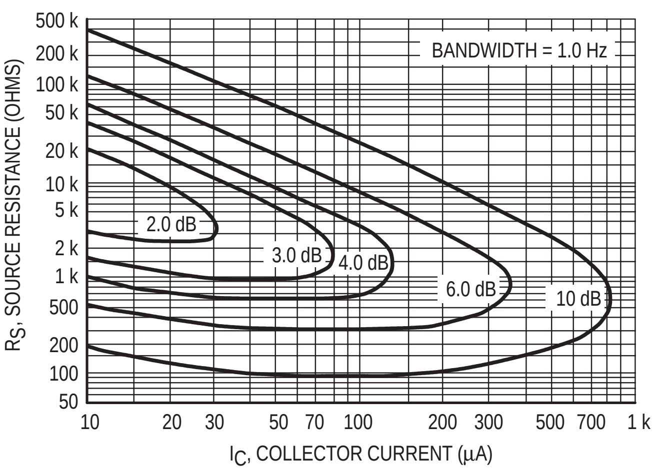


Figure 5. Narrow Band, 100 Hz

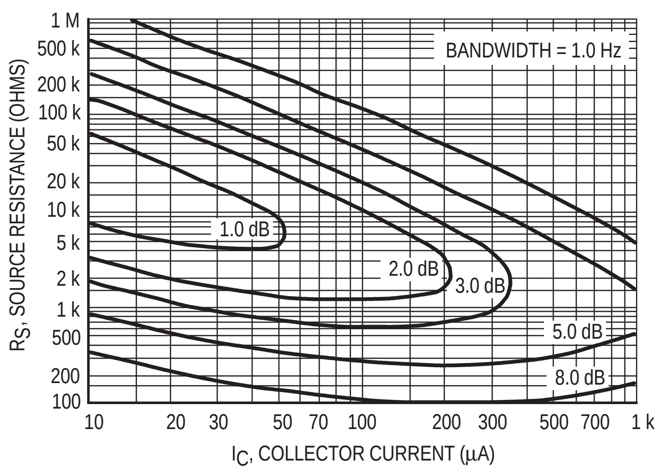


Figure 6. Narrow Band, 1.0 kHz

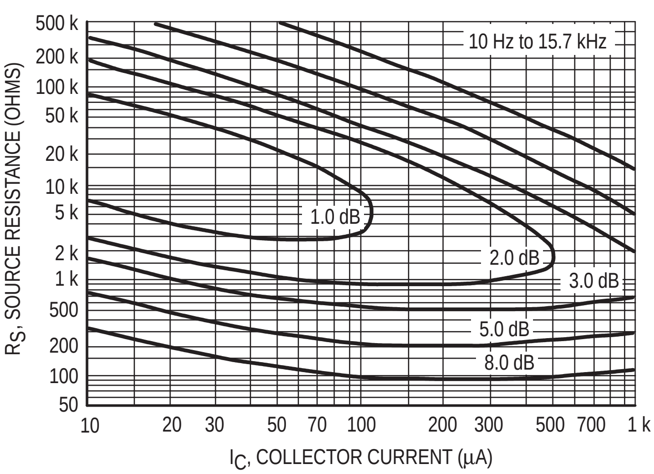


Figure 7. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

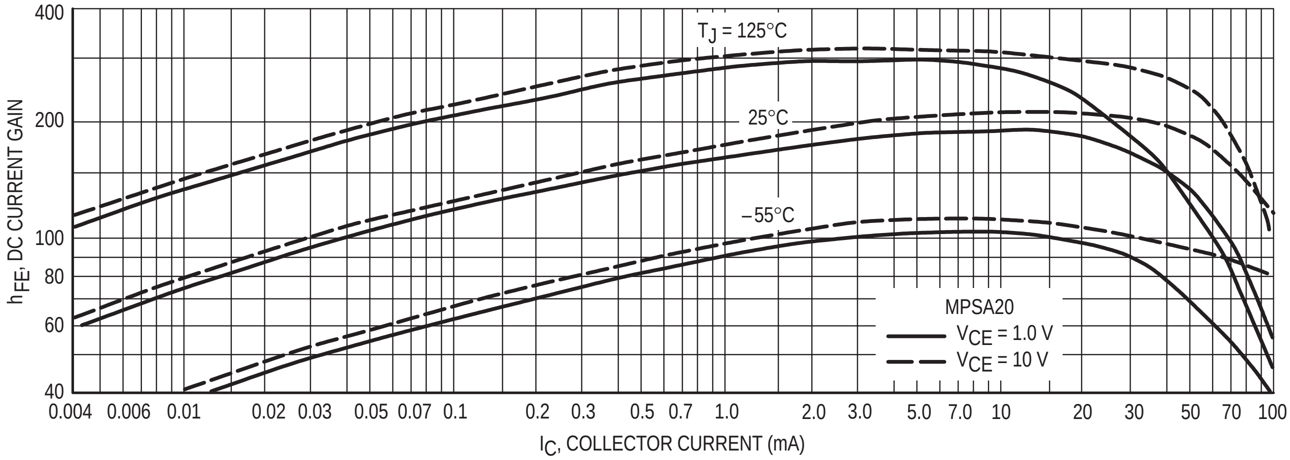


Figure 8. DC Current Gain

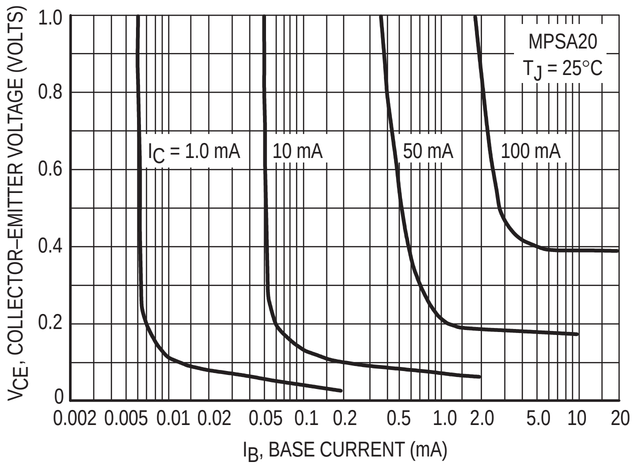


Figure 9. Collector Saturation Region

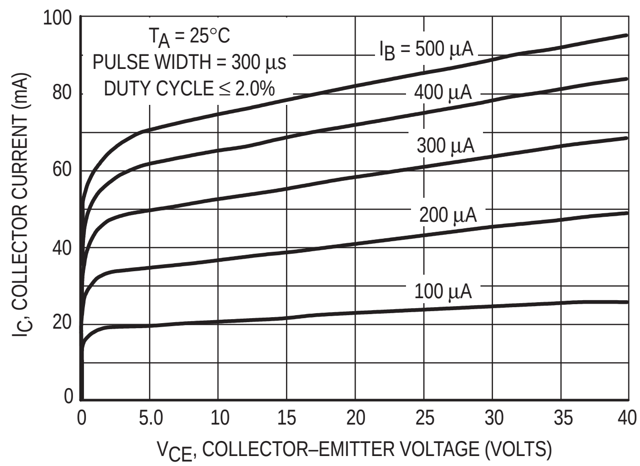


Figure 10. Collector Characteristics

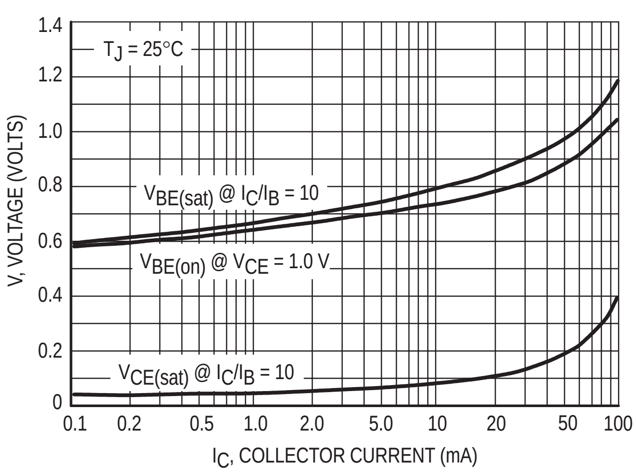


Figure 11. “On” Voltages

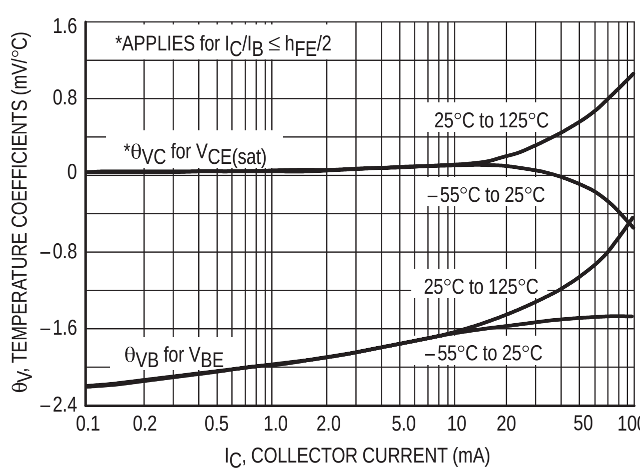


Figure 12. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

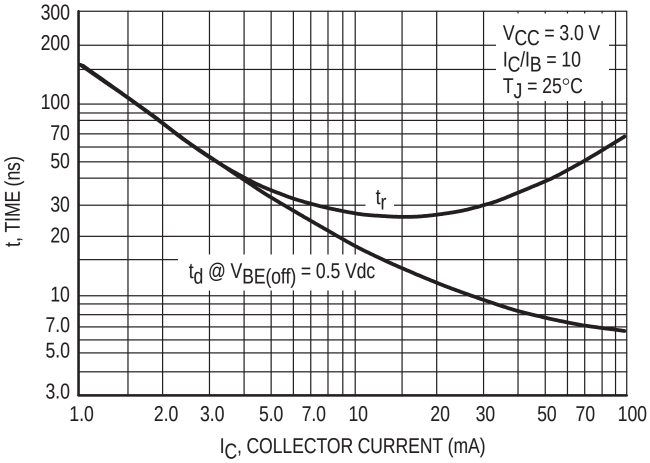


Figure 13. Turn–On Time

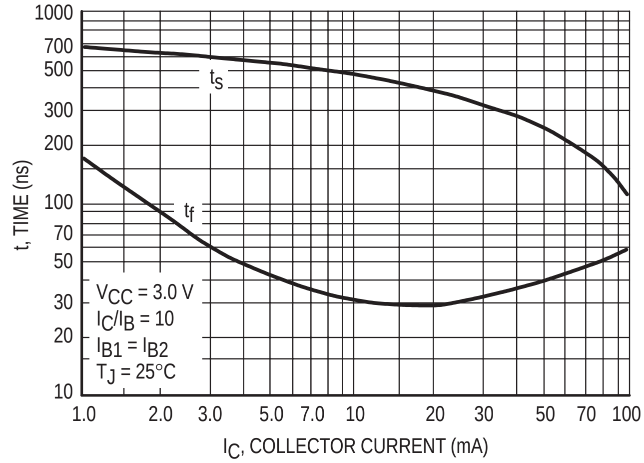


Figure 14. Turn–Off Time

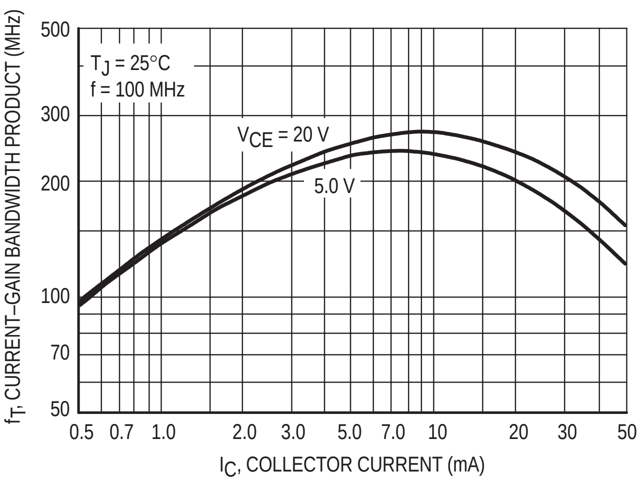


Figure 15. Current–Gain — Bandwidth Product

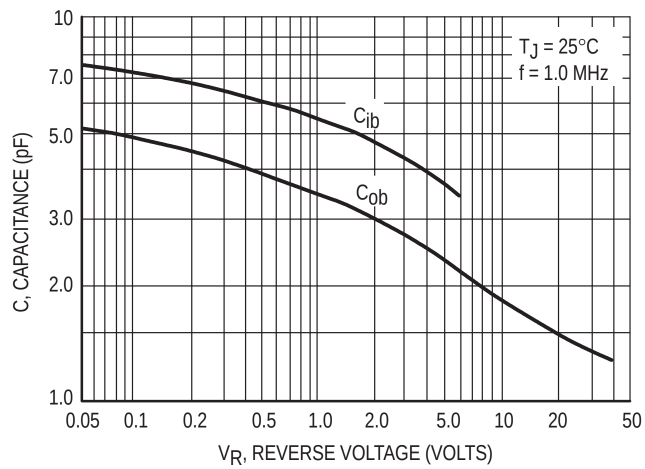


Figure 16. Capacitance

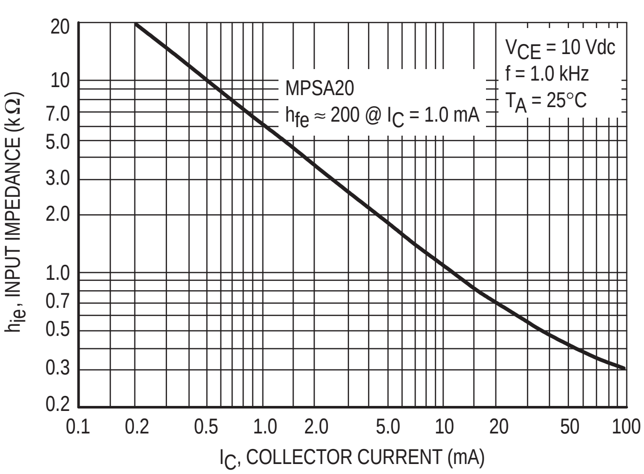


Figure 17. Input Impedance

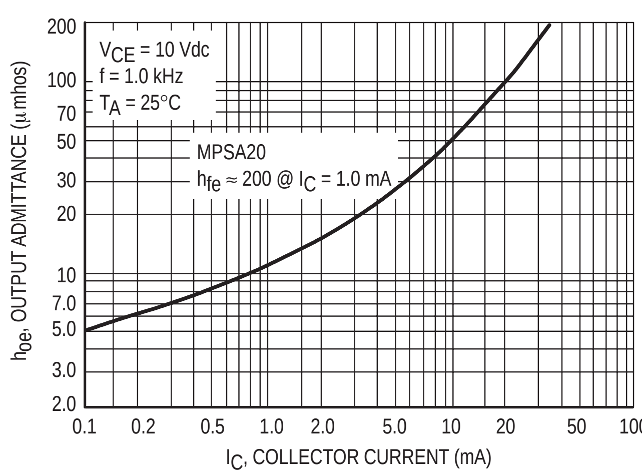


Figure 18. Output Admittance

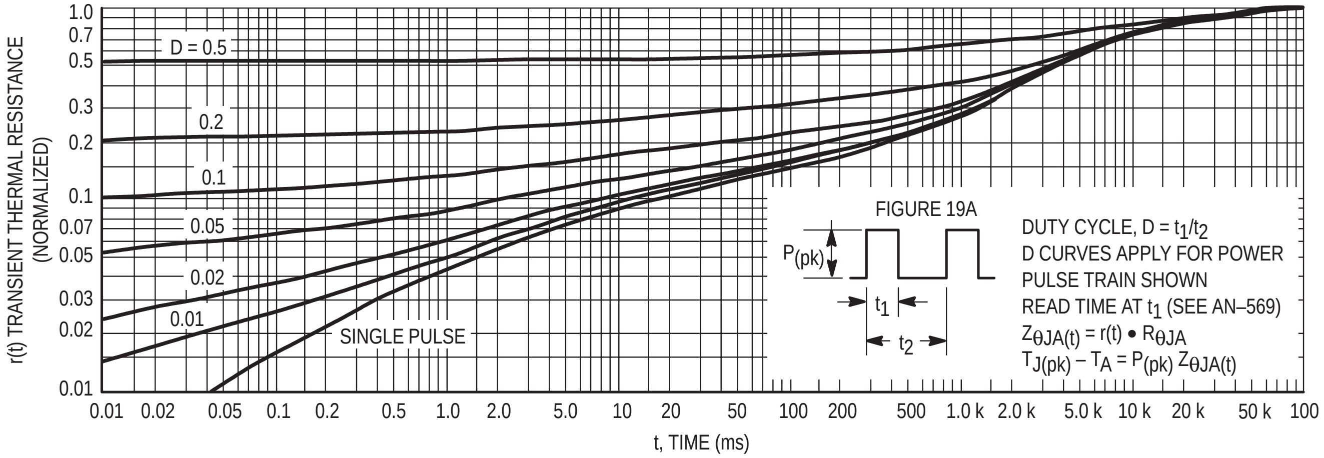


Figure 19. Thermal Response

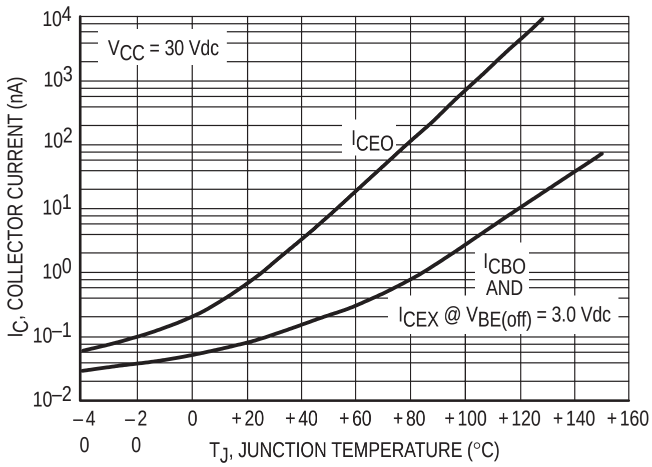


Figure 19A.

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:

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.

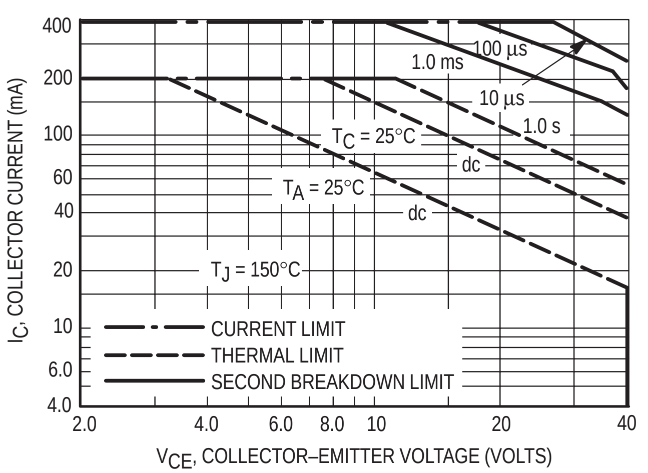


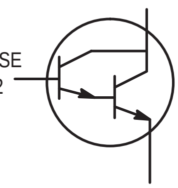
Figure 20.

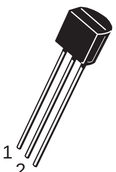
The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

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 $T_{J(pk)} \le$ 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.

Darlington Transistor
NPN Silicon

MPSA27





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	MPSA27	Unit
Collector–Emitter Voltage	V_{CES}	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 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μAdc, 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

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

Characteristic	Symbol	Min	Typ	Max	Unit
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%.

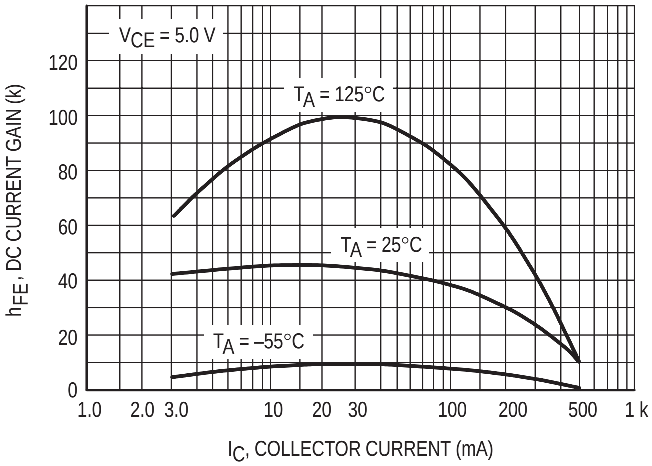


Figure 1. DC Current Gain

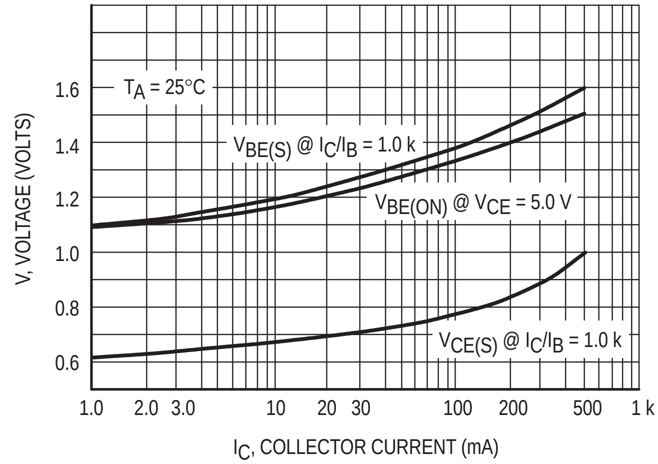


Figure 2. "ON" Voltages

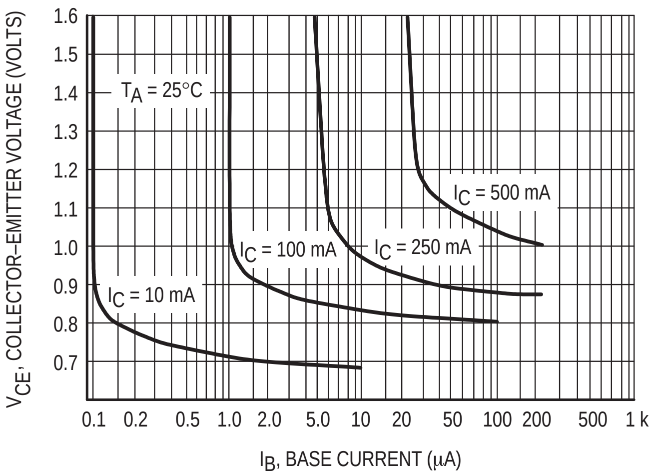


Figure 3. Collector Saturation Region

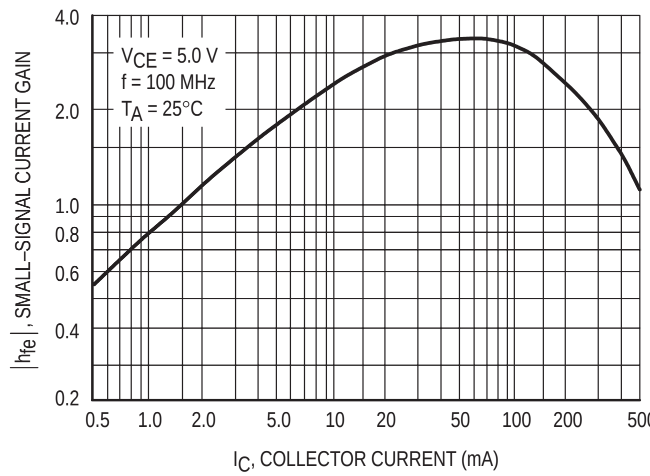


Figure 4. High Frequency Current Gain

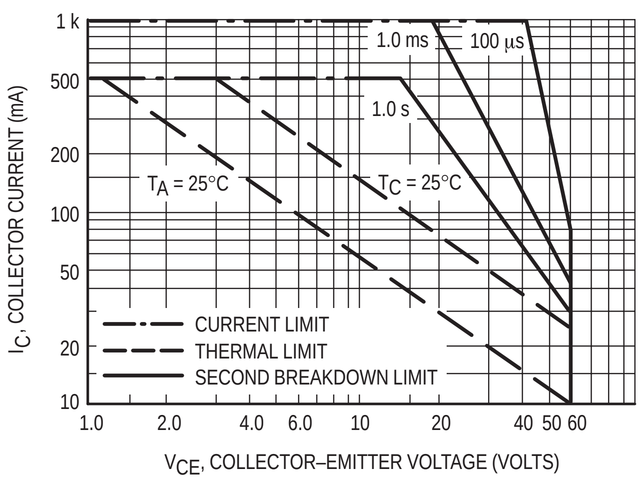
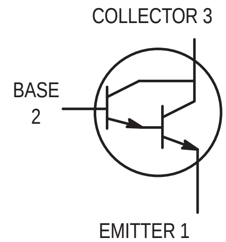


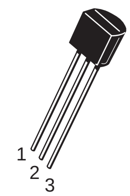
Figure 5. Active Region — Safe Operating Area

Darlington Transistors
NPN Silicon

MPSA28
MPSA29*

*Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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 μAdc, V_{BE} = 0)	 MPSA28 MPSA29	$V_{(BR)CES}$	 80 100	 — —	 — —	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPSA28 MPSA29	$V_{(BR)CBO}$	 80 100	 — —	 — —	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μAdc, 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

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
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)		10,000	—	—	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 0.01 mAdc)		—	0.7	1.2	
(I_C = 100 mAdc, I_B = 0.1 mAdc)		—	0.8	1.5	
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. $f_T = h_{fe} \cdot f_{test}$.

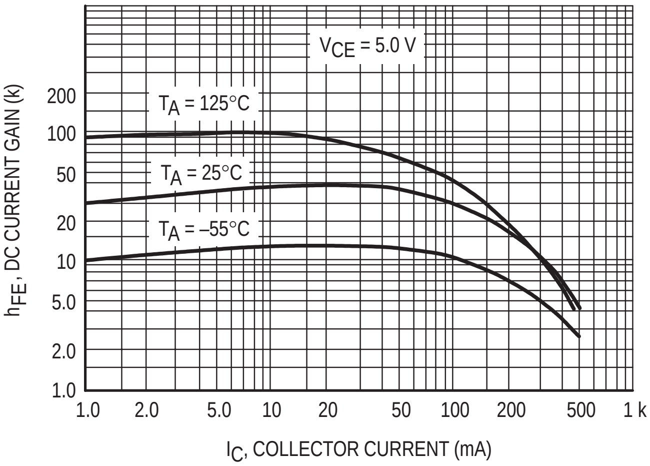


Figure 1. DC Current Gain

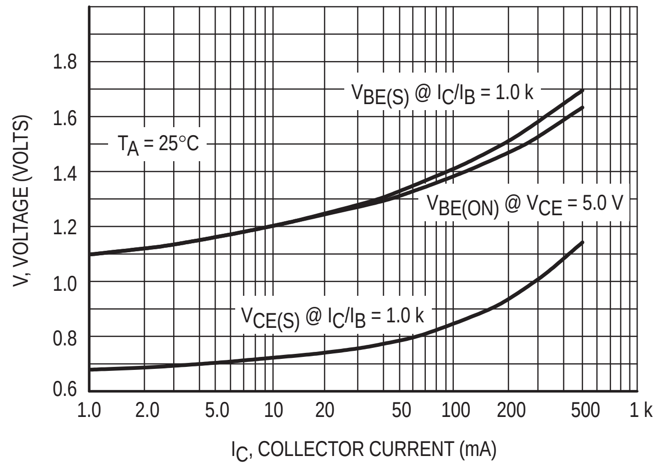


Figure 2. “ON” Voltages

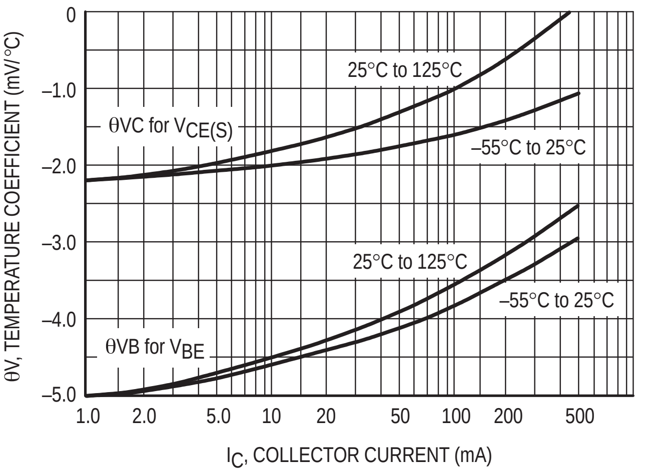


Figure 3. Temperature Coefficients

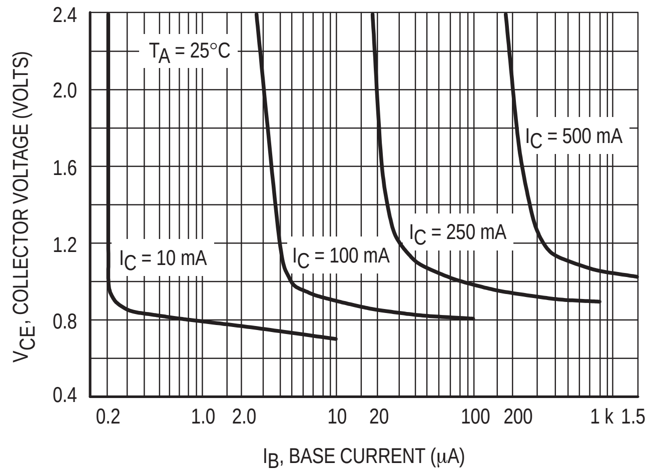


Figure 4. Collector Saturation Region

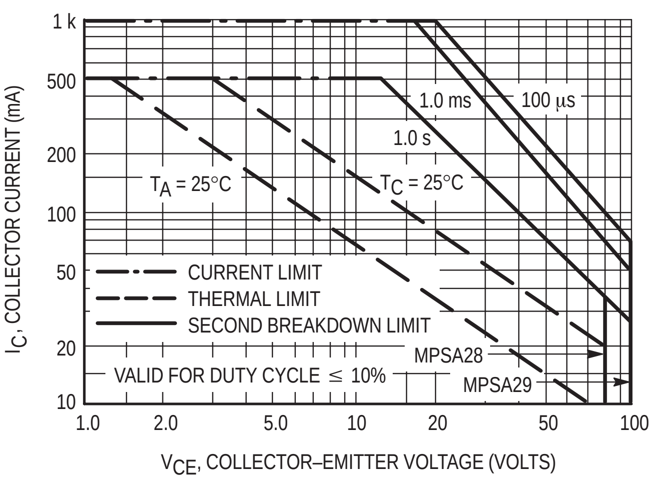


Figure 5. Active Region — Safe Operating Area

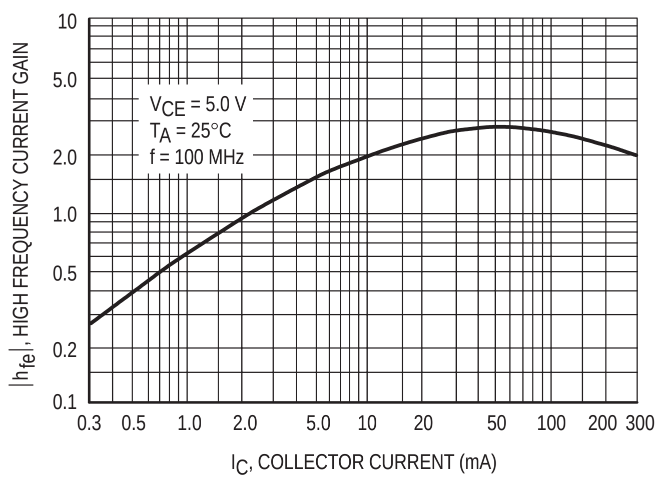
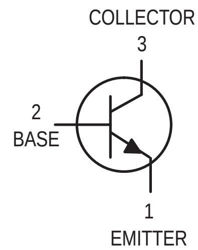


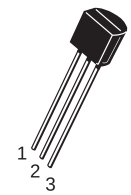
Figure 6. High Frequency Current Gain

High Voltage Transistors
NPN Silicon

MPSA42*
MPSA43

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]					
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	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 20 mAdc, I_B = 2.0 mAdc)	MPSA42		—	0.5	
	MPSA43		—	0.4	
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		C_{cb}			pF
(V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MPSA42		—	3.0	
	MPSA43		—	4.0	

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

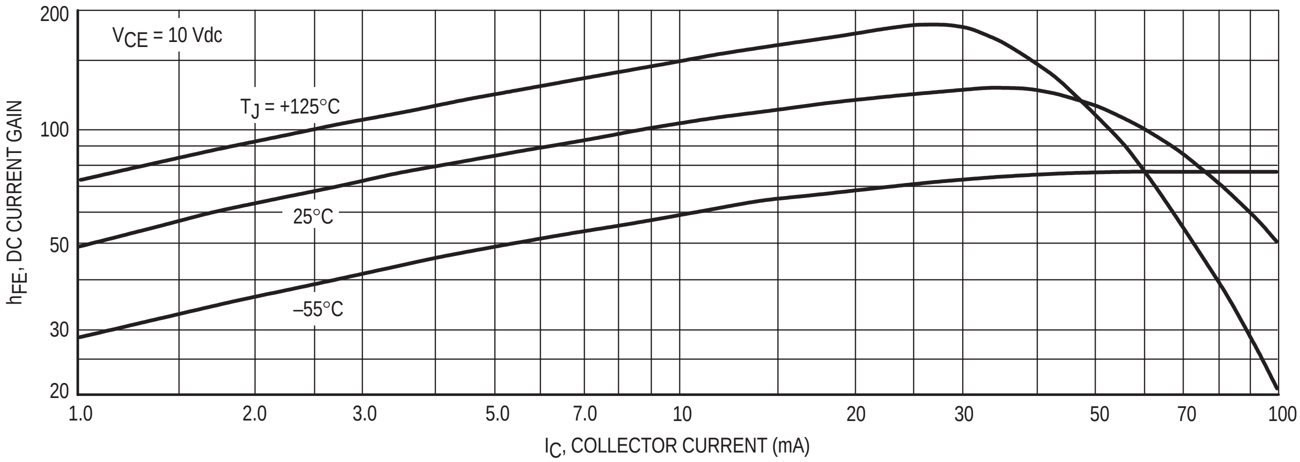


Figure 1. DC Current Gain

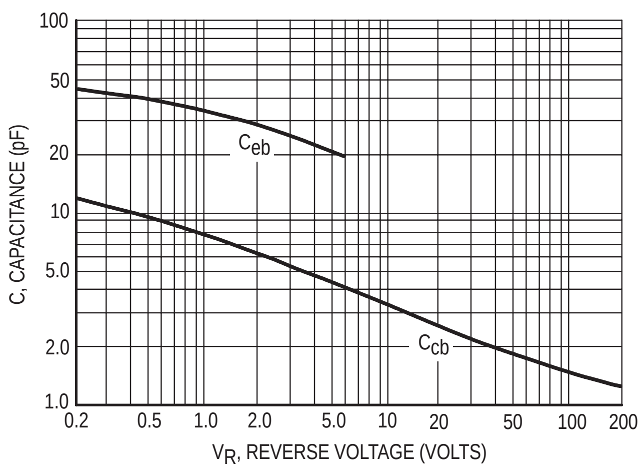


Figure 2. Capacitances

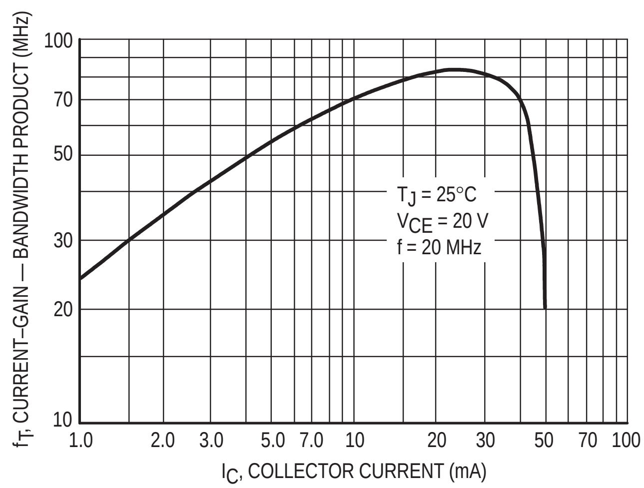


Figure 3. Current–Gain — Bandwidth Product

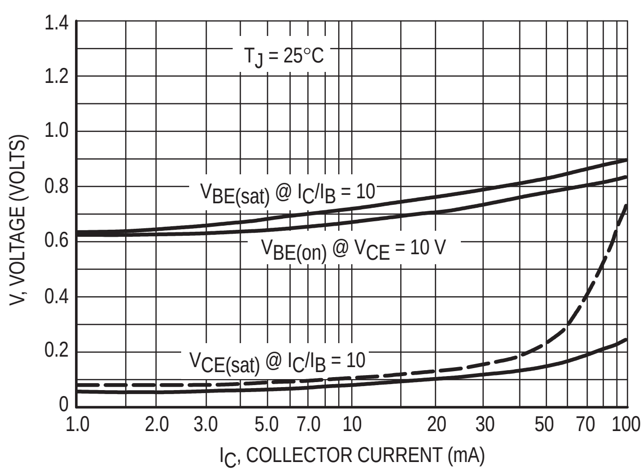


Figure 4. "On" Voltages

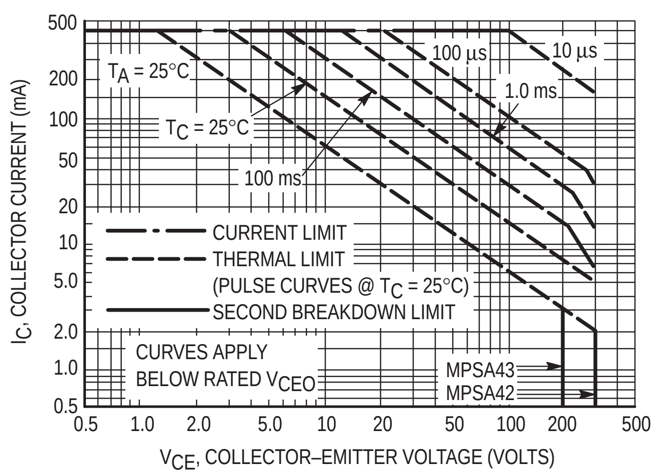
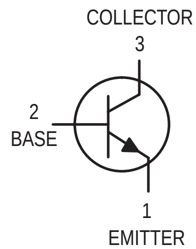


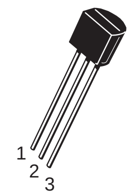
Figure 5. Maximum Forward Bias Safe Operating Area

High Voltage Transistor
NPN Silicon

MPSA44

Motorola Preferred Device





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

1. Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%.

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

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]				
DC Current Gain[1]	h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)		45	—	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)		40	—	
Collector–Emitter Saturation Voltage[1]	$V_{CE(sat)}$			Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)		—	0.4	
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.5	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	0.75	
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%.

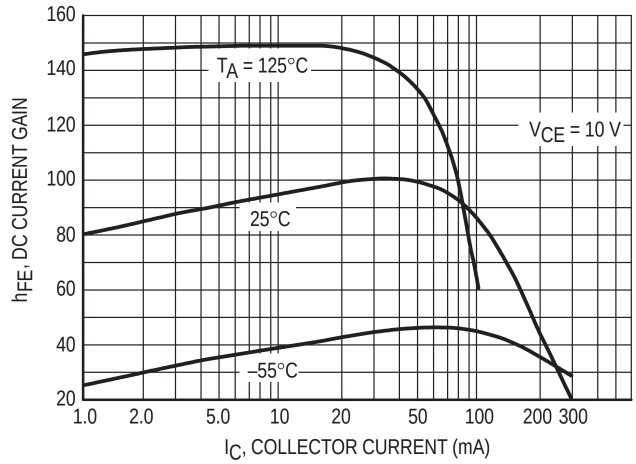


Figure 1. DC Current Gain

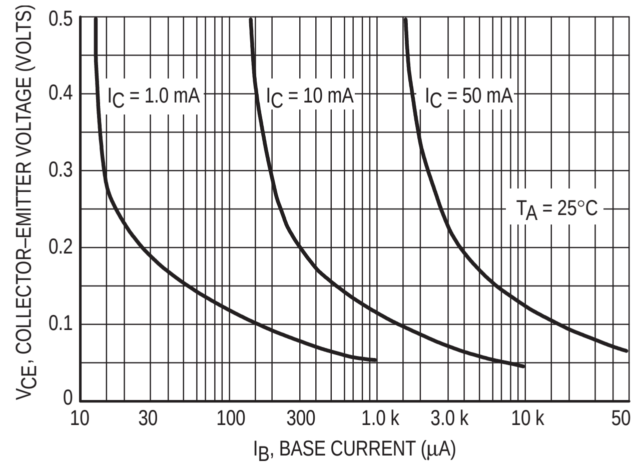


Figure 2. Collector Saturation Region

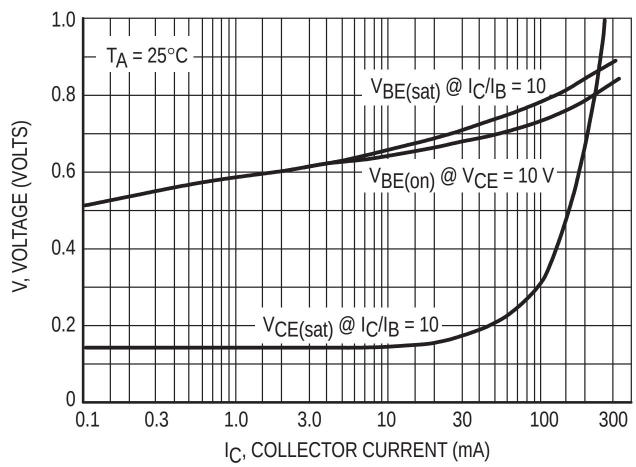


Figure 3. “On” Voltages

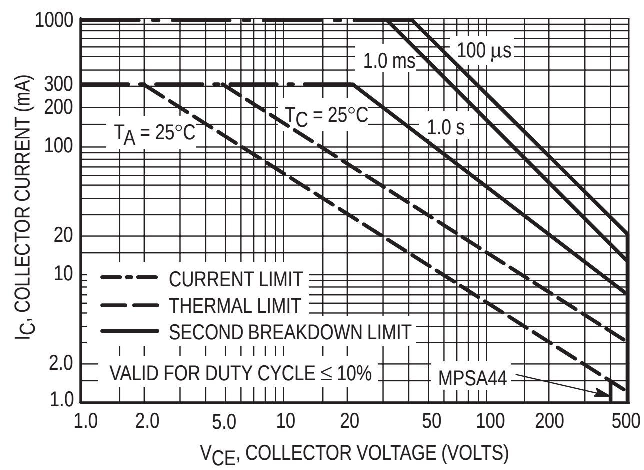


Figure 4. Active Region — Safe Operating Area

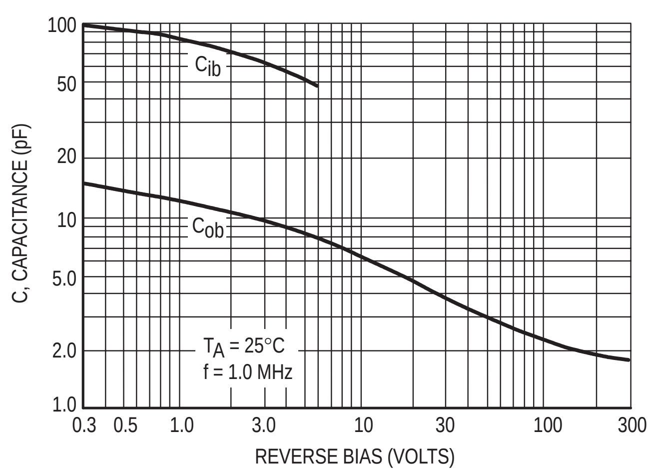


Figure 5. Capacitance

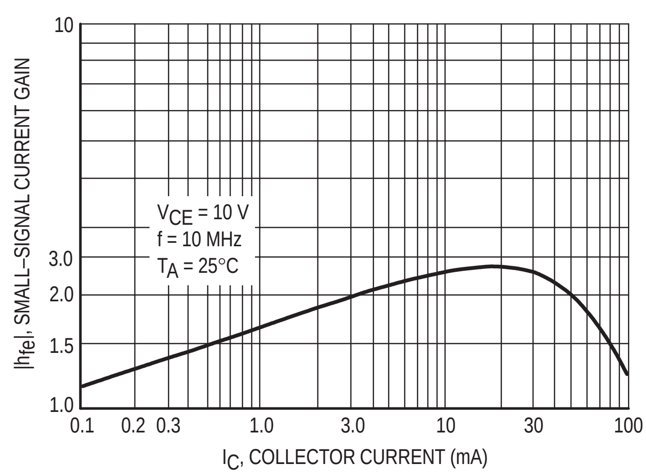


Figure 6. High Frequency Current Gain

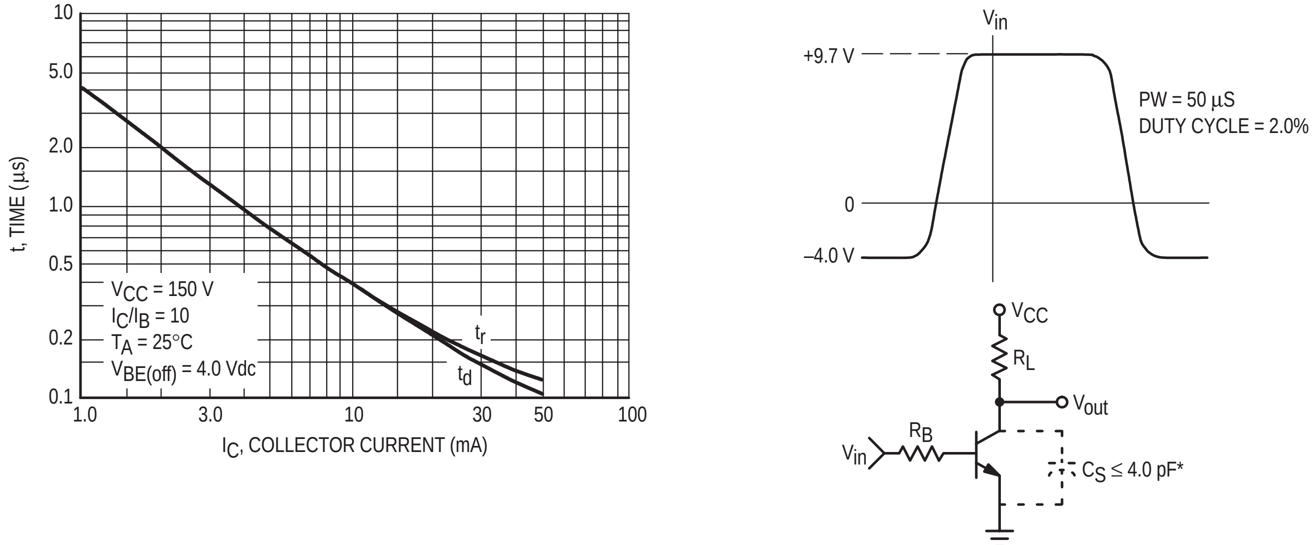


Figure 7. Turn–On Switching Times and Test Circuit

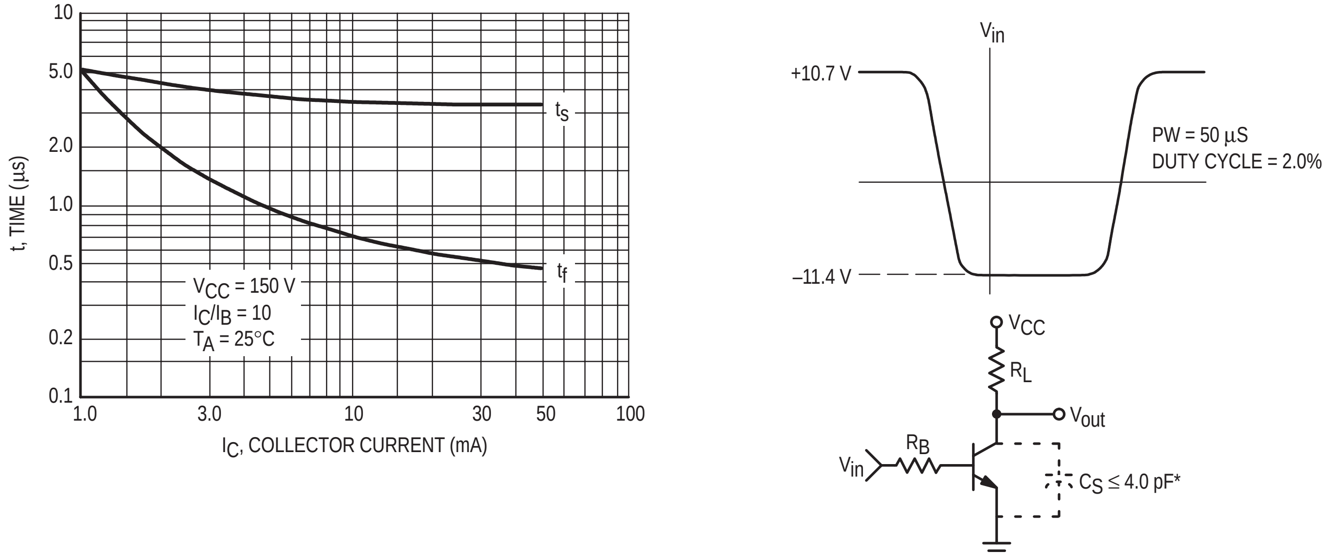


Figure 8. Turn–Off Switching Times and Test Circuit

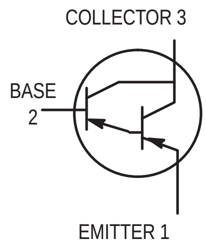
* Total Shunt Capacitance or Test Jig and Connectors.

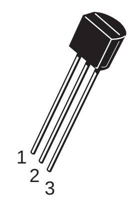
Darlington Transistors
PNP Silicon

MPSA62
MPSA63
MPSA64*

MPSA55, MPSA56
For Specifications,
See MPSA05, MPSA06 Data

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = –10 mAdc, V_{CE} = –5.0 Vdc)	MPSA63		5,000	—	
	MPSA64		10,000	—	
	MPSA62		20,000	—	
(I_C = –100 mAdc, V_{CE} = –5.0 Vdc)	MPSA63		10,000	—	
	MPSA64		20,000	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = –10 mAdc, I_B = –0.01 mAdc)	MPSA62		—	–1.0	
(I_C = –100 mAdc, I_B = –0.1 mAdc)	MPSA63, MPSA64		—	–1.5	
Base–Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = –10 mAdc, V_{CE} = –5.0 Vdc)	MPSA62		—	–1.4	
(I_C = –100 mAdc, V_{CE} = –5.0 Vdc)	MPSA63, MPSA64		—	–2.0	
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product(2)		f_T	125	—	MHz
(I_C = –100 mAdc, V_{CE} = –5.0 Vdc, f = 100 MHz)	MPSA63, MPSA64				

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

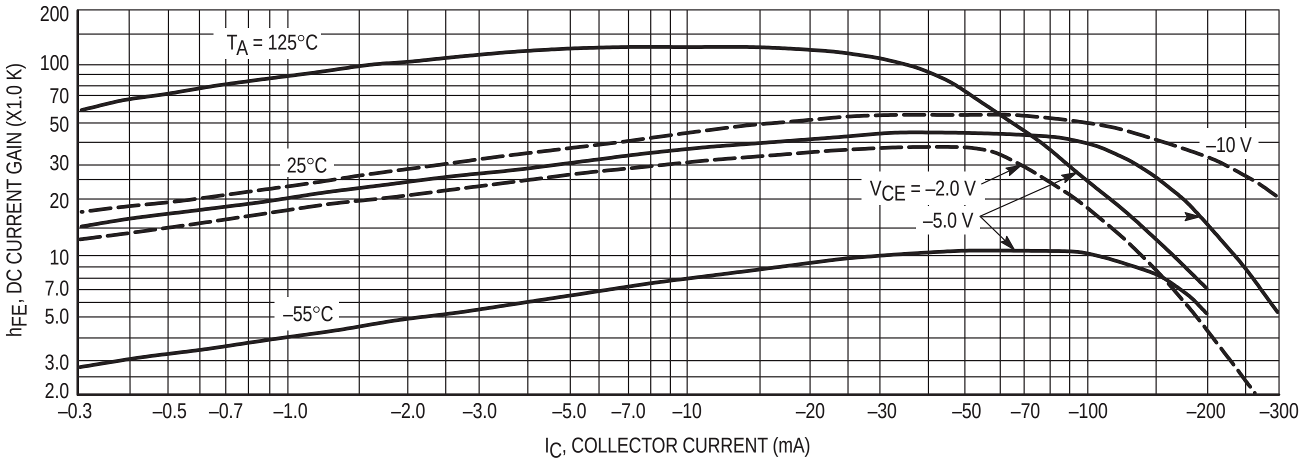


Figure 1. DC Current Gain

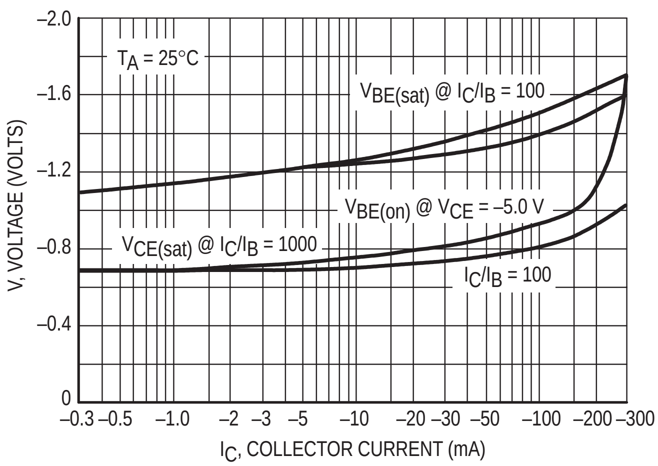


Figure 2. “On” Voltage

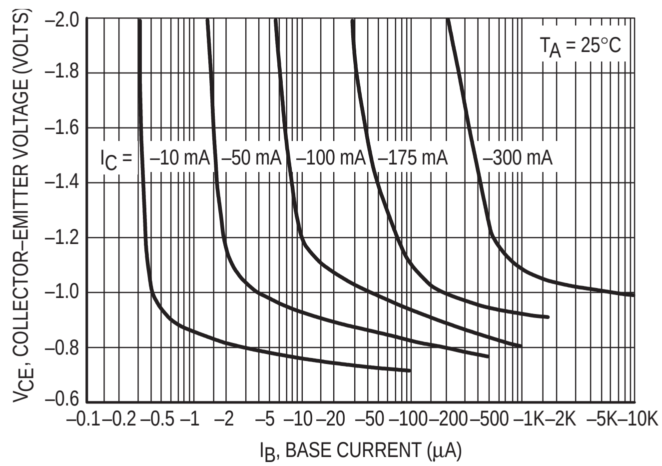


Figure 3. Collector Saturation Region

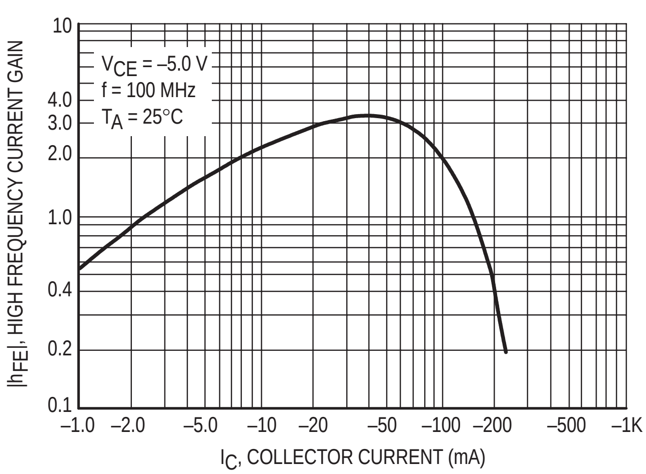


Figure 4. High Frequency Current Gain

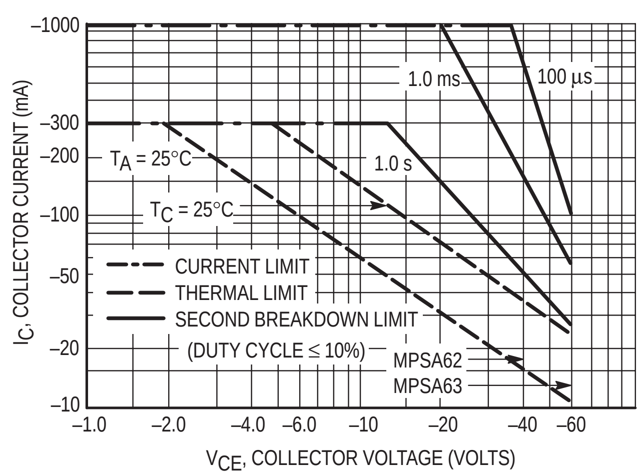
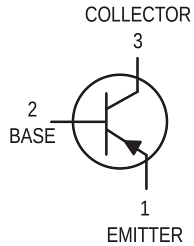
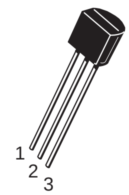


Figure 5. Active Region, Safe Operating Area

Amplifier Transistor
PNP Silicon

MPSA70





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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(1) (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

1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%.

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

Characteristic	Symbol	Min	Max	Unit
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

TYPICAL NOISE CHARACTERISTICS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

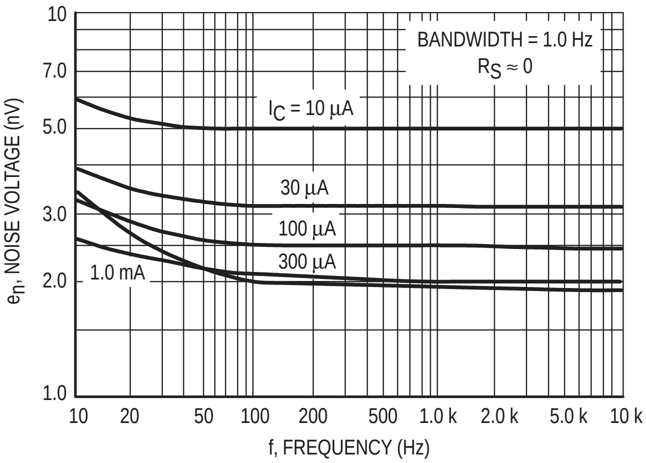


Figure 1. Noise Voltage

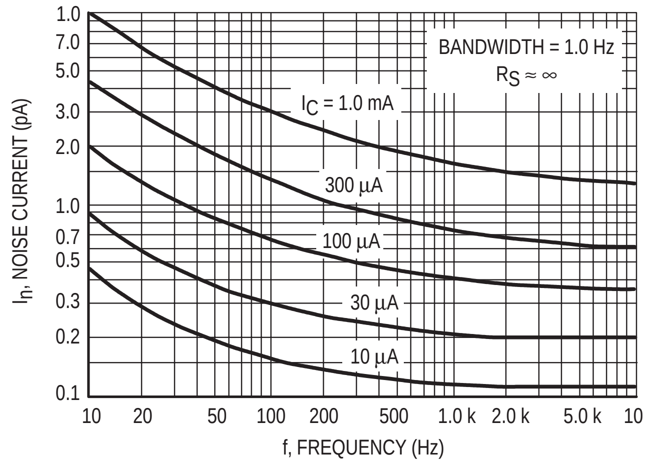


Figure 2. Noise Current

NOISE FIGURE CONTOURS

(V_{CE} = –5.0 Vdc, T_A = 25°C)

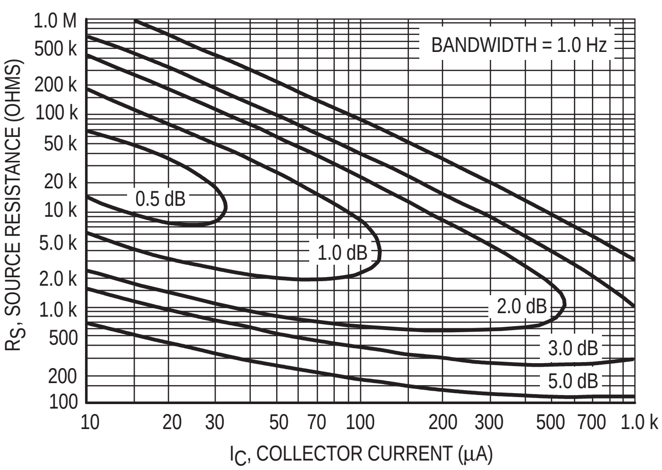


Figure 3. Narrow Band, 100 Hz

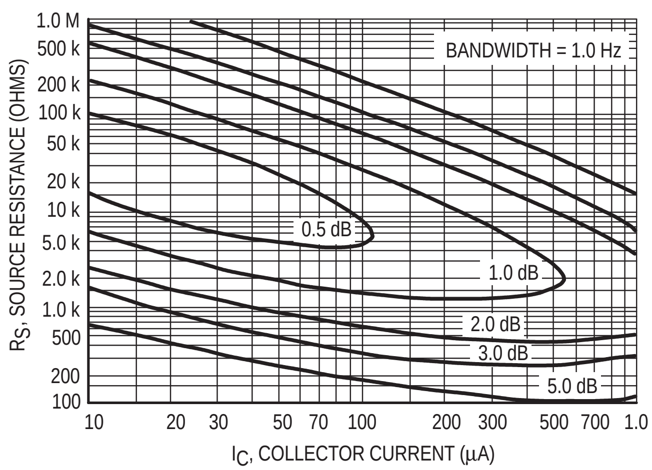


Figure 4. Narrow Band, 1.0 kHz

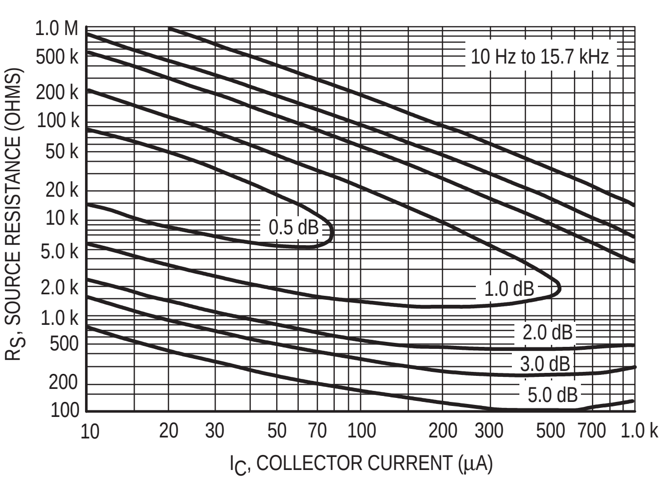


Figure 5. Wideband

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 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

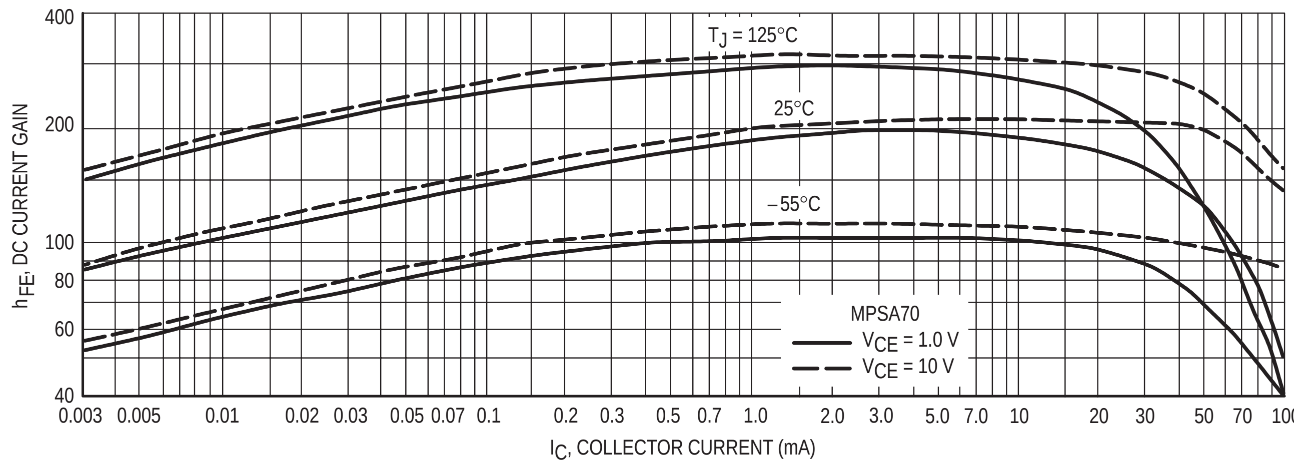


Figure 6. DC Current Gain

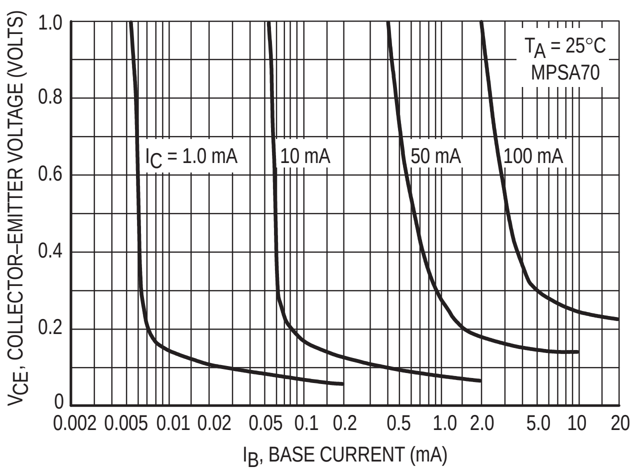


Figure 7. Collector Saturation Region

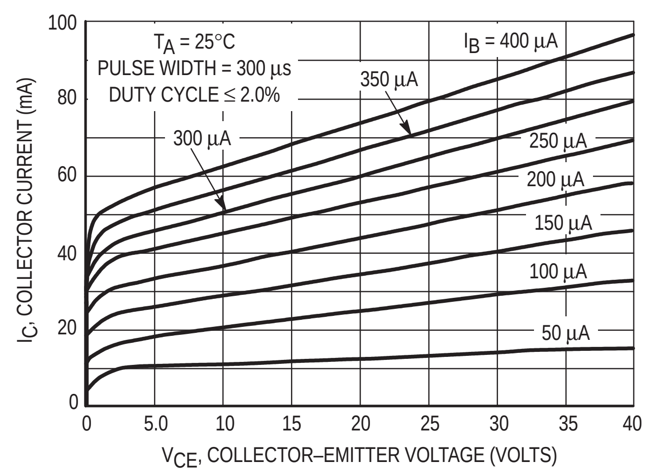


Figure 8. Collector Characteristics

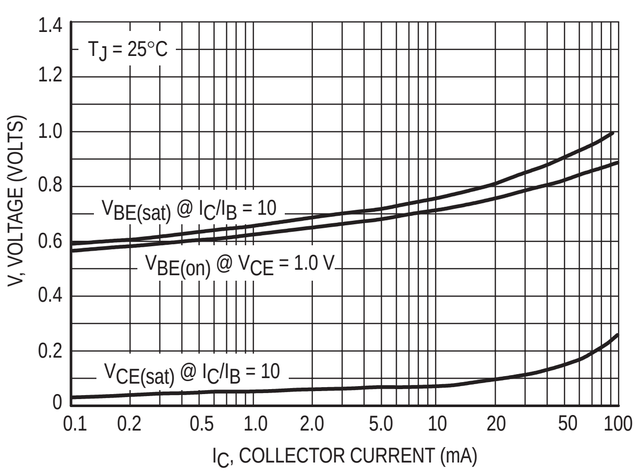


Figure 9. "On" Voltages

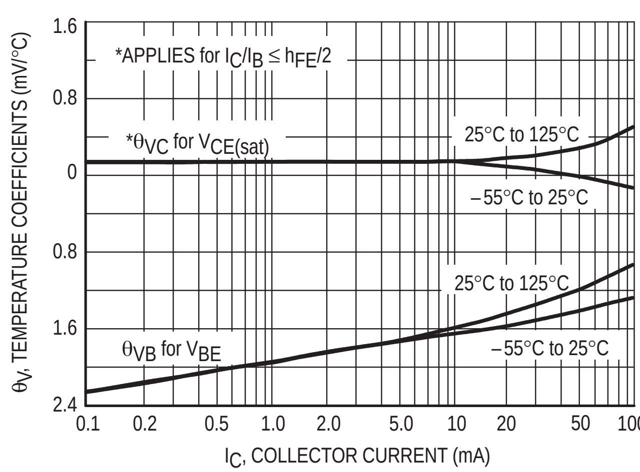


Figure 10. Temperature Coefficients

TYPICAL DYNAMIC CHARACTERISTICS

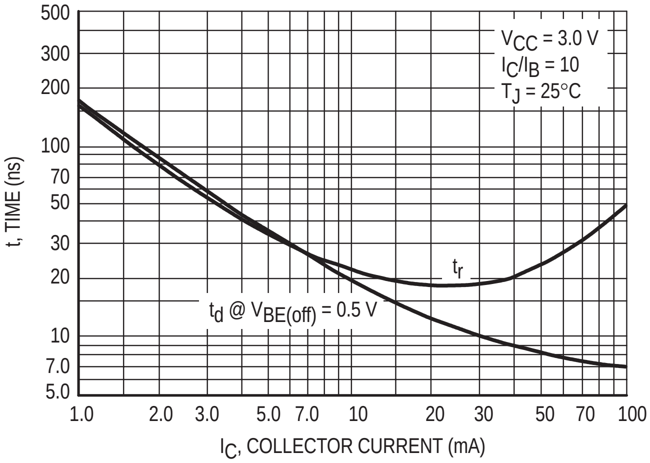


Figure 11. Turn–On Time

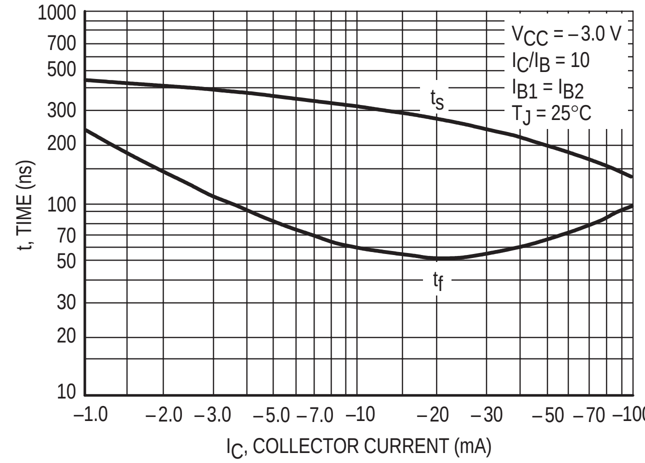


Figure 12. Turn–Off Time

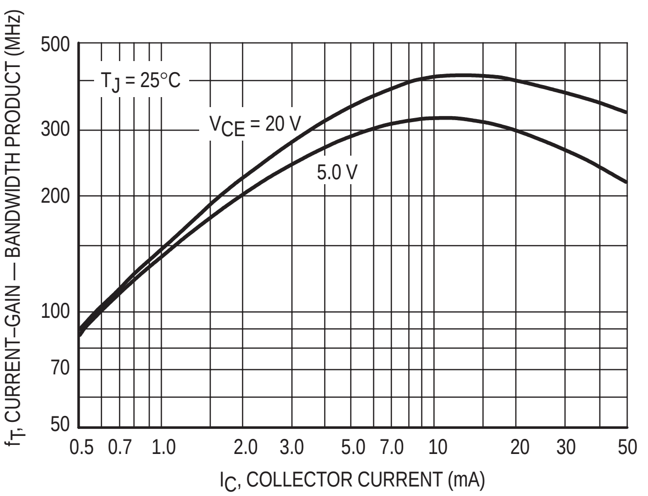


Figure 13. Current–Gain — Bandwidth Product

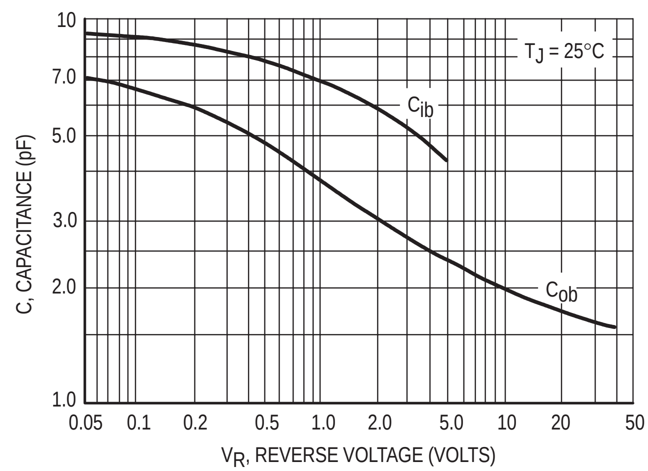


Figure 14. Capacitance

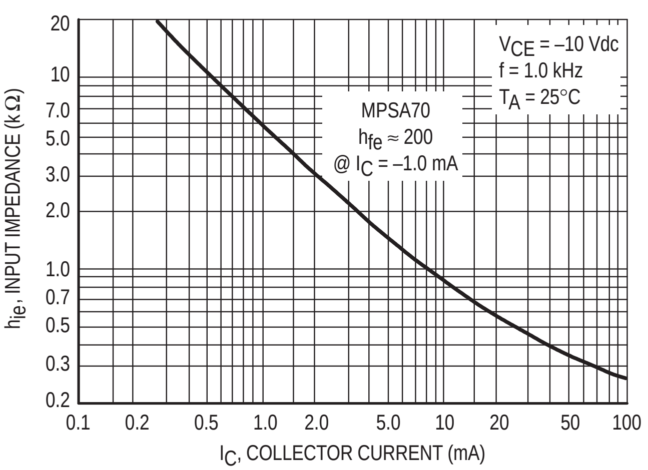


Figure 15. Input Impedance

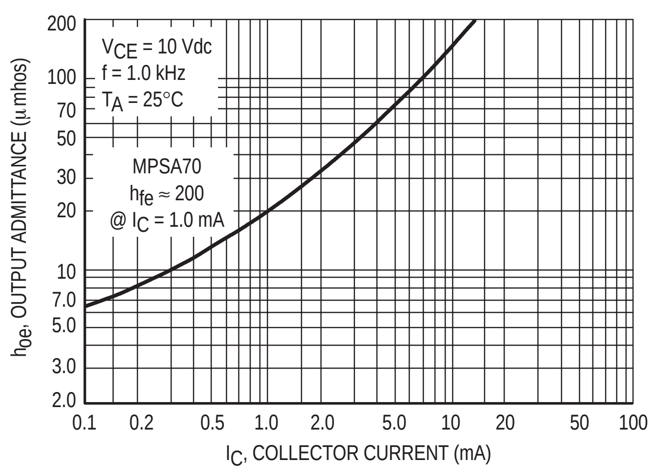


Figure 16. Output Admittance

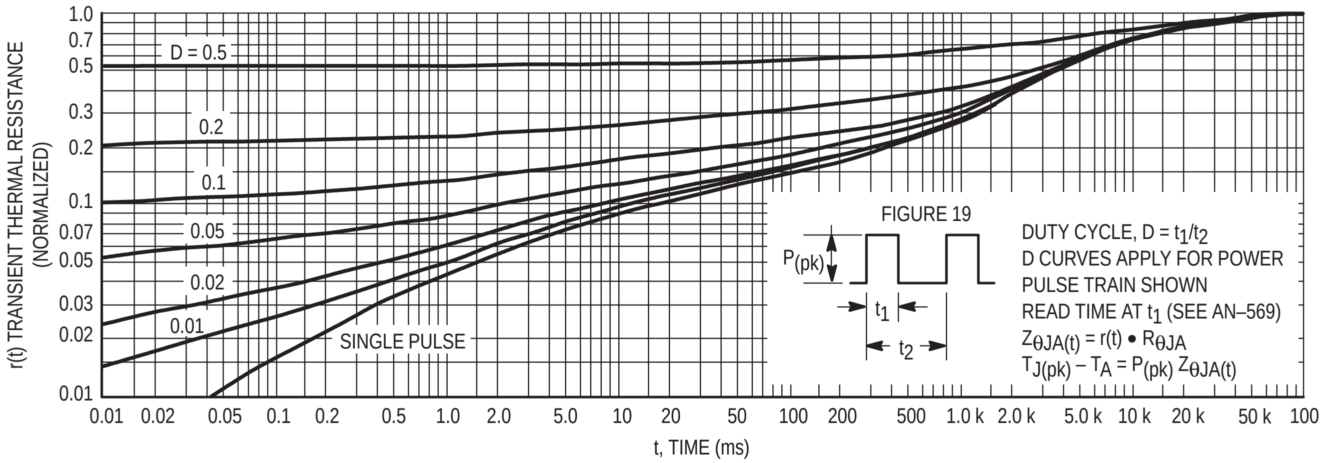


Figure 17. Thermal Response

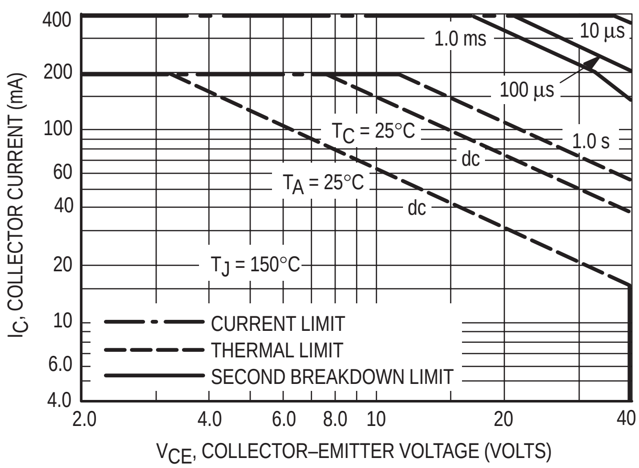


Figure 18. Active–Region Safe Operating Area

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 18 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 17. 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.

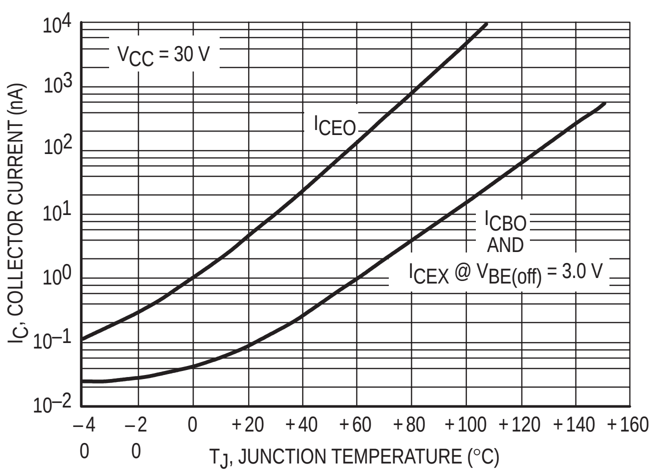


Figure 19. Typical Collector Leakage Current

DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 17 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 17 by the steady state value $R_{\theta JA}$.

Example:
Dissipating 2.0 watts peak under the following conditions:

t_1 = 1.0 ms, t_2 = 5.0 ms (D = 0.2)

Using Figure 17 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

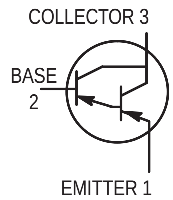
The peak rise in junction temperature is therefore

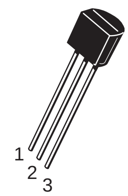
$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA}$ = 0.22 x 2.0 x 200 = 88°C.

For more information, see AN–569.

Darlington Transistors
PNP Silicon

MPSA75
MPSA77





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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	—	—

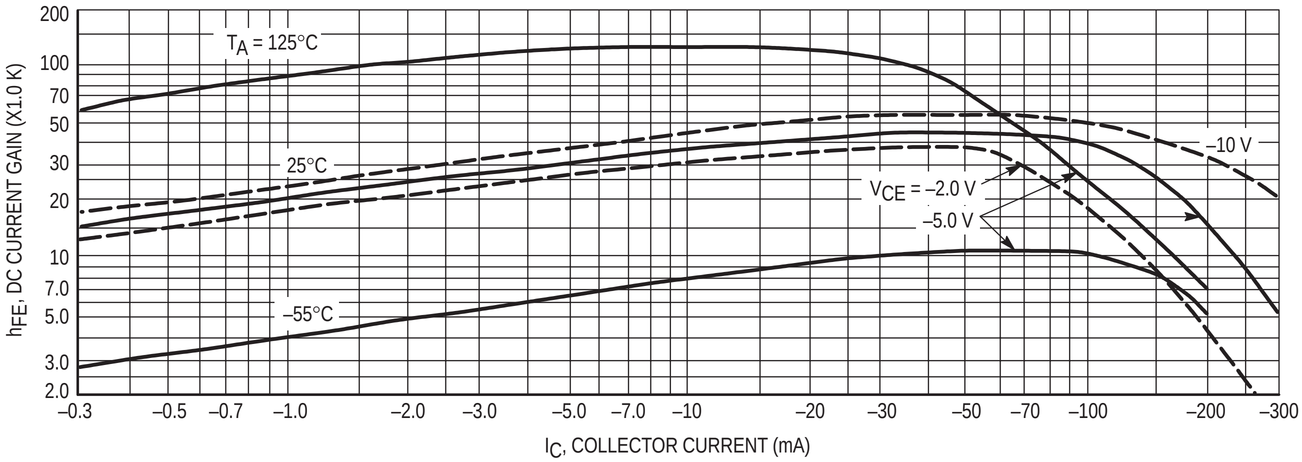


Figure 1. DC Current Gain

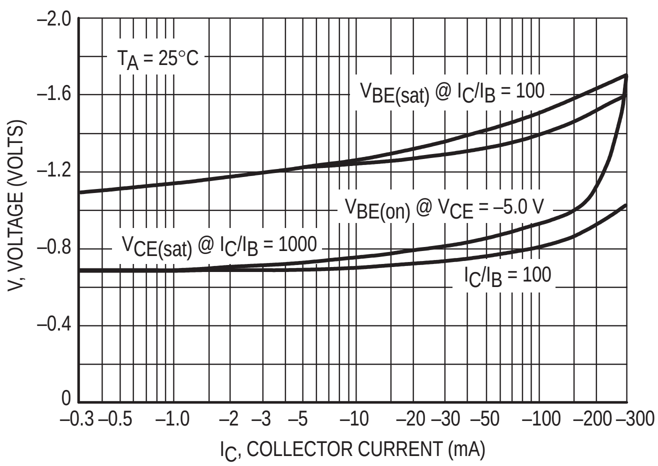


Figure 2. "On" Voltage

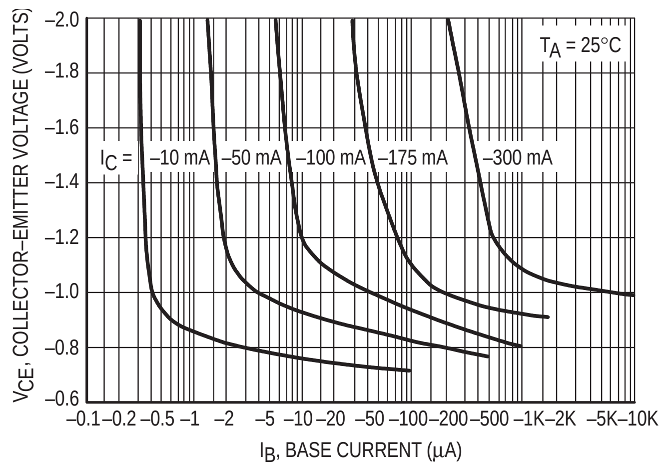


Figure 3. Collector Saturation Region

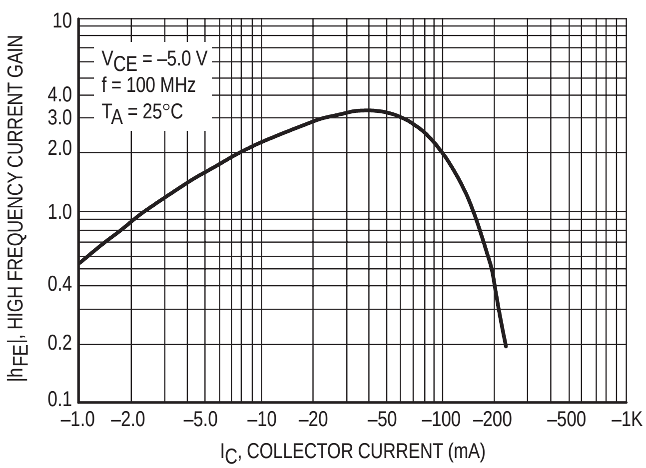


Figure 4. High Frequency Current Gain

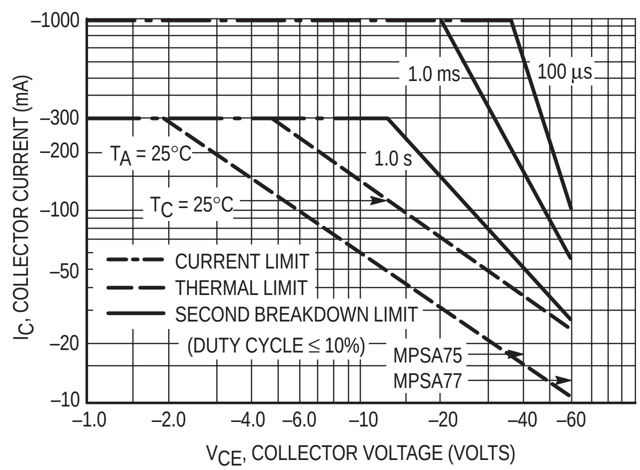
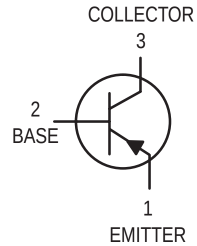


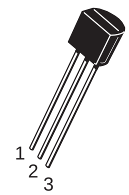
Figure 5. Active Region, Safe Operating Area

High Voltage Transistors
PNP Silicon

MPSA92*
MPSA93

***Motorola Preferred Device**





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain		h_{FE}			—
(I_C = –1.0 mAdc, V_{CE} = –10 Vdc)	Both Types		25	—	
(I_C = –10 mAdc, V_{CE} = –10 Vdc)	Both Types		40	—	
(I_C = –30 mAdc, V_{CE} = –10 Vdc)	MPSA92		25	—	
	MPSA93		25	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = –20 mAdc, I_B = –2.0 mAdc)	MPSA92		—	–0.5	
	MPSA93		—	–0.4	
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		C_{cb}			pF
(V_{CB} = –20 Vdc, I_E = 0, f = 1.0 MHz)	MPSA92		—	6.0	
	MPSA93		—	8.0	

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

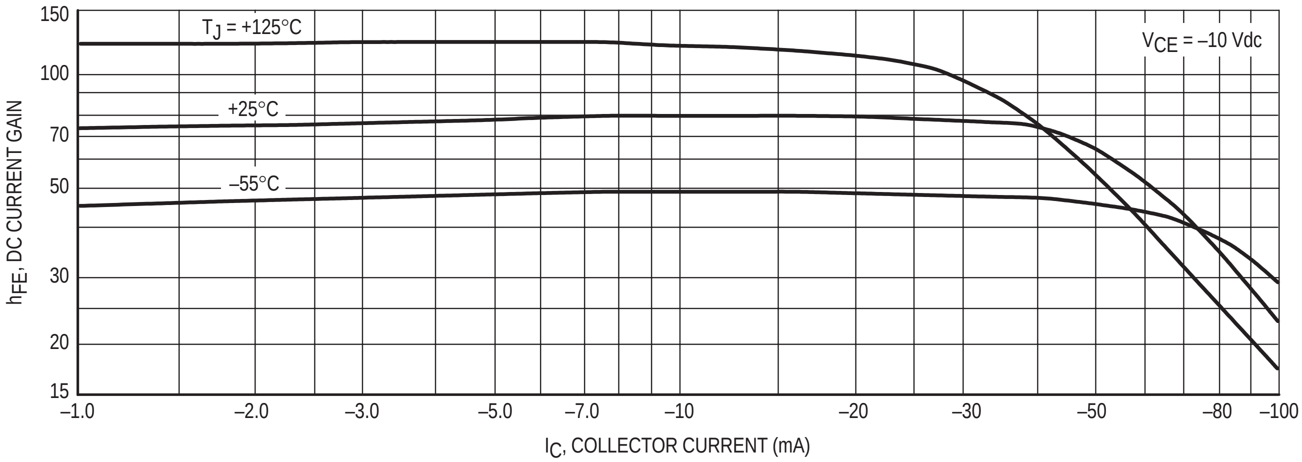


Figure 1. DC Current Gain

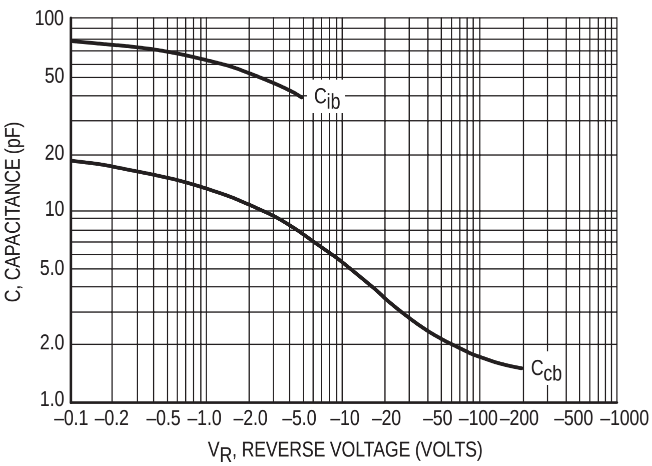


Figure 2. Capacitances

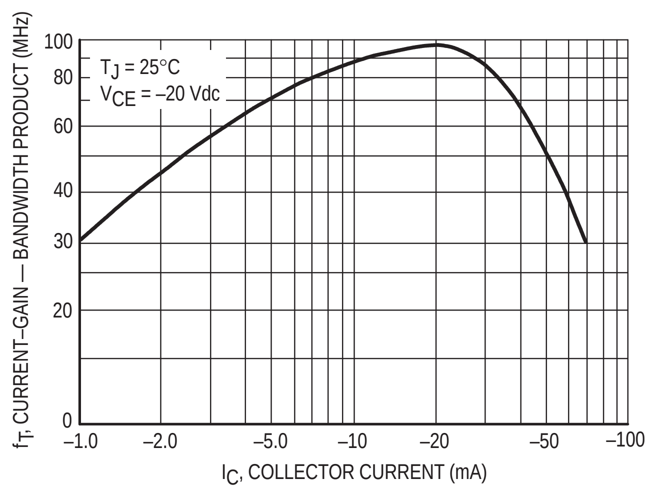


Figure 3. Current–Gain — Bandwidth Product

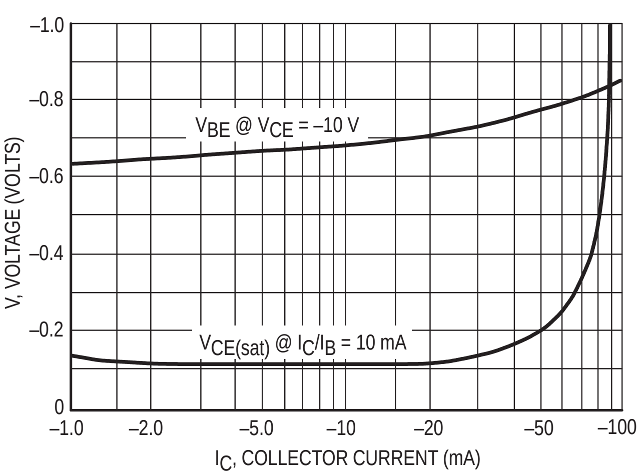


Figure 4. “On” Voltages

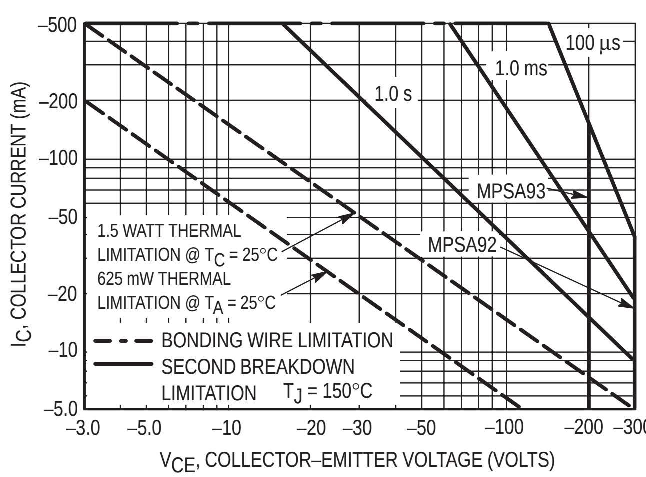


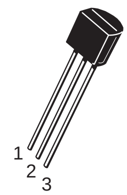
Figure 5. Active Region — Safe Operating Area

VHF/UHF Transistors

NPN Silicon

MPSH10
MPSH11

Motorola Preferred Devices



CASE 29–04, STYLE 2
TO–92 (TO–226AA)

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	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_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

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

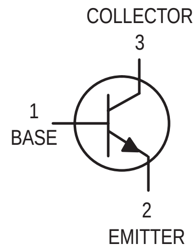
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

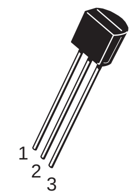
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	60	—	—
Collector–Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base–Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	—	0.95	Vdc
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)	MPSH10	C_{rb}	0.35	0.65	pF
	MPSH11		0.6	0.9	
Collector Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)		$rb'C_c$	—	9.0	ps

CATV Transistor
NPN Silicon

MPSH17

Motorola Preferred Device





CASE 29–04, STYLE 2
TO–92 (TO–226AA)

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

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

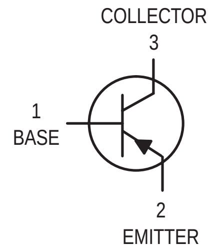
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

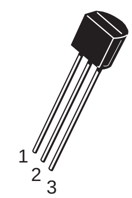
Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	250	—
Collector–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	—
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 5.0 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

RF Amplifier Transistor
PNP Silicon

MPSH81

Motorola Preferred Device





CASE 29–04, STYLE 2
TO–92 (TO–226AA)

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

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
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)

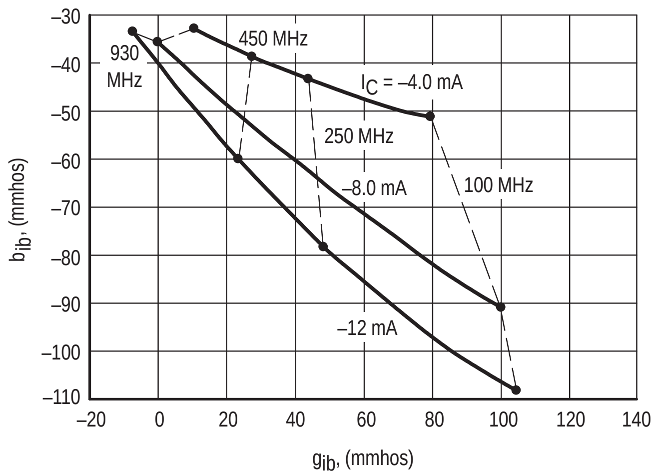


Figure 1. Input Admittance

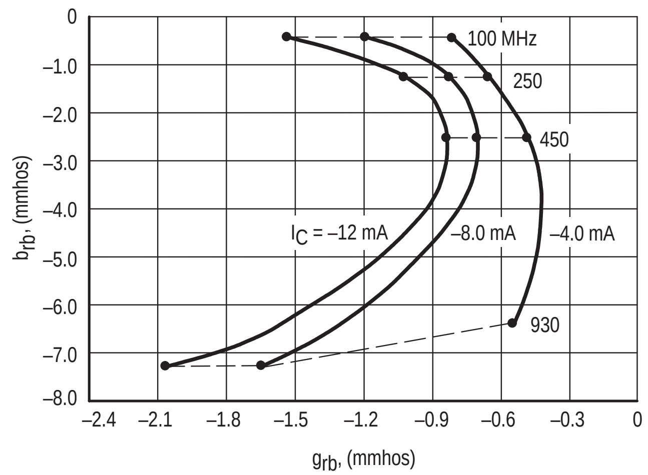


Figure 2. Reverse Transfer Admittance

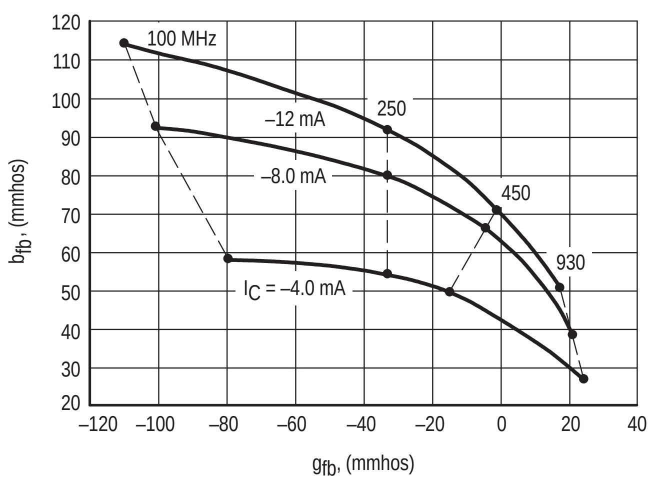


Figure 3. Forward Transfer Admittance

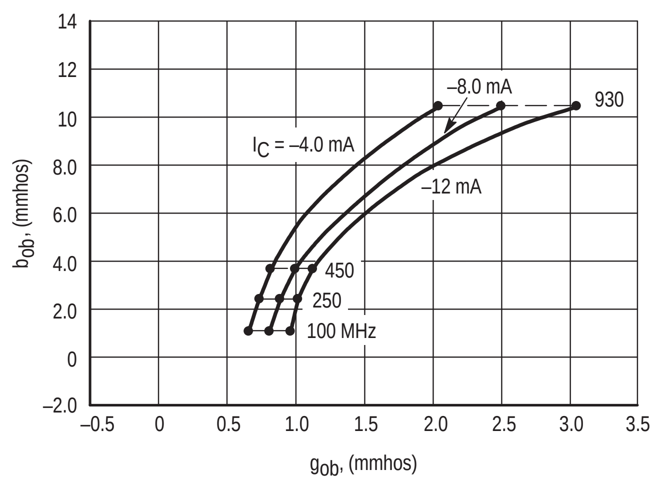


Figure 4. Output Admittance

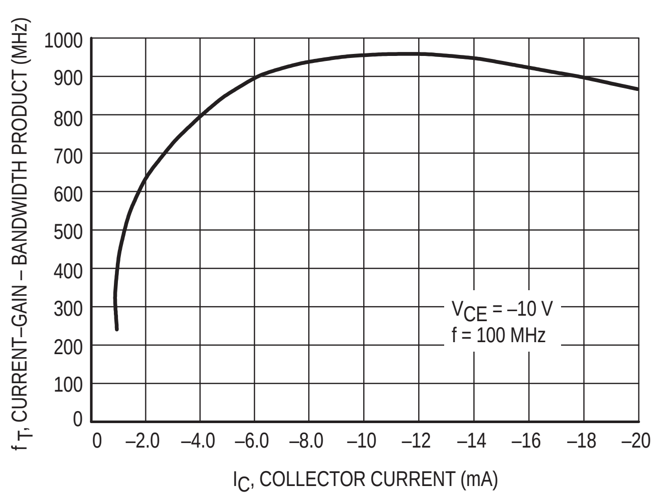
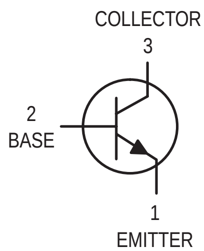


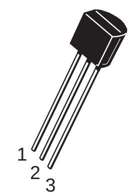
Figure 5. Current–Gain — Bandwidth Product

Amplifier Transistor

NPN Silicon

MPSL01





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

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

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

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

Characteristic	Symbol	Min	Max	Unit
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%.

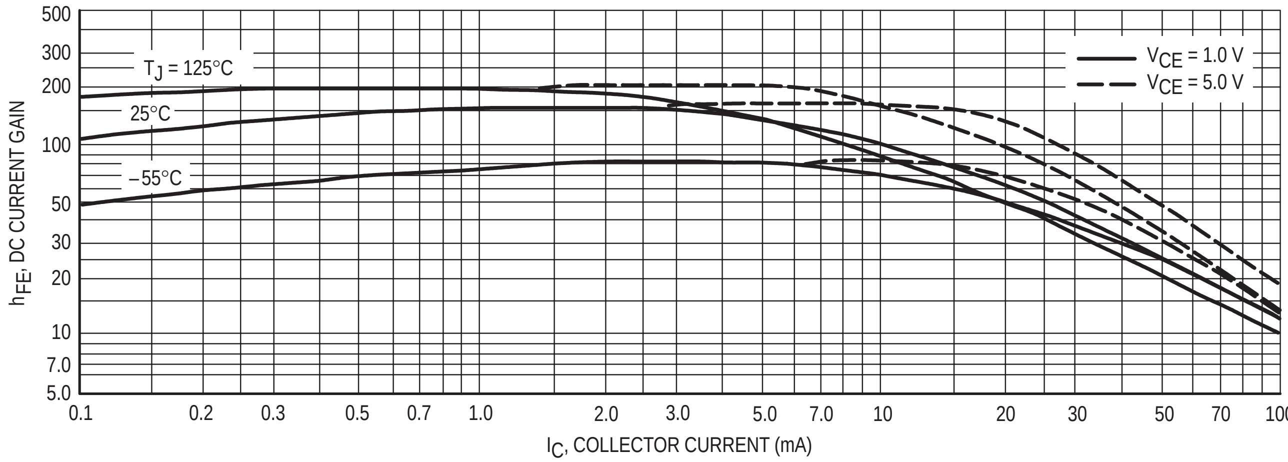


Figure 1. DC Current Gain

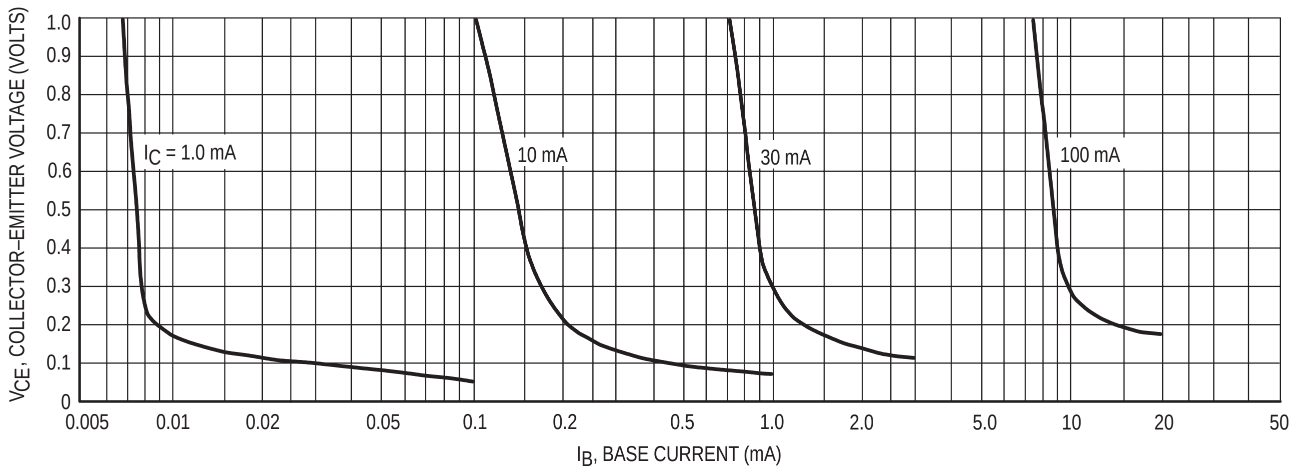


Figure 2. Collector Saturation Region

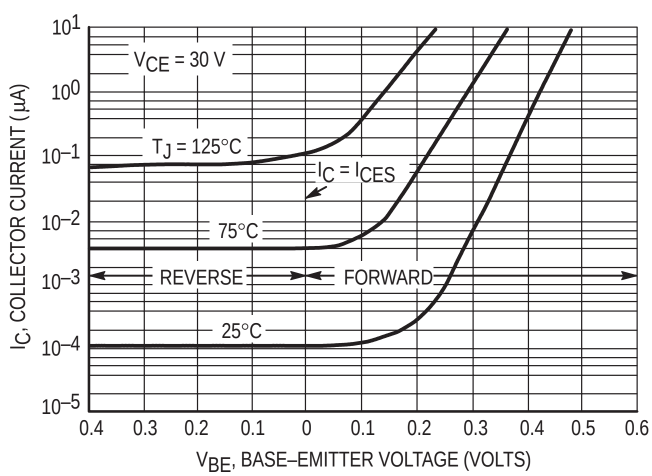


Figure 3. Collector Cut–Off Region

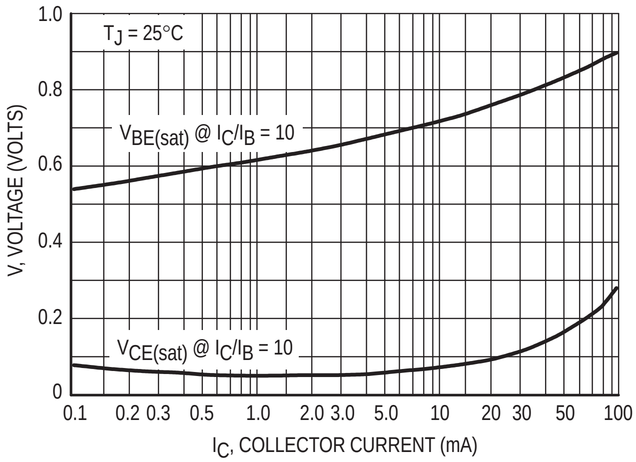


Figure 4. "On" Voltages

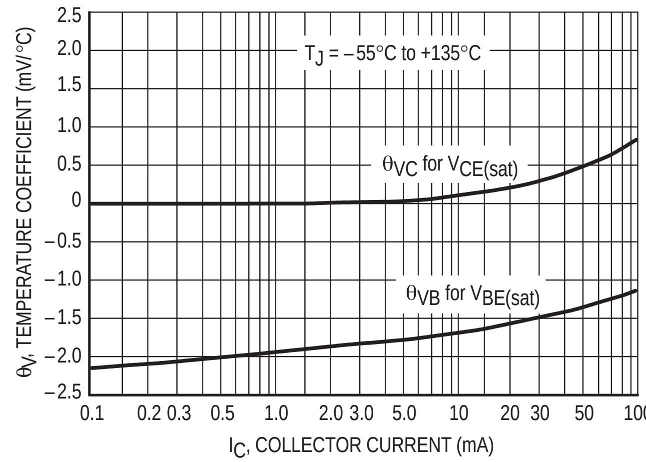
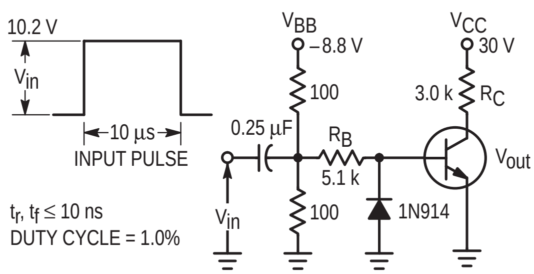


Figure 5. Temperature Coefficients



Values Shown are for I_C @ 10 mA

Figure 6. Switching Time Test Circuit

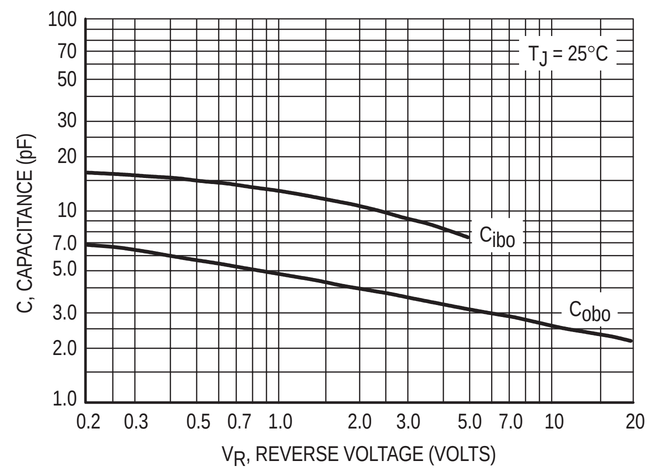


Figure 7. Capacitances

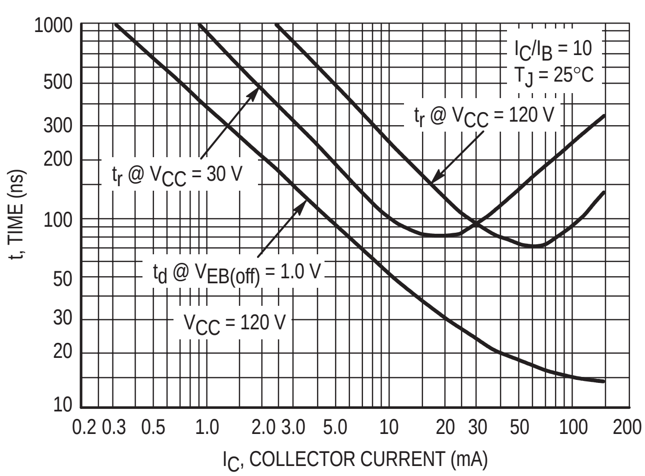


Figure 8. Turn–On Time

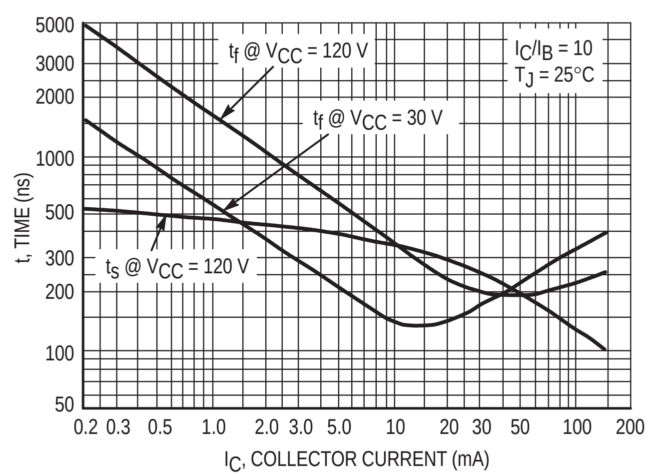
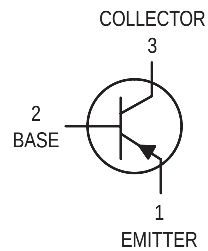
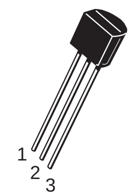


Figure 9. Turn–Off Time

Amplifier Transistor
PNP Silicon

MPSL51





CASE 29–04, STYLE 1
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	–100	Vdc
Collector–Base Voltage	V_{CBO}	–100	Vdc
Emitter–Base Voltage	V_{EBO}	–4.0	Vdc
Collector Current — Continuous	I_C	–600	mAdc
Total Device Dissipation @ T_A = 25°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)	$V_{(BR)CEO}$	–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

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

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

Characteristic	Symbol	Min	Max	Unit
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 Width = 300 μs, Duty Cycle = 2.0%.

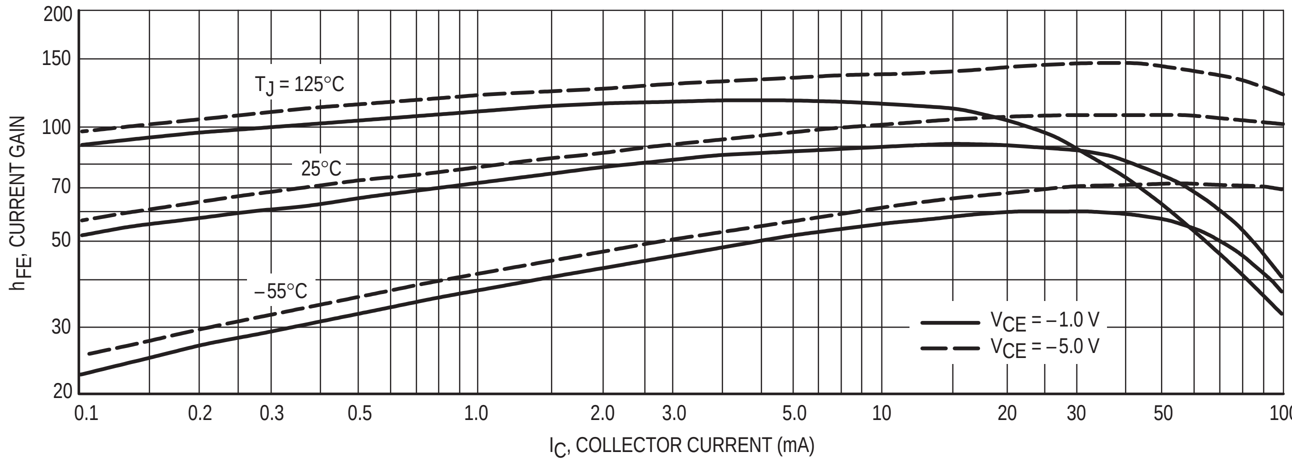


Figure 1. DC Current Gain

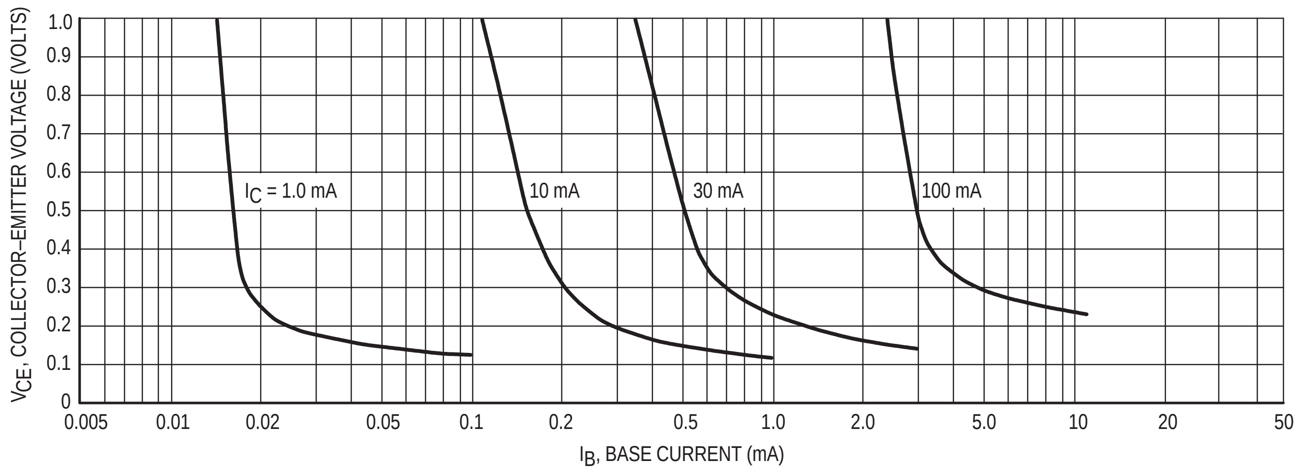


Figure 2. Collector Saturation Region

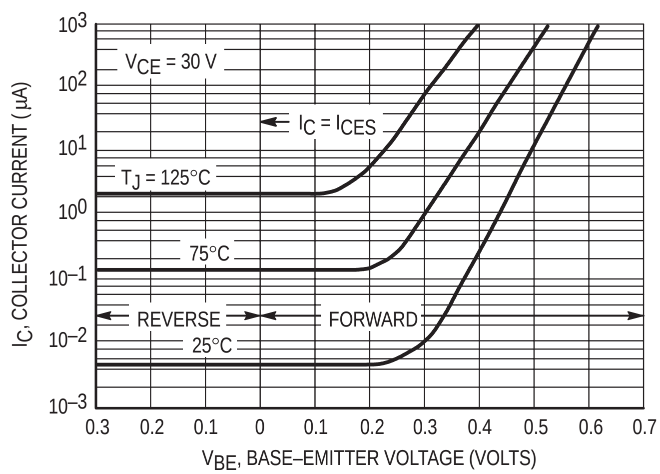


Figure 3. Collector Cut–Off Region

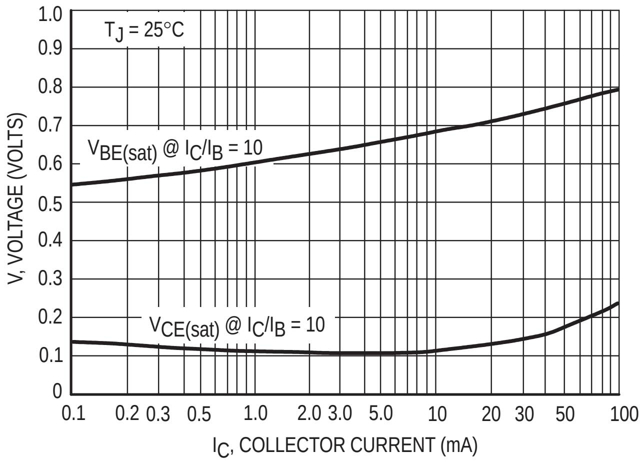


Figure 4. "On" Voltages

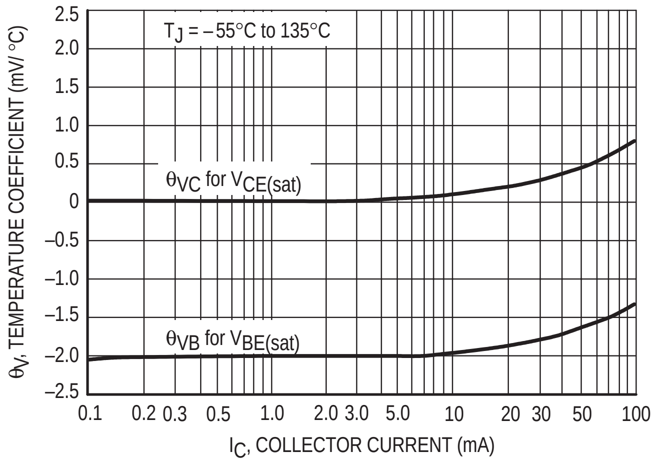
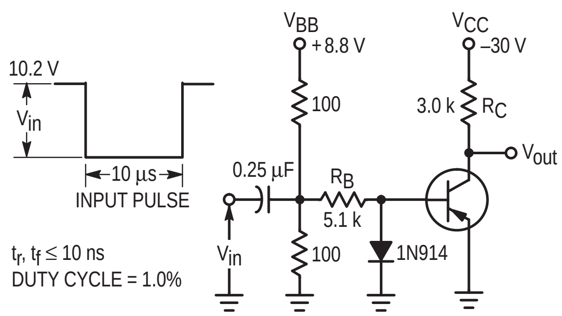


Figure 5. Temperature Coefficients



Values Shown are for I_C @ 10 mA

Figure 6. Switching Time Test Circuit

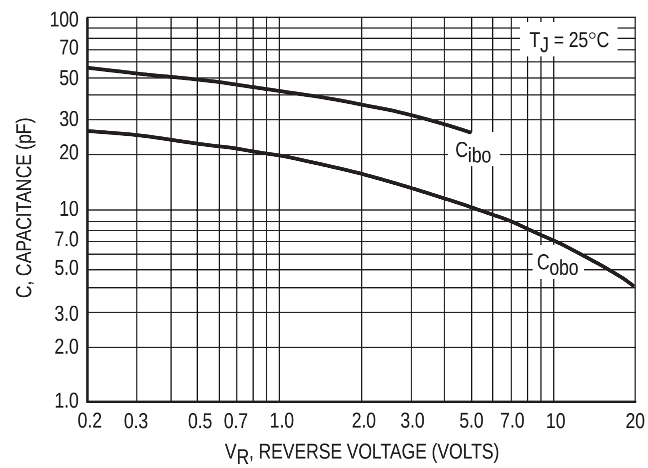


Figure 7. Capacitances

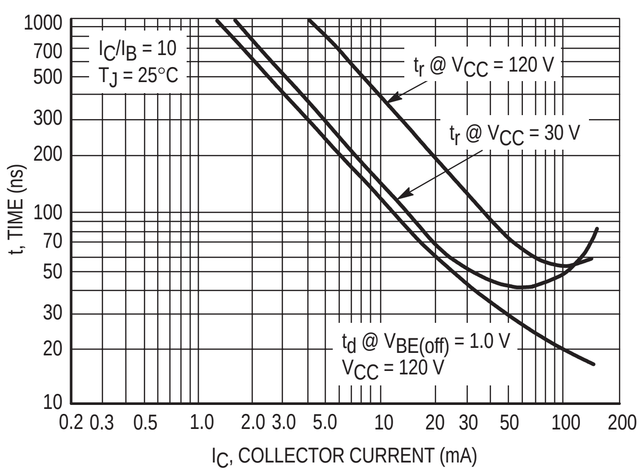


Figure 8. Turn–On Time

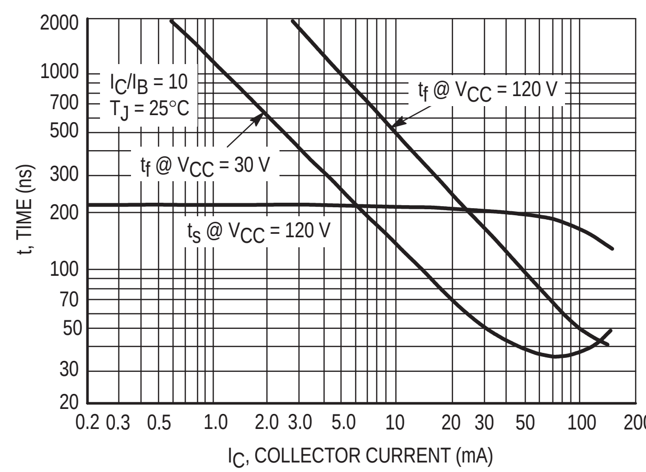
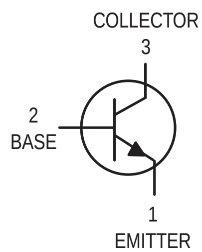


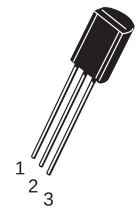
Figure 9. Turn–Off Time

One Watt High Current Transistors
NPN Silicon

MPSW01
MPSW01A*

*Motorola Preferred Device





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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	Watts 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 = 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

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

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

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

Characteristic	Symbol	Min	Max	Unit
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%.

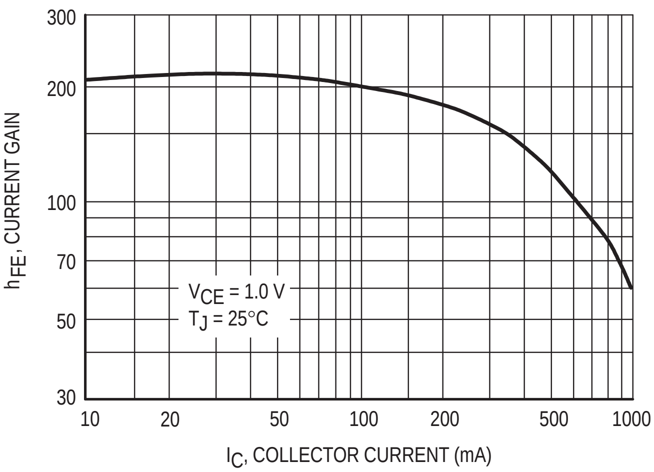


Figure 1. DC Current Gain

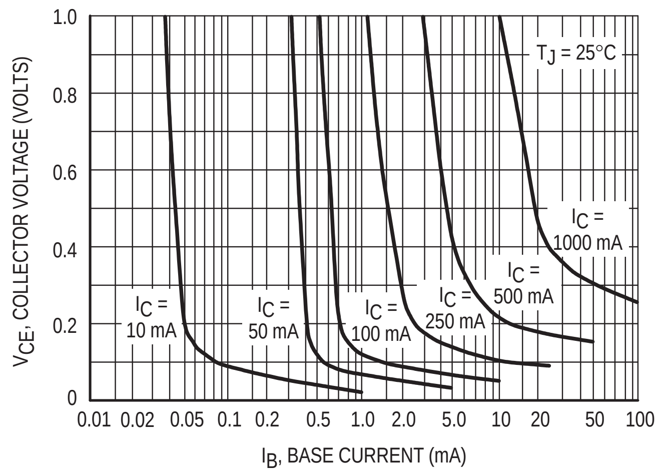


Figure 2. Collector Saturation Region

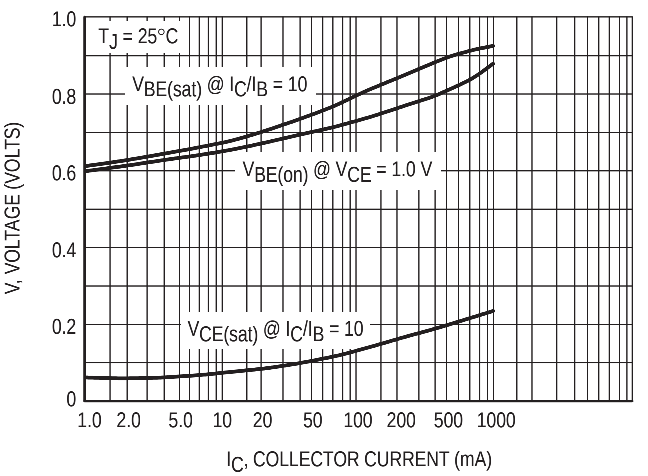


Figure 3. "ON" Voltages

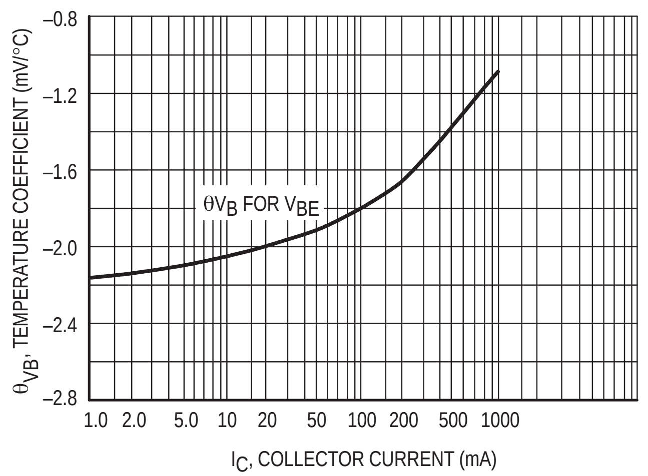


Figure 4. Temperature Coefficient

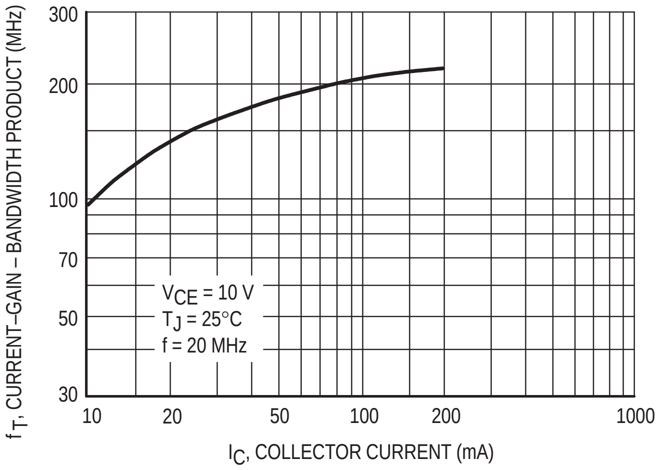


Figure 5. Current Gain — Bandwidth Product

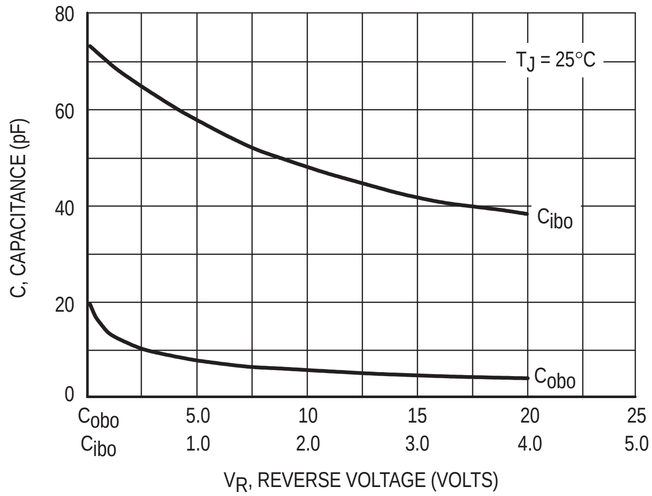


Figure 6. Capacitance

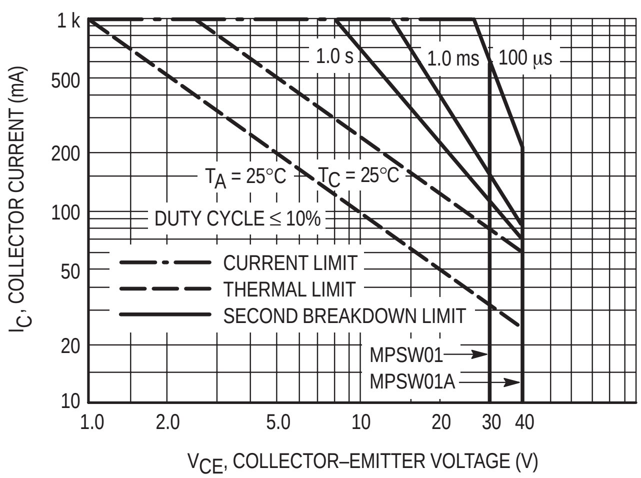


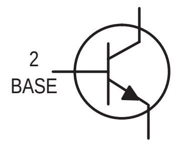
Figure 7. Active Region — Safe Operating Area

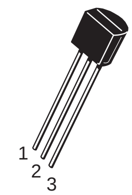
One Watt Amplifier Transistors

NPN Silicon

MPSW05
MPSW06*

*Motorola Preferred Device





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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 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)	 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

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

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

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

Characteristic	Symbol	Min	Max	Unit
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)	$V_{CE(sat)}$	—	0.4	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%.

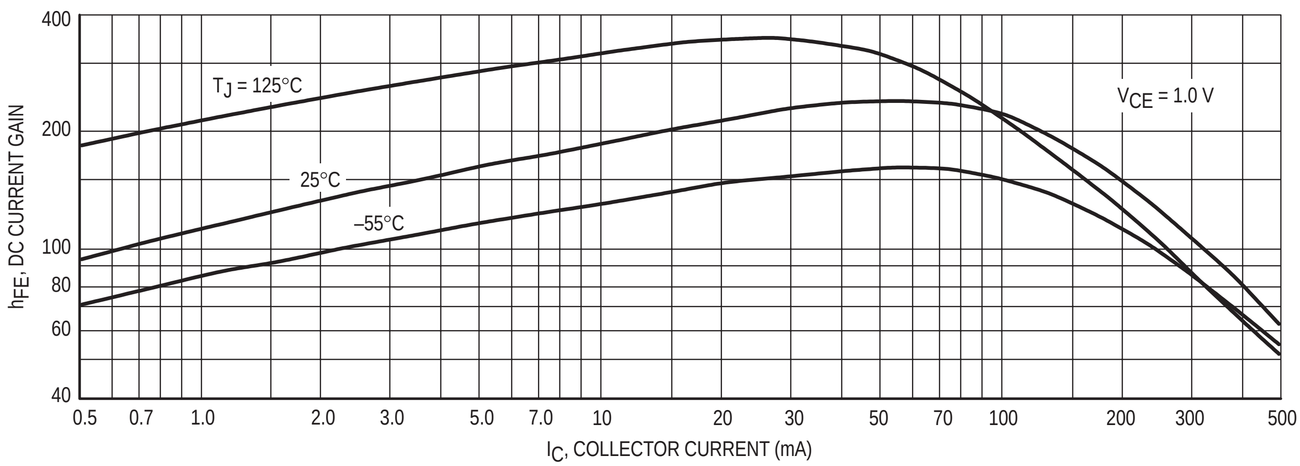


Figure 1. DC Current Gain

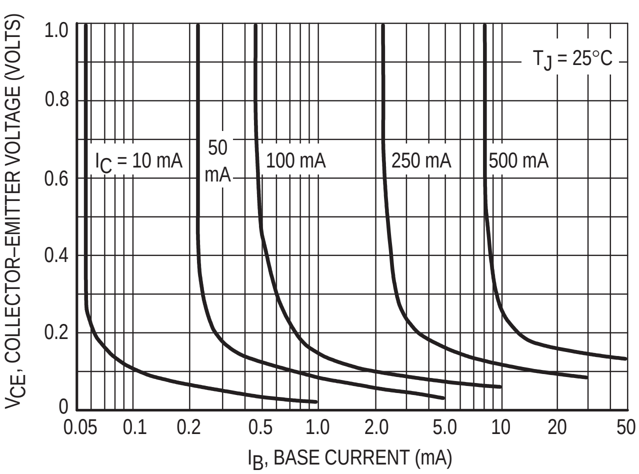


Figure 2. Collector Saturation Region

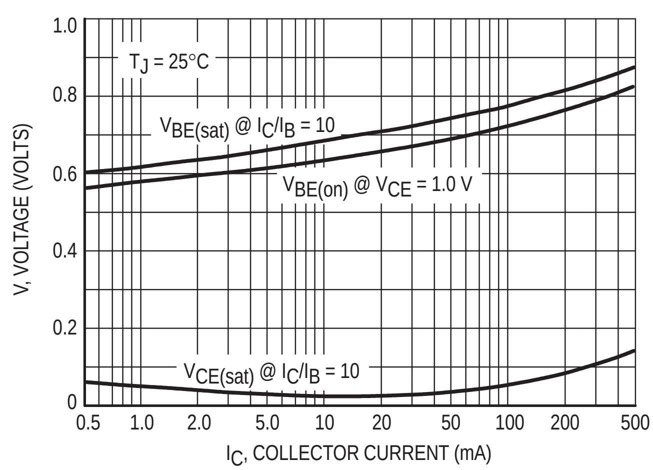


Figure 3. "On" Voltages

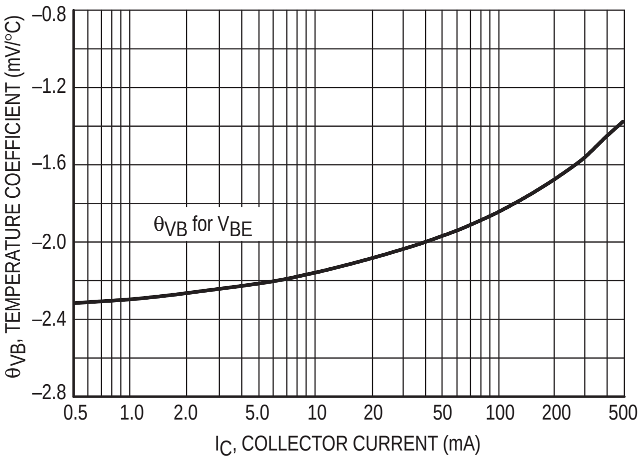


Figure 4. Base–Emitter Temperature Coefficient

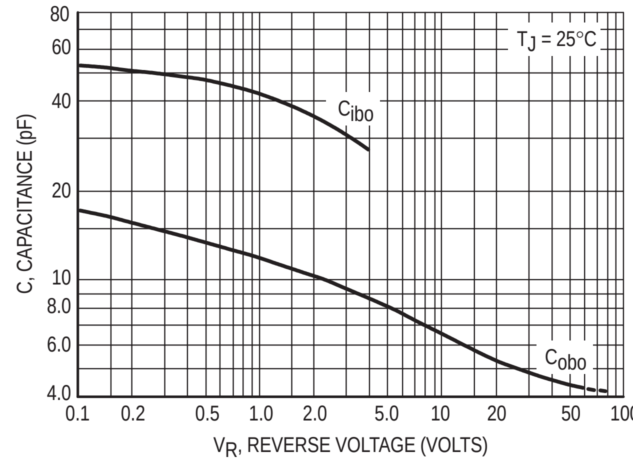


Figure 5. Capacitance

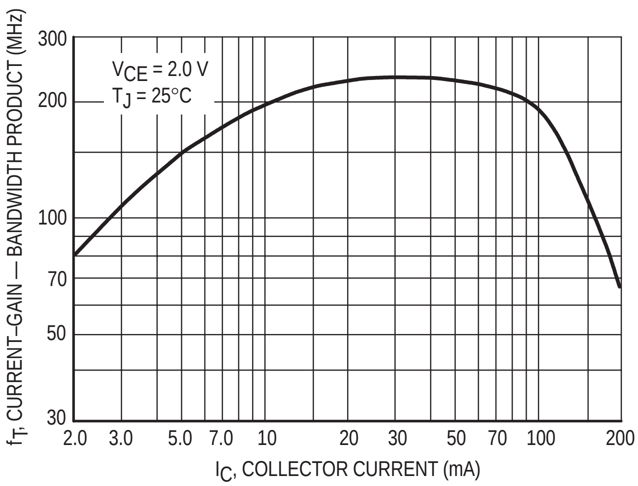


Figure 6. Current–Gain — Bandwidth Product

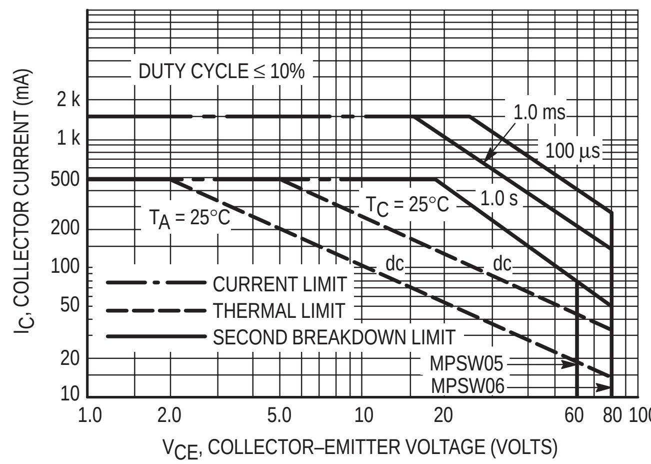
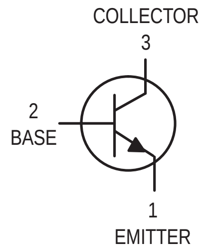
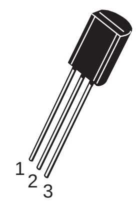


Figure 7. Active Region — Safe Operating Area

One Watt High Voltage Transistor
NPN Silicon

MPSW10





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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

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

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]				
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	—	
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%.

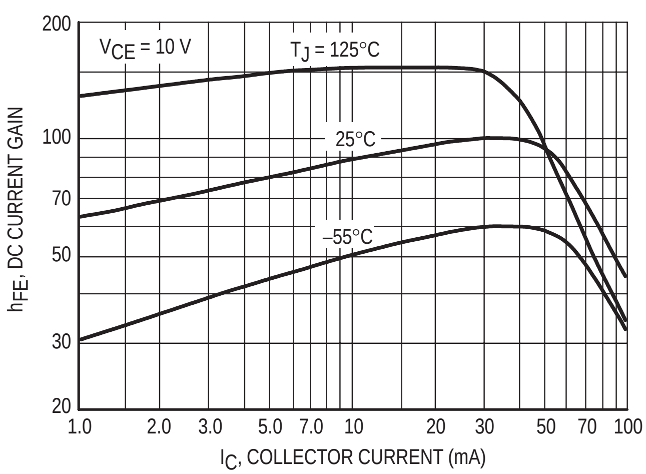


Figure 1. DC Current Gain

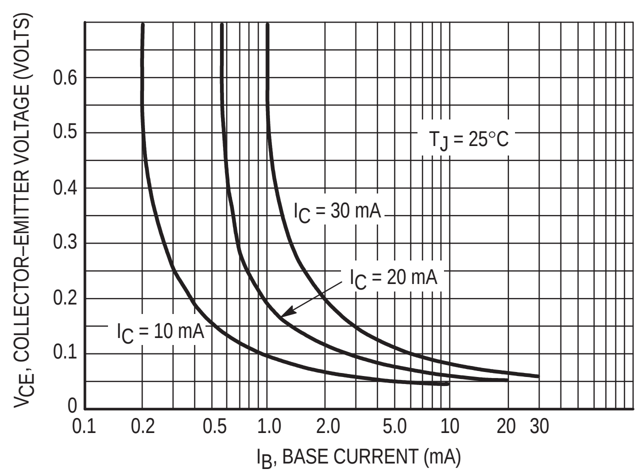


Figure 2. Collector Saturation Region

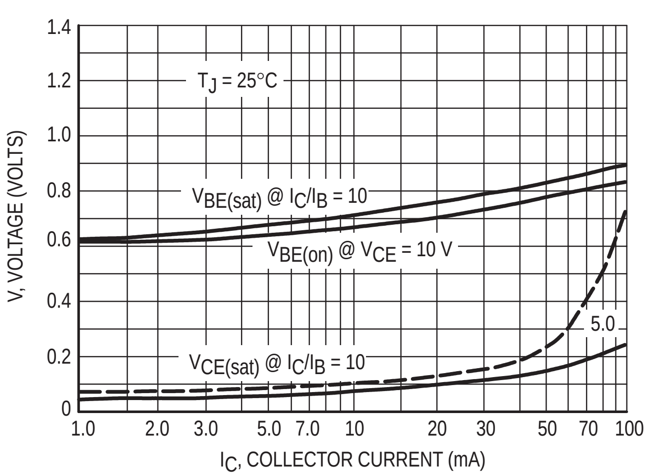


Figure 3. “On” Voltages

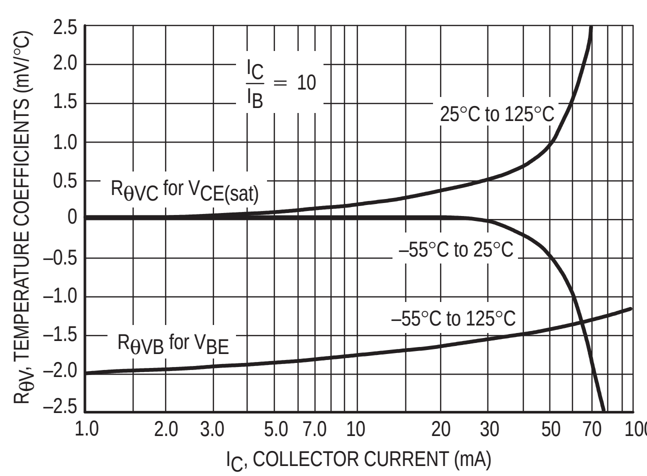


Figure 4. Temperature Coefficients

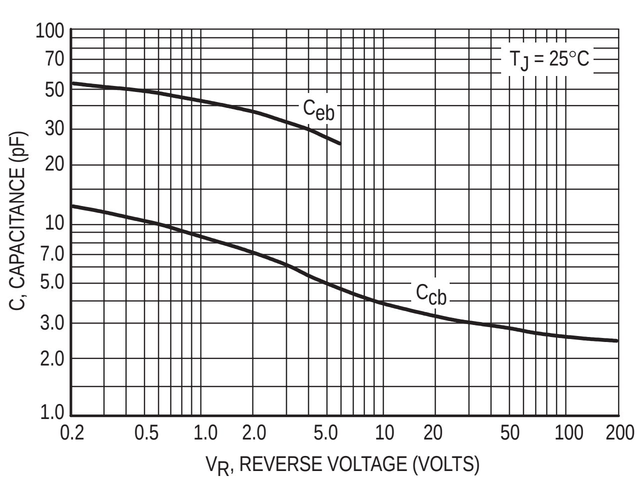


Figure 5. Capacitance

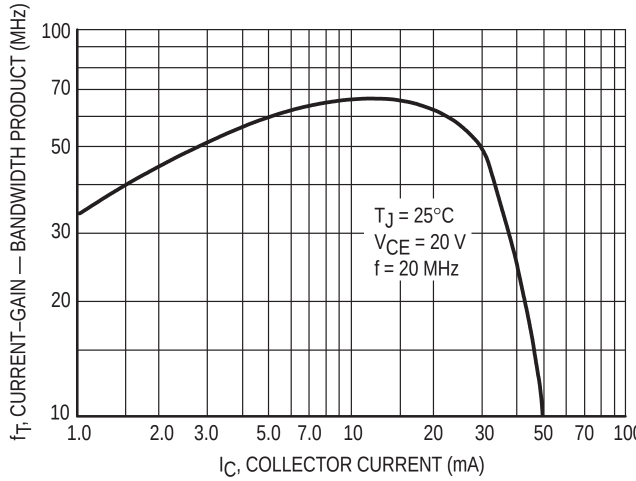


Figure 6. Current–Gain — Bandwidth Product

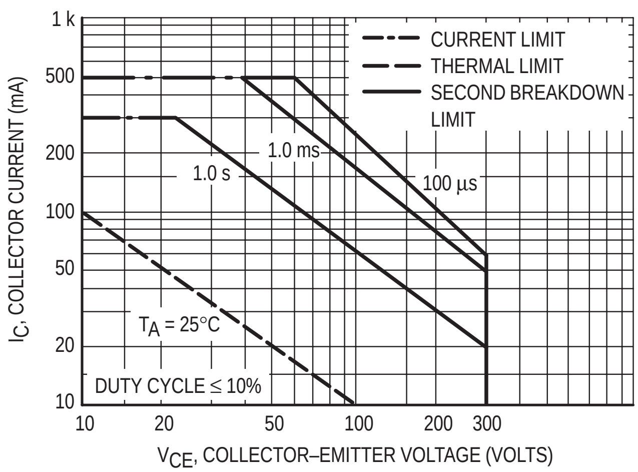
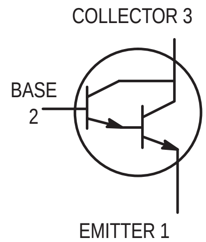
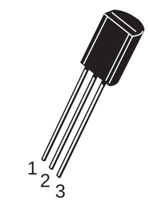


Figure 7. Active Region — Safe Operating Area

One Watt Darlington Transistors
NPN Silicon

MPSW13
MPSW14





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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	Watts 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

REV 1

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPSW13 MPSW14	h_{FE}	5,000 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 $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%.
2. $f_T = |h_{fe}| \bullet f_{test}$.

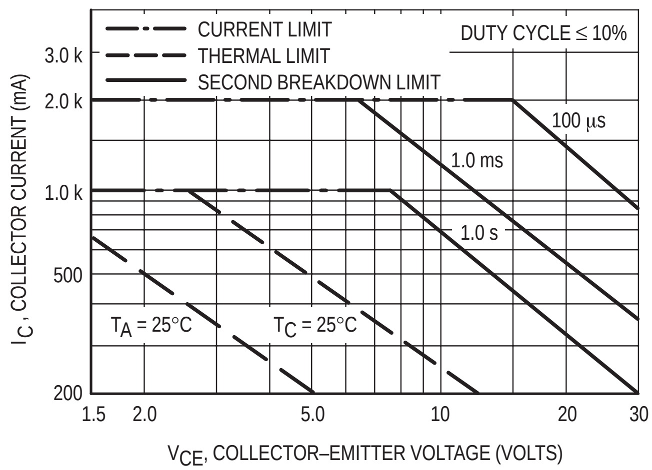


Figure 1. Active Region — Safe Operating Area

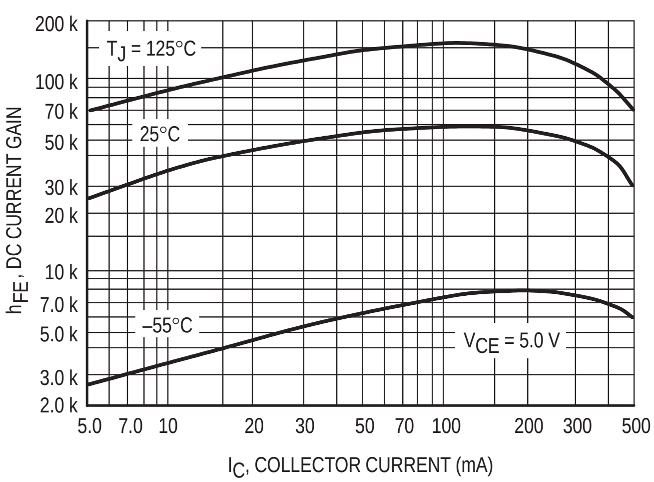


Figure 2. DC Current Gain

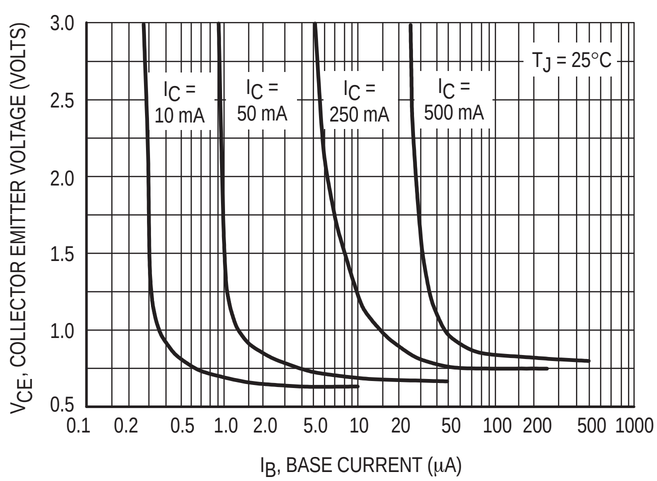


Figure 3. Collector Saturation Region

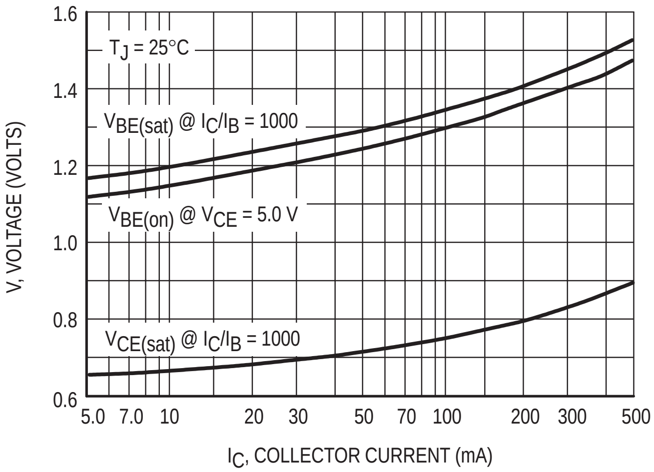


Figure 4. "ON" Voltages

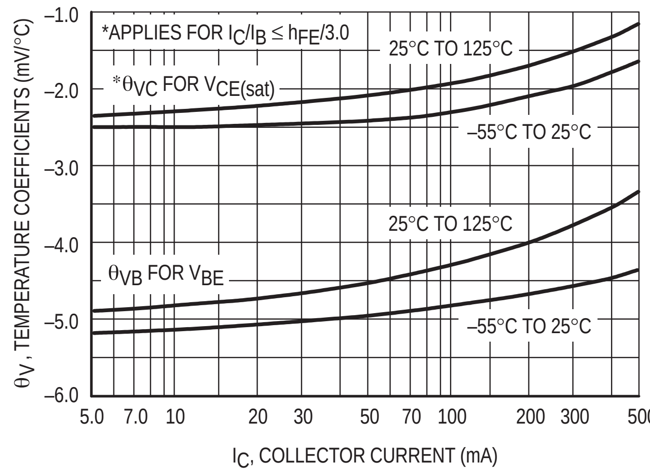


Figure 5. Temperature Coefficients

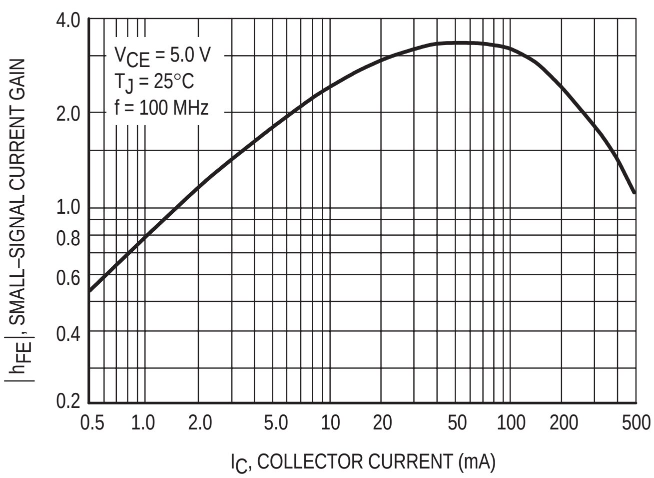


Figure 6. High Frequency Current Gain

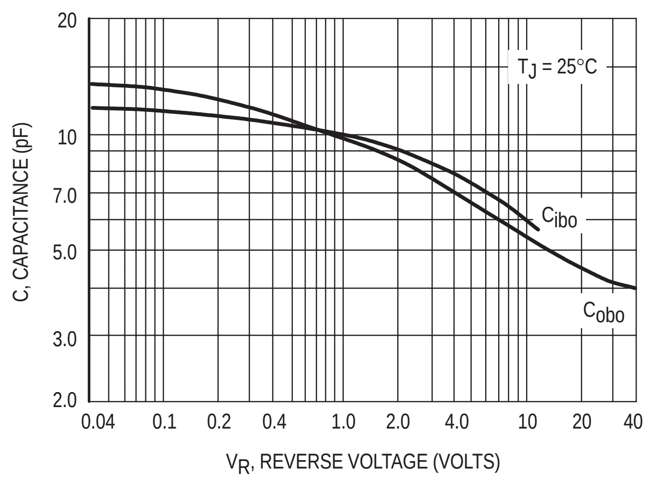


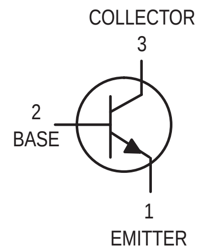
Figure 7. Capacitance

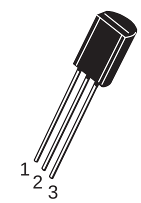
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

One Watt High Voltage Transistor
NPN Silicon

MPSW42

Motorola Preferred Device





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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

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

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

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

Characteristic	Symbol	Min	Max	Unit
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 Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	3.0	pF

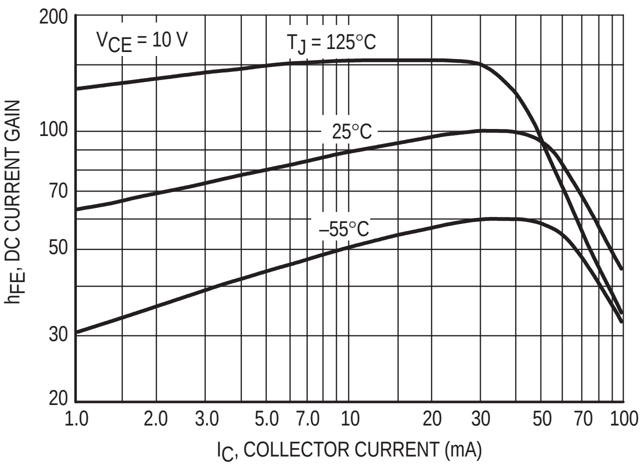


Figure 1. DC Current Gain

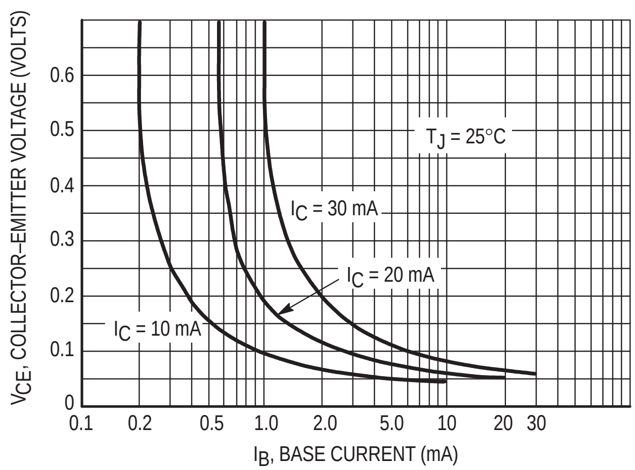


Figure 2. Collector Saturation Region

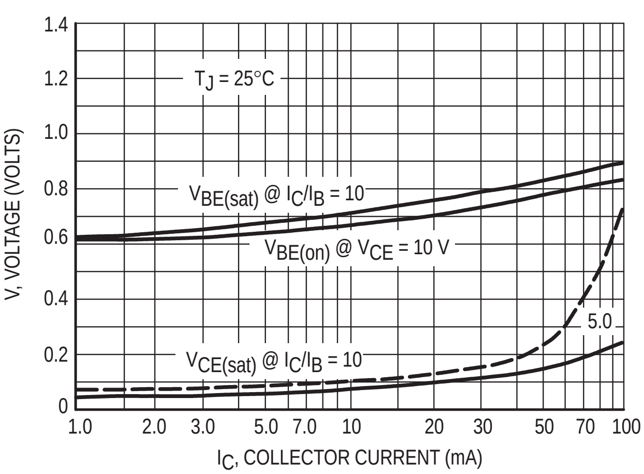


Figure 3. "On" Voltages

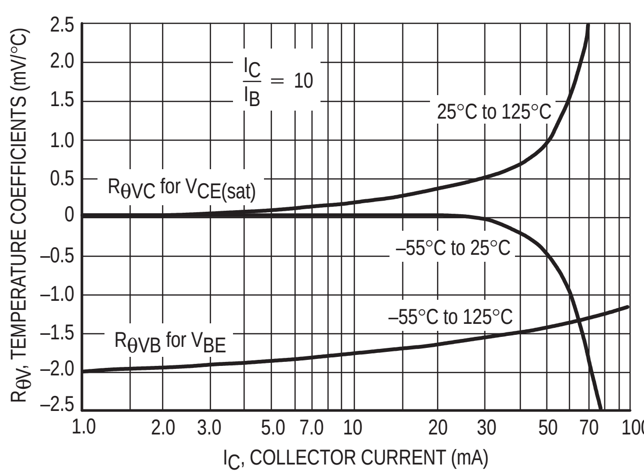


Figure 4. Temperature Coefficients

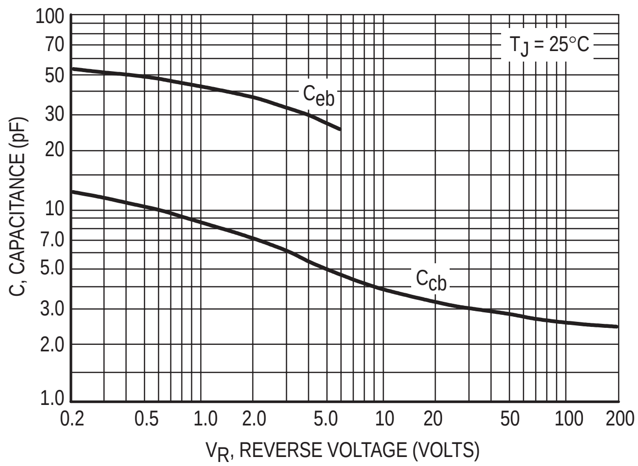


Figure 5. Capacitance

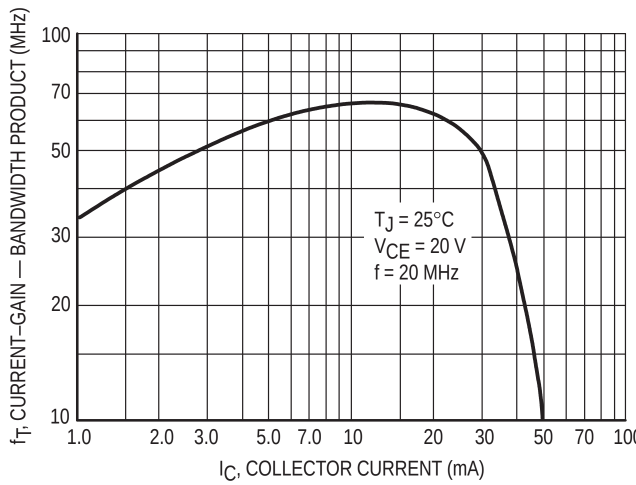


Figure 6. Current–Gain — Bandwidth Product

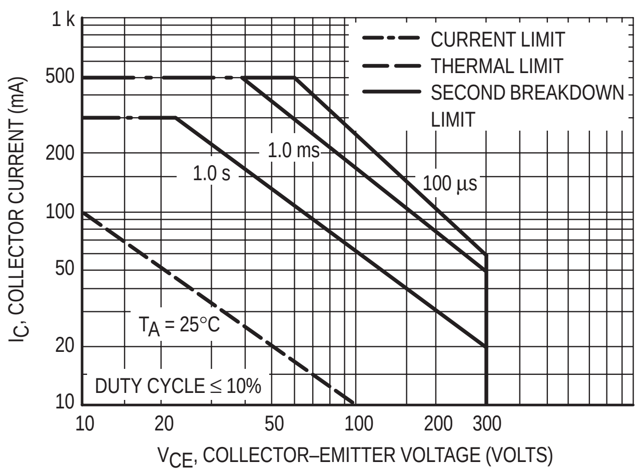
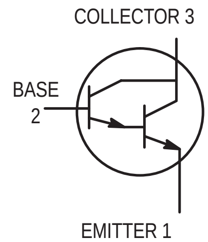


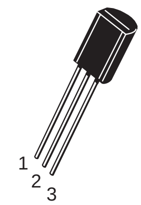
Figure 7. Active Region — Safe Operating Area

One Watt Darlington Transistors
NPN Silicon



MPSW45
MPSW45A*

*Motorola Preferred Device



CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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		Watts 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) MPSW45 (V_{CB} = 40 Vdc, I_E = 0) MPSW45A	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc

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

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

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]				
DC Current Gain	h_{FE}			—
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)		25,000	150,000	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		15,000	—	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		4,000	—	
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%.

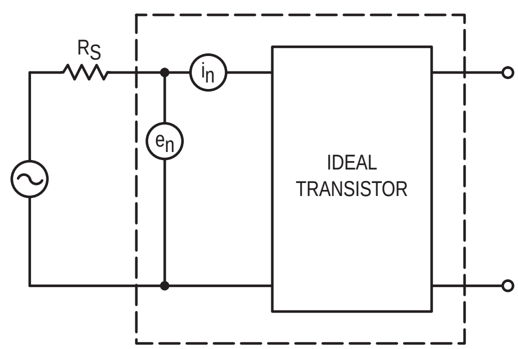


Figure 1. Transistor Noise Model

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

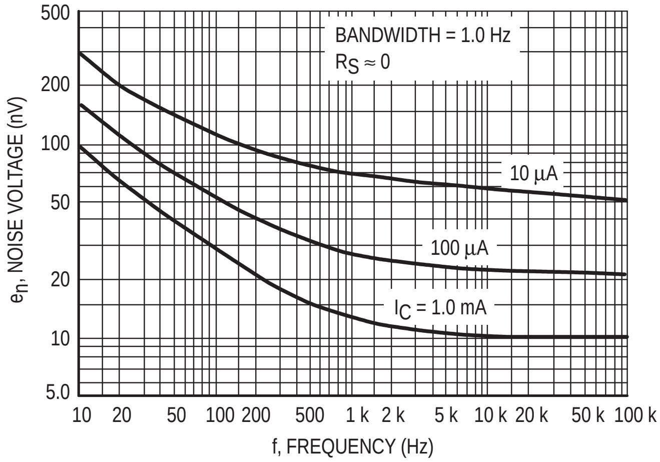


Figure 2. Noise Voltage

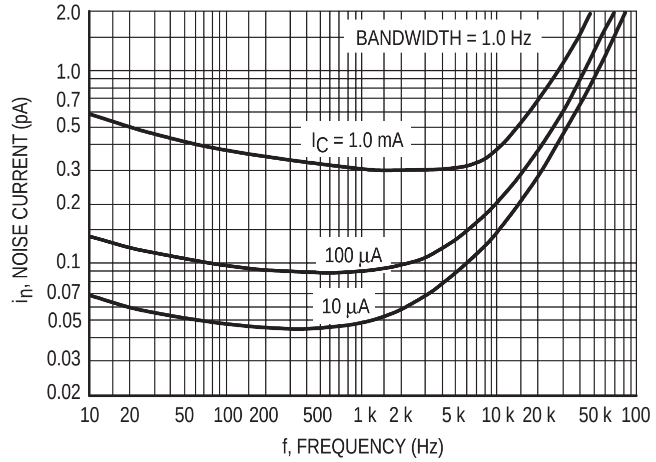


Figure 3. Noise Current

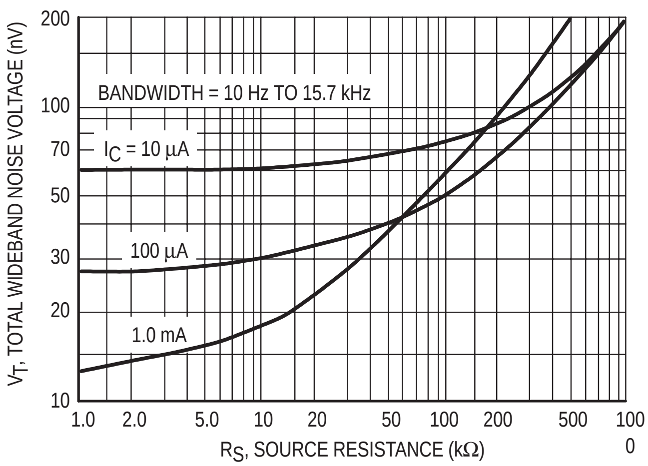


Figure 4. Total Wideband Noise Voltage

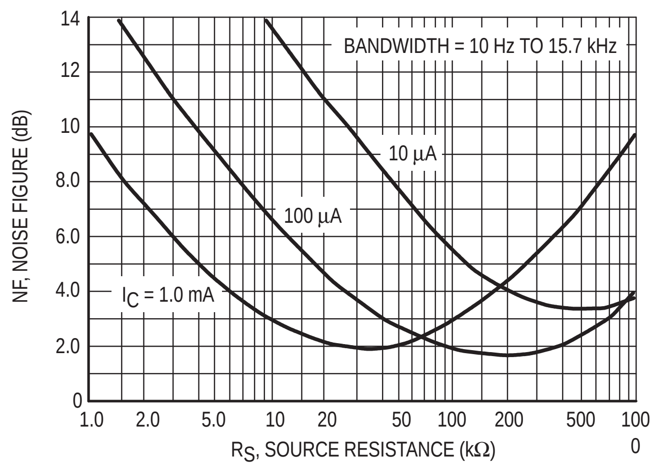


Figure 5. Wideband Noise Figure

SMALL–SIGNAL CHARACTERISTICS

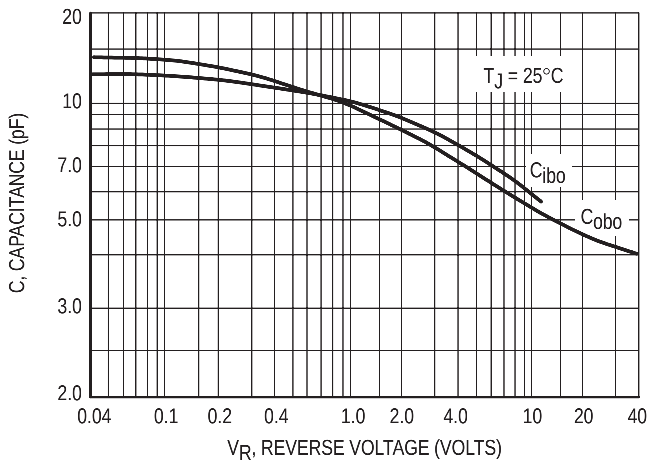


Figure 6. Capacitance

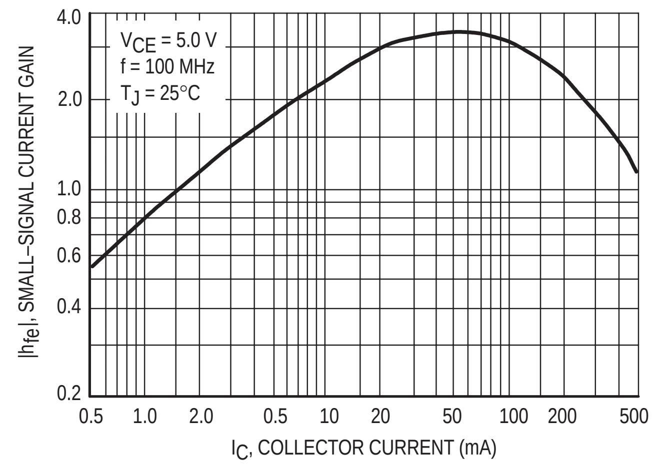


Figure 7. High Frequency Current Gain

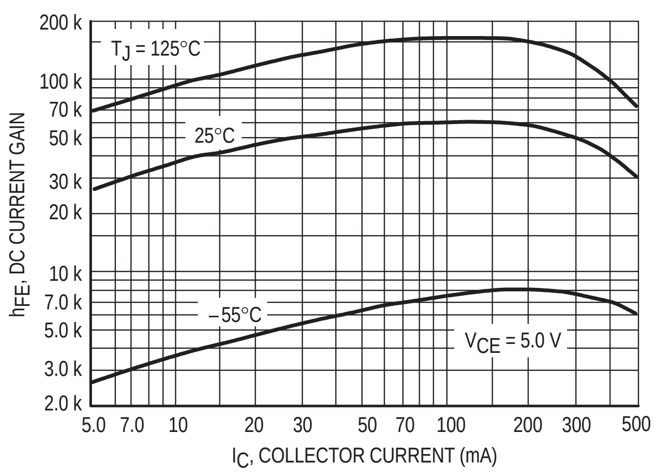


Figure 8. DC Current Gain

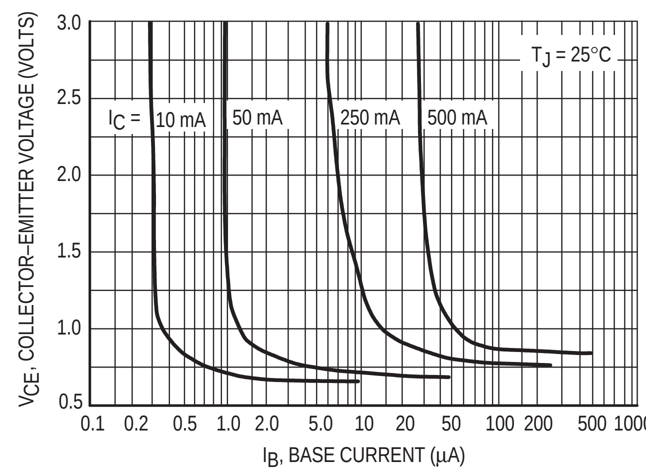


Figure 9. Collector Saturation Region

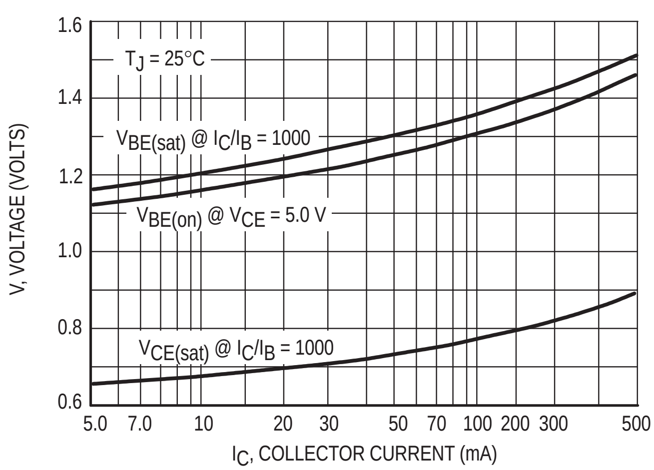


Figure 10. "On" Voltages

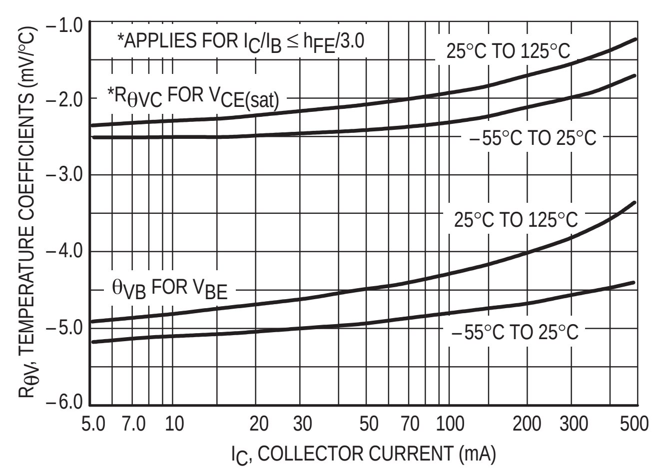


Figure 11. Temperature Coefficients

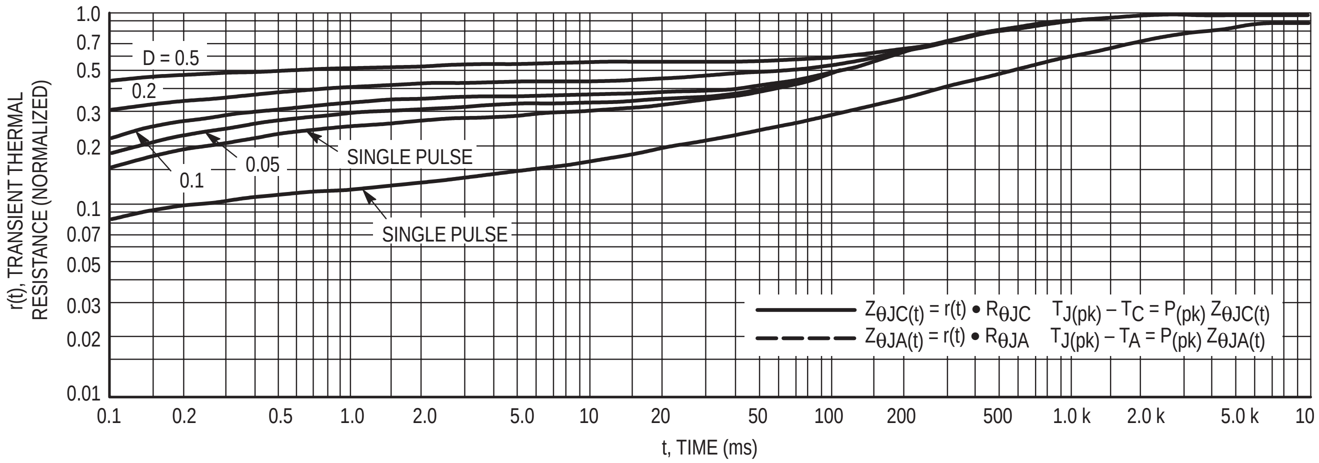


Figure 12. Thermal Response

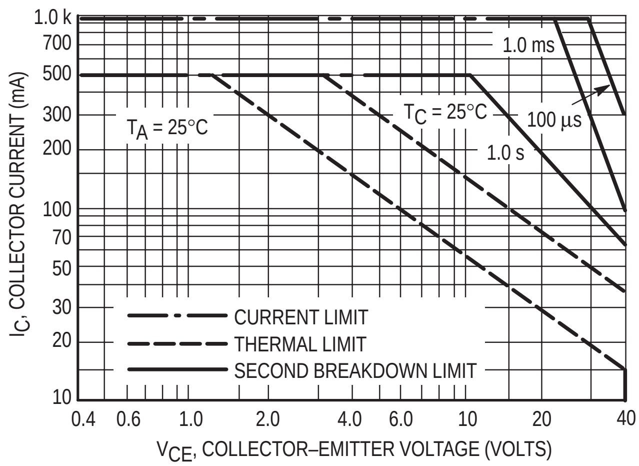
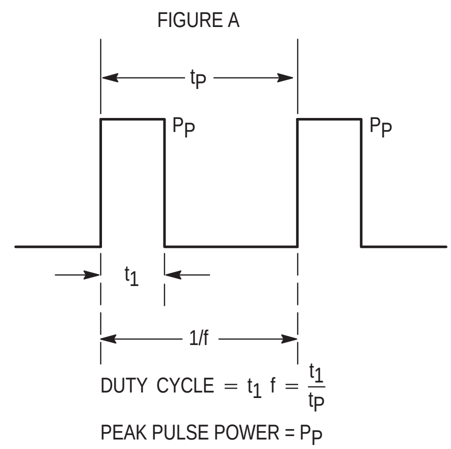


Figure 13. Active Region Safe Operating Area

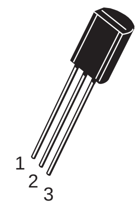


Design Note: Use of Transient Thermal Resistance Data

One Watt High Current Transistors
PNP Silicon

MPSW51
MPSW51A*

*Motorola Preferred Device



CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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	Watts 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 Cutoff Current (V_{EB} = –3.0 Vdc, I_C = 0)		I_{EBO}	—	–0.1	μAdc

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

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

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

Characteristic	Symbol	Min	Max	Unit
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

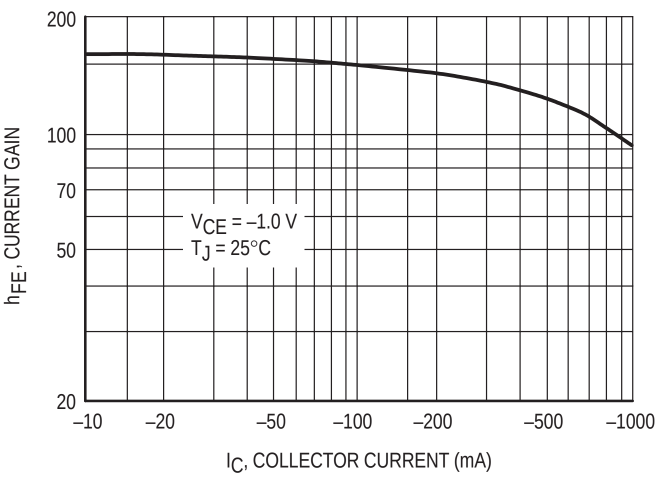


Figure 1. DC Current Gain

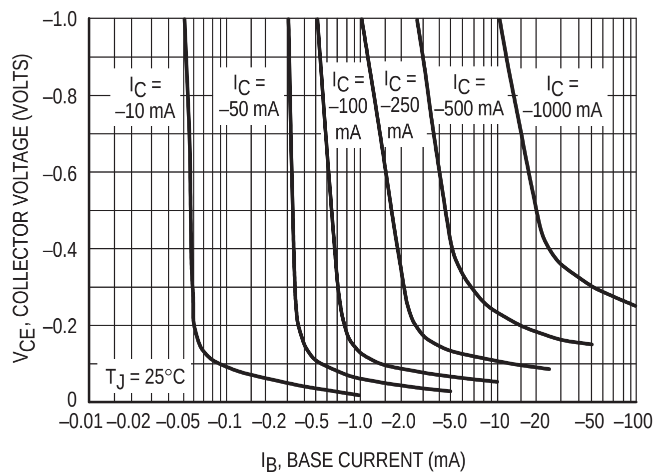


Figure 2. Collector Saturation Region

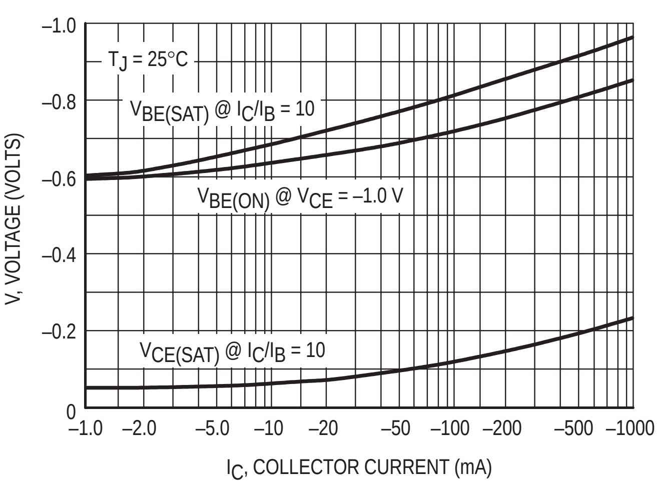


Figure 3. “ON” Voltages

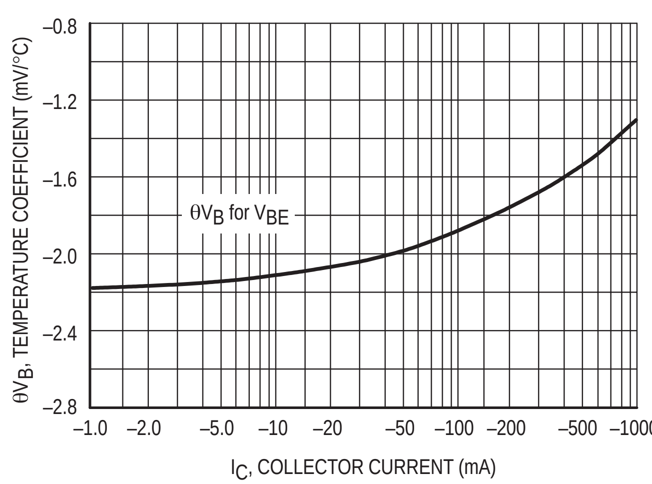


Figure 4. Temperature Coefficient

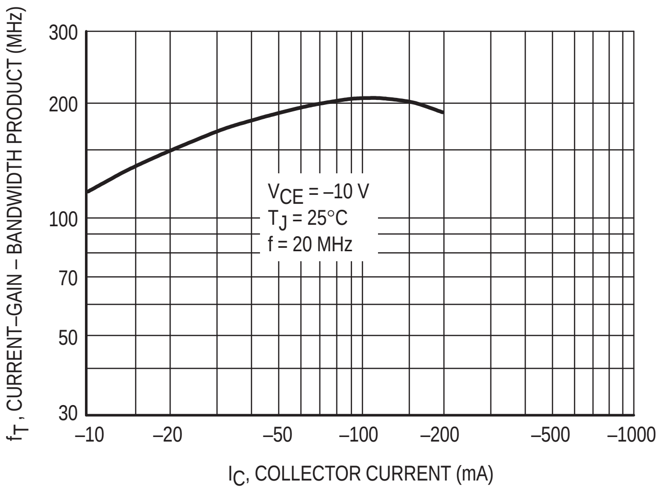


Figure 5. Current Gain — Bandwidth Product

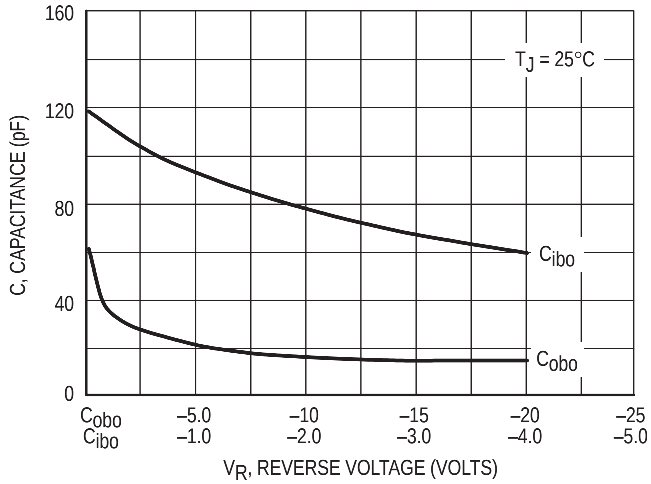


Figure 6. Capacitance

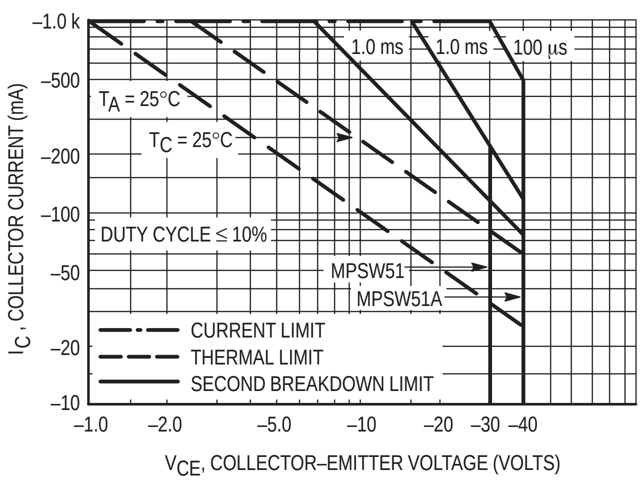


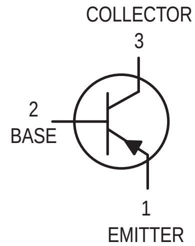
Figure 7. Active Region — Safe Operating Area

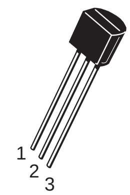
One Watt Amplifier Transistors

PNP Silicon

MPSW55
MPSW56*

*Motorola Preferred Device





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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

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

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

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

Characteristic	Symbol	Min	Max	Unit
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%.

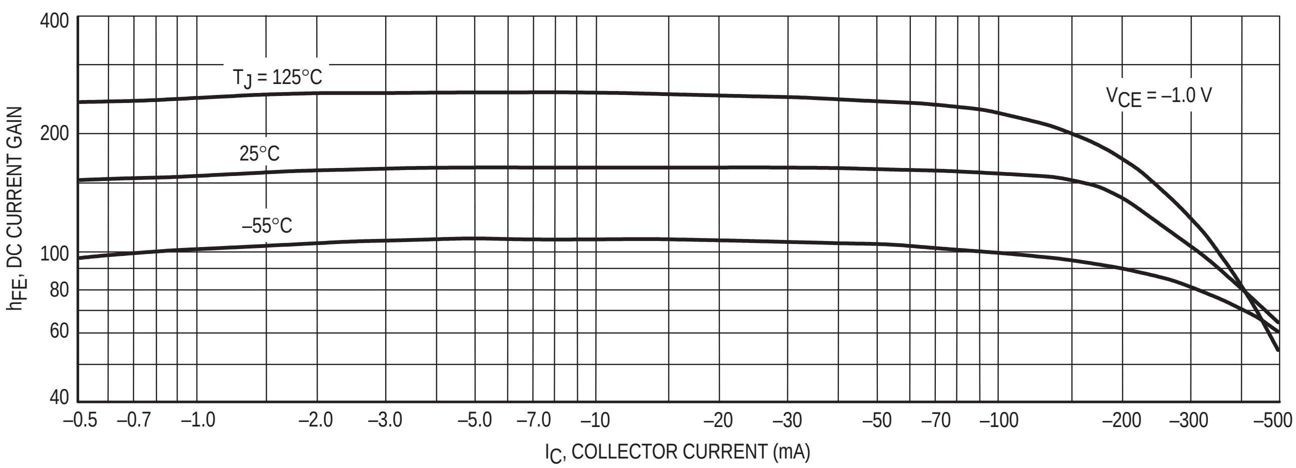


Figure 1. DC Current Gain

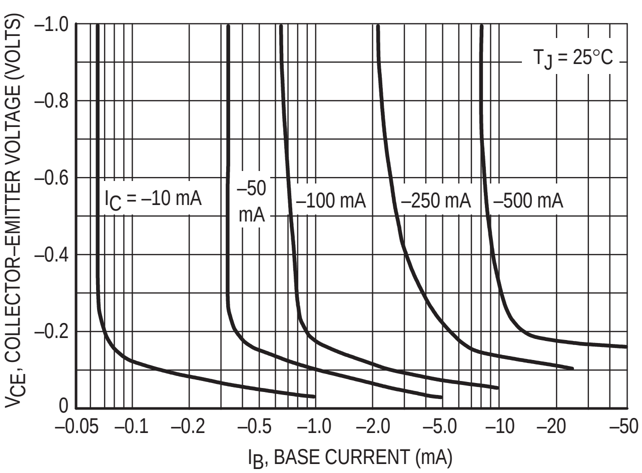


Figure 2. Collector Saturation Region

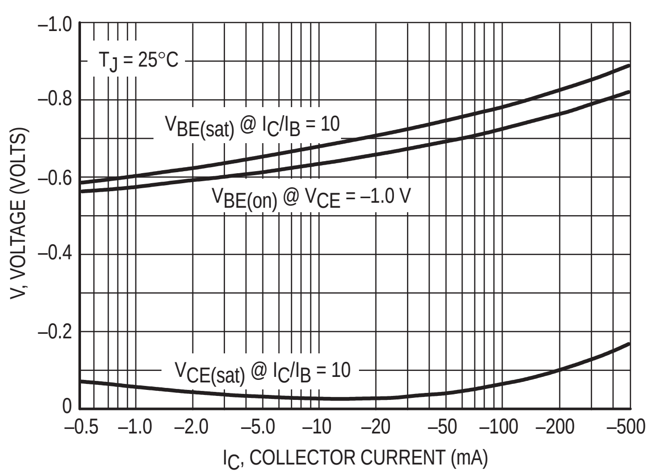


Figure 3. “On” Voltages

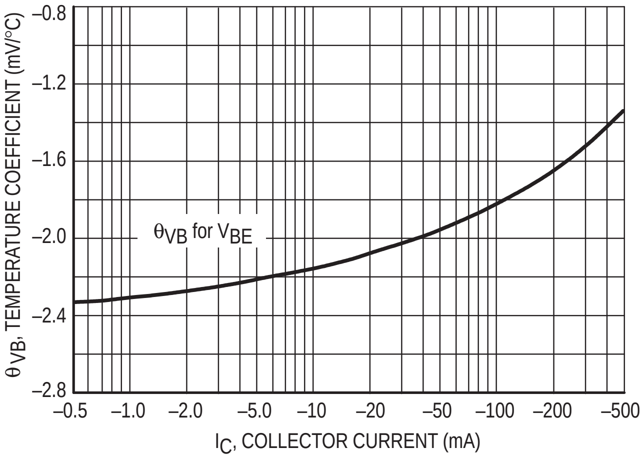


Figure 4. Base–Emitter Temperature Coefficient

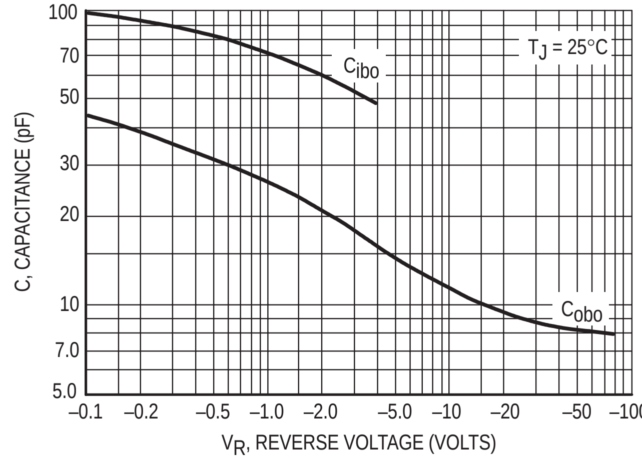


Figure 5. Capacitance

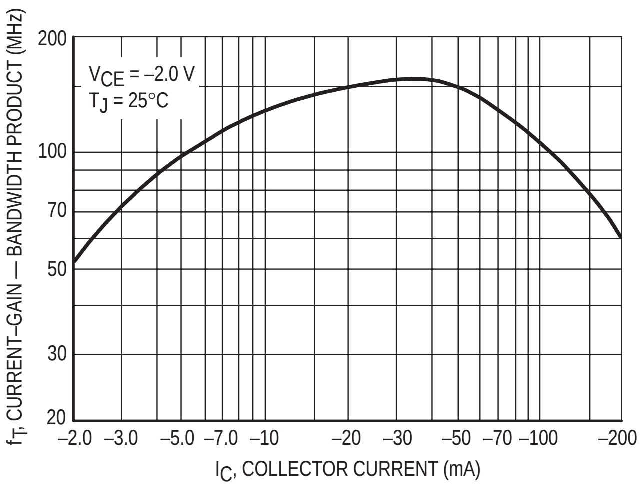


Figure 6. Current–Gain — Bandwidth Product

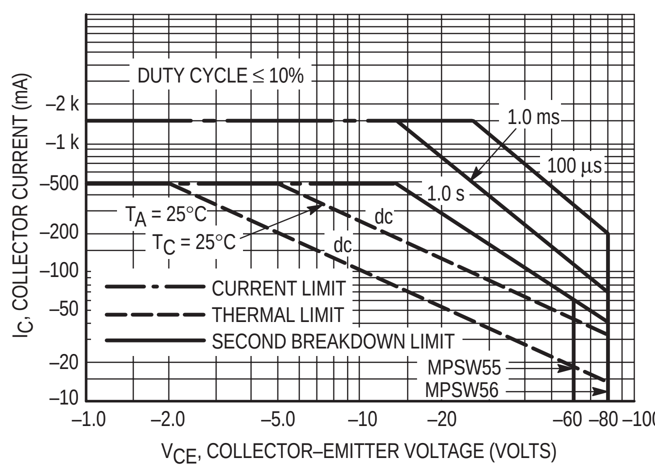


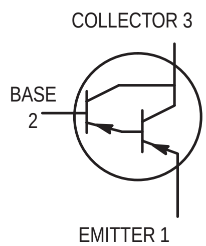
Figure 7. Active Region — Safe Operating Area

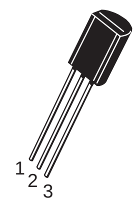
One Watt Darlington Transistors

PNP Silicon

MPSW63
MPSW64*

*Motorola Preferred Device





CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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

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

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[1]					
DC Current Gain (I_C = –10 mAdc, V_{CE} = –5.0 Vdc)	MPSW63	h_{FE}	5,000	—	—
	MPSW64		10,000	—	
(I_C = –100 mAdc, V_{CE} = –5.0 Vdc)	MPSW63		10,000	—	
	MPSW64		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. $f_T = |h_{fe}| \bullet f_{test}$.

TYPICAL ELECTRICAL CHARACTERISTICS

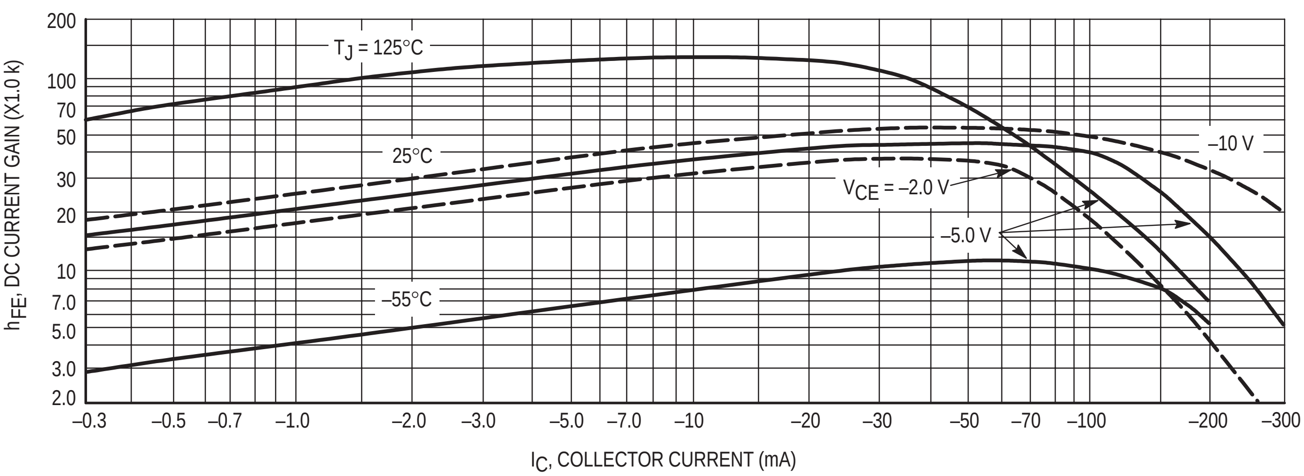


Figure 1. DC Current Gain

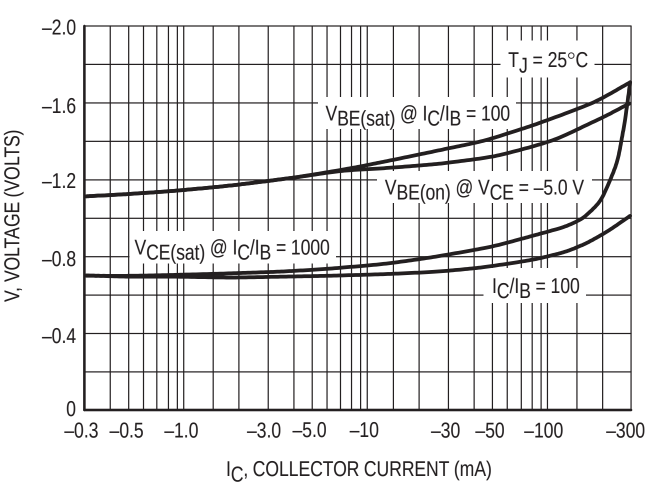


Figure 2. "ON" Voltage

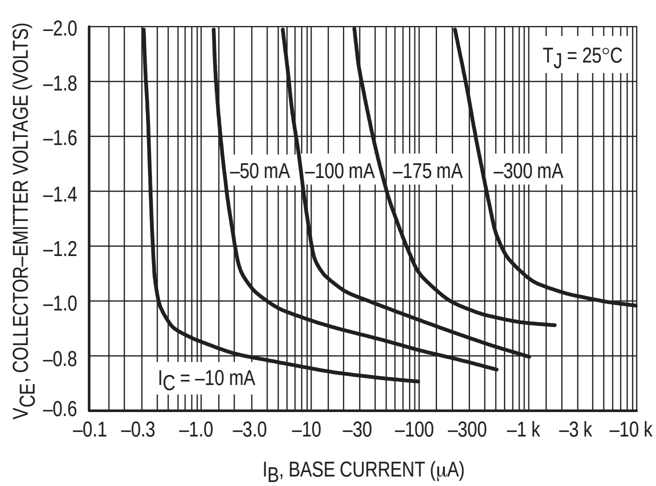


Figure 3. Collector Saturation Region

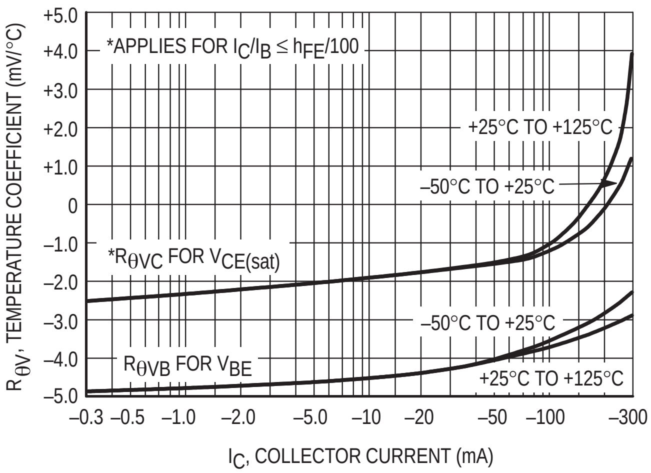


Figure 4. Temperature Coefficients

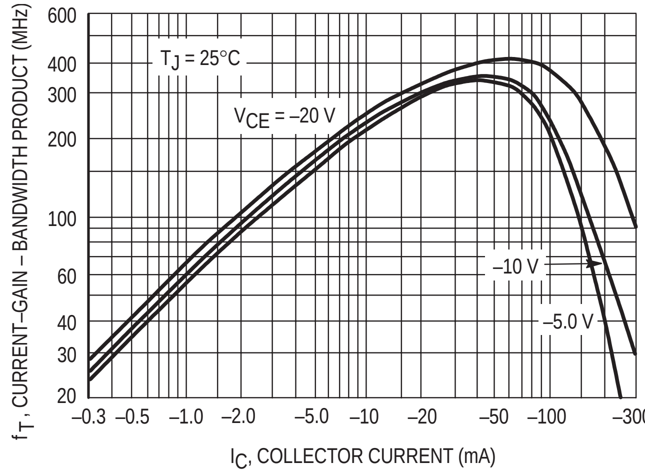


Figure 5. Current–Gain — Bandwidth Product

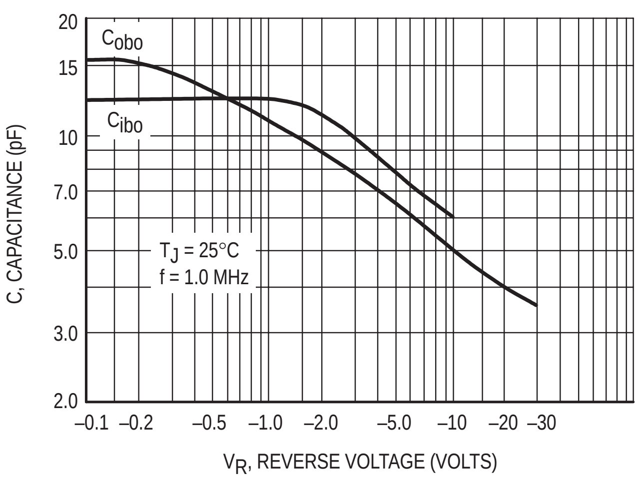


Figure 6. Capacitance

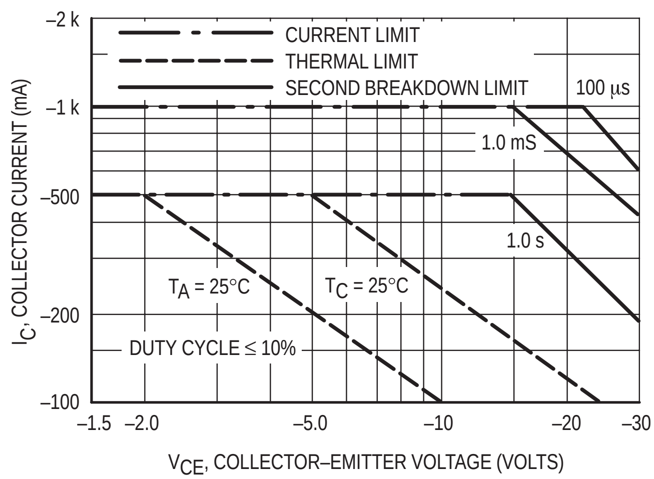
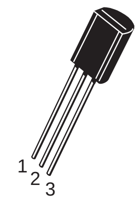


Figure 7. Active Region, Safe Operating Area

One Watt High Voltage Transistor
PNP Silicon

MPSW92

Motorola Preferred Device



CASE 29–05, STYLE 1
TO–92 (TO–226AE)

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

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

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

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

Characteristic	Symbol	Min	Max	Unit
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%.

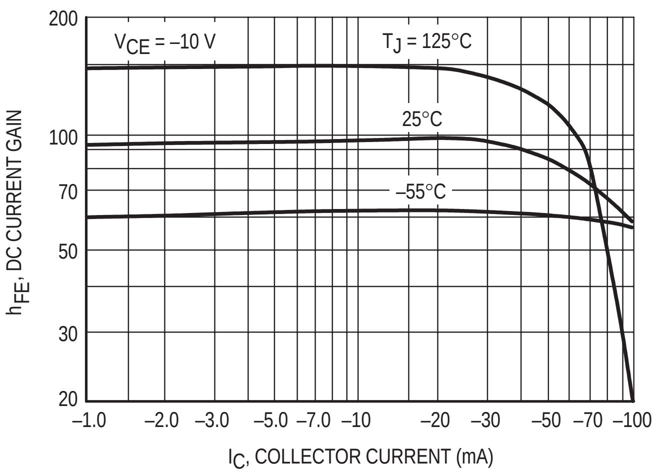


Figure 1. DC Current Gain

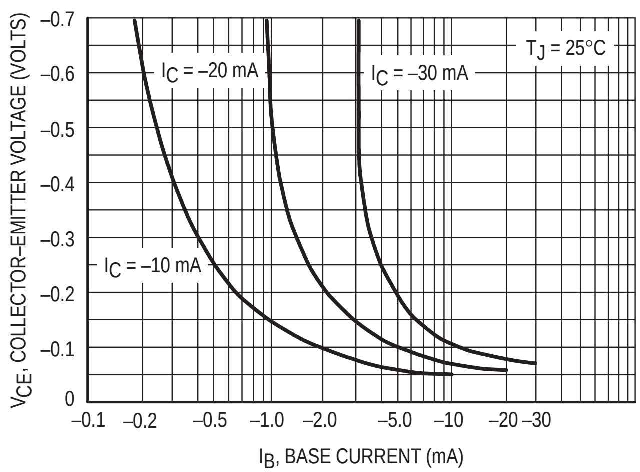


Figure 2. Collector Saturation Region

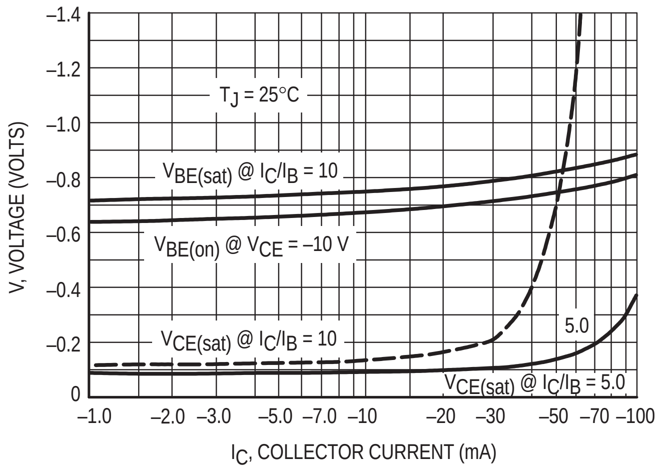


Figure 3. "ON" Voltages

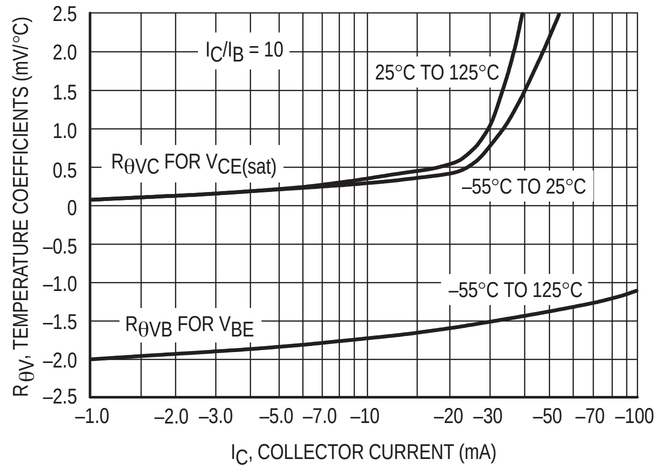


Figure 4. Temperature Coefficients

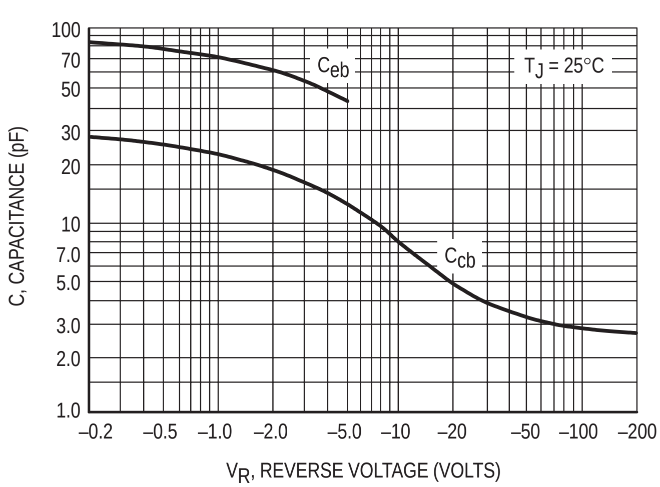


Figure 5. Capacitance

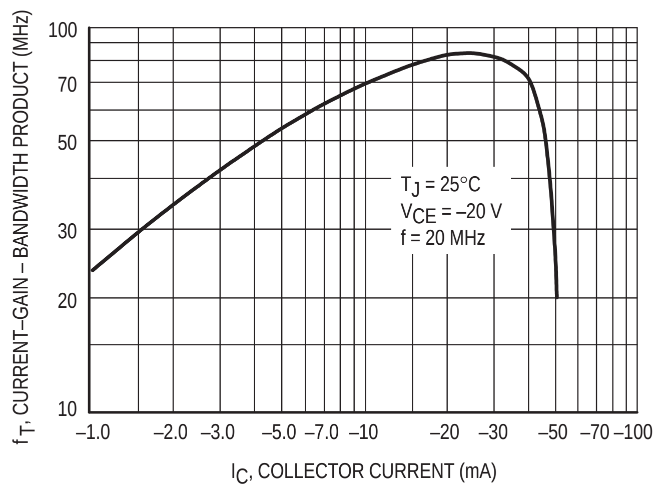


Figure 6. Current–Gain — Bandwidth Product

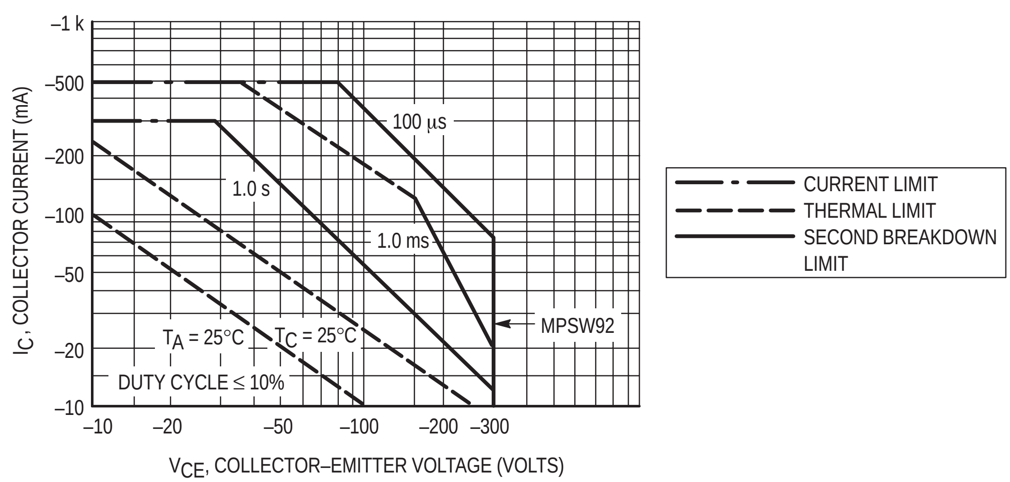
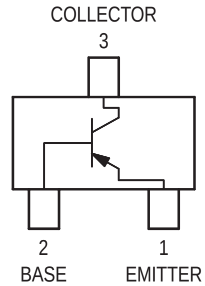


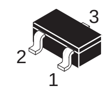
Figure 7. Active Region Safe Operating Area

PNP RF Amplifier Transistor Surface Mount

MSA1022-CT1

Motorola Preferred Device





CASE 318D–03, STYLE 1
SC–59

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector–Base Voltage	V_{CBO}	–30	Vdc
Collector–Emitter Voltage	V_{CEO}	–20	Vdc
Emitter–Base Voltage	V_{EBO}	–5.0	Vdc
Collector Current — Continuous	I_C	–30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ +150	°C

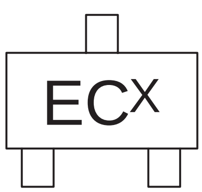
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = –10 Vdc, I_E = 0)	I_{CBO}	—	–0.1	µAdc
Collector–Emitter Breakdown Voltage (V_{CE} = –20 Vdc, I_B = 0)	I_{CEO}	—	–100	µAdc
Emitter–Base Breakdown Voltage (V_{EB} = –5.0 Vdc, I_C = 0)	I_{EBO}	—	–10	µAdc
DC Current Gain(1) (V_{CE} = –10 Vdc, I_C = –1.0 mAdc)	h_{FE}	110	220	—
Current–Gain — Bandwidth Product (V_{CB} = –10 Vdc, I_E = 1.0 mAdc)	f_T	150	—	MHz

1. 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.

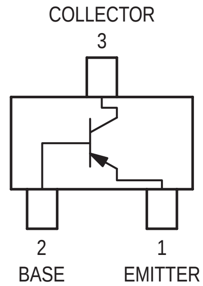
Preferred devices are Motorola recommended choices for future use and best overall value.

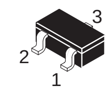
(Replaces MSA1022–BT1/D)

PNP General Purpose Amplifier Transistor Surface Mount

MSB709-RT1

Motorola Preferred Device





CASE 318D–03, STYLE 1
SC–59

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector–Base Voltage	$V_{(BR)CBO}$	–60	Vdc
Collector–Emitter Voltage	$V_{(BR)CEO}$	–45	Vdc
Emitter–Base Voltage	$V_{(BR)EBO}$	–7.0	Vdc
Collector Current — Continuous	I_C	–100	mAdc
Collector Current — Peak	$I_{C(P)}$	–200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ +150	°C

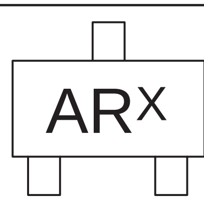
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Max	Unit
Collector–Emitter Breakdown Voltage (I_C = –2.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	–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_E = 0)	$V_{(BR)EBO}$	–7.0	—	Vdc
Collector–Base Cutoff Current (V_{CB} = –45 Vdc, I_E = 0)	I_{CBO}	—	–0.1	µAdc
Collector–Emitter Cutoff Current (V_{CE} = –10 Vdc, I_B = 0)	I_{CEO}	—	–100	nAdc
DC Current Gain(1) (V_{CE} = –10 Vdc, I_C = –2.0 mAdc)	h_{FE1}	210	340	—
Collector–Emitter Saturation Voltage (I_C = –100 mAdc, I_B = –10 mAdc)	$V_{CE(sat)}$	—	–0.5	Vdc

1. Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol

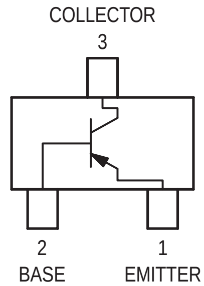


The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

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

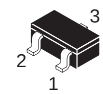
REV 3

PNP General Purpose Amplifier Transistor Surface Mount



MSB710-RT1

Motorola Preferred Device



CASE 318D–04, STYLE 1
SC–59

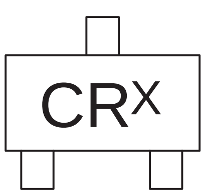
MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector–Base Voltage	$V_{(BR)CBO}$	–60	Vdc
Collector–Emitter Voltage	$V_{(BR)CEO}$	–50	Vdc
Emitter–Base Voltage	$V_{(BR)EBO}$	–7.0	Vdc
Collector Current — Continuous	I_C	–500	mAdc
Collector Current — Peak	$I_{C(P)}$	–1.0	Adc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ +150	°C

DEVICE MARKING



The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

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

replaces MSB710–QT1/D

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Max	Unit
Collector–Emitter Breakdown Voltage (I_C = –10 mAdc, I_B = 0)	$V_{(BR)CEO}$	–50	—	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)	$V_{(BR)EBO}$	–7.0	—	Vdc
Collector–Base Cutoff Current (V_{CB} = –20 Vdc, I_E = 0)	I_{CBO}	—	–0.1	µAdc
DC Current Gain(1)				—
(V_{CE} = –10 Vdc, I_C = –150 mAdc)	h_{FE1}	120	240	
(V_{CE} = –10 Vdc, I_C = 500 mAdc)	h_{FE2}	40	—	
Collector–Emitter Saturation Voltage (I_C = –300 mAdc, I_B = –30 mAdc)	$V_{CE(sat)}$	—	–0.6	Vdc
Collector–Base Saturation Voltage (I_C = –300 mAdc, I_B = –30 mAdc)	$V_{BE(sat)}$	—	–1.5	Vdc
Output Capacitance (V_{CB} = –10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	15	pF

1. Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

PNP Silicon General Purpose Amplifier Transistor

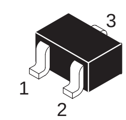
This PNP Silicon Epitaxial Planar Transistor is designed for general purpose amplifier applications. This device is housed in the SC–70/SOT–323 package which is designed for low power surface mount applications.

- High h_{FE}, 210 – 460
- Low $V_{CE(sat)}$, < 0.5 V
- Available in 8 mm, 7–inch/3000 Unit Tape and Reel

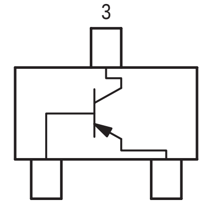
MSB1218A-RT1

Motorola Preferred Devices

PNP GENERAL PURPOSE AMPLIFIER TRANSISTORS SURFACE MOUNT



CASE 419–02, STYLE 3
SC–70/SOT–323



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector–Base Voltage	$V_{(BR)CBO}$	45	Vdc
Collector–Emitter Voltage	$V_{(BR)CEO}$	45	Vdc
Emitter–Base Voltage	$V_{(BR)EBO}$	7.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Collector Current — Peak	$I_{C(P)}$	200	mAdc

DEVICE MARKING

MSB1218A–RT1 = BR

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation(1)	P_D	150	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	– 55 ~ + 150	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Collector–Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	45	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 µAdc, I_E = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector–Base Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	0.1	µA
Collector–Emitter Cutoff Current (V_{CE} = 10 Vdc, I_B = 0)	I_{CEO}	—	100	µA
DC Current Gain(2) (V_{CE} = 10 Vdc, I_C = 2.0 mAdc)	h_{FE1}	210	340	—
Collector–Emitter Saturation Voltage(2) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.
2. Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

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

REV 2

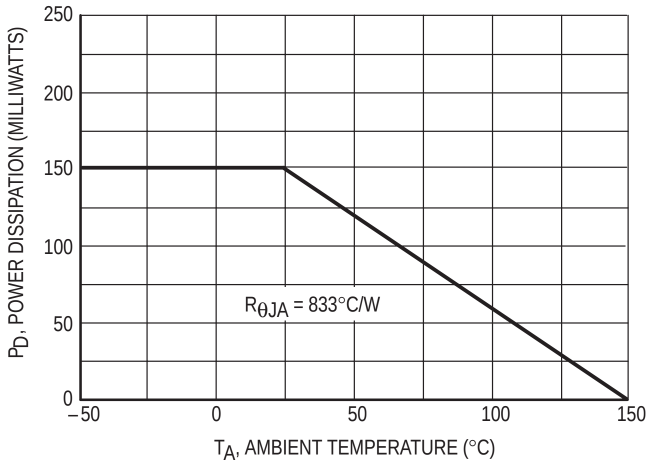


Figure 1. Derating Curve

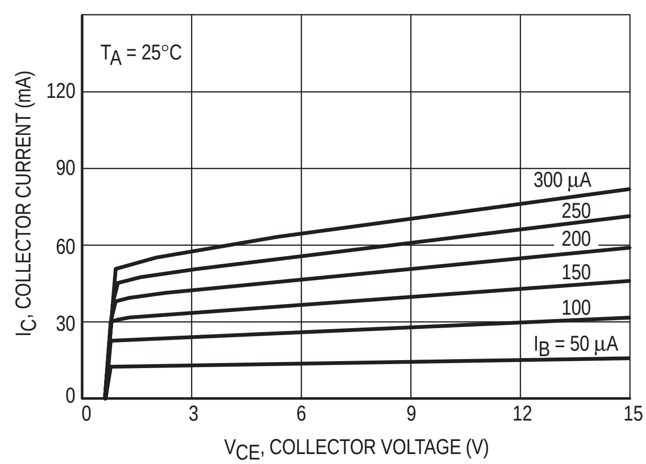


Figure 2. I_C – V_{CE}

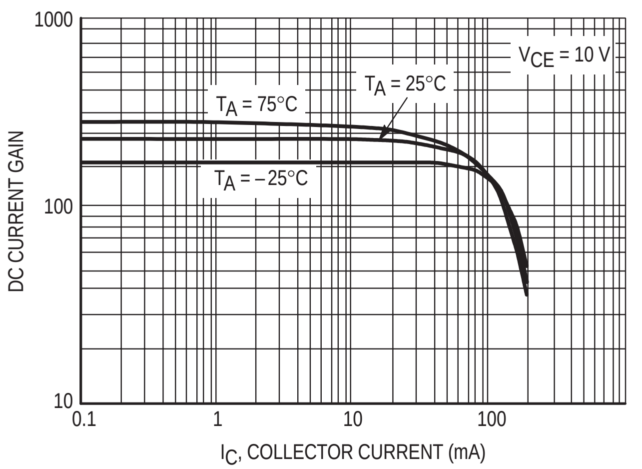


Figure 3. DC Current Gain

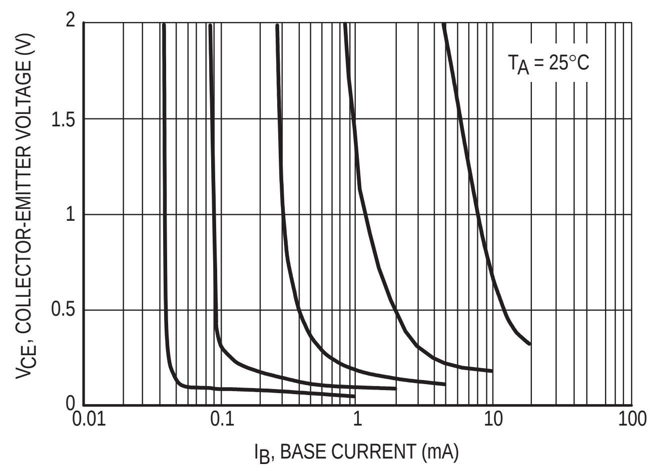


Figure 4. Collector Saturation Region

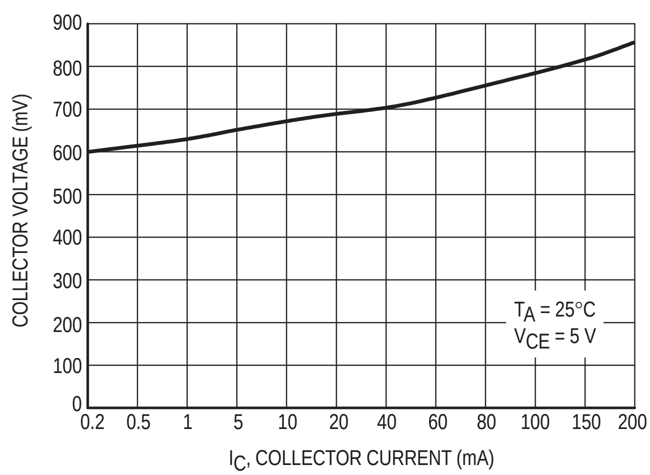


Figure 5. On Voltage

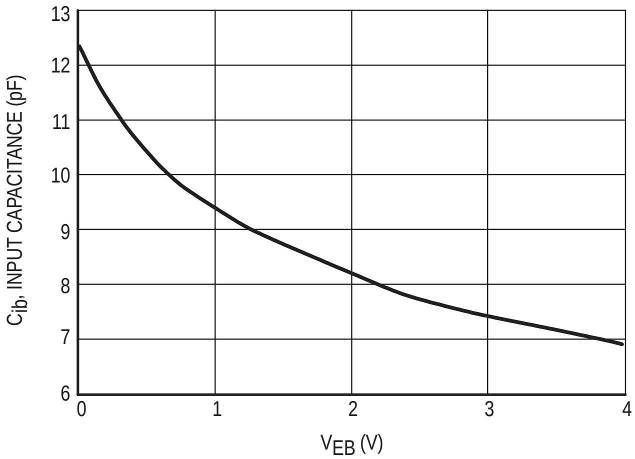


Figure 6. Capacitance

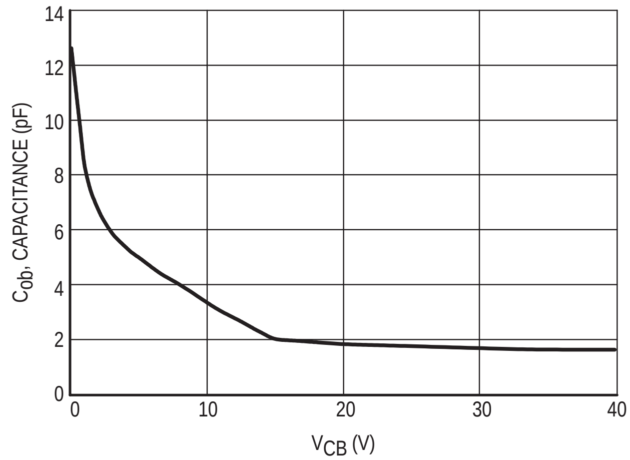
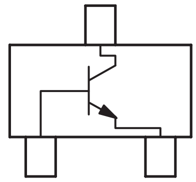


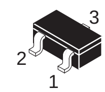
Figure 7. Capacitance

NPN RF Amplifier Transistors Surface Mount

MSC2295-BT1
MSC2295-CT1

Motorola Preferred Devices





CASE 318D–03, STYLE 1
SC–59

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	$V_{(BR)EBO}$	5.0	Vdc
Collector Current — Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	– 55 ~ +150	°C

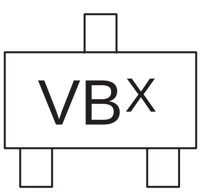
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Max	Unit
Collector–Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	0.1	µAdc
DC Current Gain(1) (V_{CB} = 10 Vdc, I_C = –1.0 mAdc) MSC2295–BT1	h_{FE}	70	140	—
MSC2295–CT1		110	220	
Collector–Gain — Bandwidth Product (V_{CB} = 10 Vdc, I_E = –1.0 mAdc)	f_T	150	—	MHz
Reverse Transistor Capacitance (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 10.7 MHz)	C_{re}	—	1.5	pF

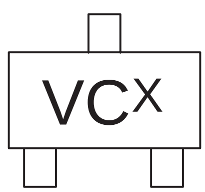
1. Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSC2295–BT1



MSC2295–CT1

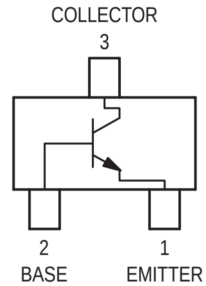
The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

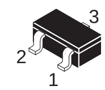
Preferred devices are Motorola recommended choices for future use and best overall value.

NPN RF Amplifier Transistor Surface Mount

MSC3130T1

Motorola Preferred Device





CASE 318D–03, STYLE 1
SC–59

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector–Base Voltage	V_{CBO}	15	Vdc
Collector–Emitter Voltage	V_{CEO}	10	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ +150	°C

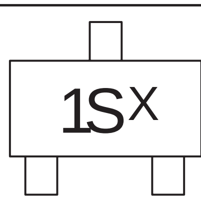
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	1.0	µAdc
Collector–Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	V_{CEO}	10	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	V_{EBO}	3.0	—	Vdc
DC Current Gain(1) (V_{CE} = 4.0 Vdc, I_C = 5.0 mAdc)	h_{FE}	75	400	—
Collector–Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 4.0 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Current–Gain — Bandwidth Product (V_{CB} = 4.0 Vdc, I_E = –5.0 mAdc)	f_T	1.4	2.5	GHz

1. Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



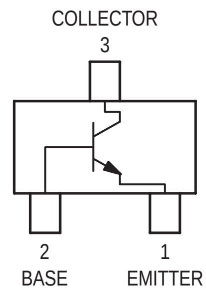
The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

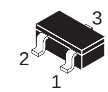
Preferred devices are Motorola recommended choices for future use and best overall value.

NPN General Purpose Amplifier Transistors Surface Mount

MSD601-RT1*
MSD601-ST1

***Motorola Preferred Device**





CASE 318D–03, STYLE 1
SC–59

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector–Base Voltage	$V_{(BR)CBO}$	60	Vdc
Collector–Emitter Voltage	$V_{(BR)CEO}$	50	Vdc
Emitter–Base Voltage	$V_{(BR)EBO}$	7.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Collector Current — Peak	$I_{C(P)}$	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	– 55 ~ +150	°C

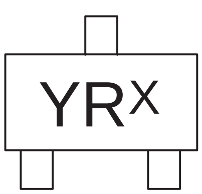
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Max	Unit
Collector–Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	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)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector–Base Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Collector–Emitter Cutoff Current (V_{CE} = 10 Vdc, I_B = 0)	I_{CEO}	—	100	nAdc
DC Current Gain(1)				—
(V_{CE} = 10 Vdc, I_C = 2.0 mAdc) MSD601–RT1	h_{FE1}	210	340	
MSD601–ST1		290	460	
(V_{CE} = 2.0 Vdc, I_C = 100 mAdc)	h_{FE2}	90	—	
Collector–Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc

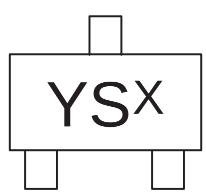
1. Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

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.

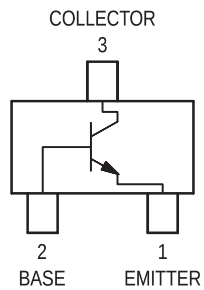
Preferred devices are Motorola recommended choices for future use and best overall value.

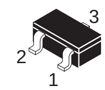
REV 2

NPN General Purpose Amplifier Transistor Surface Mount

MSD602-RT1

Motorola Preferred Device





CASE 318D–03, STYLE 1
SC–59

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector–Base Voltage	$V_{(BR)CBO}$	60	Vdc
Collector–Emitter Voltage	$V_{(BR)CEO}$	50	Vdc
Emitter–Base Voltage	$V_{(BR)EBO}$	7.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Collector Current — Peak	$I_{C(P)}$	1.0	Adc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ +150	°C

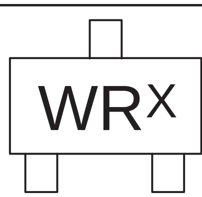
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Max	Unit
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	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)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector–Base Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	0.1	µAdc
DC Current Gain(1) (V_{CE} = 10 Vdc, I_C = 150 mAdc) (V_{CE} = 10 Vdc, I_C = 500 mAdc)	 h_{FE1} h_{FE2}	 120 40	 240 —	—
Collector–Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{CE(sat)}$	—	0.6	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	15	pF

1. 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.

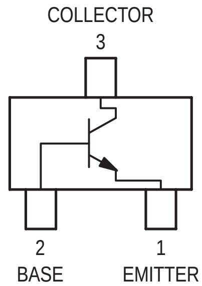
Preferred devices are Motorola recommended choices for future use and best overall value.

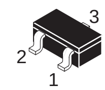
REV 1

NPN Low Voltage Output Amplifier Surface Mount

MSD1328-RT1

Motorola Preferred Device





CASE 318D–03, STYLE 1
SC–59

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	$V_{(BR)EBO}$	12	Vdc
Collector Current — Continuous	I_C	500	mAdc
Collector Current — Peak	$I_{C(P)}$	1000	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ +150	°C

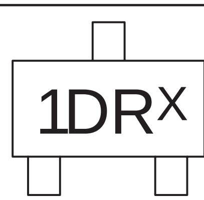
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Max	Unit
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)	$V_{(BR)CBO}$	25	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 µAdc, I_E = 0)	$V_{(BR)EBO}$	12	—	Vdc
Collector–Base Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	0.1	µAdc
DC Current Gain(1) (V_{CE} = 2.0 Vdc, I_C = 500 mAdc)	h_{FE}	200	350	—
Collector–Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base–Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	—	1.2	Vdc

1. 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.

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

NPN Silicon General Purpose Amplifier Transistor

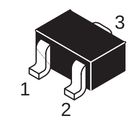
MSD1819A-RT1

Motorola Preferred Devices

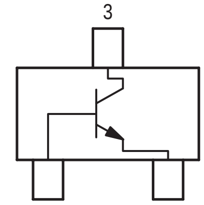
This NPN Silicon Epitaxial Planar Transistor is designed for general purpose amplifier applications. This device is housed in the SC-70/SOT-323 package which is designed for low power surface mount applications.

- High h_{FE}, 210 – 460
- Low $V_{CE(sat)}$, < 0.5 V
- Available in 8 mm, 7-inch/3000 Unit Tape and Reel

NPN GENERAL PURPOSE AMPLIFIER TRANSISTORS SURFACE MOUNT



CASE 419–02, STYLE 3
SC–70/SOT–323



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	60	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	50	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	7.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Collector Current — Peak	$I_{C(P)}$	200	mAdc

DEVICE MARKING

MSD1819A-RT1 = ZR

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation(1)	P_D	150	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	– 55 ~ + 150	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	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_E = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	0.1	μA
Collector-Emitter Cutoff Current (V_{CE} = 10 Vdc, I_B = 0)	I_{CEO}	—	100	μA
DC Current Gain(2)				—
(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)	h_{FE1}	210	340	
(V_{CE} = 2.0 Vdc, I_C = 100 mAdc)	h_{FE2}	90	—	
Collector-Emitter Saturation Voltage(2) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc

1. Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.
2. Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

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

REV 2

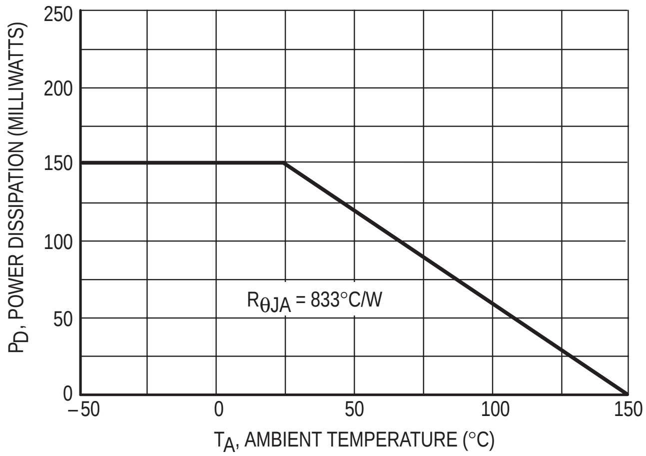


Figure 1. Derating Curve

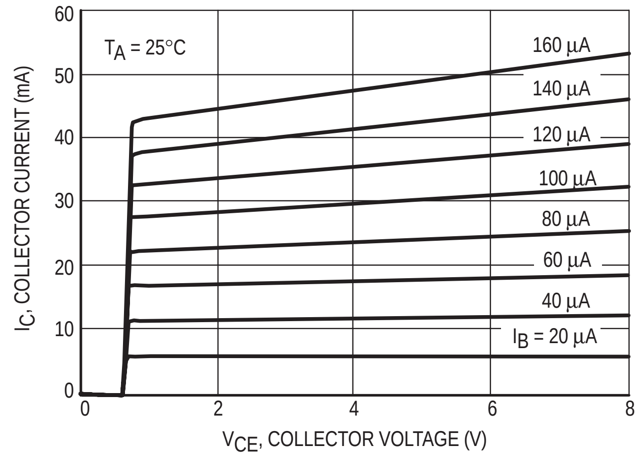


Figure 2. I_C – V_{CE}

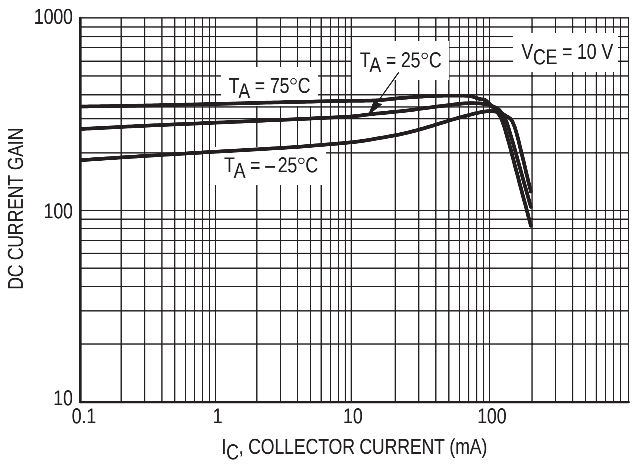


Figure 3. DC Current Gain

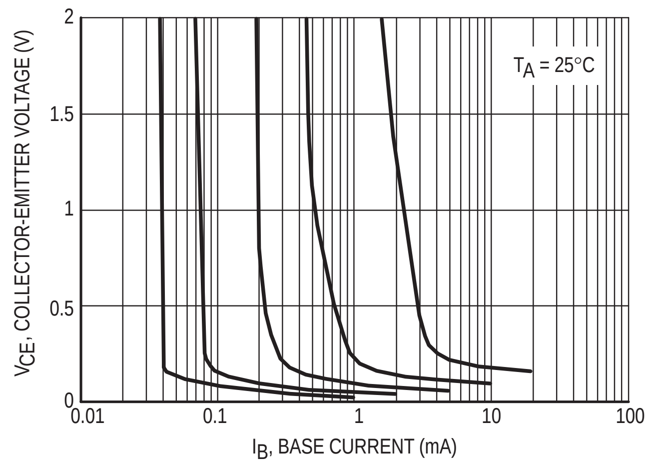


Figure 4. Collector Saturation Region

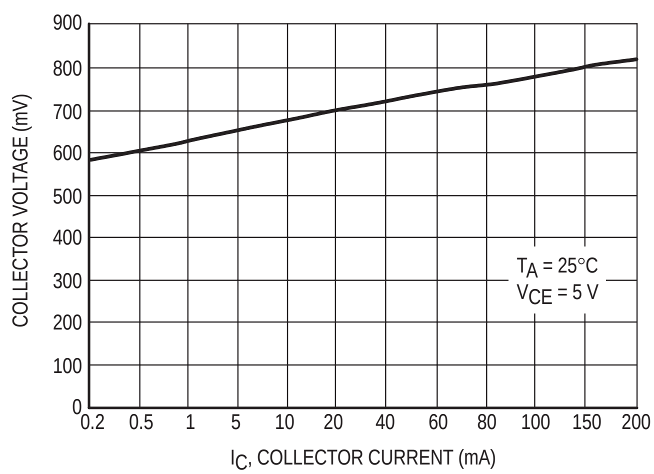


Figure 5. On Voltage

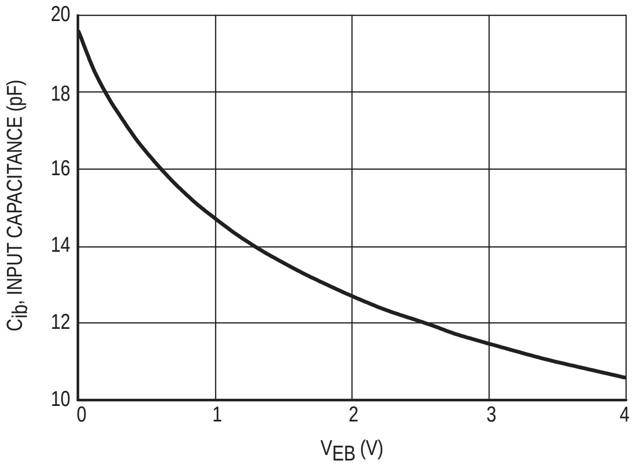


Figure 6. Capacitance

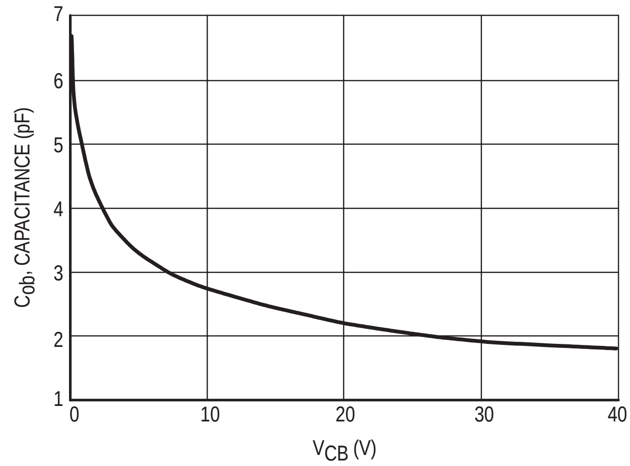


Figure 7. Capacitance

Bias Resistor Transistor

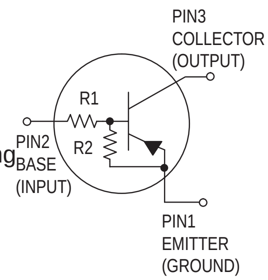
PNP Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

MUN2111T1 SERIES

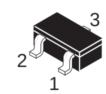
Motorola Preferred Devices

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(1) 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 10	°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
MUN2115T1(2)	6E	10	∞
MUN2116T1(2)	6F	4.7	∞
MUN2130T1(2)	6G	1.0	1.0
MUN2131T1(2)	6H	2.2	2.2
MUN2132T1(2)	6J	4.7	4.7
MUN2133T1(2)	6K	4.7	47
MUN2134T1(2)	6L	22	47

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.
2. New devices. Updated curves to follow in subsequent data sheets.

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

REV 5

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	MUN2111T1	I_{EBO}	—	—	0.5	mAdc
(V_{EB} = 6.0 V, I_C = 0)	MUN2112T1		—	—	0.2	
	MUN2113T1		—	—	0.1	
	MUN2114T1		—	—	0.2	
	MUN2115T1		—	—	0.9	
	MUN2116T1		—	—	1.9	
	MUN2130T1		—	—	4.3	
	MUN2131T1		—	—	2.3	
	MUN2132T1		—	—	1.5	
	MUN2133T1		—	—	0.18	
	MUN2134T1		—	—	0.13	
Collector–Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector–Emitter Breakdown Voltage(3) (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS(3)						
DC Current Gain	MUN2111T1	h_{FE}	35	60	—	
(V_{CE} = 10 V, I_C = 5.0 mA)	MUN2112T1		60	100	—	
	MUN2113T1		80	140	—	
	MUN2114T1		80	140	—	
	MUN2115T1		160	250	—	
	MUN2116T1		160	250	—	
	MUN2130T1		3.0	5.0	—	
	MUN2131T1		8.0	15	—	
	MUN2132T1		15	27	—	
	MUN2133T1		80	140	—	
	MUN2134T1		80	130	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mA, I_B = 0.3 mA)	MUN2111T1		—	—	0.25	
	MUN2112T1		—	—	0.25	
	MUN2113T1		—	—	0.25	
	MUN2114T1		—	—	0.25	
	MUN2115T1		—	—	0.25	
	MUN2130T1		—	—	0.25	
(I_C = 10 mA, I_B = 5.0 mA)	MUN2131T1		—	—	0.25	
(I_C = 10 mA, I_B = 1.0 mA)	MUN2116T1		—	—	0.25	
	MUN2132T1		—	—	0.25	
	MUN2134T1		—	—	0.25	
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	
	MUN2115T1		—	—	0.2	
	MUN2116T1		—	—	0.2	
	MUN2130T1		—	—	0.2	
	MUN2131T1		—	—	0.2	
	MUN2132T1		—	—	0.2	
	MUN2133T1		—	—	0.2	
	MUN2134T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MUN2113T1		—	—	0.2	

3. 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
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ) (V_{CC} = 5.0 V, V_B = 0.050 V, R_L = 1.0 kΩ) (V_{CC} = 5.0 V, V_B = 0.25 V, R_L = 1.0 kΩ)	 MUN2130T1 MUN2115T1 MUN2116T1 MUN2131T1 MUN2132T1	V_{OH}	4.9	—	—	Vdc
Input Resistor	MUN2111T1 MUN2112T1 MUN2113T1 MUN2114T1 MUN2115T1 MUN2116T1 MUN2130T1 MUN2131T1 MUN2132T1 MUN2133T1 MUN2134T1	R1	7.0 15.4 32.9 7.0 7.0 3.3 0.7 1.5 3.3 3.3 15.4	10 22 47 10 10 4.7 1.0 2.2 4.7 4.7 22	13 28.6 61.1 13 13 6.1 1.3 2.9 6.1 6.1 28.6	k Ω
Resistor Ratio	MUN2111T1/MUN2112T1/MUN2113T1 MUN2114T1 MUN2115T1/MUN2116T1 MUN2130T1/MUN2131T1/MUN2132T1 MUN2133T1 MUN2134T1	R_1/R_2	0.8 0.17 — 0.8 0.055 0.38	1.0 0.21 — 1.0 0.1 0.47	1.2 0.25 — 1.2 0.185 0.56	

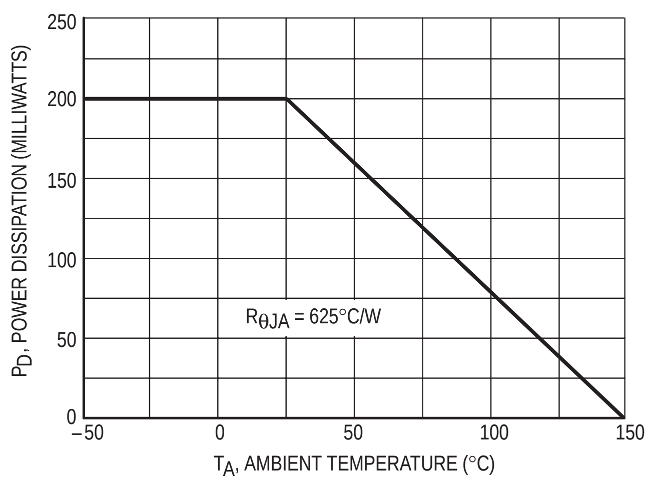


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2111T1

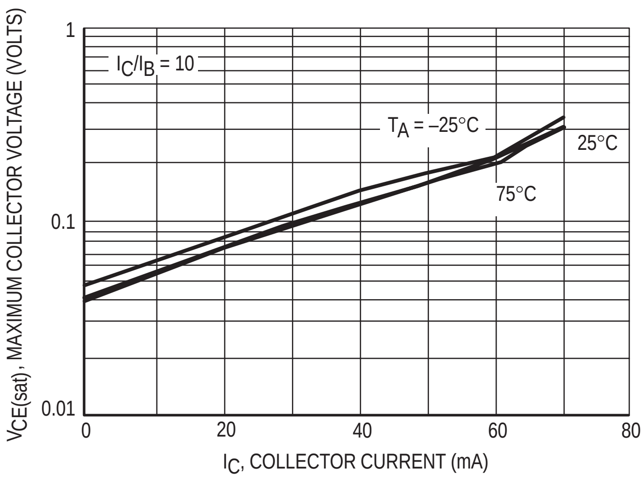


Figure 2. $V_{CE(sat)}$ versus I_C

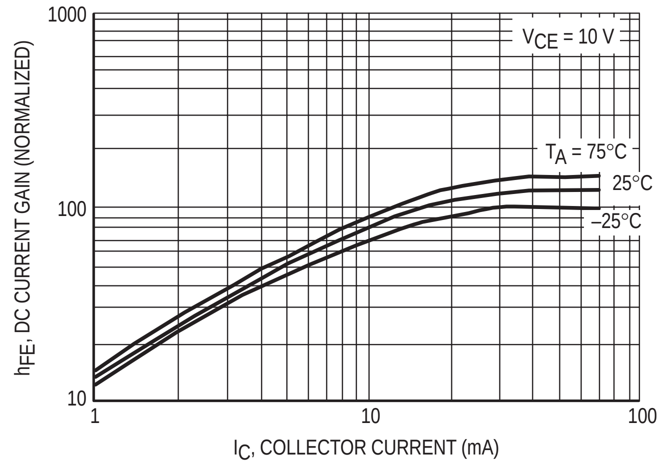


Figure 3. DC Current Gain

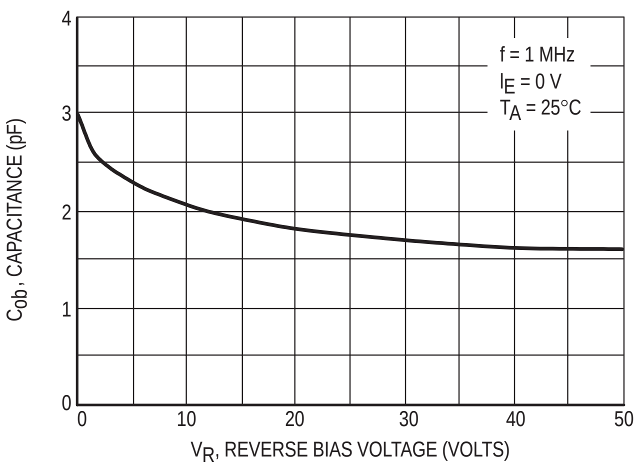


Figure 4. Output Capacitance

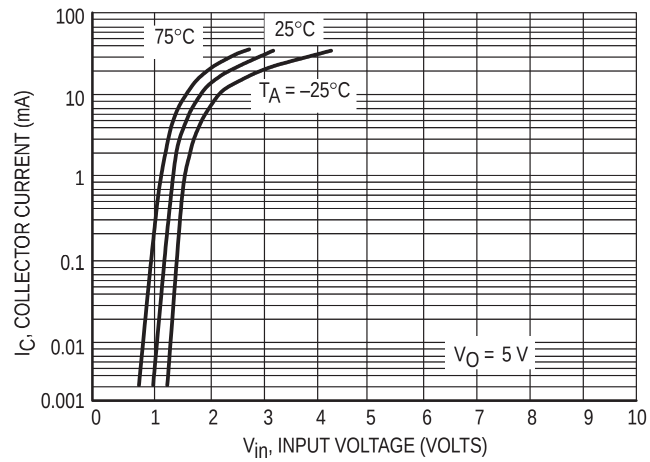


Figure 5. Output Current versus Input Voltage

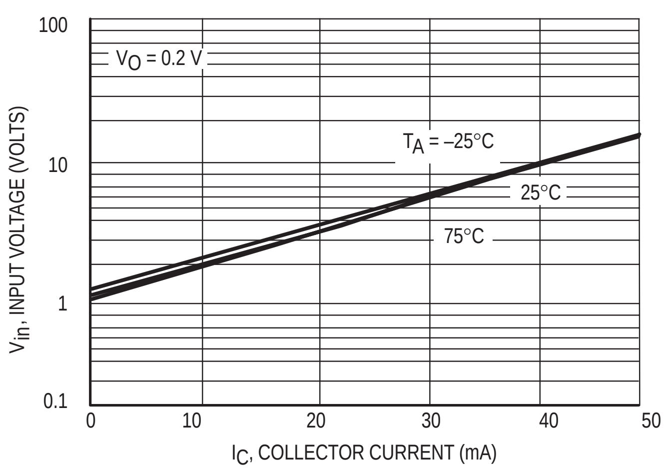


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2112T1

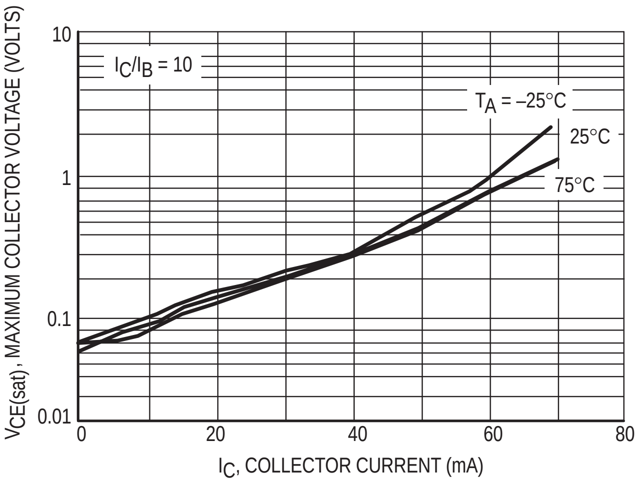


Figure 7. $V_{CE(sat)}$ versus I_C

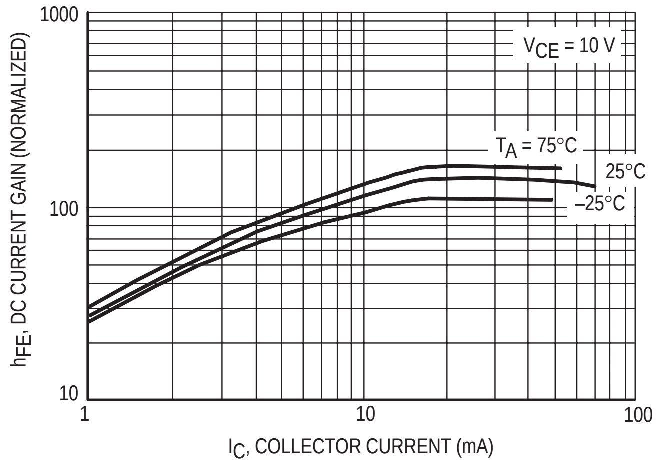


Figure 8. DC Current Gain

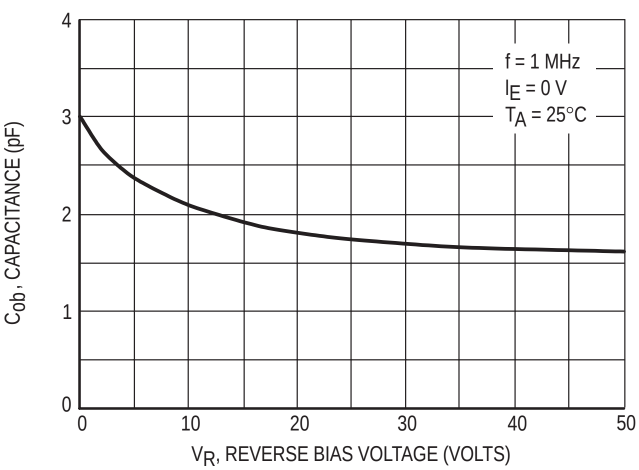


Figure 9. Output Capacitance

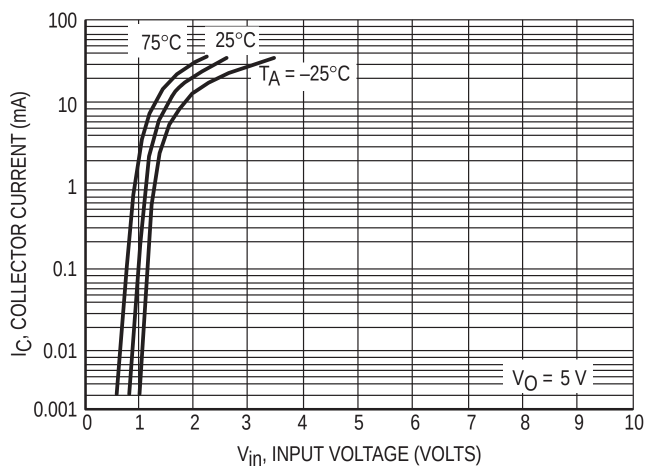


Figure 10. Output Current versus Input Voltage

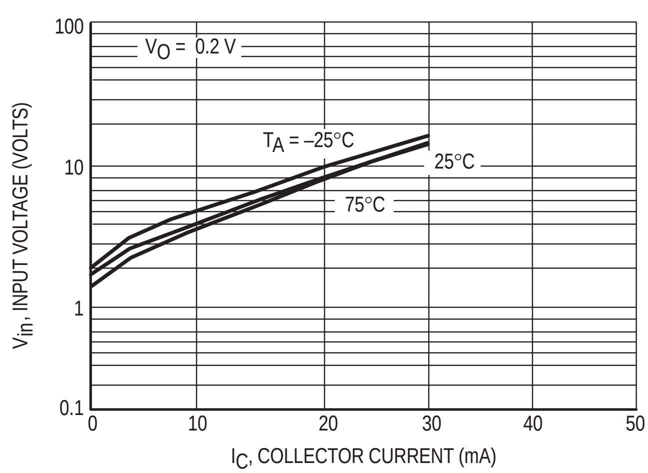


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2113T1

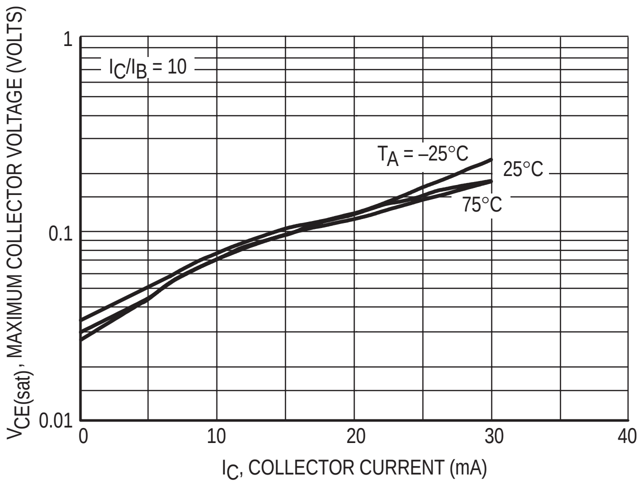


Figure 12. $V_{CE(sat)}$ versus I_C

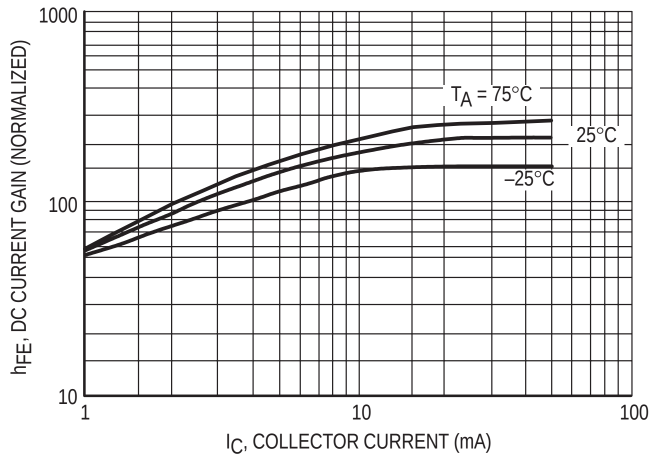


Figure 13. DC Current Gain

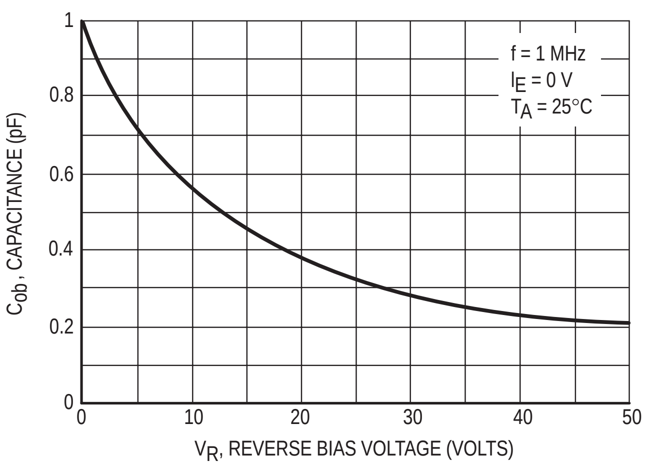


Figure 14. Output Capacitance

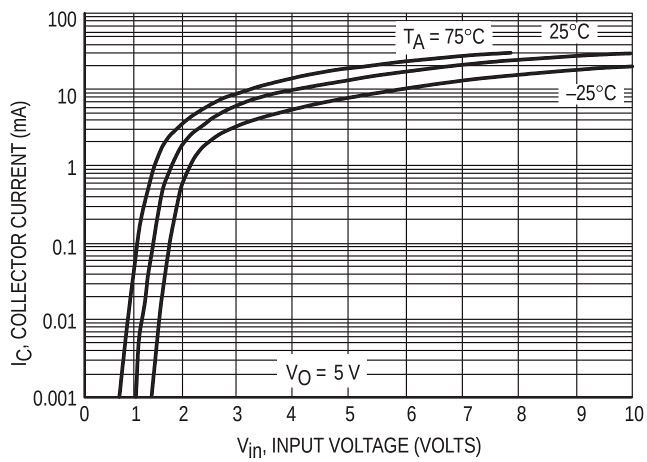


Figure 15. Output Current versus Input Voltage

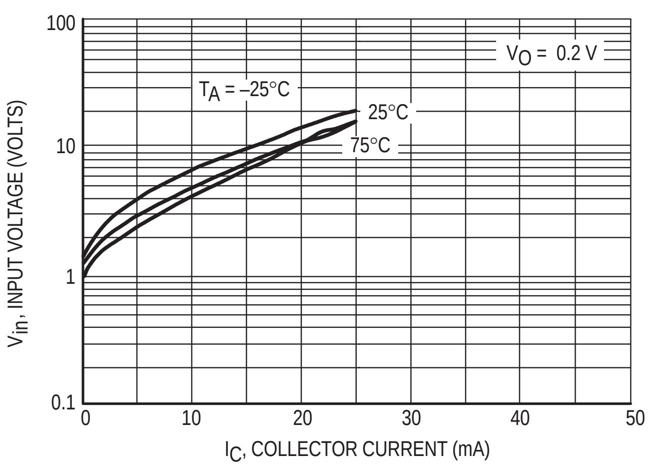


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2114T1

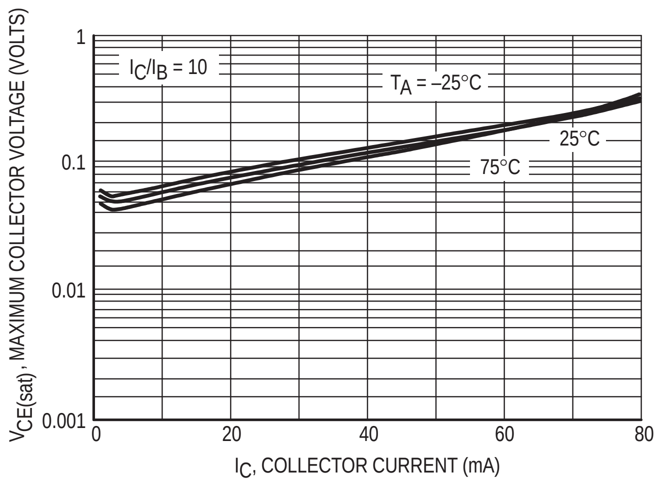


Figure 17. $V_{CE(sat)}$ versus I_C

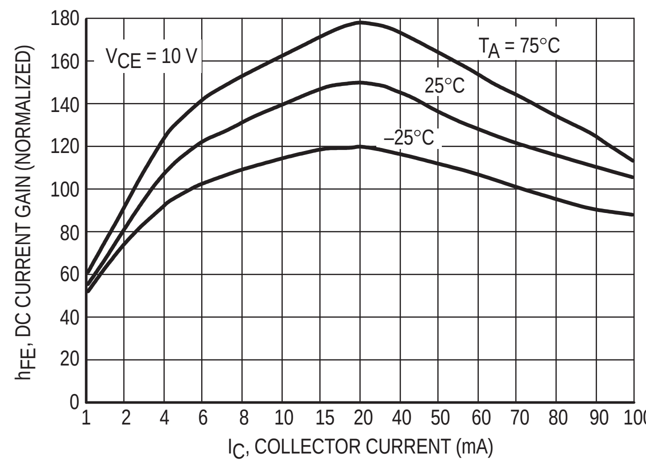


Figure 18. DC Current Gain

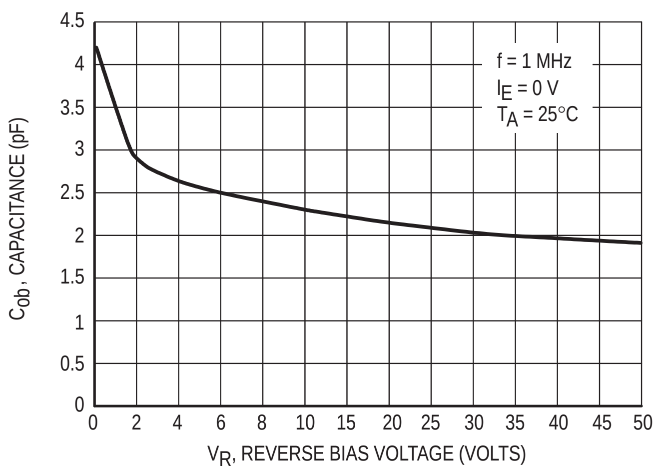


Figure 19. Output Capacitance

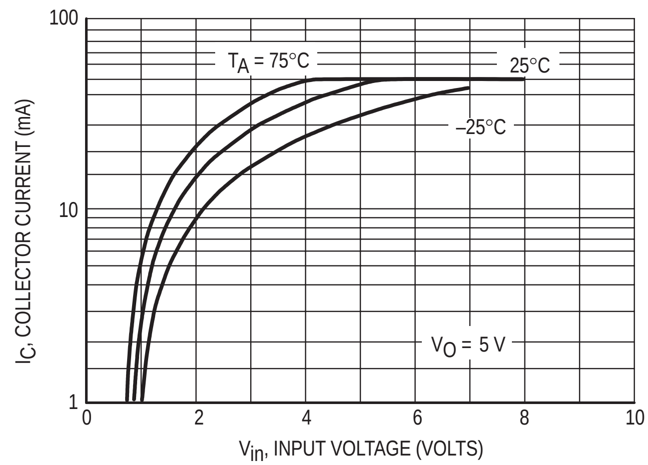


Figure 20. Output Current versus Input Voltage

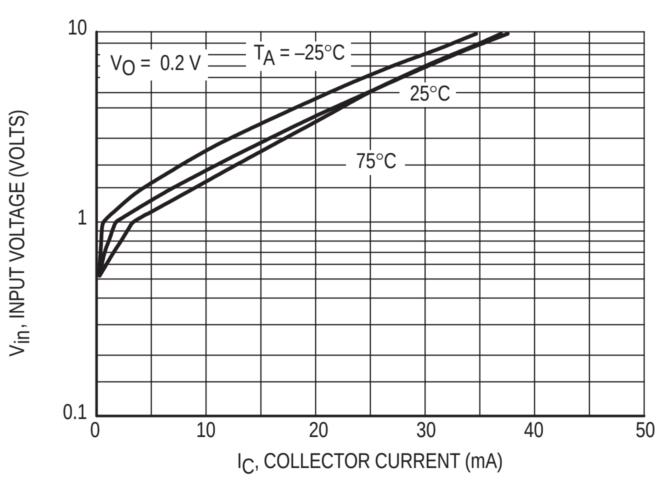


Figure 21. Input Voltage versus Output Current

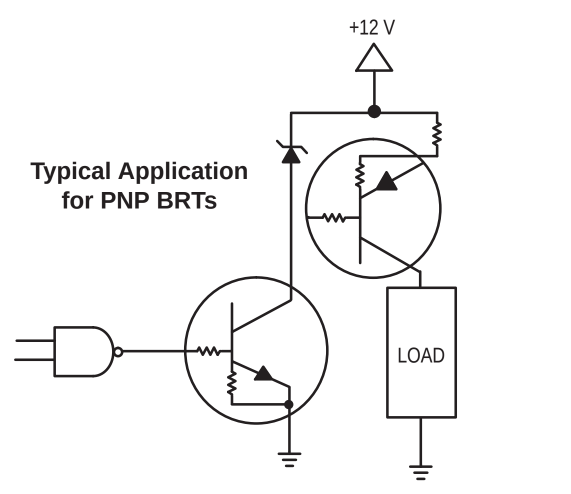


Figure 22. Inexpensive, Unregulated Current Source

Bias Resistor Transistor

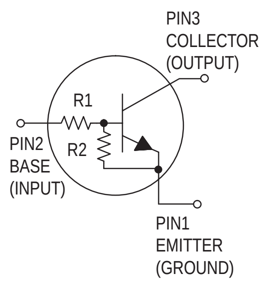
NPN Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

MUN2211T1 SERIES

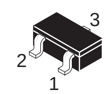
Motorola Preferred Devices

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.



**NPN 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(1) 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 10	°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
MUN2215T1(2)	8E	10	∞
MUN2216T1(2)	8F	4.7	∞
MUN2230T1(2)	8G	1.0	1.0
MUN2231T1(2)	8H	2.2	2.2
MUN2232T1(2)	8J	4.7	4.7
MUN2233T1(2)	8K	4.7	47
MUN2234T1(2)	8L	22	47

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.
2. New devices. Updated curves to follow in subsequent data sheets.

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

REV 4

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	MUN2211T1	I_{EBO}	—	—	0.5	mAdc
(V_{EB} = 6.0 V, I_C = 0)	MUN2212T1		—	—	0.2	
	MUN2213T1		—	—	0.1	
	MUN2214T1		—	—	0.2	
	MUN2215T1		—	—	0.9	
	MUN2216T1		—	—	1.9	
	MUN2230T1		—	—	4.3	
	MUN2231T1		—	—	2.3	
	MUN2232T1		—	—	1.5	
	MUN2233T1		—	—	0.18	
	MUN2234T1		—	—	0.13	
Collector–Base Breakdown Voltage (I_C = 10 µA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector–Emitter Breakdown Voltage(3) (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS(3)						
DC Current Gain	MUN2211T1	h_{FE}	35	60	—	
(V_{CE} = 10 V, I_C = 5.0 mA)	MUN2212T1		60	100	—	
	MUN2213T1		80	140	—	
	MUN2214T1		80	140	—	
	MUN2215T1		160	350	—	
	MUN2216T1		160	350	—	
	MUN2230T1		3.0	5.0	—	
	MUN2231T1		8.0	15	—	
	MUN2232T1		15	30	—	
	MUN2233T1		80	200	—	
	MUN2234T1		80	150	—	
Collector–Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA) (I_C = 10 mA, I_B = 5 mA) MUN2230T1/MUN2231T1 (I_C = 10 mA, I_B = 1 mA) MUN2215T1/MUN2216T1/ MUN2232T1/MUN2233T1/MUN2234T1		$V_{CE(sat)}$	—	—	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	
	MUN2215T1		—	—	0.2	Vdc
	MUN2216T1		—	—	0.2	
	MUN2230T1		—	—	0.2	
	MUN2231T1		—	—	0.2	
	MUN2232T1		—	—	0.2	
	MUN2233T1		—	—	0.2	
	MUN2234T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MUN2213T1		—	—	0.2	

3. 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
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
(V_{CC} = 5.0 V, V_B = 0.050 V, R_L = 1.0 kΩ)	MUN2230T1					
(V_{CC} = 5.0 V, V_B = 0.25 V, R_L = 1.0 kΩ)	MUN2215T1					
	MUN2216T1					
	MUN2233T1					
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	
	MUN2215T1		7.0	10	13	
	MUN2216T1		3.3	4.7	6.1	
	MUN2230T1		0.7	1.0	1.3	
	MUN2231T1		1.5	2.2	2.9	
	MUN2232T1		3.3	4.7	6.1	
	MUN2233T1		3.3	4.7	6.1	
	MUN2234T1		15.4	22	28.6	
Resistor Ratio	MUN2211T1/MUN2212T1/MUN2213T1	R1/R2	0.8	1.0	1.2	
	MUN2214T1		0.17	0.21	0.25	
	MUN2215T1/MUN2216T1		—	—	—	
	MUN2230T1/MUN2231T1/MUN2232T1		0.8	1.0	1.2	
	MUN2233T1		0.055	0.1	0.185	
	MUN2234T1		0.38	0.47	0.56	

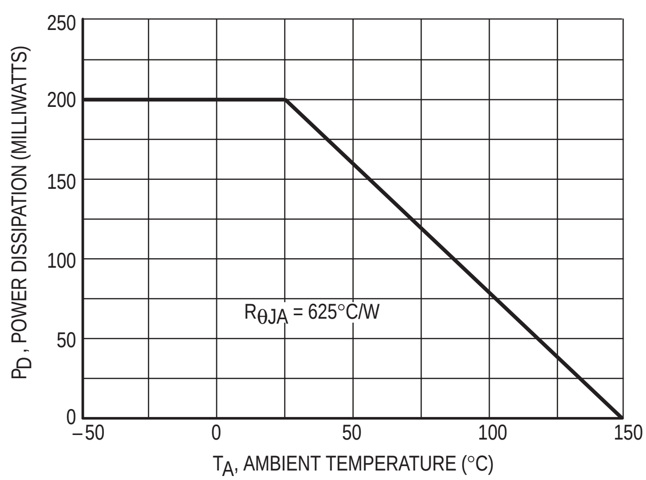


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2211T1

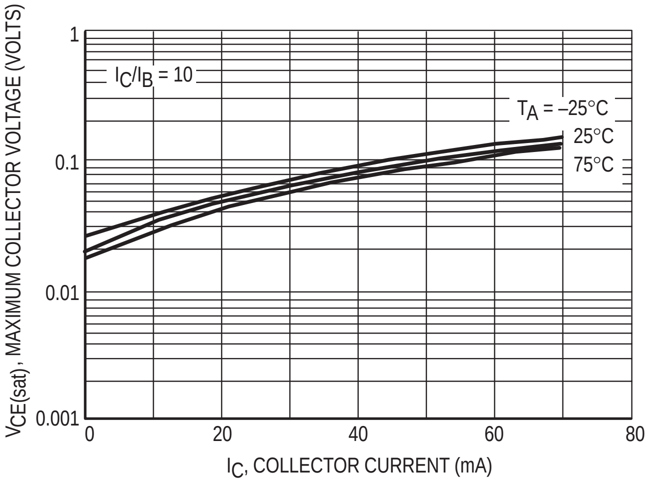


Figure 2. $V_{CE(sat)}$ versus I_C

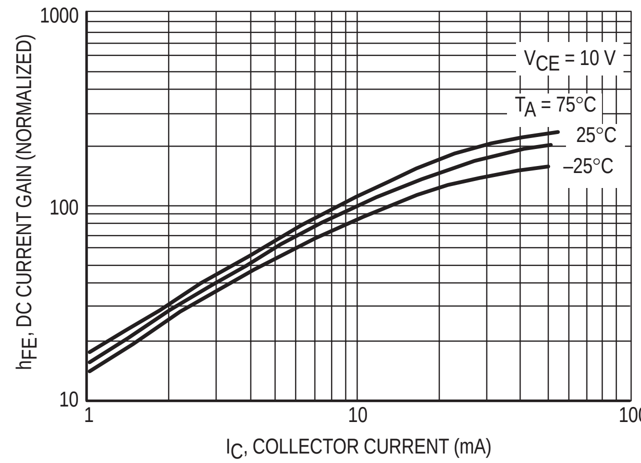


Figure 3. DC Current Gain

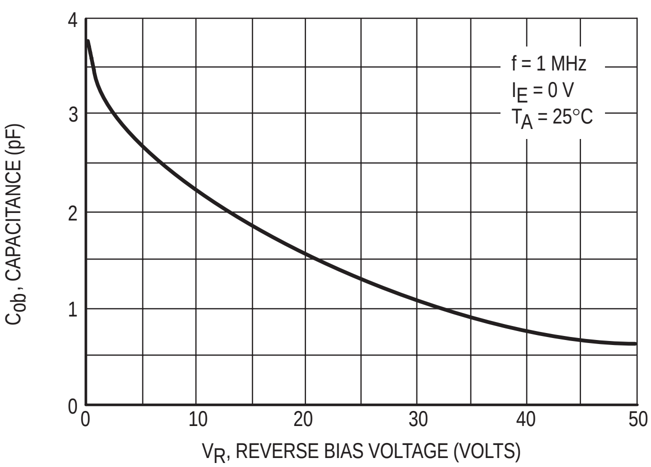


Figure 4. Output Capacitance

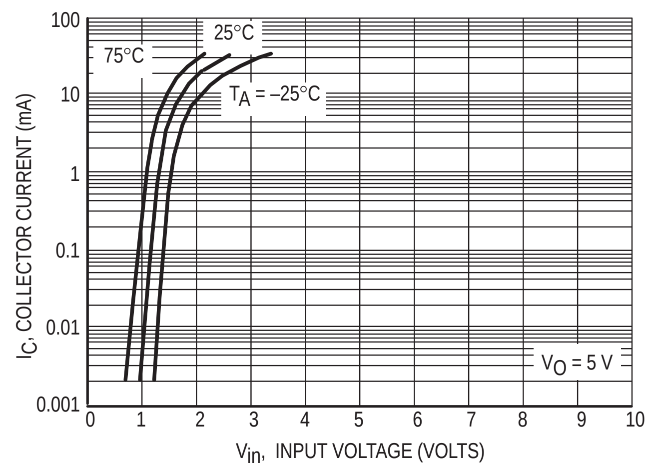


Figure 5. Output Current versus Input Voltage

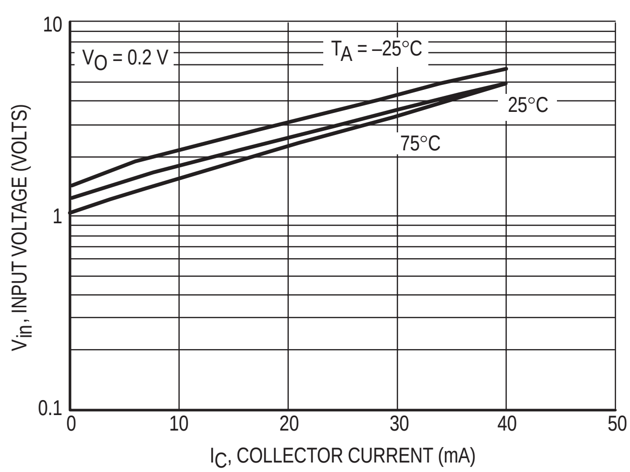


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2212T1

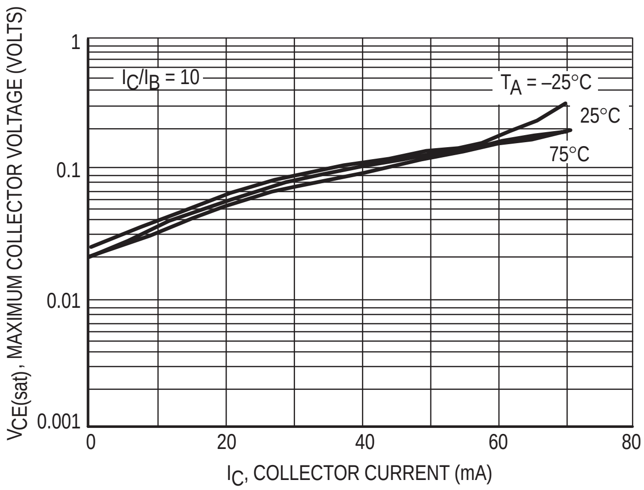


Figure 7. $V_{CE(sat)}$ versus I_C

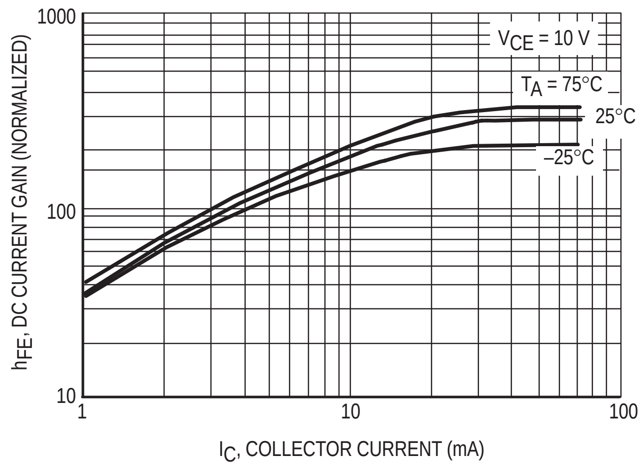


Figure 8. DC Current Gain

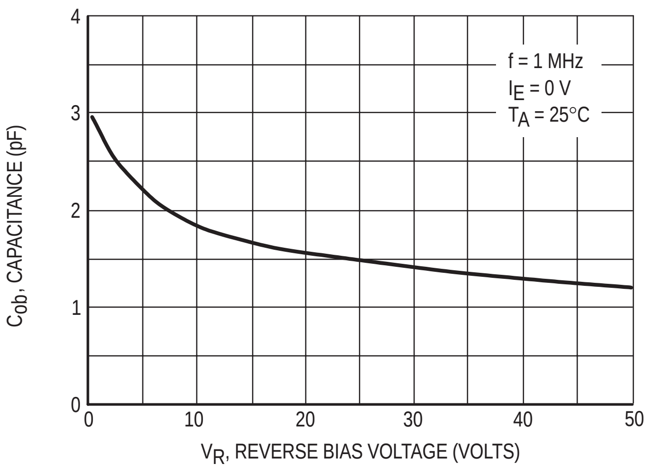


Figure 9. Output Capacitance

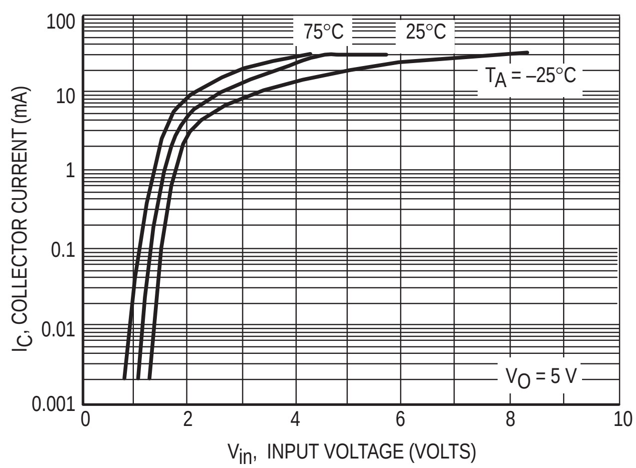


Figure 10. Output Current versus Input Voltage

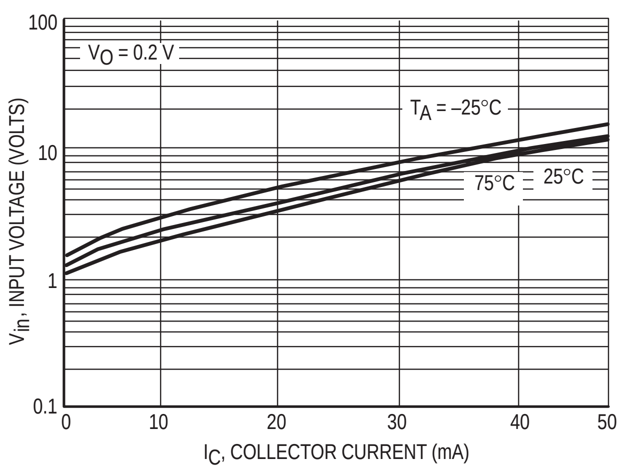


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2213T1

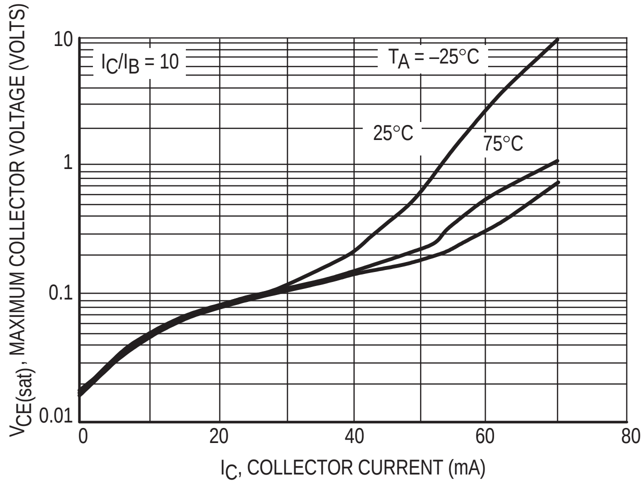


Figure 12. $V_{CE(sat)}$ versus I_C

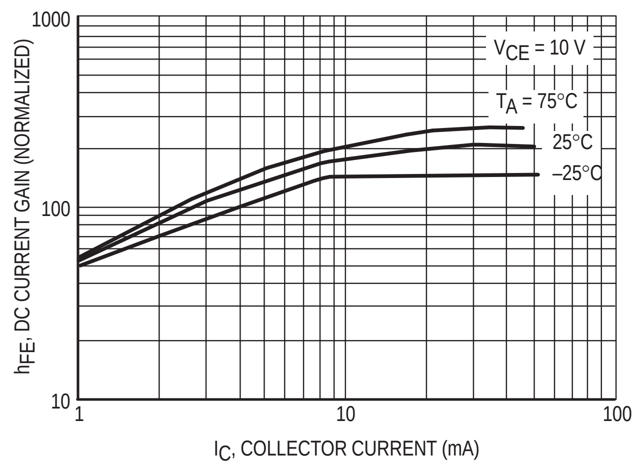


Figure 13. DC Current Gain

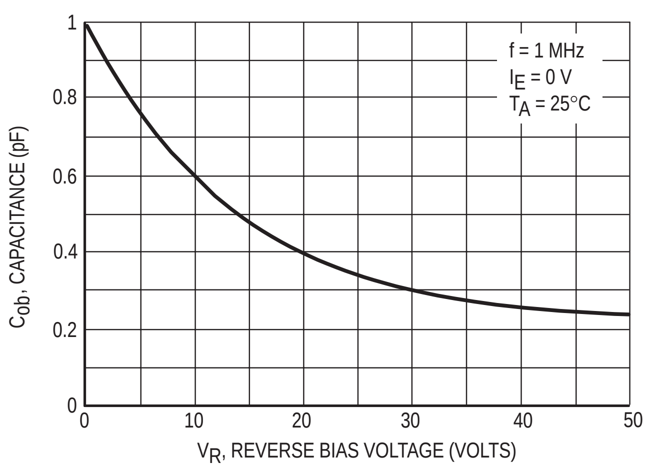


Figure 14. Output Capacitance

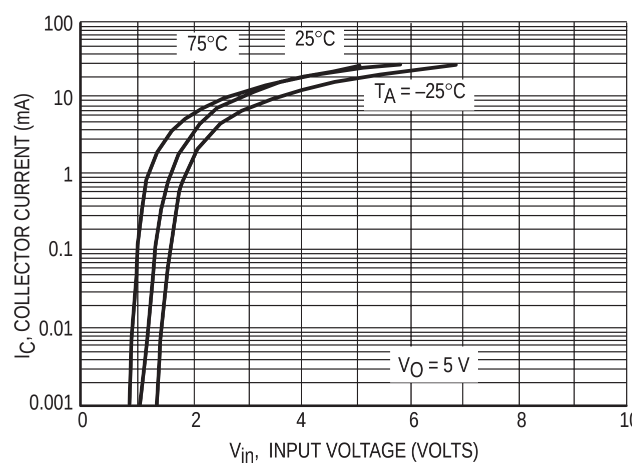


Figure 15. Output Current versus Input Voltage

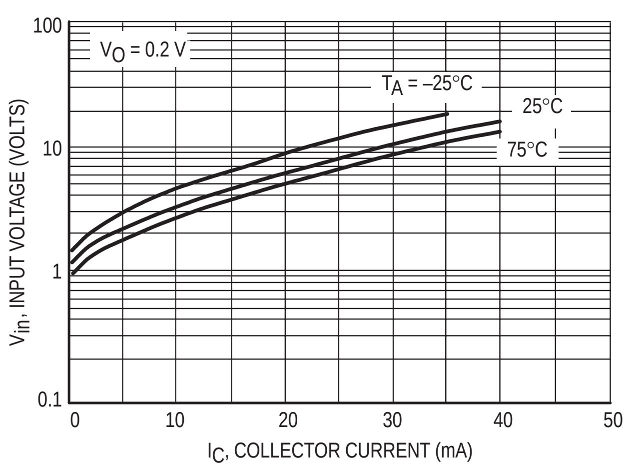


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2214T1

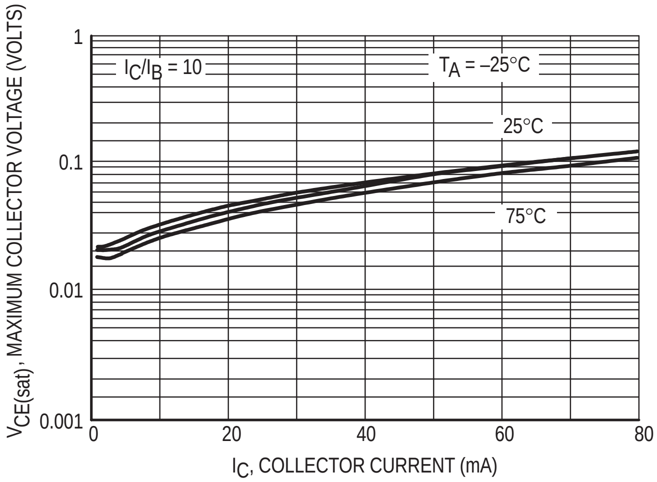


Figure 17. $V_{CE(sat)}$ versus I_C

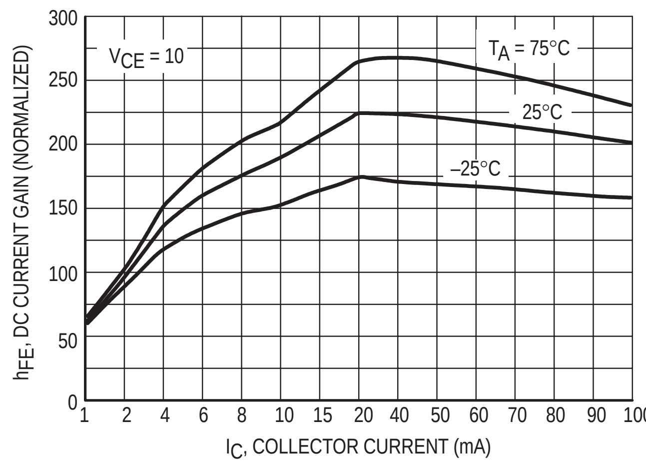


Figure 18. DC Current Gain

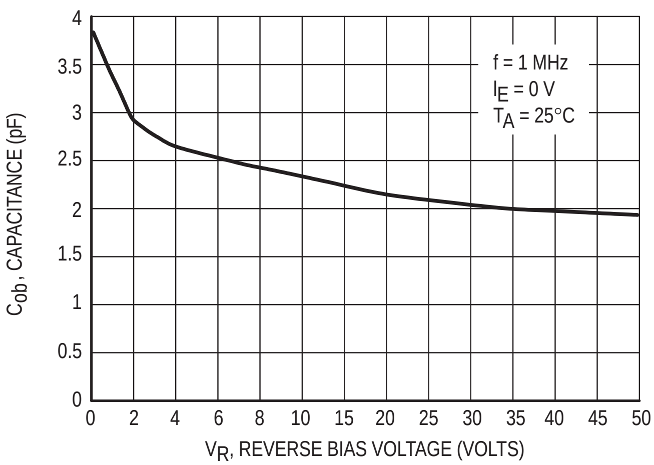


Figure 19. Output Capacitance

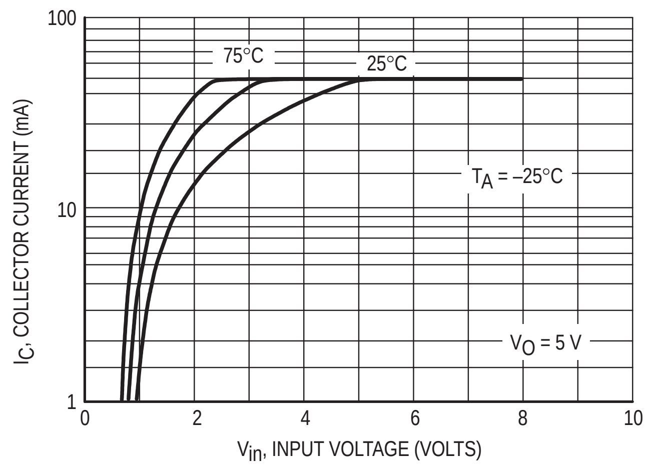


Figure 20. Output Current versus Input Voltage

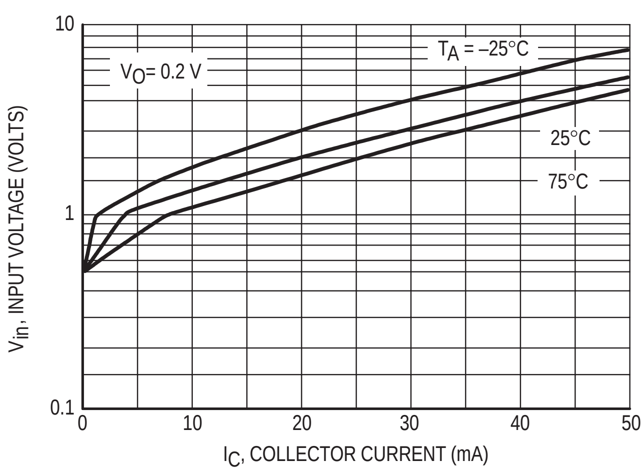


Figure 21. Input Voltage versus Output Current

TYPICAL APPLICATIONS FOR NPN BRTs

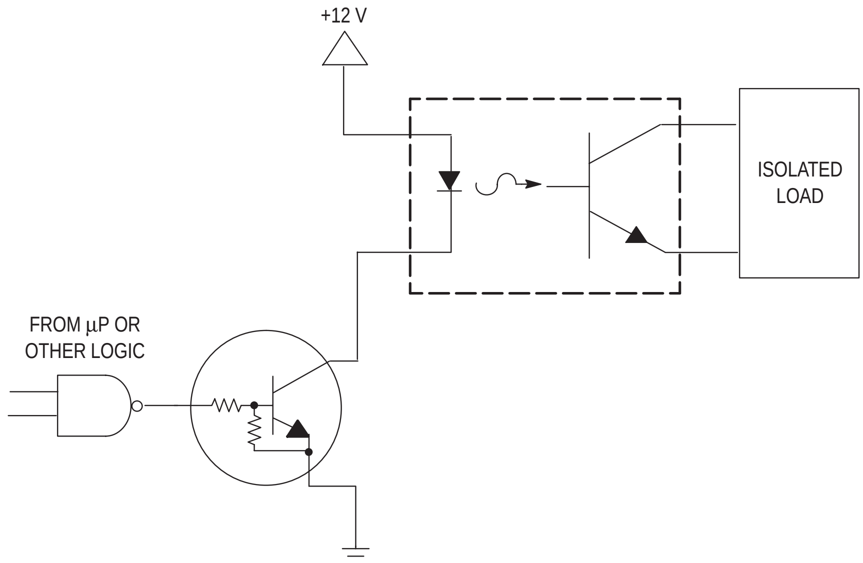


Figure 22. Level Shifter: Connects 12 or 24 Volt Circuits to Logic

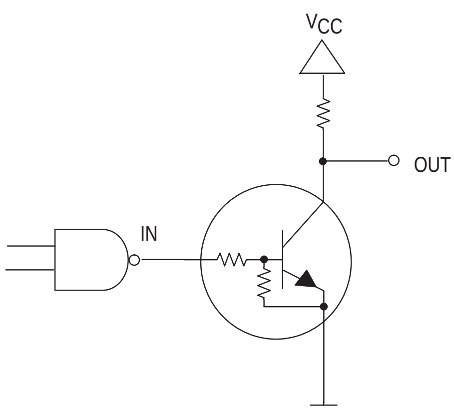


Figure 23. Open Collector Inverter: Inverts the Input Signal

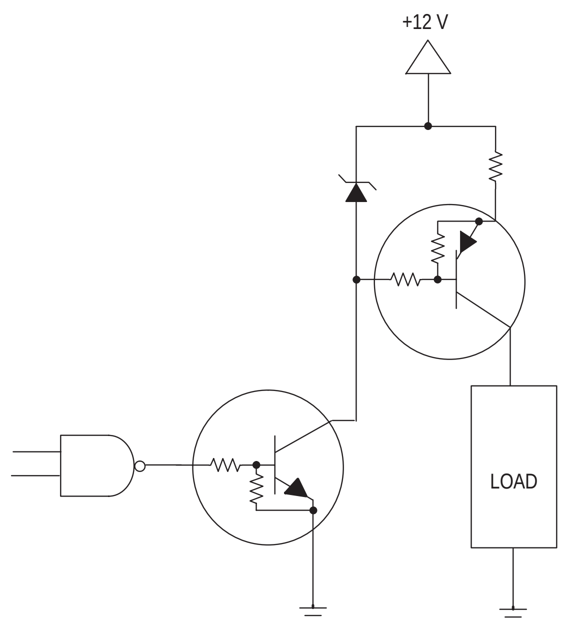
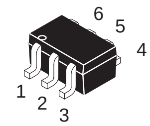


Figure 24. Inexpensive, Unregulated Current Source

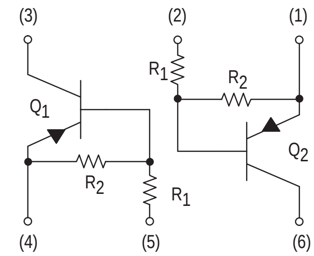
Dual Bias Resistor Transistors
PNP Silicon Surface Mount Transistors with Monolithic Bias Resistor Network

MUN5111DW1T1 SERIES

Motorola Preferred Devices



CASE 419B–01, STYLE 1
SOT–363



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. These digital transistors are designed to replace a single device and its external resistor bias network. The BRT eliminates these individual components by integrating them into a single device. In the MUN5111DW1T1 series, two BRT devices are housed in the SOT–363 package which is ideal for low–power surface mount applications where board space is at a premium.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Available in 8 mm, 7 inch/3000 Unit Tape and Reel.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted, common for Q_1 and Q_2)

Rating	Symbol	Value	Unit
Collector–Base Voltage	V_{CBO}	–50	Vdc
Collector–Emitter Voltage	V_{CEO}	–50	Vdc
Collector Current	I_C	–100	mAdc

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
Total Package Dissipation @ T_A = 25°C(1)	P_D	150	mW

DEVICE MARKING AND RESISTOR VALUES: MUN5111DW1T1 SERIES

Device	Marking	R1 (K)	R2 (K)
MUN5111DW1T1	0A	10	10
MUN5112DW1T1	0B	22	22
MUN5113DW1T1	0C	47	47
MUN5114DW1T1	0D	10	47
MUN5115DW1T1(2)	0E	10	∞
MUN5116DW1T1(2)	0F	4.7	∞
MUN5130DW1T1(2)	0G	1.0	1.0
MUN5131DW1T1(2)	0H	2.2	2.2
MUN5132DW1T1(2)	0J	4.7	4.7
MUN5133DW1T1(2)	0K	4.7	47
MUN5134DW1T1(2)	0L	22	47
MUN5135DW1T1(2)	0M	2.2	47

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.
2. New resistor combinations. Updated curves to follow in subsequent data sheets.

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

REV 2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, common for Q_1 and Q_2)

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)	MUN5111DW1T1	I_{EBO}	—	—	–0.5	mAdc
	MUN5112DW1T1		—	—	–0.2	
	MUN5113DW1T1		—	—	–0.1	
	MUN5114DW1T1		—	—	–0.2	
	MUN5115DW1T1		—	—	–0.9	
	MUN5116DW1T1		—	—	–1.9	
	MUN5130DW1T1		—	—	–4.3	
	MUN5131DW1T1		—	—	–2.3	
	MUN5132DW1T1		—	—	–1.5	
	MUN5133DW1T1		—	—	–0.18	
	MUN5134DW1T1		—	—	–0.13	
	MUN5135DW1T1		—	—	–0.2	
Collector–Base Breakdown Voltage (I_C = –10 µA, I_E = 0)		$V_{(BR)CBO}$	–50	—	—	Vdc
Collector–Emitter Breakdown Voltage(3) (I_C = –2.0 mA, I_B = 0)		$V_{(BR)CEO}$	–50	—	—	Vdc
ON CHARACTERISTICS(3)						
DC Current Gain (V_{CE} = –10 V, I_C = –5.0 mA)	MUN5111DW1T1	h_{FE}	35	60	—	
	MUN5112DW1T1		60	100	—	
	MUN5113DW1T1		80	140	—	
	MUN5114DW1T1		80	140	—	
	MUN5115DW1T1		160	250	—	
	MUN5116DW1T1		160	250	—	
	MUN5130DW1T1		3.0	5.0	—	
	MUN5131DW1T1		8.0	15	—	
	MUN5132DW1T1		15	27	—	
	MUN5133DW1T1		80	140	—	
	MUN5134DW1T1		80	130	—	
	MUN5135DW1T1		80	140	—	
Collector–Emitter Saturation Voltage (I_C = –10 mA, I_E = –0.3 mA) (I_C = –10 mA, I_B = –5 mA) MUN5130DW1T1/MUN5131DW1T1 (I_C = –10 mA, I_B = –1 mA) MUN5115DW1T1/MUN5116DW1T1/ MUN5132DW1T1/MUN5133DW1T1/MUN5134DW1T1		$V_{CE(sat)}$	—	—	–0.25	Vdc
Output Voltage (on)		V_{OL}				Vdc
(V_{CC} = –5.0 V, V_B = –2.5 V, R_L = 1.0 kΩ)	MUN5111DW1T1		—	—	–0.2	
	MUN5112DW1T1		—	—	–0.2	
	MUN5114DW1T1		—	—	–0.2	
	MUN5115DW1T1		—	—	–0.2	
	MUN5116DW1T1		—	—	–0.2	
	MUN5130DW1T1		—	—	–0.2	
	MUN5131DW1T1		—	—	–0.2	
	MUN5132DW1T1		—	—	–0.2	
	MUN5133DW1T1		—	—	–0.2	
	MUN5134DW1T1		—	—	–0.2	
	MUN5135DW1T1		—	—	–0.2	
(V_{CC} = –5.0 V, V_B = –3.5 V, R_L = 1.0 kΩ)	MUN5113DW1T1		—	—	–0.2	

3. Pulse Test: Pulse Width < 300 µs, Duty Cycle < 2.0%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, common for Q_1 and Q_2) (Continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Voltage (off) (V_{CC} = –5.0 V, V_B = –0.5 V, R_L = 1.0 kΩ)		V_{OH}	–4.9	—	—	Vdc
(V_{CC} = –5.0 V, V_B = –0.050 V, R_L = 1.0 kΩ)	MUN5130DW1T1					
(V_{CC} = –5.0 V, V_B = –0.25 V, R_L = 1.0 kΩ)	MUN5115DW1T1					
	MUN5116DW1T1					
	MUN5131DW1T1					
	MUN5132DW1T1					
Input Resistor	MUN5111DW1T1	R1	7.0	10	13	kΩ
	MUN5112DW1T1		15.4	22	28.6	
	MUN5113DW1T1		32.9	47	61.1	
	MUN5114DW1T1		7.0	10	13	
	MUN5115DW1T1		7.0	10	13	
	MUN5116DW1T1		3.3	4.7	6.1	
	MUN5130DW1T1		0.7	1.0	1.3	
	MUN5131DW1T1		1.5	2.2	2.9	
	MUN5132DW1T1		3.3	4.7	6.1	
	MUN5133DW1T1		3.3	4.7	6.1	
	MUN5134DW1T1		15.4	22	28.6	
	MUN5135DW1T1		1.54	2.2	2.86	
Resistor Ratio	MUN5111DW1T1/MUN5112DW1T1/MUN5113DW1T1	R_1/R_2	0.8	1.0	1.2	
	MUN5114DW1T1		0.17	0.21	0.25	
	MUN5115DW1T1/MUN5116DW1T1		—	—	—	
	MUN5130DW1T1/MUN5131DW1T1/MUN5132DW1T1		0.8	1.0	1.2	
	MUN5133DW1T1		0.055	0.1	0.185	
	MUN5134DW1T1		0.38	0.47	0.56	
	MUN5135DW1T1		0.038	0.047	0.056	

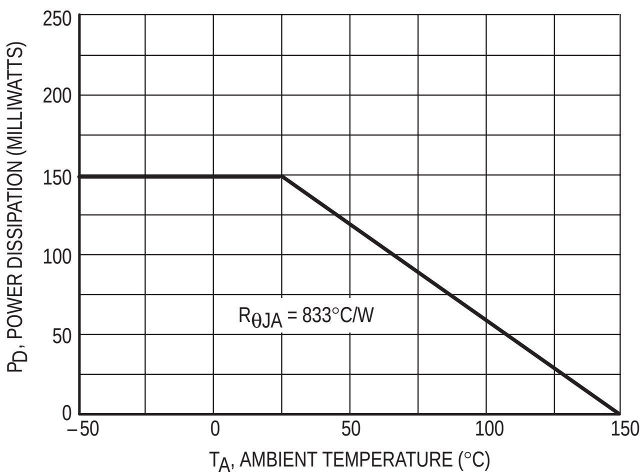


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5111DW1T1

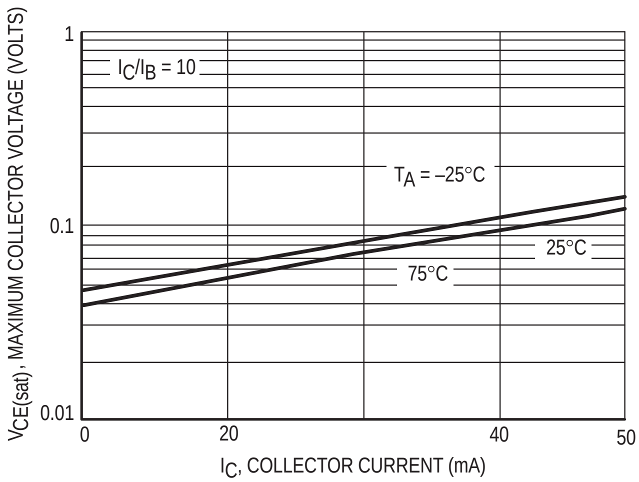


Figure 2. $V_{CE(sat)}$ versus I_C

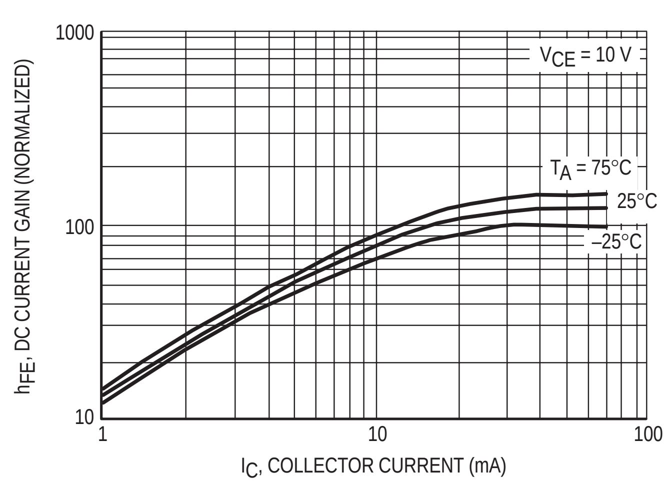


Figure 3. DC Current Gain

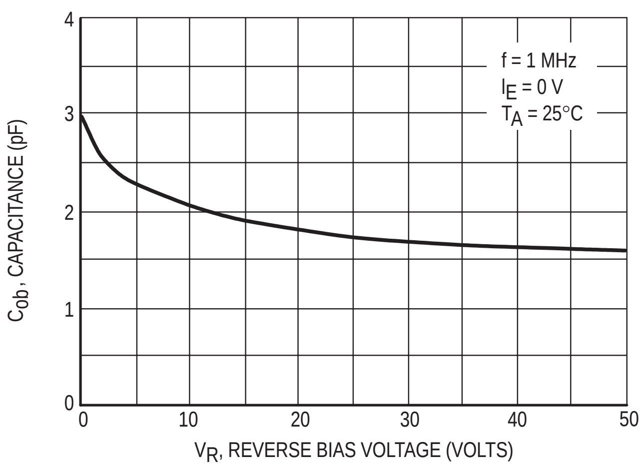


Figure 4. Output Capacitance

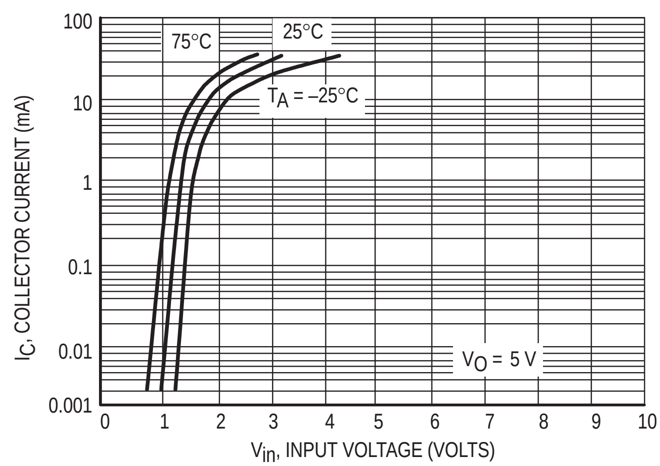


Figure 5. Output Current versus Input Voltage

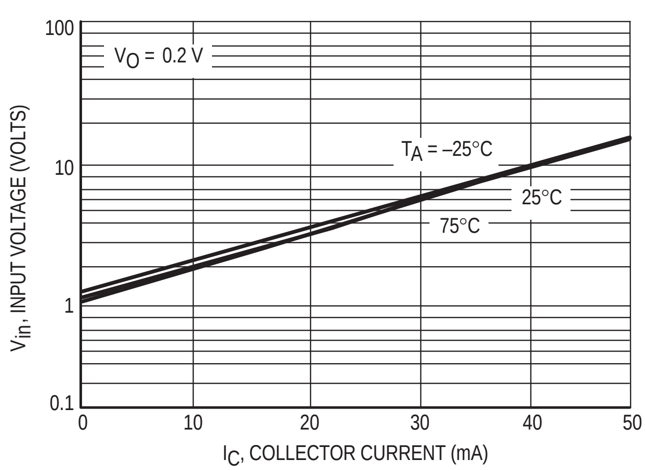


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5112DW1T1

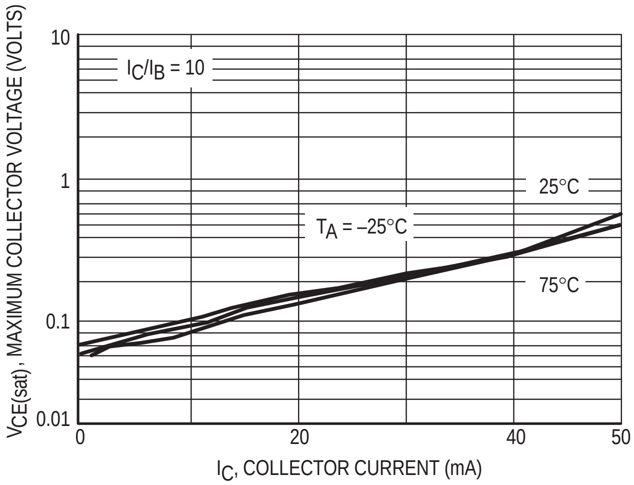


Figure 7. $V_{CE(sat)}$ versus I_C

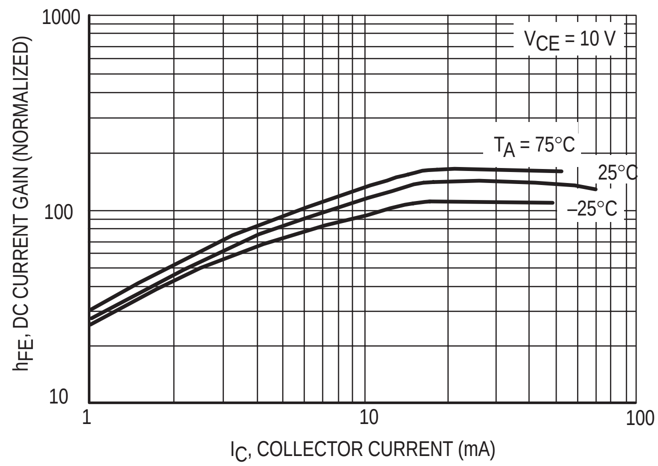


Figure 8. DC Current Gain

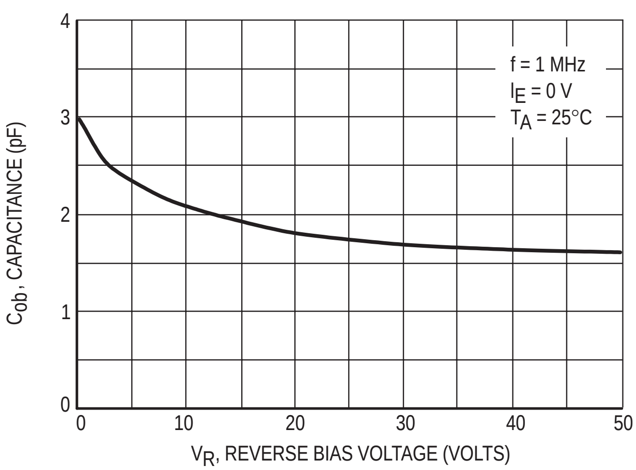


Figure 9. Output Capacitance

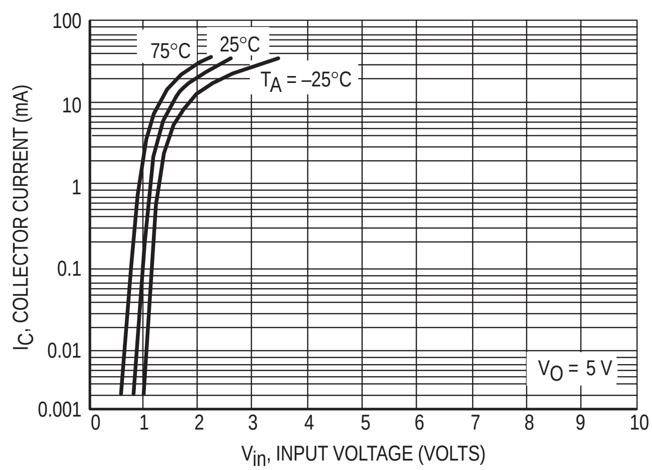


Figure 10. Output Current versus Input Voltage

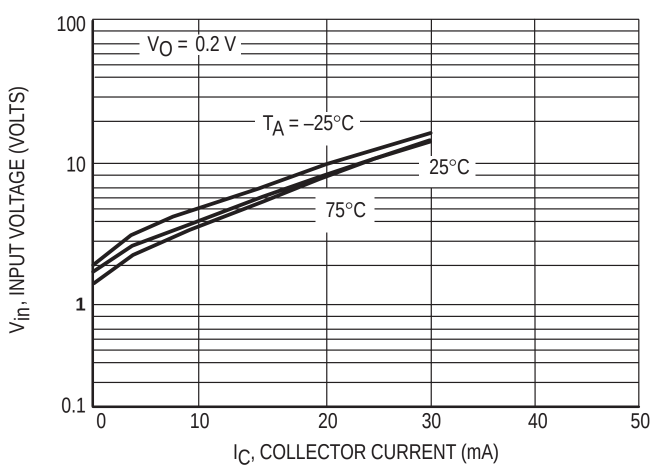


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5113DW1T1

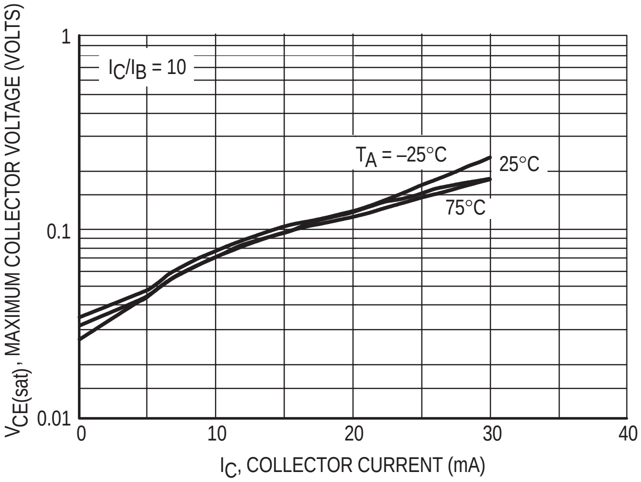


Figure 12. $V_{CE(sat)}$ versus I_C

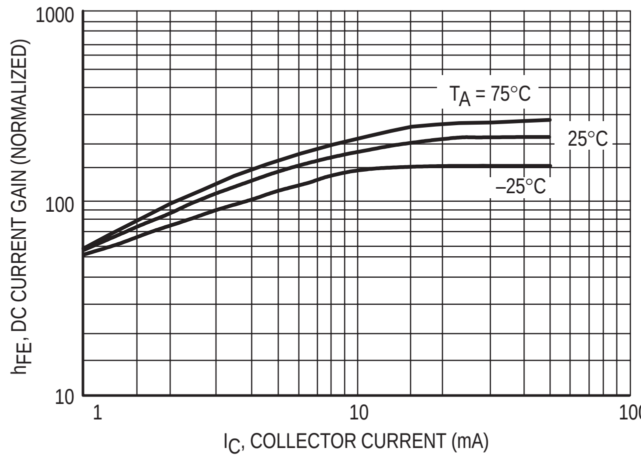


Figure 13. DC Current Gain

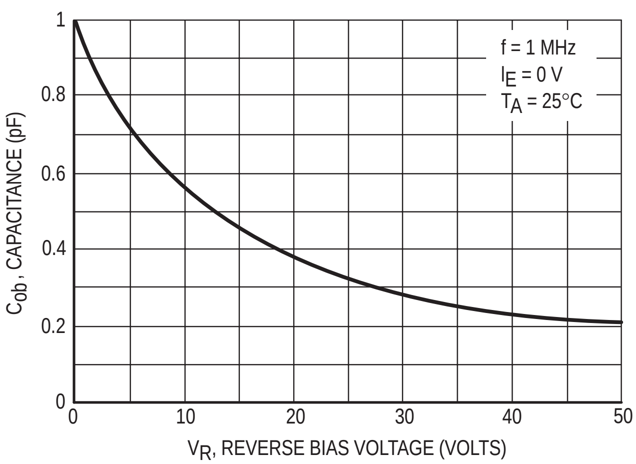


Figure 14. Output Capacitance

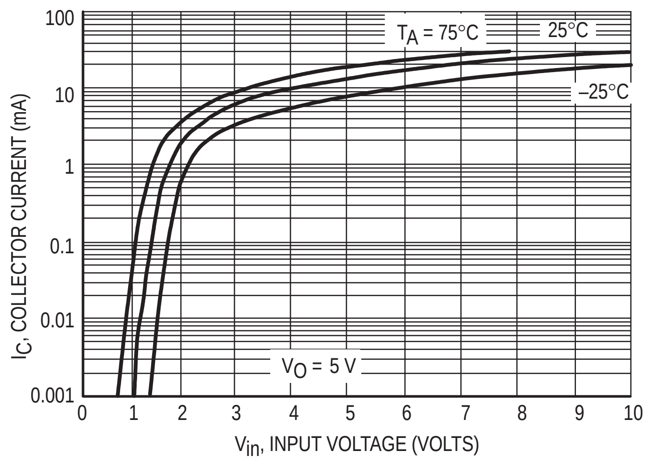


Figure 15. Output Current versus Input Voltage

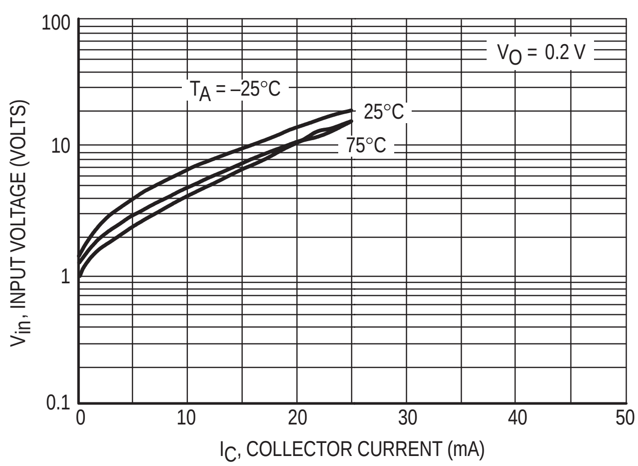


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5114DW1T1

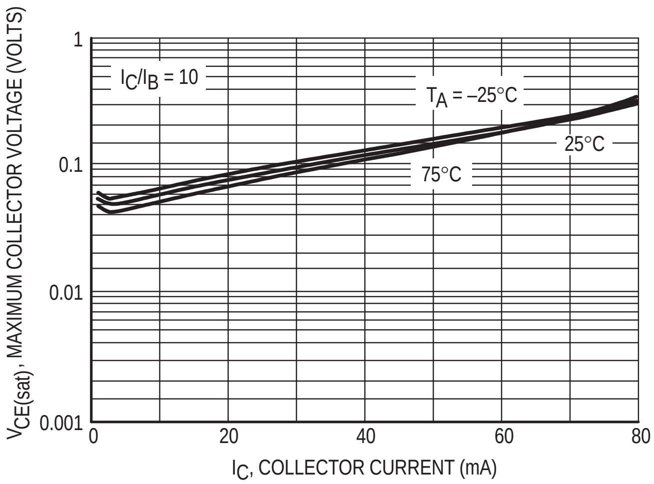


Figure 17. $V_{CE(sat)}$ versus I_C

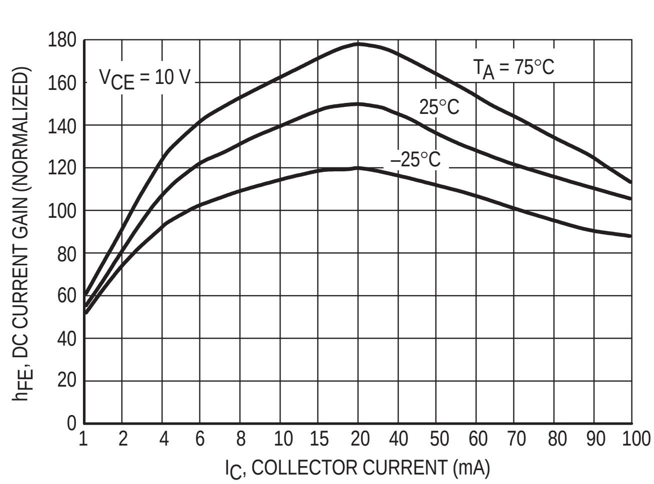


Figure 18. DC Current Gain

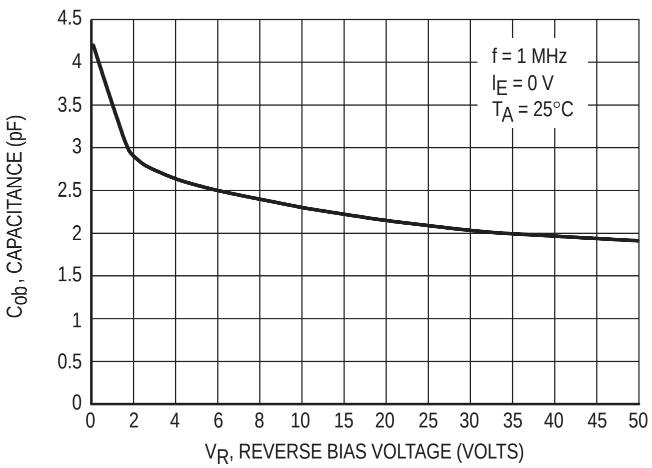


Figure 19. Output Capacitance

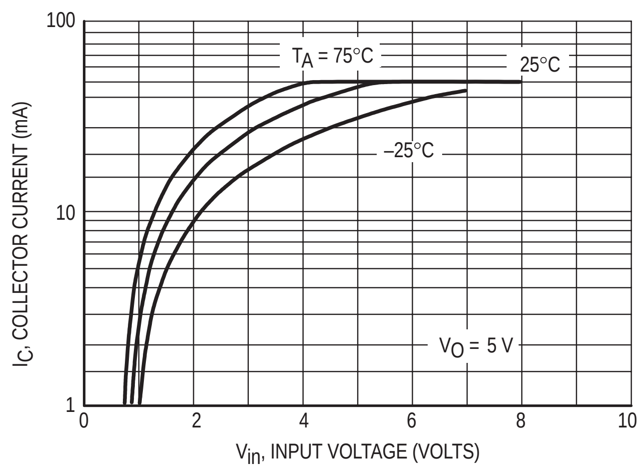


Figure 20. Output Current versus Input Voltage

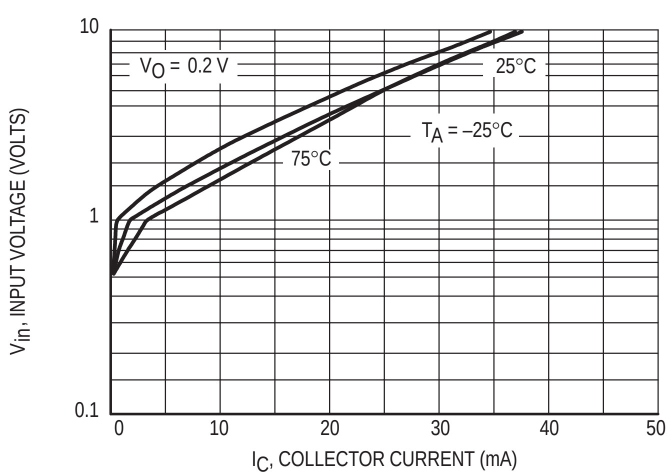


Figure 21. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5115DW1T1

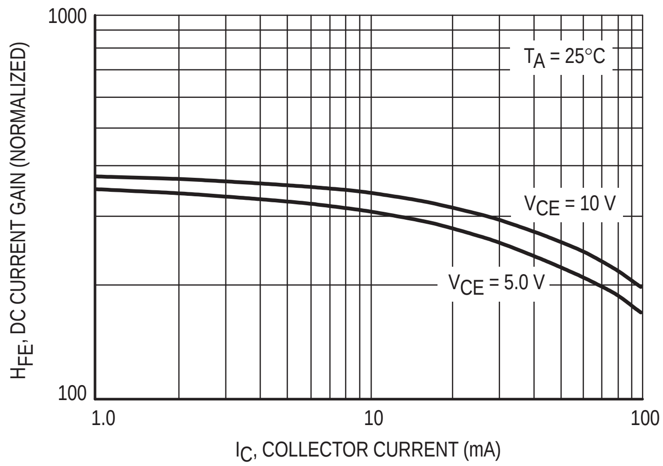


Figure 22. DC Current Gain

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5116DW1T1

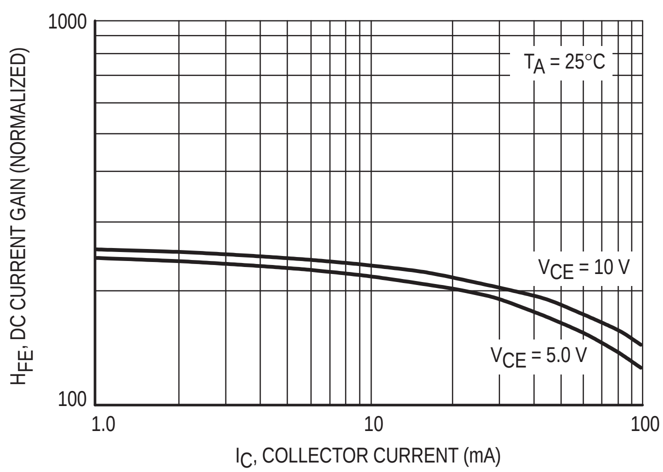


Figure 23. DC Current Gain

Bias Resistor Transistor

PNP Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

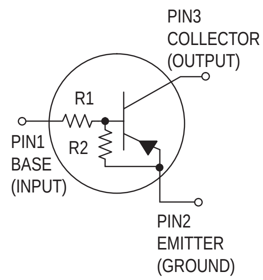
MUN5111T1 SERIES

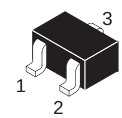
Motorola Preferred Devices

PNP SILICON BIAS RESISTOR TRANSISTOR

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	100	mAdc
Total Power Dissipation @ T_A = 25°C(1) 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 10	°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
MUN5115T1(2)	6E	10	∞
MUN5116T1(2)	6F	4.7	∞
MUN5130T1(2)	6G	1.0	1.0
MUN5131T1(2)	6H	2.2	2.2
MUN5132T1(2)	6J	4.7	4.7
MUN5133T1(2)	6K	4.7	47
MUN5134T1(2)	6L	22	47

1. Device mounted on a FR–4 glass epoxy printed circuit board using the minimum recommended footprint.
2. New devices. Updated curves to follow in subsequent data sheets.

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

REV 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)	MUN5111T1	I_{EBO}	—	—	0.5	mAdc
	MUN5112T1		—	—	0.2	
	MUN5113T1		—	—	0.1	
	MUN5114T1		—	—	0.2	
	MUN5115T1		—	—	0.9	
	MUN5116T1		—	—	1.9	
	MUN5130T1		—	—	4.3	
	MUN5131T1		—	—	2.3	
	MUN5132T1		—	—	1.5	
	MUN5133T1		—	—	0.18	
	MUN5134T1		—	—	0.13	
Collector–Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector–Emitter Breakdown Voltage(3) (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS(3)						
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	—	
	MUN5115T1		160	250	—	
	MUN5116T1		160	250	—	
	MUN5130T1		3.0	5.0	—	
	MUN5131T1		8.0	15	—	
	MUN5132T1		15	27	—	
	MUN5133T1		80	140	—	
	MUN5134T1		80	130	—	
Collector–Emitter Saturation Voltage (I_C = 10 mA, I_E = 0.3 mA) (I_C = 10 mA, I_B = 5 mA) MUN5130T1/MUN5131T1 (I_C = 10 mA, I_B = 1 mA) MUN5115T1/MUN5116T1/ MUN5132T1/MUN5133T1/MUN5134T1		$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (on)		V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ)	MUN5111T1		—	—	0.2	
	MUN5112T1		—	—	0.2	
	MUN5114T1		—	—	0.2	
	MUN5115T1		—	—	0.2	
	MUN5116T1		—	—	0.2	
	MUN5130T1		—	—	0.2	
	MUN5131T1		—	—	0.2	
	MUN5132T1		—	—	0.2	
	MUN5133T1		—	—	0.2	
	MUN5134T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MUN5113T1		—	—	0.2	

3. Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%

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

Characteristic		Symbol	Min	Typ	Max	Unit
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
(V_{CC} = 5.0 V, V_B = 0.050 V, R_L = 1.0 kΩ)	MUN5130T1					
(V_{CC} = 5.0 V, V_B = 0.25 V, R_L = 1.0 kΩ)	MUN5115T1					
	MUN5116T1					
	MUN5131T1					
	MUN5132T1					
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	
	MUN5115T1		7.0	10	13	
	MUN5116T1		3.3	4.7	6.1	
	MUN5130T1		0.7	1.0	1.3	
	MUN5131T1		1.5	2.2	2.9	
	MUN5132T1		3.3	4.7	6.1	
	MUN5133T1		3.3	4.7	6.1	
	MUN5134T1		15.4	22	28.6	
Resistor Ratio	MUN5111T1/MUN5112T1/MUN5113T1	R_1/R_2	0.8	1.0	1.2	
	MUN5114T1		0.17	0.21	0.25	
	MUN5115T1/MUN5116T1		—	—	—	
	MUN5130T1/MUN5131T1/MUN5132T1		0.8	1.0	1.2	
	MUN5133T1		0.055	0.1	0.185	
	MUN5134T1		0.38	0.47	0.56	

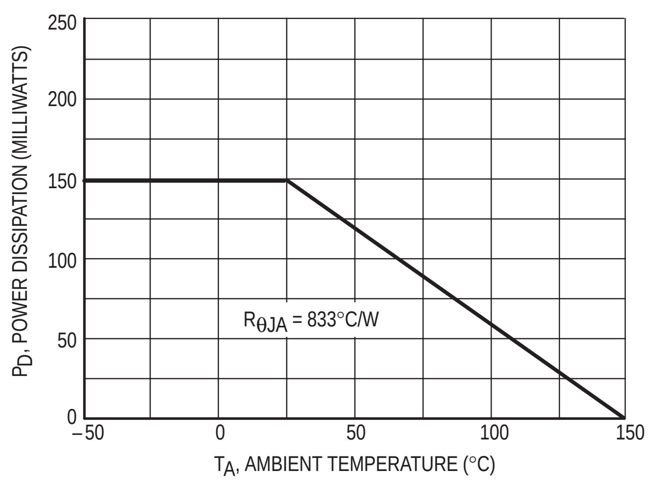


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5111T1

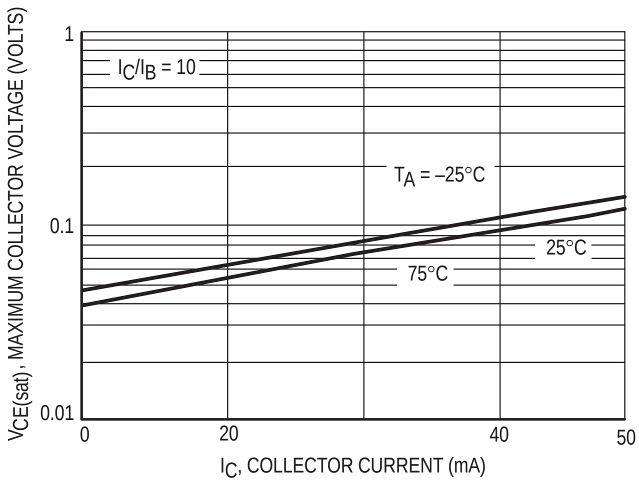


Figure 2. $V_{CE(sat)}$ versus I_C

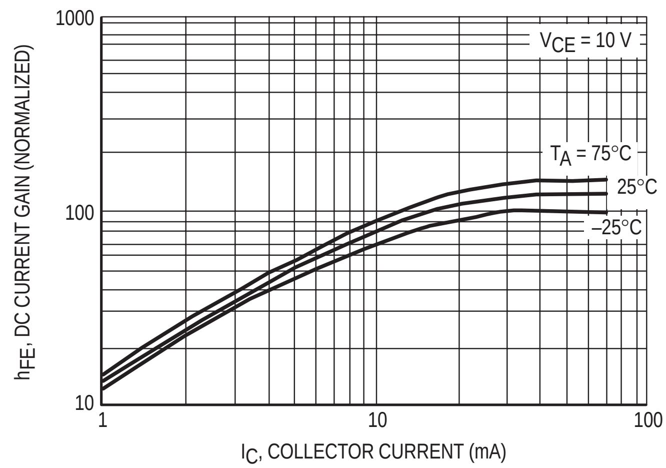


Figure 3. DC Current Gain

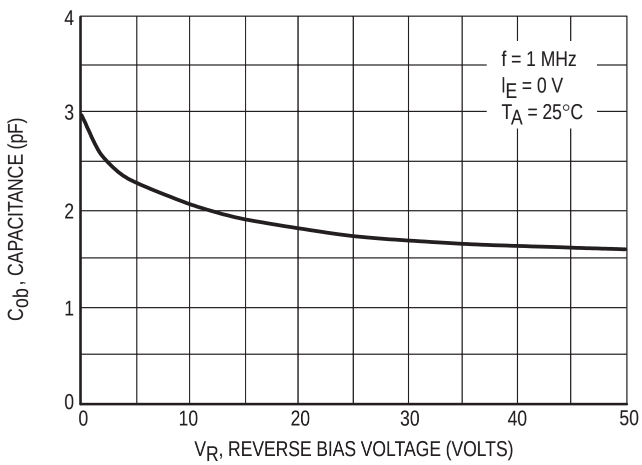


Figure 4. Output Capacitance

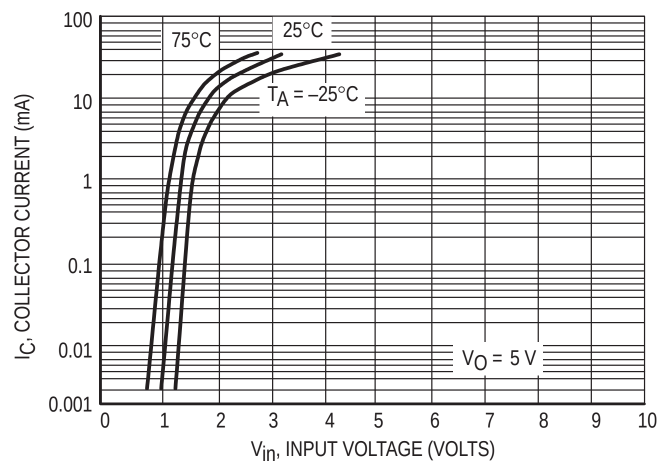


Figure 5. Output Current versus Input Voltage

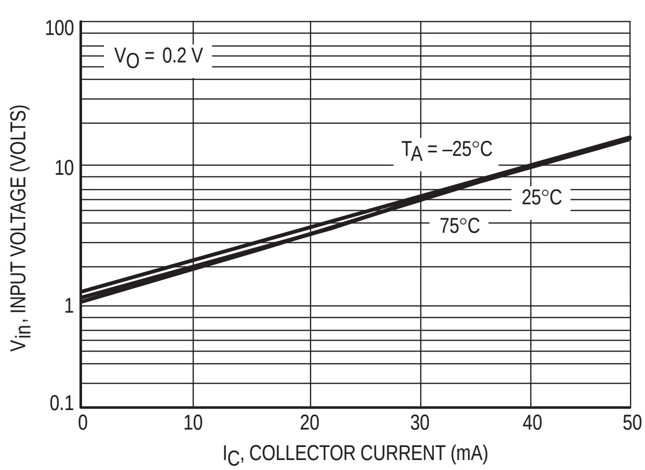


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5112T1

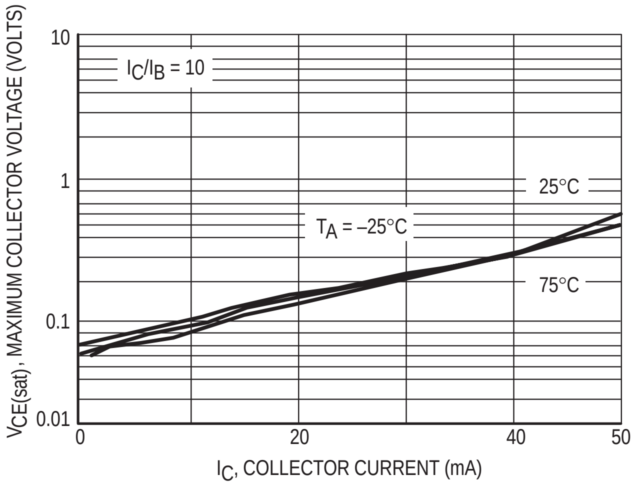


Figure 7. $V_{CE(sat)}$ versus I_C

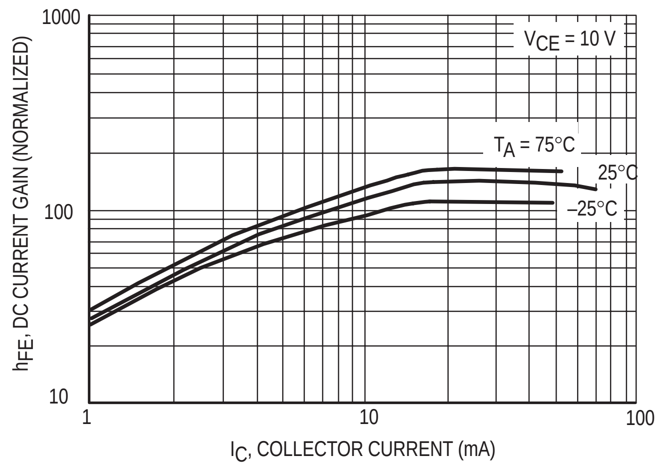


Figure 8. DC Current Gain

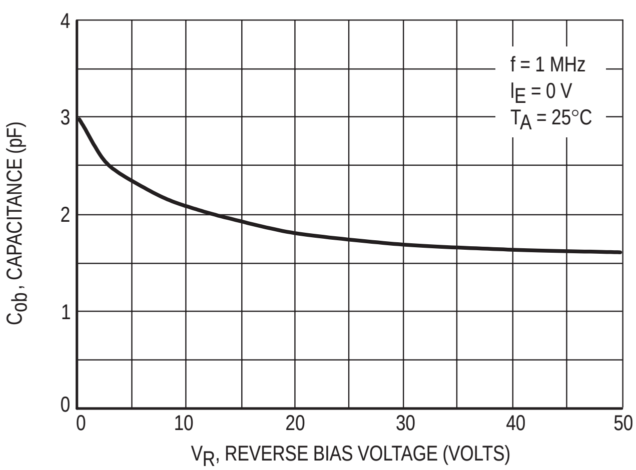


Figure 9. Output Capacitance

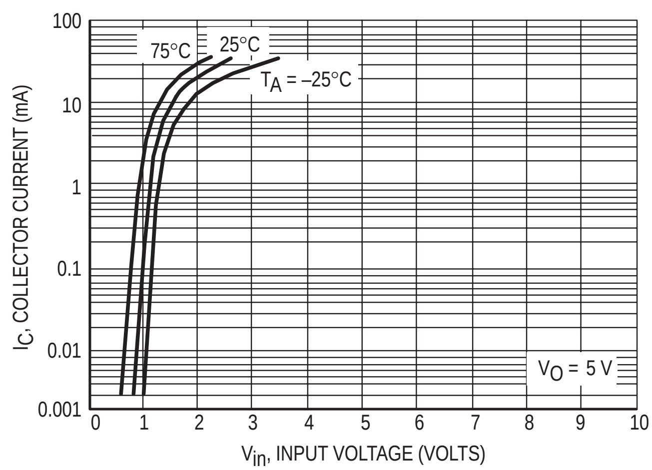


Figure 10. Output Current versus Input Voltage

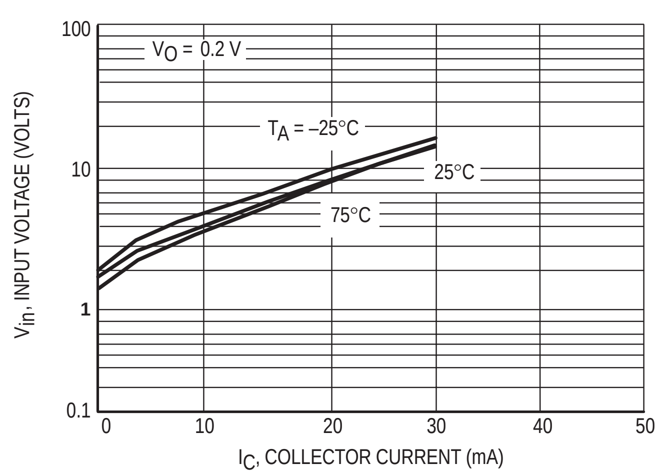


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5113T1

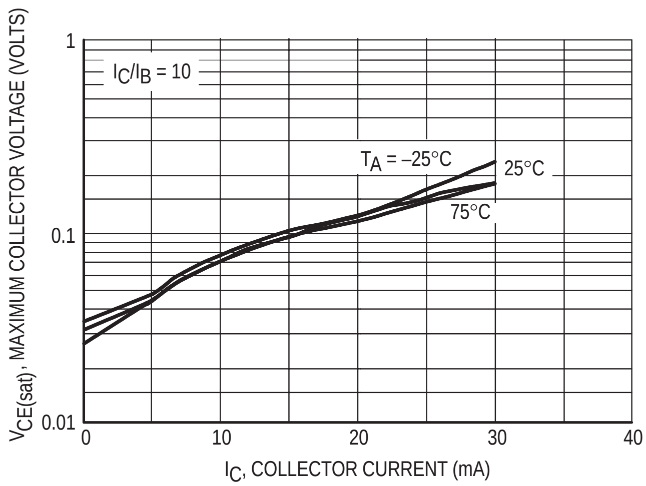


Figure 12. $V_{CE(sat)}$ versus I_C

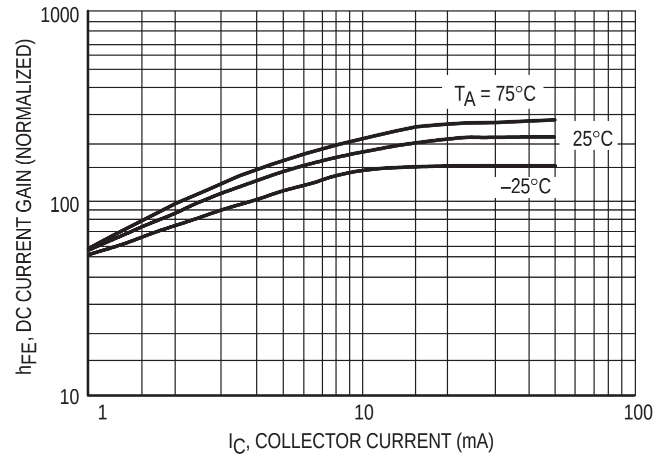


Figure 13. DC Current Gain

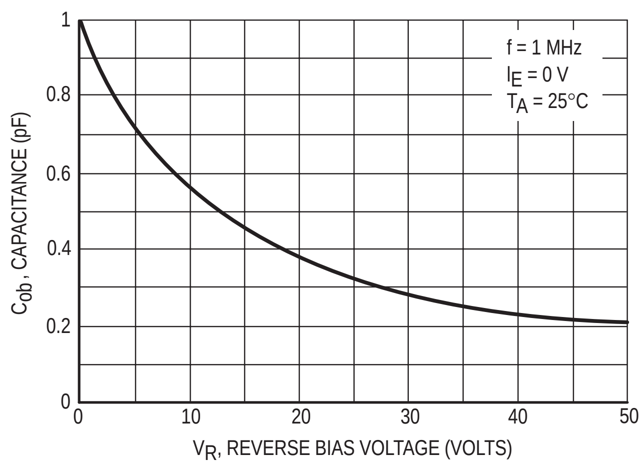


Figure 14. Output Capacitance

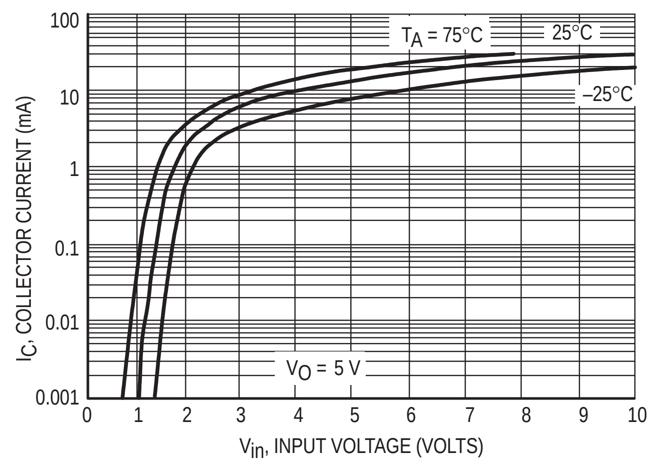


Figure 15. Output Current versus Input Voltage

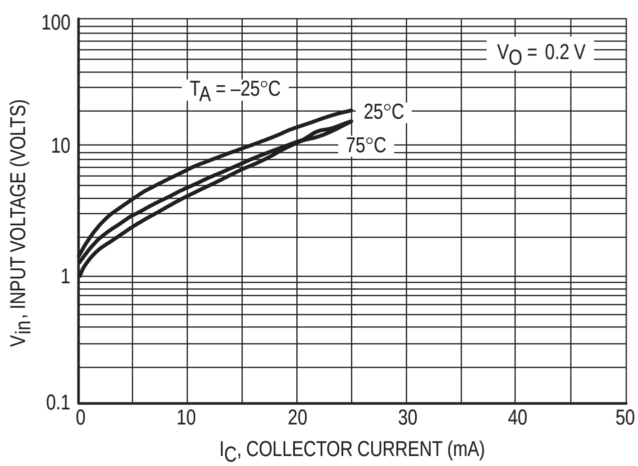


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5114T1

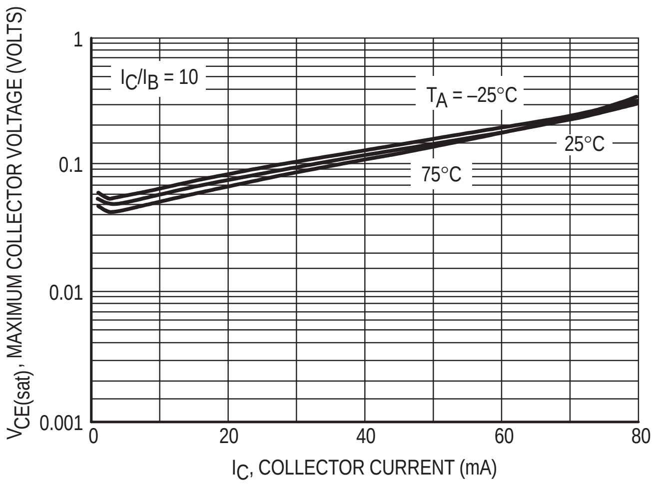


Figure 17. $V_{CE(sat)}$ versus I_C

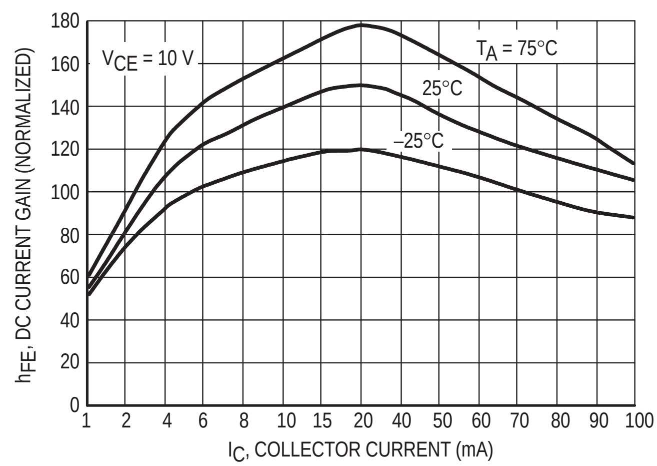


Figure 18. DC Current Gain

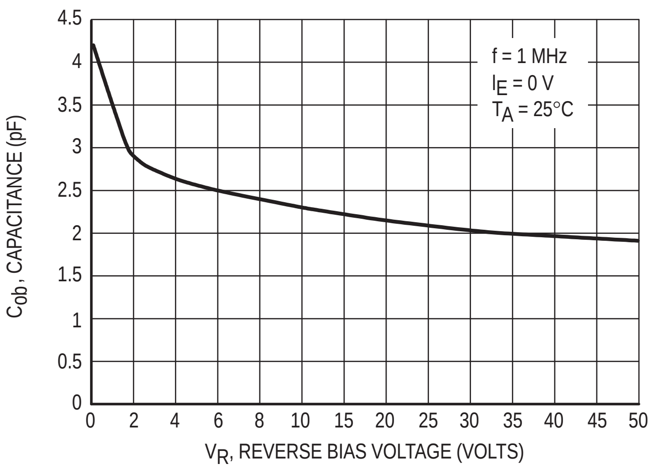


Figure 19. Output Capacitance

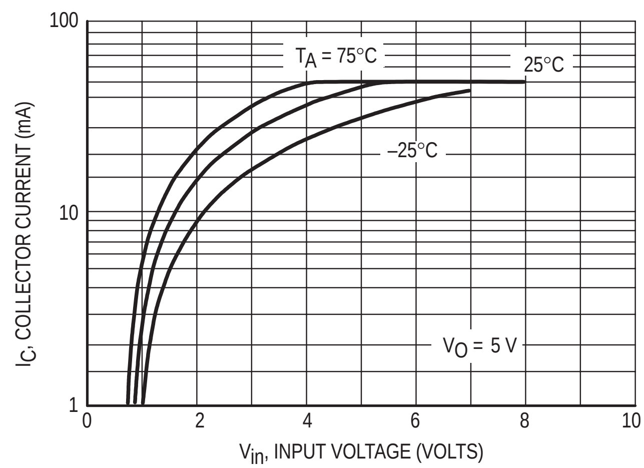


Figure 20. Output Current versus Input Voltage

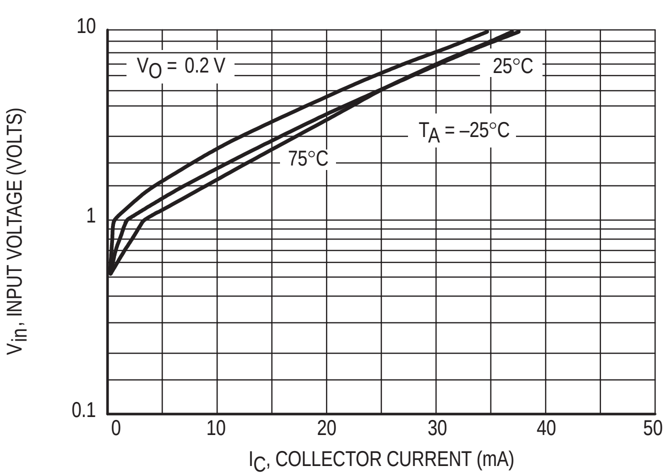


Figure 21. Input Voltage versus Output Current

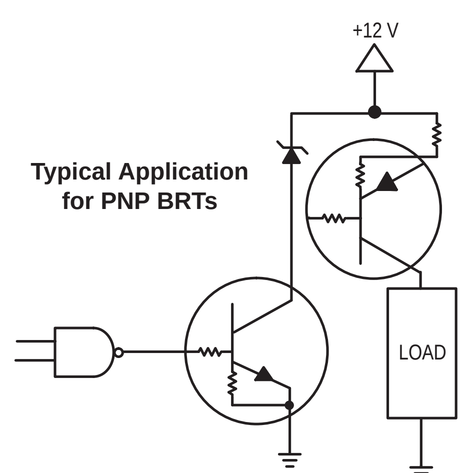


Figure 22. Inexpensive, Unregulated Current Source

MUN5211DW1T1 SERIES

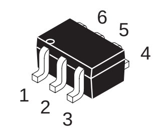
Motorola Preferred Devices

Dual Bias Resistor Transistors

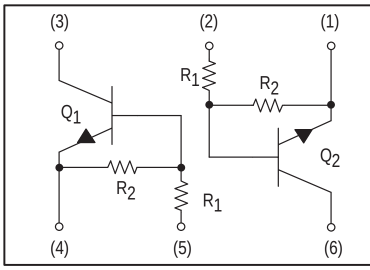
NPN Silicon Surface Mount Transistors with Monolithic Bias Resistor Network

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. These digital transistors are designed to replace a single device and its external resistor bias network. The BRT eliminates these individual components by integrating them into a single device. In the MUN5211DW1T1 series, two BRT devices are housed in the SOT–363 package which is ideal for low power surface mount applications where board space is at a premium.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Available in 8 mm, 7 inch/3000 Unit Tape and Reel.



CASE 419B–01, STYLE 1
SOT–363



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted, common for Q_1 and Q_2)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	100	mAdc

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
Total Package Dissipation @ T_A = 25°C(1)	P_D	150	mW

DEVICE MARKING AND RESISTOR VALUES: MUN5211DW1T1 SERIES

Device	Marking	R1 (K)	R2 (K)
MUN5211DW1T1	7A	10	10
MUN5212DW1T1	7B	22	22
MUN5213DW1T1	7C	47	47
MUN5214DW1T1	7D	10	47
MUN5215DW1T1(2)	7E	10	∞
MUN5216DW1T1(2)	7F	4.7	∞
MUN5230DW1T1(2)	7G	1.0	1.0
MUN5231DW1T1(2)	7H	2.2	2.2
MUN5232DW1T1(2)	7J	4.7	4.7
MUN5233DW1T1(2)	7K	4.7	47
MUN5234DW1T1(2)	7L	22	47
MUN5235DW1T1(2)	7M	2.2	47

1. Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.
2. New resistor combinations. Updated curves to follow in subsequent data sheets.

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

REV 2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, common for Q_1 and Q_2)

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	MUN5211DW1T1	I_{EBO}	—	—	0.5	mAdc
(V_{EB} = 6.0 V, I_C = 0)	MUN5212DW1T1		—	—	0.2	
	MUN5213DW1T1		—	—	0.1	
	MUN5214DW1T1		—	—	0.2	
	MUN5215DW1T1		—	—	0.9	
	MUN5216DW1T1		—	—	1.9	
	MUN5230DW1T1		—	—	4.3	
	MUN5231DW1T1		—	—	2.3	
	MUN5232DW1T1		—	—	1.5	
	MUN5233DW1T1		—	—	0.18	
	MUN5234DW1T1		—	—	0.13	
	MUN5235DW1T1		—	—	0.2	
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage(3) (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS(3)						
DC Current Gain	MUN5211DW1T1	h_{FE}	35	60	—	
(V_{CE} = 10 V, I_C = 5.0 mA)	MUN5212DW1T1		60	100	—	
	MUN5213DW1T1		80	140	—	
	MUN5214DW1T1		80	140	—	
	MUN5215DW1T1		160	350	—	
	MUN5216DW1T1		160	350	—	
	MUN5230DW1T1		3.0	5.0	—	
	MUN5231DW1T1		8.0	15	—	
	MUN5232DW1T1		15	30	—	
	MUN5233DW1T1		80	200	—	
	MUN5234DW1T1		80	150	—	
	MUN5235DW1T1		80	140	—	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA)		$V_{CE(sat)}$	—	—	0.25	Vdc
(I_C = 10 mA, I_B = 5 mA)	MUN5230DW1T1/MUN5231DW1T1					
(I_C = 10 mA, I_B = 1 mA)	MUN5215DW1T1/MUN5216DW1T1					
	MUN5232DW1T1/MUN5233DW1T1/MUN5234DW1T1					
Output Voltage (on)		V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ)	MUN5211lDW1T1		—	—	0.2	
	MUN5212DW1T1		—	—	0.2	
	MUN5214DW1T1		—	—	0.2	
	MUN5215DW1T1		—	—	0.2	
	MUN5216DW1T1		—	—	0.2	
	MUN5230DW1T1		—	—	0.2	
	MUN5231DW1T1		—	—	0.2	
	MUN5232DW1T1		—	—	0.2	
	MUN5233DW1T1		—	—	0.2	
	MUN5234DW1T1		—	—	0.2	
	MUN5235DW1T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MUN5213DW1T1		—	—	0.2	

3. Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, common for Q_1 and Q_2) (Continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ) (V_{CC} = 5.0 V, V_B = 0.050 V, R_L = 1.0 kΩ) MUN5230DW1T1 (V_{CC} = 5.0 V, V_B = 0.25 V, R_L = 1.0 kΩ) MUN5215DW1T1 MUN5216DW1T1 MUN5233DW1T1	V_{OH}	4.9	—	—	Vdc
Input Resistor MUN5211DW1T1	R1	7.0	10	13	k Ω
MUN5212DW1T1		15.4	22	28.6	
MUN5213DW1T1		32.9	47	61.1	
MUN5214DW1T1		7.0	10	13	
MUN5215DW1T1		7.0	10	13	
MUN5216DW1T1		3.3	4.7	6.1	
MUN5230DW1T1		0.7	1.0	1.3	
MUN5231DW1T1		1.5	2.2	2.9	
MUN5232DW1T1		3.3	4.7	6.1	
MUN5233DW1T1		3.3	4.7	6.1	
MUN5234DW1T1		15.4	22	28.6	
MUN5235DW1T1		1.54	2.2	2.86	
Resistor Ratio MUN5211DW1T1/MUN5212DW1T1/MUN5213DW1T1	R1/R2	0.8	1.0	1.2	
MUN5214DW1T1		0.17	0.21	0.25	
MUN5215DW1T1/MUN5216DW1T1		—	—	—	
MUN5230DW1T1/MUN5231DW1T1/MUN5232DW1T1		0.8	1.0	1.2	
MUN5233DW1T1		0.055	0.1	0.185	
MUN5234DW1T1		0.38	0.47	0.56	
MUN5235DW1T1		0.038	0.047	0.056	

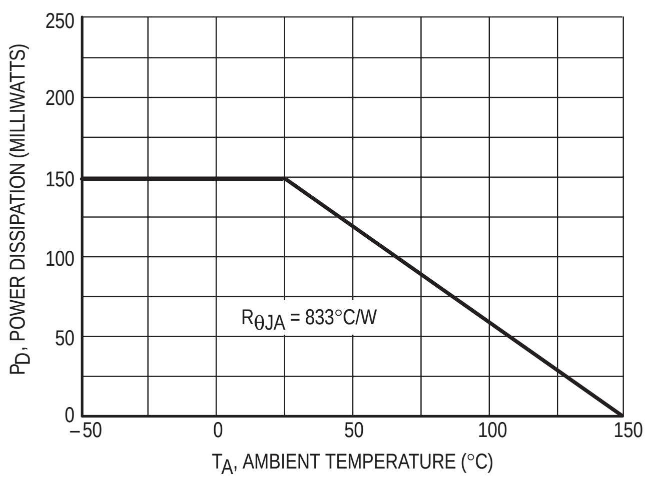


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5211DW1T1

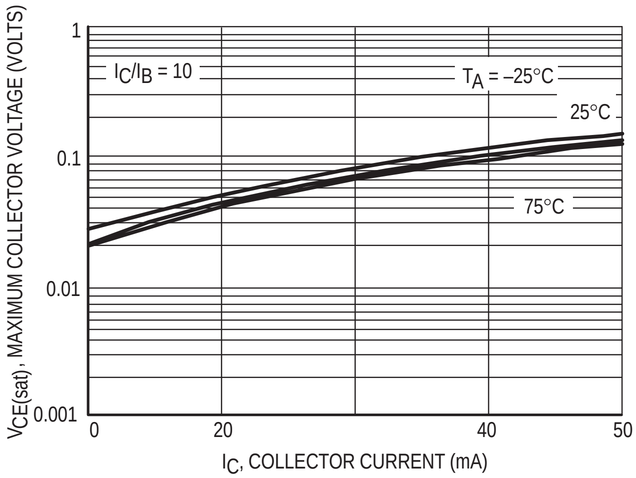


Figure 2. $V_{CE(sat)}$ versus I_C

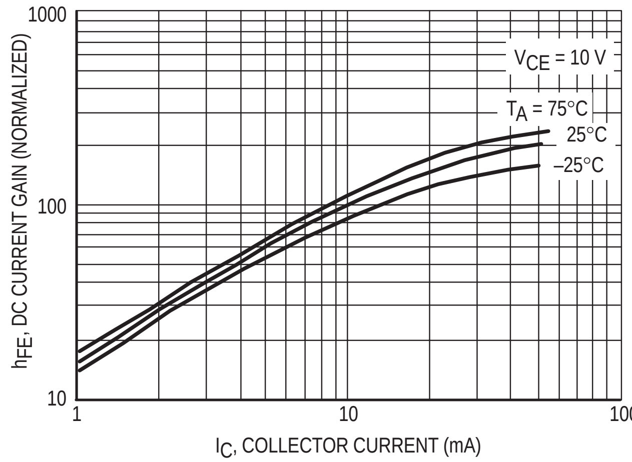


Figure 3. DC Current Gain

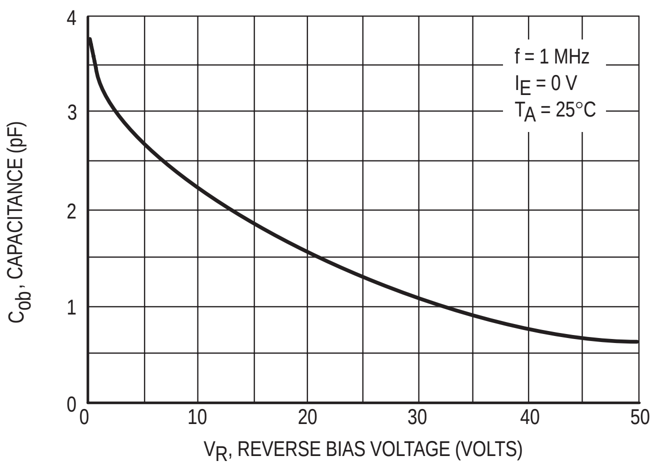


Figure 4. Output Capacitance

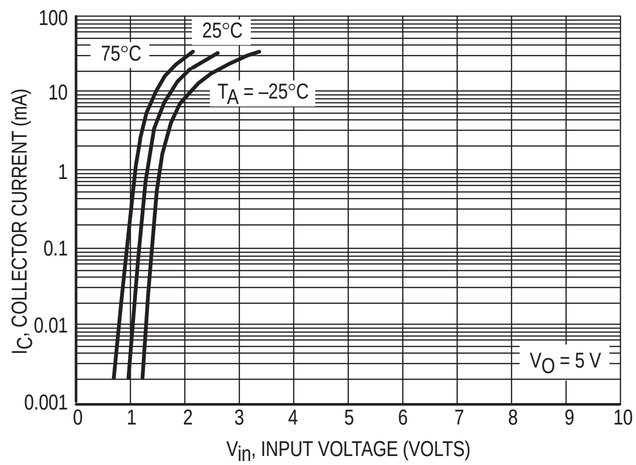


Figure 5. Output Current versus Input Voltage

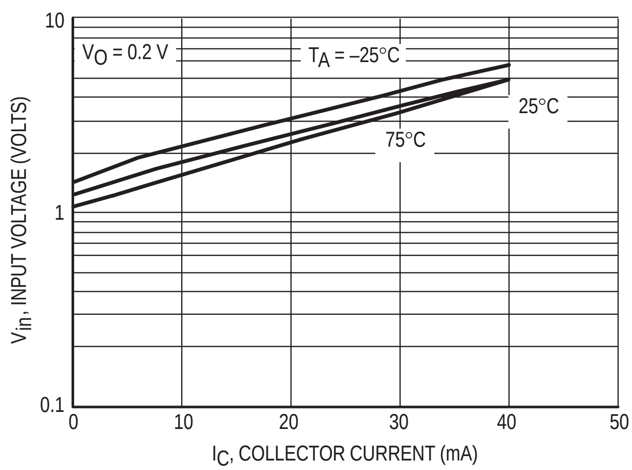


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5212DW1T1

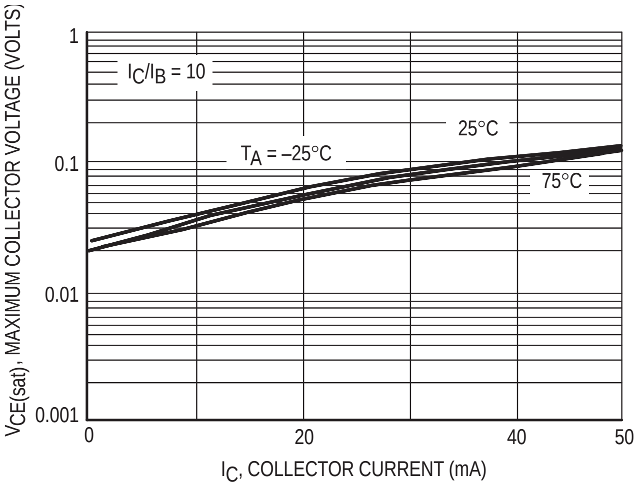


Figure 7. $V_{CE(sat)}$ versus I_C

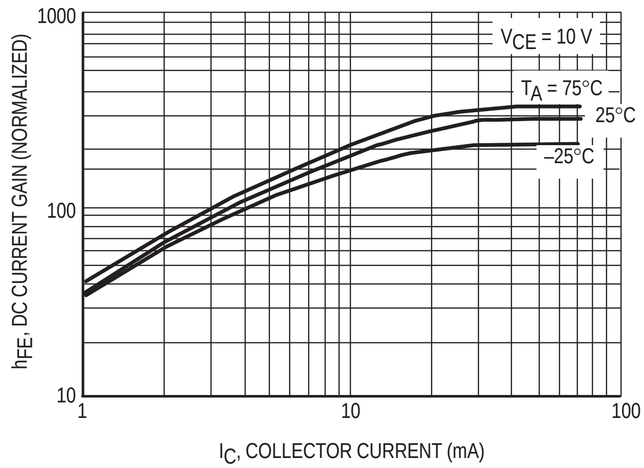


Figure 8. DC Current Gain

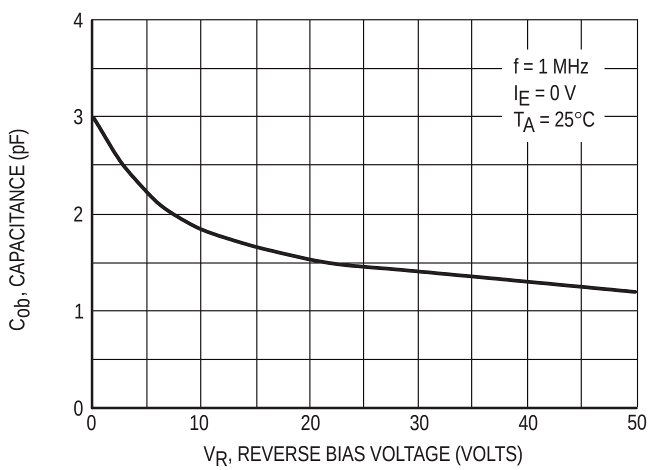


Figure 9. Output Capacitance

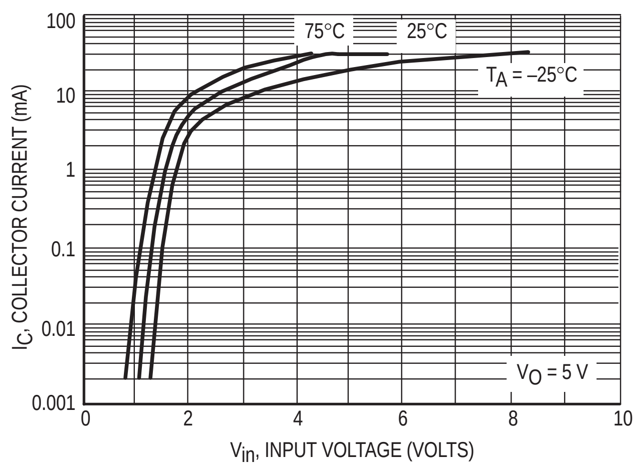


Figure 10. Output Current versus Input Voltage

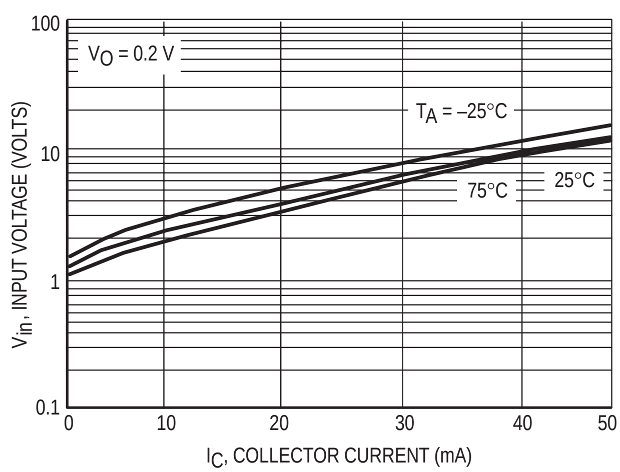


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5213DW1T1

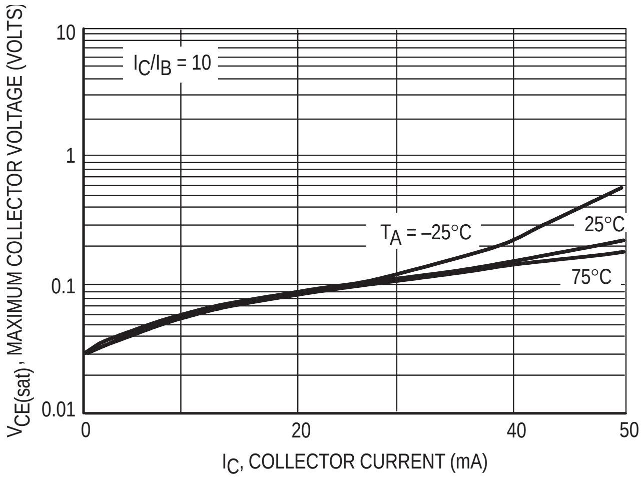


Figure 12. $V_{CE(sat)}$ versus I_C

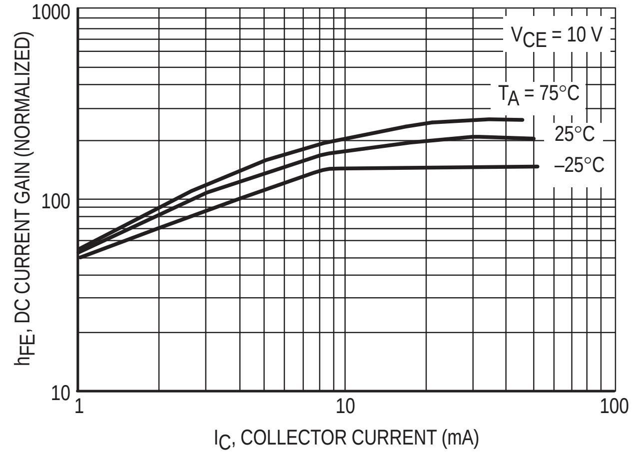


Figure 13. DC Current Gain

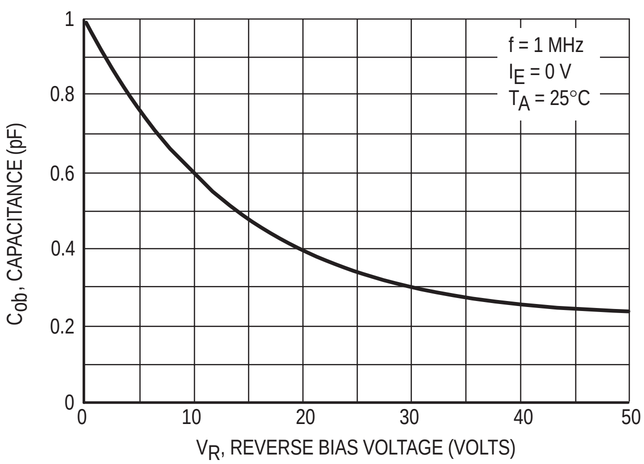


Figure 14. Output Capacitance

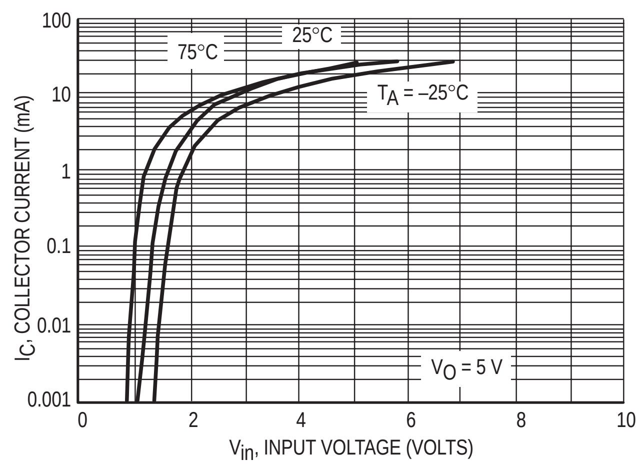


Figure 15. Output Current versus Input Voltage

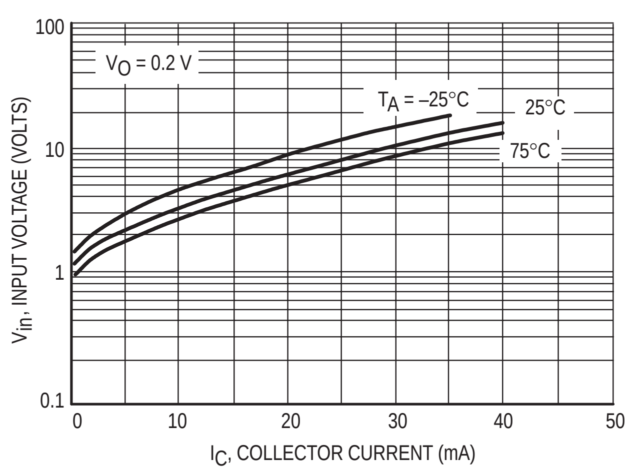


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5214DW1T1

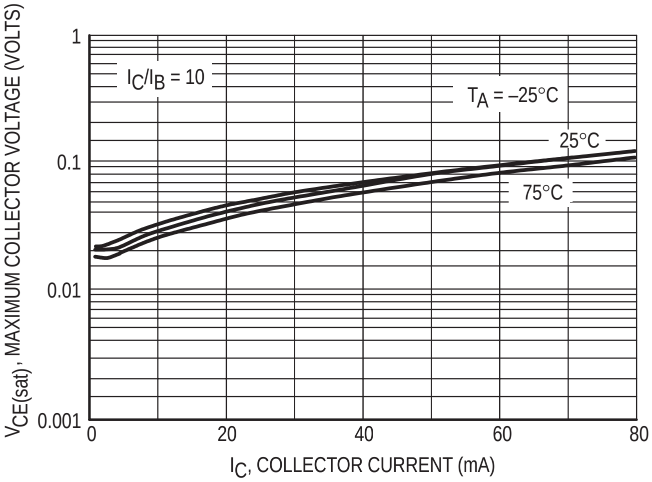


Figure 17. $V_{CE(sat)}$ versus I_C

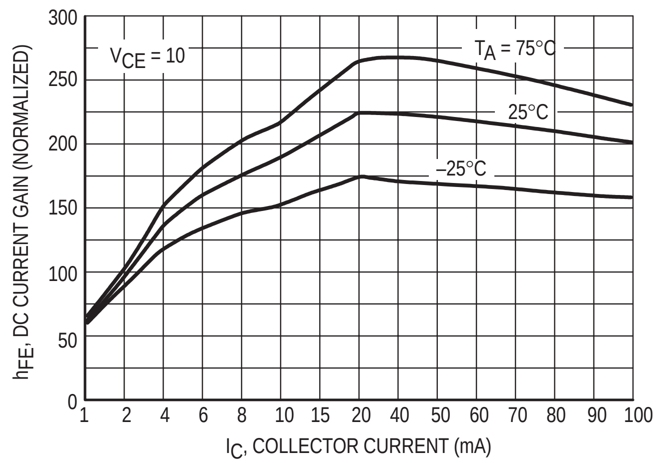


Figure 18. DC Current Gain

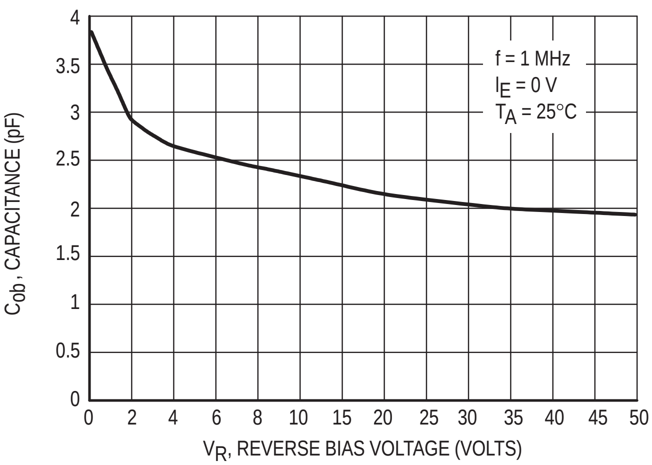


Figure 19. Output Capacitance

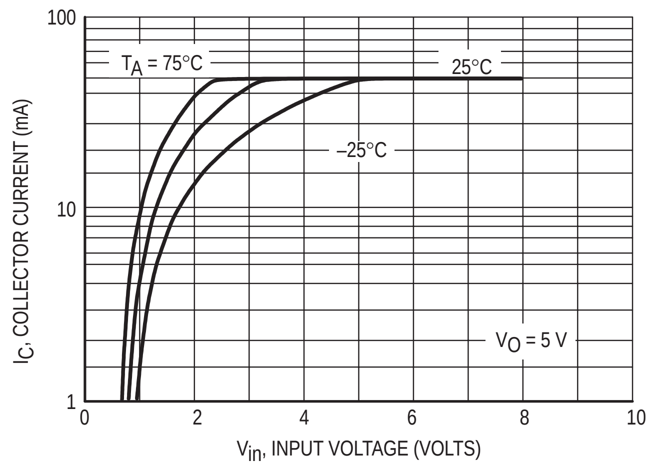


Figure 20. Output Current versus Input Voltage

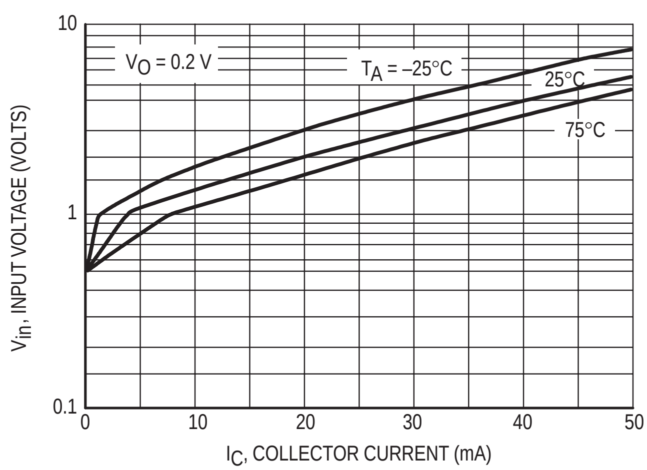


Figure 21. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5215DW1T1

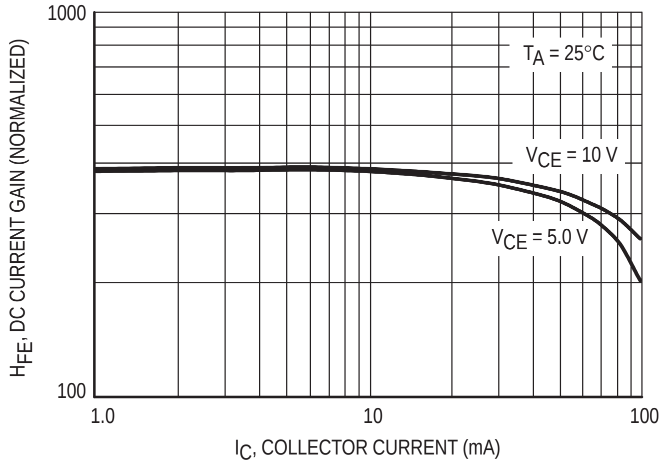


Figure 22. DC Current Gain

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5216DW1T1

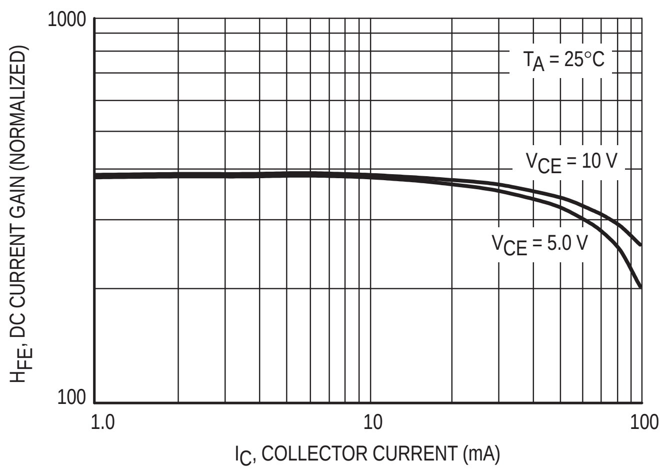


Figure 23. DC Current Gain

Bias Resistor Transistor

NPN Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

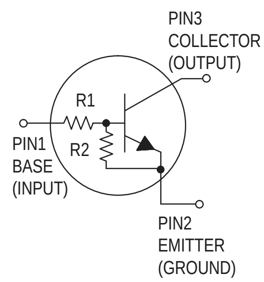
MUN5211T1 SERIES

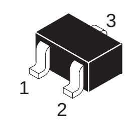
Motorola Preferred Devices

NPN 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	100	mAdc
Total Power Dissipation @ T_A = 25°C(1) 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 10	°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
MUN5215T1(2)	8E	10	∞
MUN5216T1(2)	8F	4.7	∞
MUN5230T1(2)	8G	1.0	1.0
MUN5231T1(2)	8H	2.2	2.2
MUN5232T1(2)	8J	4.7	4.7
MUN5233T1(2)	8K	4.7	47
MUN5234T1(2)	8L	22	47

1. Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.
2. New devices. Updated curves to follow in subsequent data sheets.

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

REV 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 MUN5211T1	I_{EBO}	—	—	0.5	mAdc
(V_{EB} = 6.0 V, I_C = 0) MUN5212T1		—	—	0.2	
MUN5213T1		—	—	0.1	
MUN5214T1		—	—	0.2	
MUN5215T1		—	—	0.9	
MUN5216T1		—	—	1.9	
MUN5230T1		—	—	4.3	
MUN5231T1		—	—	2.3	
MUN5232T1		—	—	1.5	
MUN5233T1		—	—	0.18	
MUN5234T1		—	—	0.13	
Collector-Base Breakdown Voltage (I_C = 10 µA, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage(3) (I_C = 2.0 mA, I_B = 0)	$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS(3)					
DC Current Gain MUN5211T1	h_{FE}	35	60	—	
(V_{CE} = 10 V, I_C = 5.0 mA) MUN5212T1		60	100	—	
MUN5213T1		80	140	—	
MUN5214T1		80	140	—	
MUN5215T1		160	350	—	
MUN5216T1		160	350	—	
MUN5230T1		3.0	5.0	—	
MUN5231T1		8.0	15	—	
MUN5232T1		15	30	—	
MUN5233T1		80	200	—	
MUN5234T1		80	150	—	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA)	$V_{CE(sat)}$	—	—	0.25	Vdc
(I_C = 10 mA, I_B = 5 mA) MUN5230T1/MUN5231T1					
(I_C = 10 mA, I_B = 1 mA) MUN5215T1/MUN5216T1					
MUN5232T1/MUN5233T1/MUN5234T1					
Output Voltage (on)	V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ) MUN5211IT1		—	—	0.2	
MUN5212T1		—	—	0.2	
MUN5214T1		—	—	0.2	
MUN5215T1		—	—	0.2	
MUN5216T1		—	—	0.2	
MUN5230T1		—	—	0.2	
MUN5231T1		—	—	0.2	
MUN5232T1		—	—	0.2	
MUN5233T1		—	—	0.2	
MUN5234T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ) MUN5213T1		—	—	0.2	

3. Pulse Test: Pulse Width < 300 µs, Duty Cycle < 2.0%

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

Characteristic		Symbol	Min	Typ	Max	Unit
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
(V_{CC} = 5.0 V, V_B = 0.050 V, R_L = 1.0 kΩ)	MUN5230T1					
(V_{CC} = 5.0 V, V_B = 0.25 V, R_L = 1.0 kΩ)	MUN5215T1					
	MUN5216T1					
	MUN5233T1					
Input Resistor	MUN5211T1	R1	7.0	10	13	k Ω
	MUN5212T1		15.4	22	28.6	
	MUN5213T1		32.9	47	61.1	
	MUN5214T1		7.0	10	13	
	MUN5215T1		7.0	10	13	
	MUN5216T1		3.3	4.7	6.1	
	MUN5230T1		0.7	1.0	1.3	
	MUN5231T1		1.5	2.2	2.9	
	MUN5232T1		3.3	4.7	6.1	
	MUN5233T1		3.3	4.7	6.1	
	MUN5234T1		15.4	22	28.6	
Resistor Ratio	MUN5211T1/MUN5212T1/MUN5213T1	R1/R2	0.8	1.0	1.2	
	MUN5214T1		0.17	0.21	0.25	
	MUN5215T1/MUN5216T1		—	—	—	
	MUN5230T1/MUN5231T1/MUN5232T1		0.8	1.0	1.2	
	MUN5233T1		0.055	0.1	0.185	
	MUN5234T1		0.38	0.47	0.56	

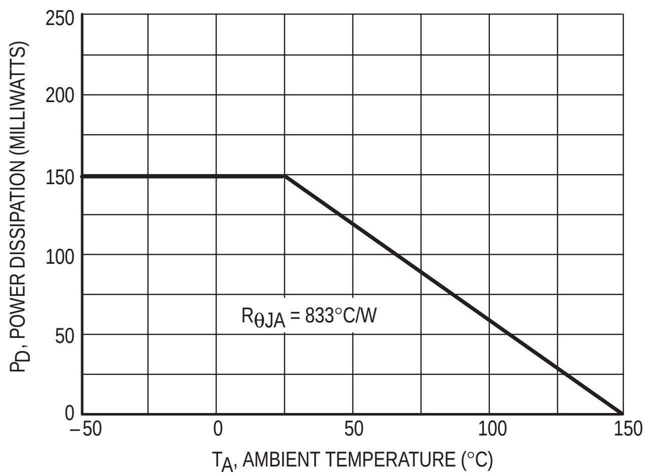


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5211T1

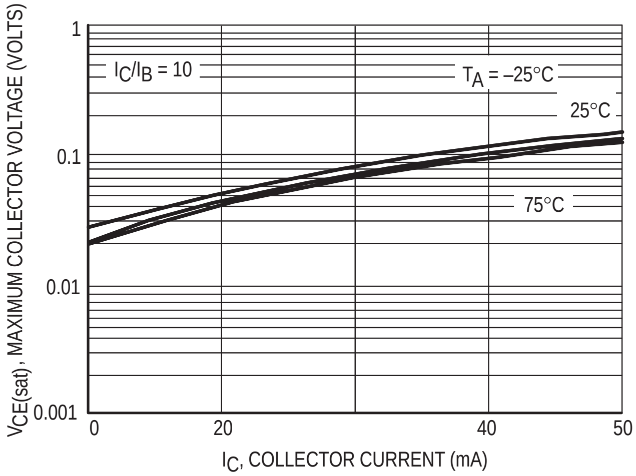


Figure 2. $V_{CE(sat)}$ versus I_C

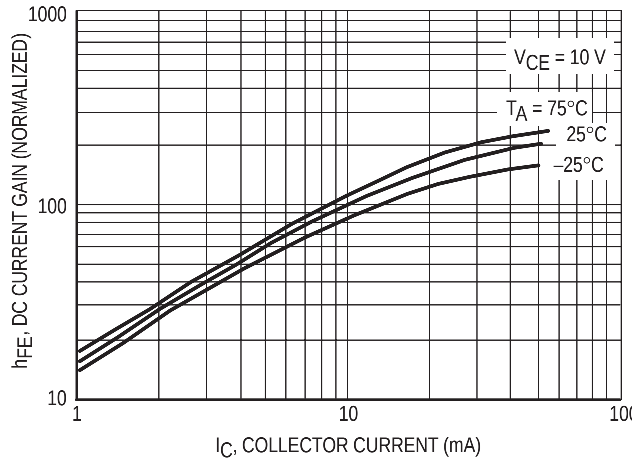


Figure 3. DC Current Gain

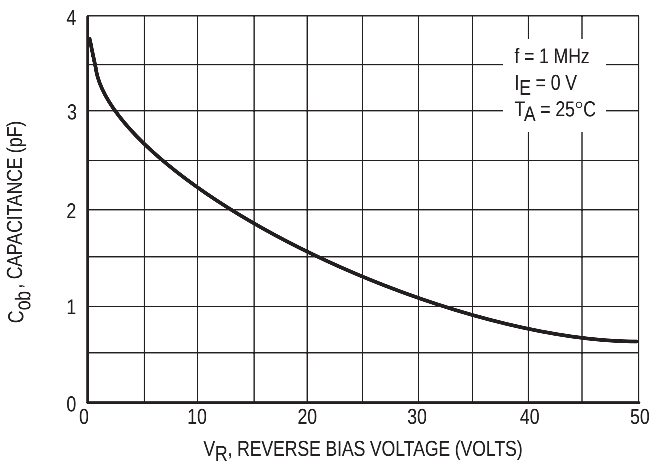


Figure 4. Output Capacitance

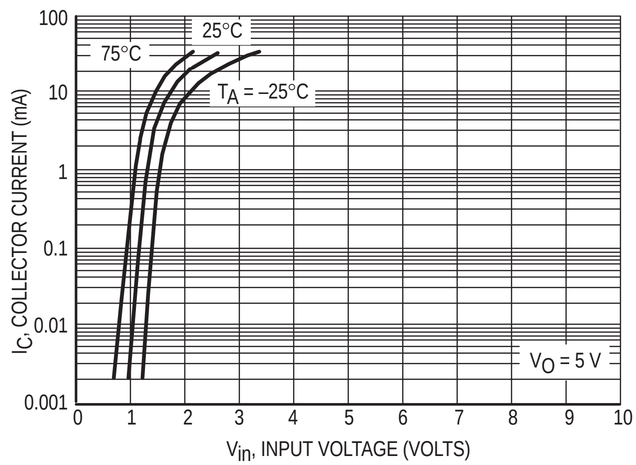


Figure 5. Output Current versus Input Voltage

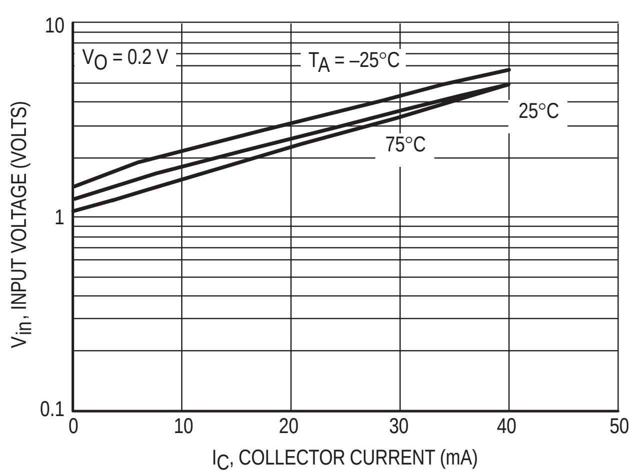


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5212T1

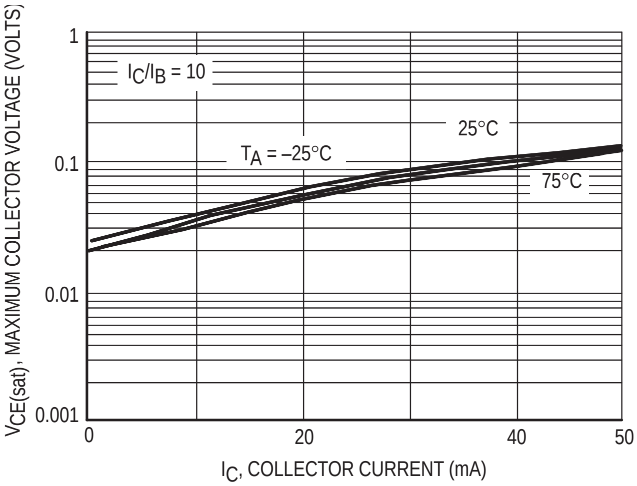


Figure 7. $V_{CE(sat)}$ versus I_C

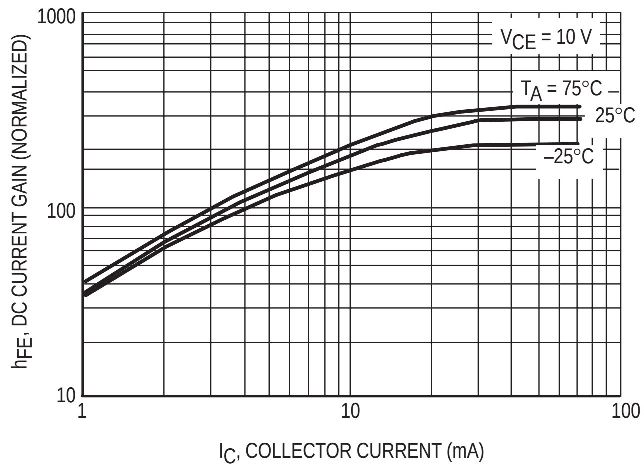


Figure 8. DC Current Gain

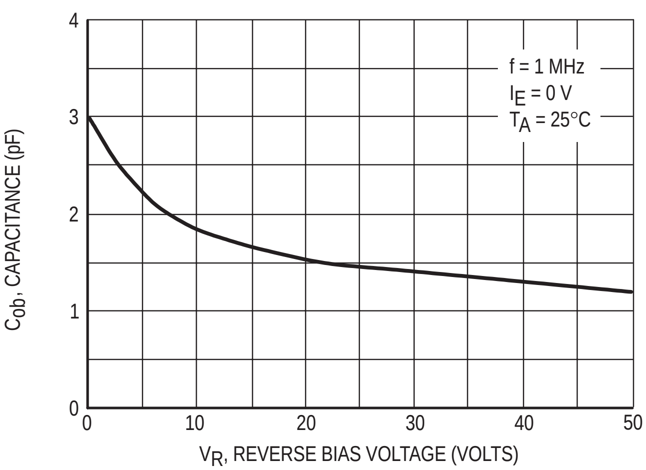


Figure 9. Output Capacitance

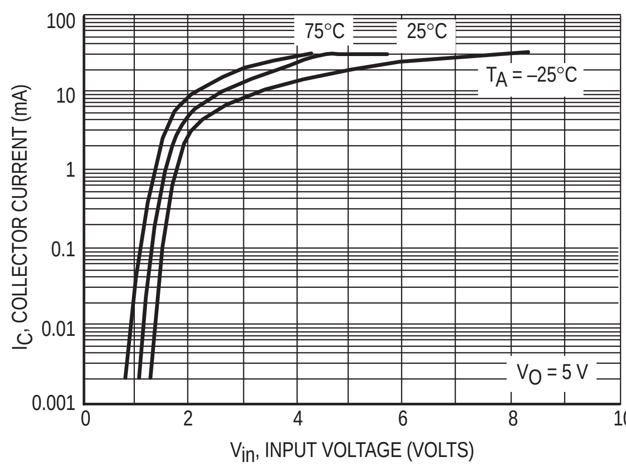


Figure 10. Output Current versus Input Voltage

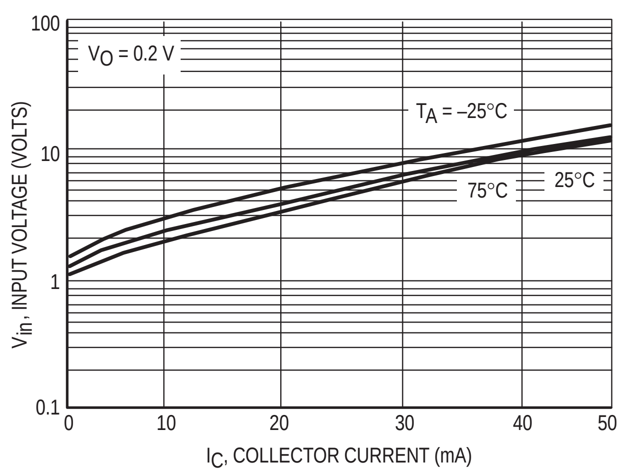


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5213T1

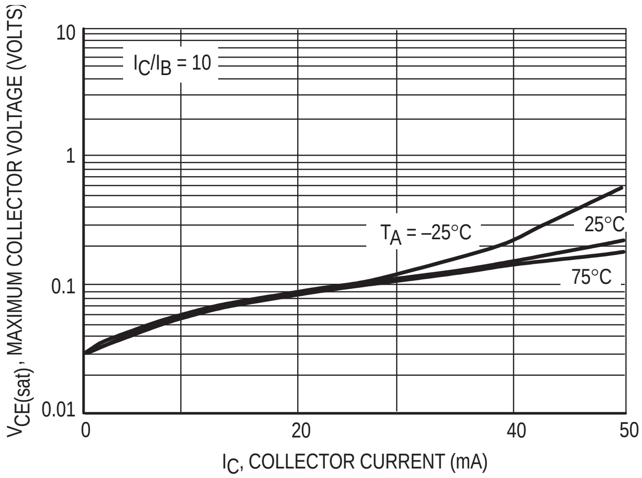


Figure 12. $V_{CE(sat)}$ versus I_C

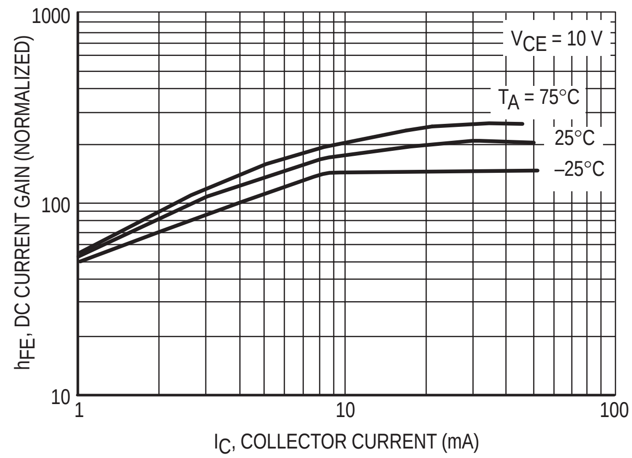


Figure 13. DC Current Gain

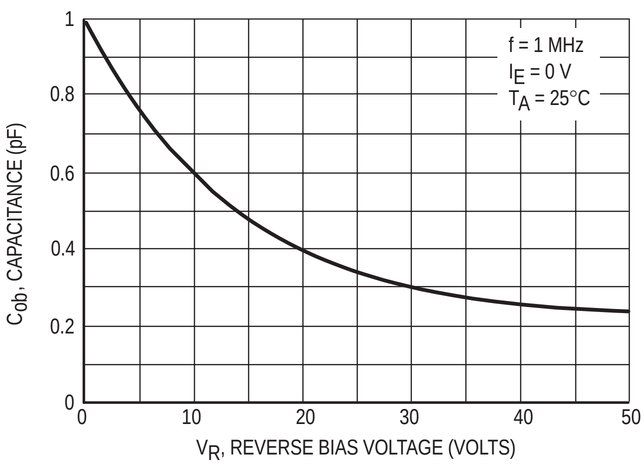


Figure 14. Output Capacitance

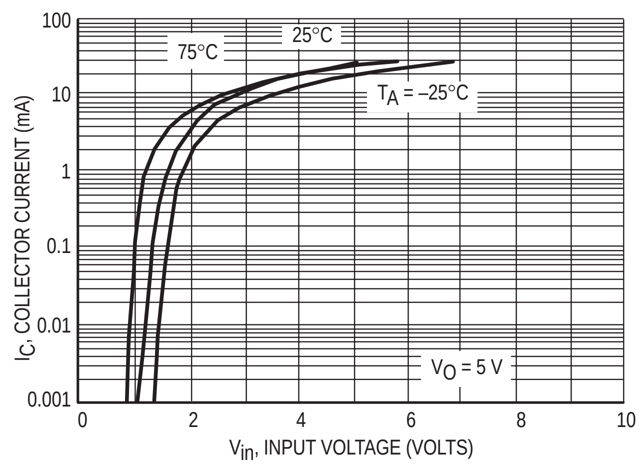


Figure 15. Output Current versus Input Voltage

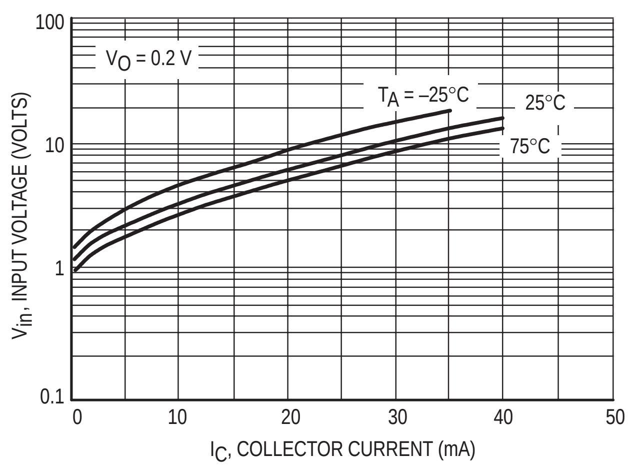


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5214T1

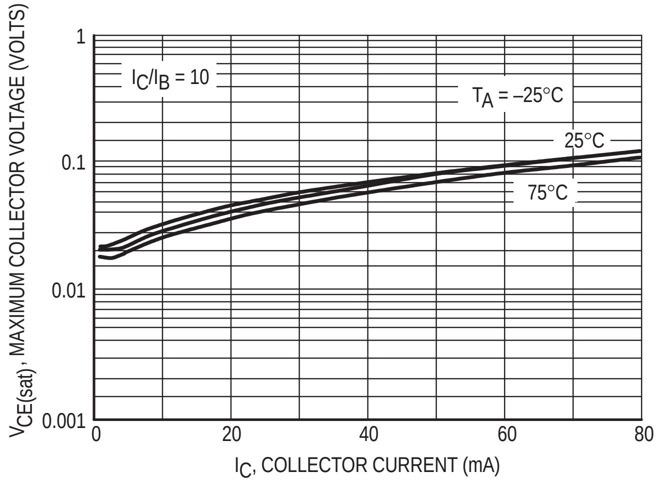


Figure 17. $V_{CE(sat)}$ versus I_C

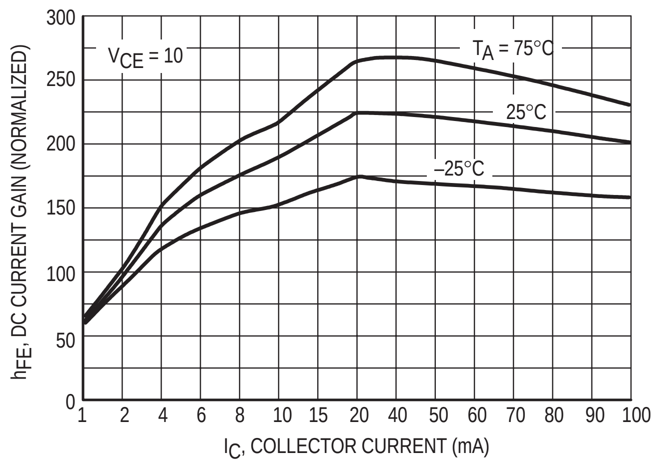


Figure 18. DC Current Gain

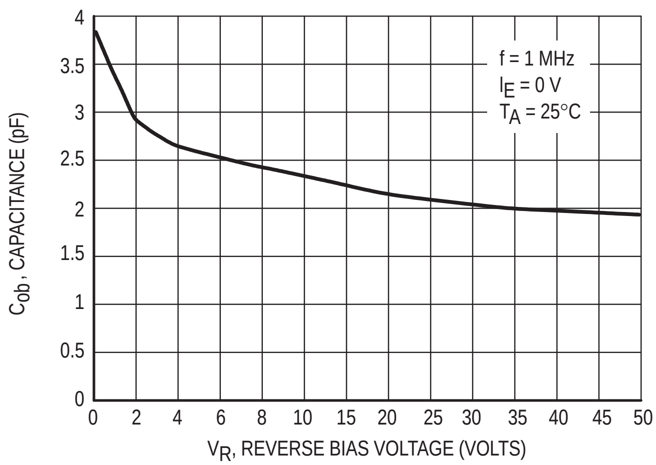


Figure 19. Output Capacitance

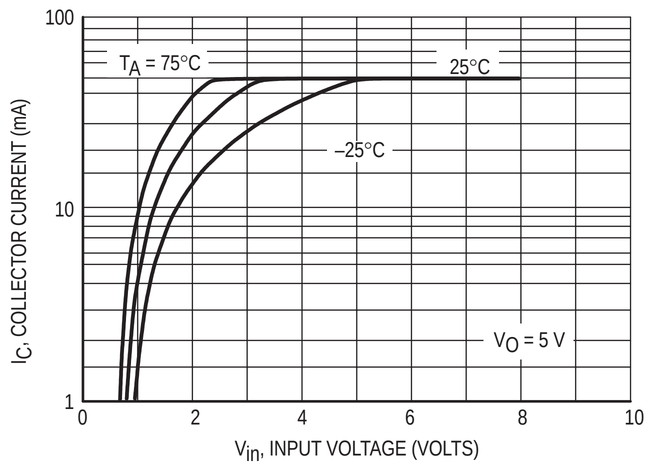


Figure 20. Output Current versus Input Voltage

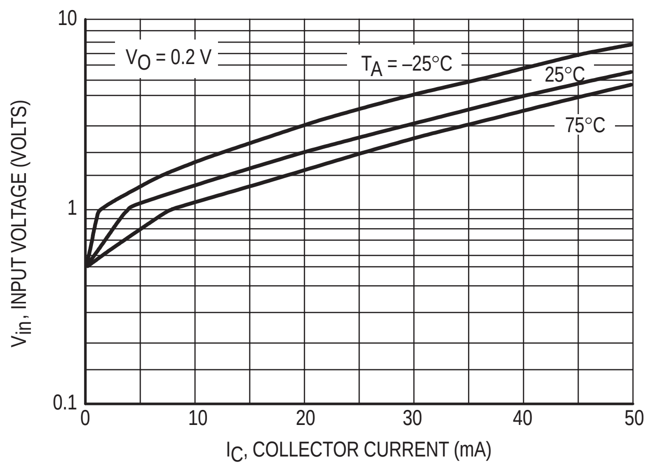


Figure 21. Input Voltage versus Output Current

TYPICAL APPLICATIONS FOR NPN BRTs

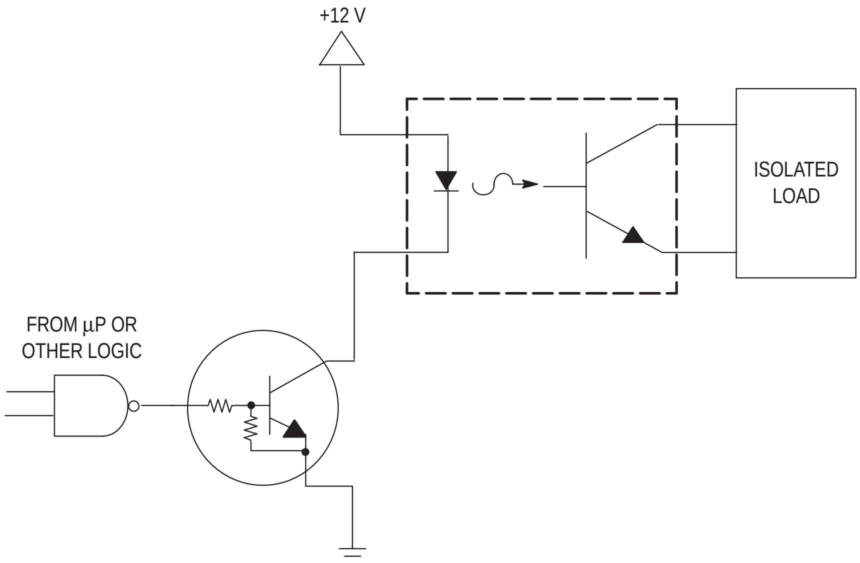


Figure 22. Level Shifter: Connects 12 or 24 Volt Circuits to Logic

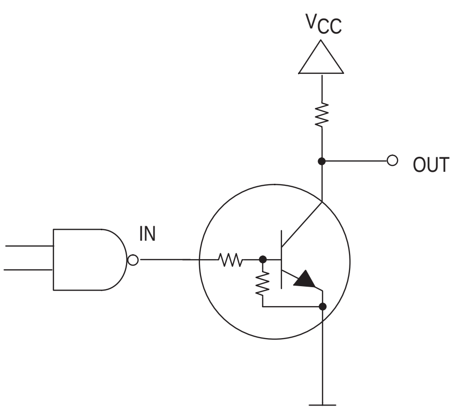


Figure 23. Open Collector Inverter: Inverts the Input Signal

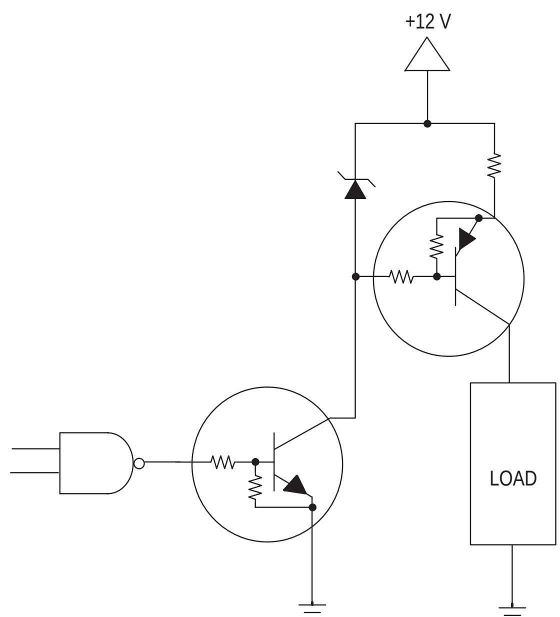


Figure 24. Inexpensive, Unregulated Current Source

Dual Bias Resistor Transistors

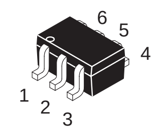
NPN and PNP Silicon Surface Mount Transistors with Monolithic Bias Resistor Network

MUN5311DW1T1 SERIES

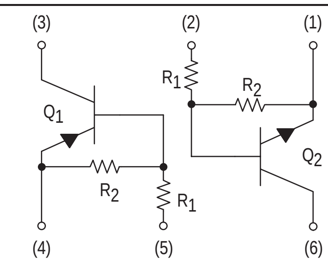
Motorola Preferred Devices

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. These digital transistors are designed to replace a single device and its external resistor bias network. The BRT eliminates these individual components by integrating them into a single device. In the MUN5311DW1T1 series, two complementary BRT devices are housed in the SOT–363 package which is ideal for low power surface mount applications where board space is at a premium.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Available in 8 mm, 7 inch/3000 Unit Tape and Reel.



CASE 419B–01, STYLE 1
SOT–363



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted, common for Q_1 and Q_2, – minus sign for Q_2 (PNP) omitted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	100	mAdc

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
Total Package Dissipation @ T_A = 25°C(1)	P_D	150	mW

DEVICE MARKING AND RESISTOR VALUES: MUN5311DW1T1 SERIES

Device	Marking	R1 (K)	R2 (K)
MUN5311DW1T1	11	10	10
MUN5312DW1T1	12	22	22
MUN5313DW1T1	13	47	47
MUN5314DW1T1	14	10	47
MUN5315DW1T1(2)	15	10	∞
MUN5316DW1T1(2)	16	4.7	∞
MUN5330DW1T1(2)	30	1.0	1.0
MUN5331DW1T1(2)	31	2.2	2.2
MUN5332DW1T1(2)	32	4.7	4.7
MUN5333DW1T1(2)	33	4.7	47
MUN5334DW1T1(2)	34	22	47
MUN5335DW1T1(2)	35	2.2	47

1. Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.
2. New resistor combinations. Updated curves to follow in subsequent data sheets.

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

REV 4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, common for Q_1 and Q_2, – minus sign for Q_2 (PNP) omitted)

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	MUN5311DW1T1	I_{EBO}	—	—	0.5	mAdc
(V_{EB} = 6.0 V, I_C = 0)	MUN5312DW1T1		—	—	0.2	
	MUN5313DW1T1		—	—	0.1	
	MUN5314DW1T1		—	—	0.2	
	MUN5315DW1T1		—	—	0.9	
	MUN5316DW1T1		—	—	1.9	
	MUN5330DW1T1		—	—	4.3	
	MUN5331DW1T1		—	—	2.3	
	MUN5332DW1T1		—	—	1.5	
	MUN5333DW1T1		—	—	0.18	
	MUN5334DW1T1		—	—	0.13	
	MUN5335DW1T1		—	—	0.2	
Collector-Base Breakdown Voltage (I_C = 10 µA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage(3) (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS(3)						
DC Current Gain	MUN5311DW1T1	h_{FE}	35	60	—	
(V_{CE} = 10 V, I_C = 5.0 mA)	MUN5312DW1T1		60	100	—	
	MUN5313DW1T1		80	140	—	
	MUN5314DW1T1		80	140	—	
	MUN5315DW1T1		160	350	—	
	MUN5316DW1T1		160	350	—	
	MUN5330DW1T1		3.0	5.0	—	
	MUN5331DW1T1		8.0	15	—	
	MUN5332DW1T1		15	30	—	
	MUN5333DW1T1		80	200	—	
	MUN5334DW1T1		80	150	—	
	MUN5335DW1T1		80	140	—	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA) (I_C = 10 mA, I_B = 5 mA) MUN5330DW1T1/MUN5331DW1T1 (I_C = 10 mA, I_B = 1 mA) MUN5315DW1T1/MUN5316DW1T1 MUN5332DW1T1/MUN5333DW1T1/MUN5334DW1T1		$V_{CE(sat)}$	—	—	0.25	Vdc
Output Voltage (on)		V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ)	MUN5311lDW1T1		—	—	0.2	
	MUN5312DW1T1		—	—	0.2	
	MUN5314DW1T1		—	—	0.2	
	MUN5315DW1T1		—	—	0.2	
	MUN5316DW1T1		—	—	0.2	
	MUN5330DW1T1		—	—	0.2	
	MUN5331DW1T1		—	—	0.2	
	MUN5332DW1T1		—	—	0.2	
	MUN5333DW1T1		—	—	0.2	
	MUN5334DW1T1		—	—	0.2	
	MUN5335DW1T1		—	—	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	MUN5313DW1T1		—	—	0.2	

3. Pulse Test: Pulse Width < 300 µs, Duty Cycle < 2.0%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, common for Q_1 and Q_2, – minus sign for Q_2 (PNP) omitted) (Continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ) (V_{CC} = 5.0 V, V_B = 0.050 V, R_L = 1.0 kΩ) (V_{CC} = 5.0 V, V_B = 0.25 V, R_L = 1.0 kΩ)	 MUN5330DW1T1 MUN5315DW1T1 MUN5316DW1T1 MUN5333DW1T1	V_{OH}	4.9	—	—	Vdc
Input Resistor	MUN5311DW1T1 MUN5312DW1T1 MUN5313DW1T1 MUN5314DW1T1 MUN5315DW1T1 MUN5316DW1T1 MUN5330DW1T1 MUN5331DW1T1 MUN5332DW1T1 MUN5333DW1T1 MUN5334DW1T1 MUN5335DW1T1	R1	7.0 15.4 32.9 7.0 7.0 3.3 0.7 1.5 3.3 3.3 15.4 1.54	10 22 47 10 10 4.7 1.0 2.2 4.7 4.7 22 2.2	13 28.6 61.1 13 13 6.1 1.3 2.9 6.1 6.1 28.6 2.86	k Ω
Resistor Ratio	MUN5311DW1T1/MUN5312DW1T1/MUN5313DW1T1 MUN5314DW1T1 MUN5315DW1T1/MUN5316DW1T1 MUN5330DW1T1/MUN5331DW1T1/MUN5332DW1T1 MUN5333DW1T1 MUN5334DW1T1 MUN5335DW1T1	R1/R2	0.8 0.17 — 0.8 0.055 0.38 0.038	1.0 0.21 — 1.0 0.1 0.47 0.047	1.2 0.25 — 1.2 0.185 0.56 0.056	

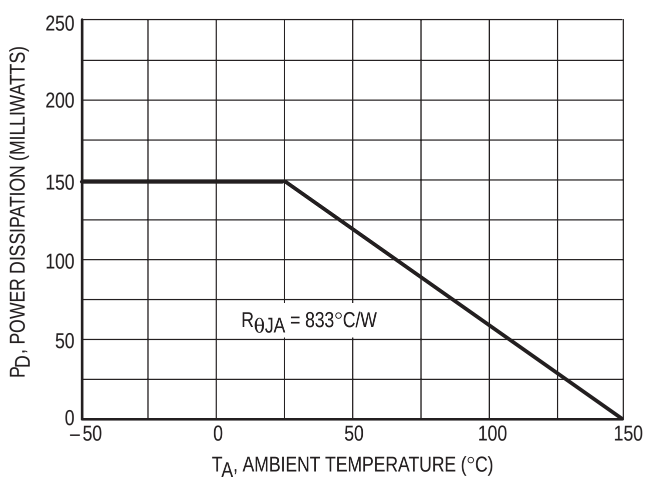


Figure 1. Derating Curve

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5311DW1T1 NPN TRANSISTOR

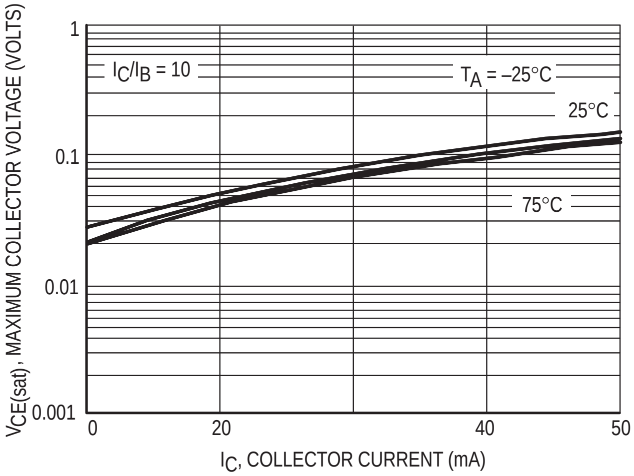


Figure 2. $V_{CE(sat)}$ versus I_C

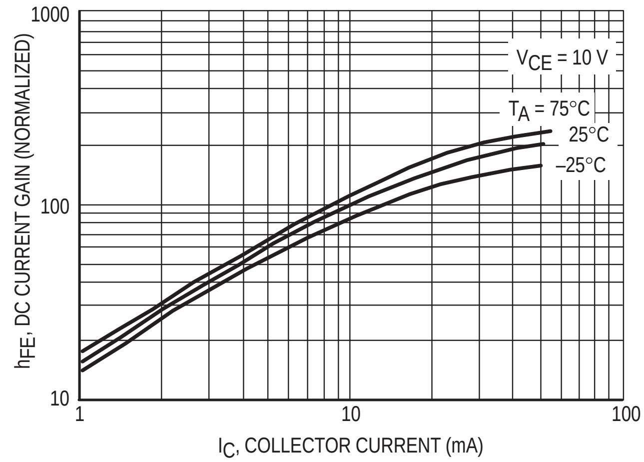


Figure 3. DC Current Gain

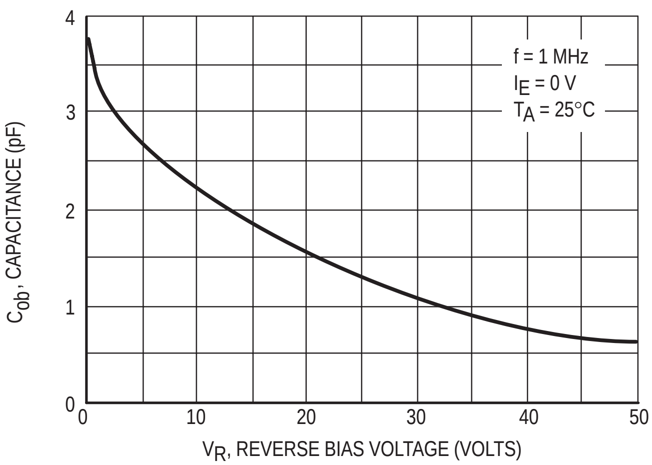


Figure 4. Output Capacitance

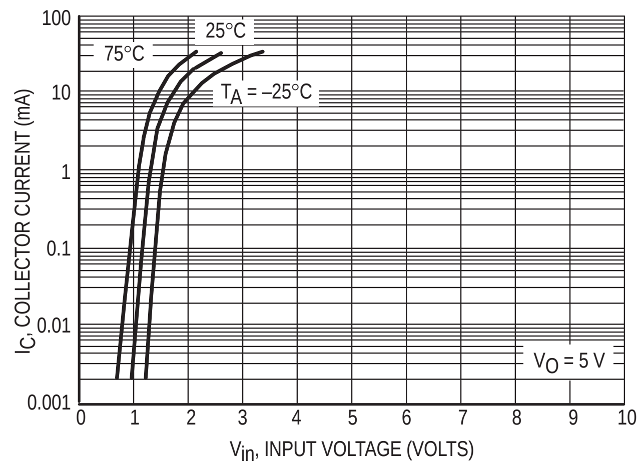


Figure 5. Output Current versus Input Voltage

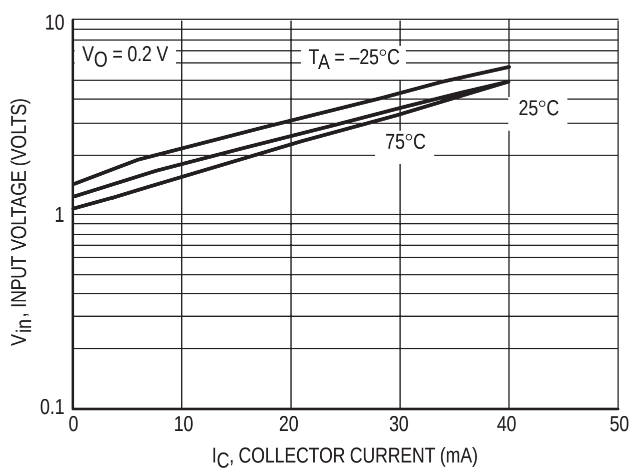


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5311DW1T1 PNP TRANSISTOR

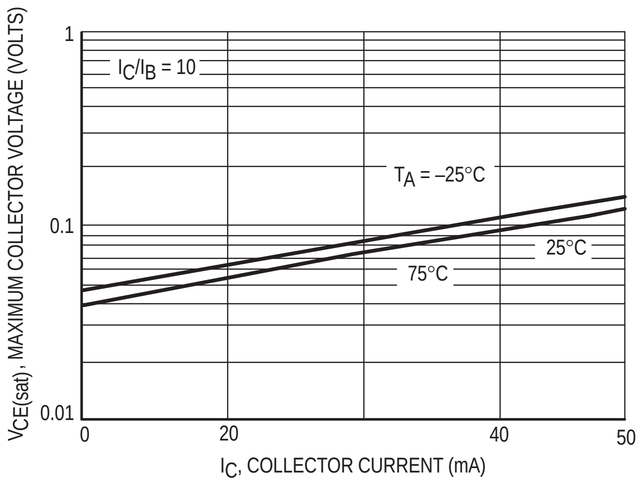


Figure 7. $V_{CE(sat)}$ versus I_C

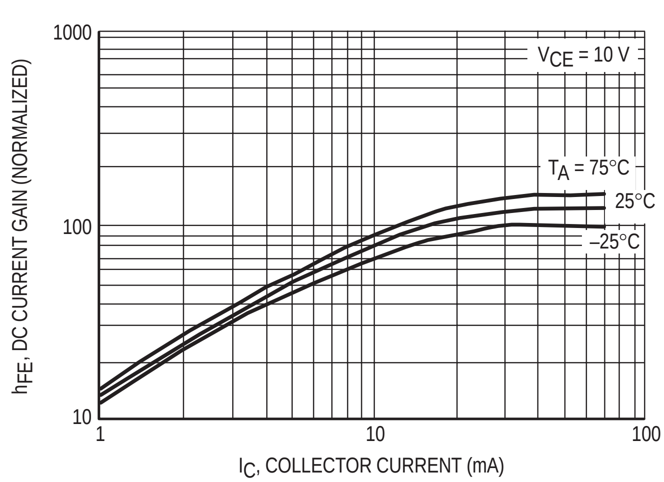


Figure 8. DC Current Gain

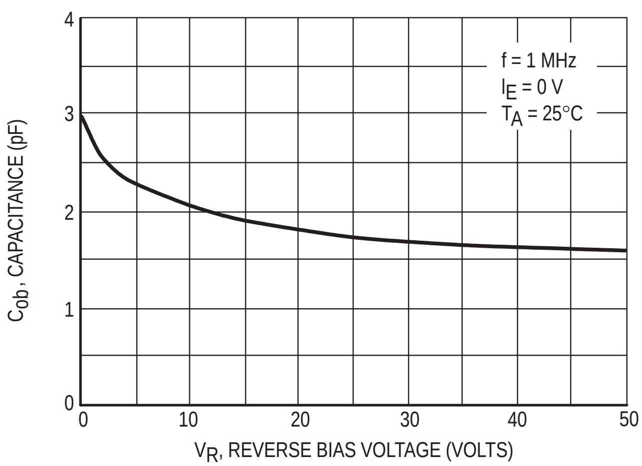


Figure 9. Output Capacitance

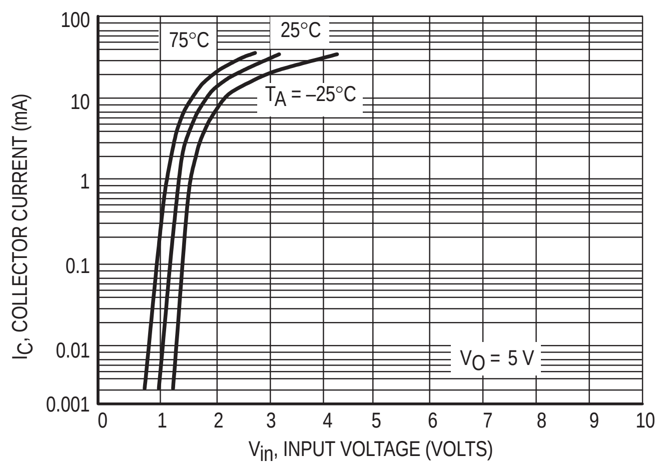


Figure 10. Output Current versus Input Voltage

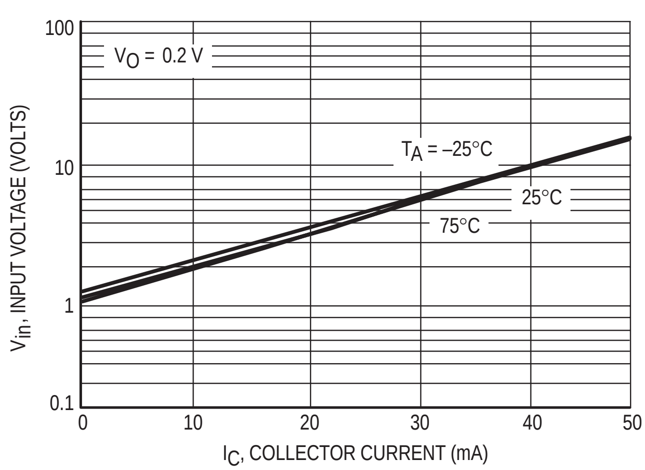


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5312DW1T1 NPN TRANSISTOR

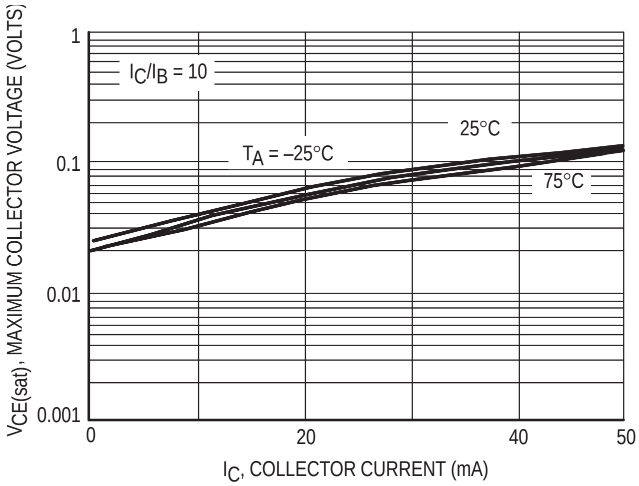


Figure 12. $V_{CE(sat)}$ versus I_C

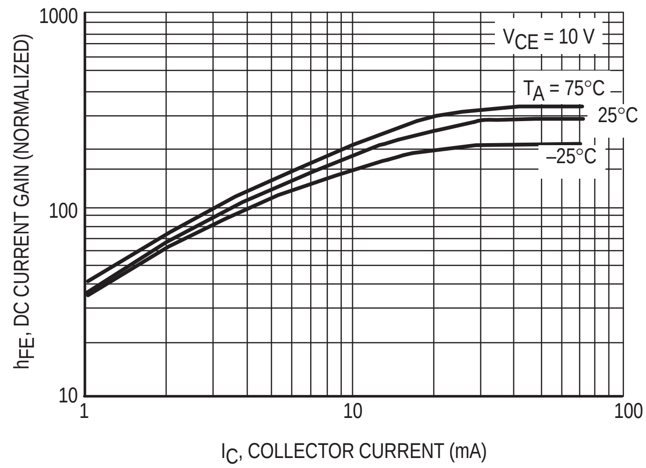


Figure 13. DC Current Gain

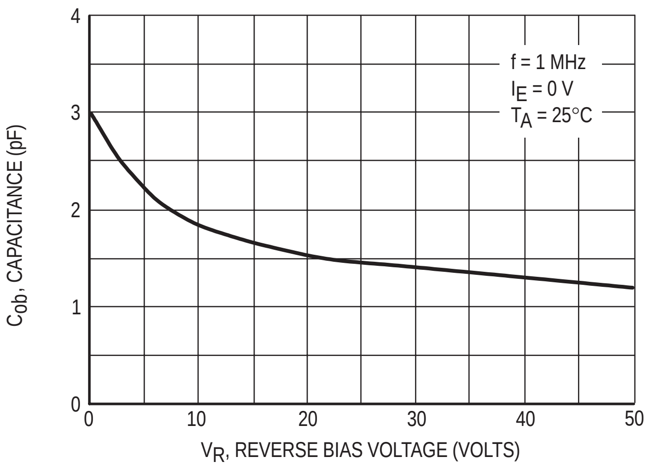


Figure 14. Output Capacitance

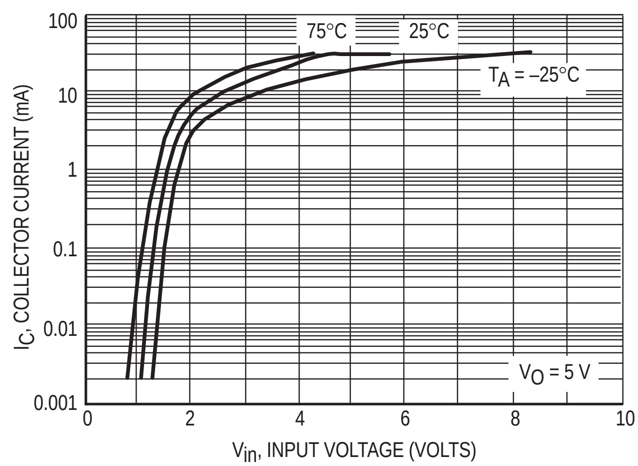


Figure 15. Output Current versus Input Voltage

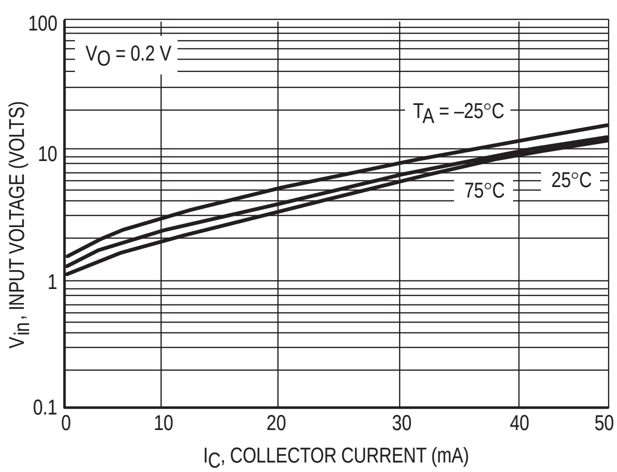


Figure 16. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5312DW1T1 PNP TRANSISTOR

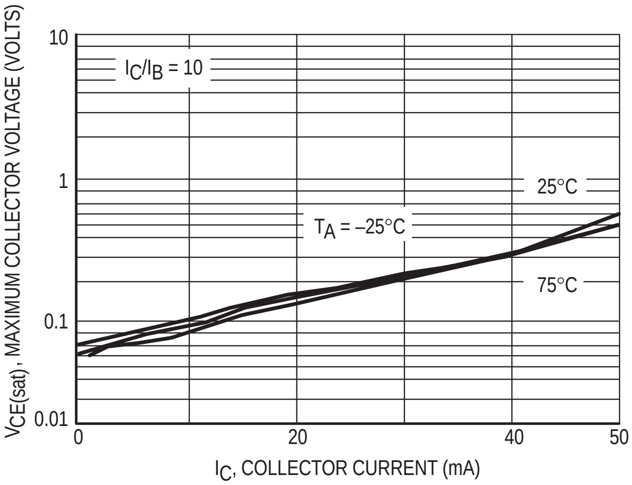


Figure 17. $V_{CE(sat)}$ versus I_C

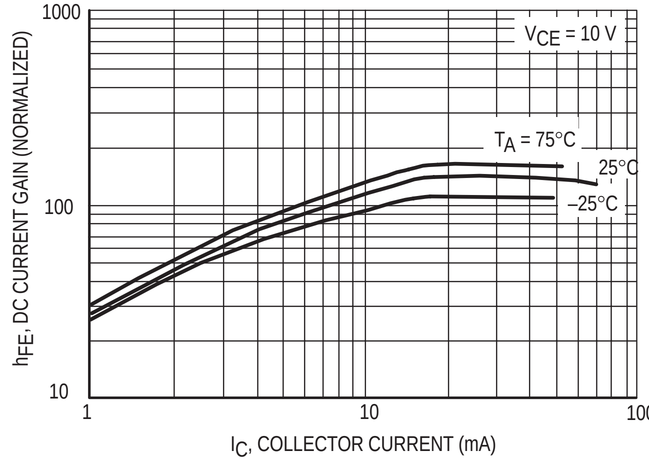


Figure 18. DC Current Gain

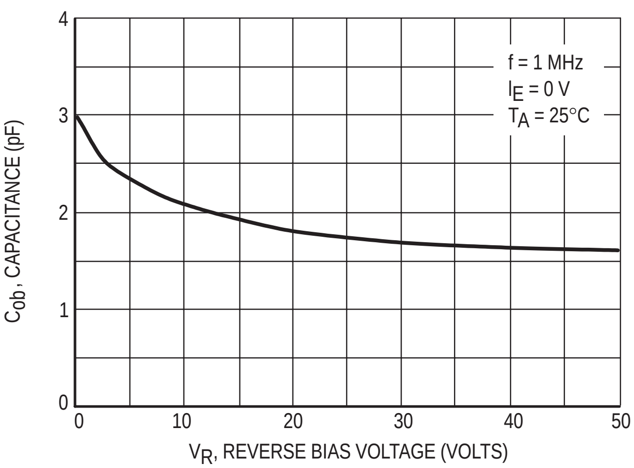


Figure 19. Output Capacitance

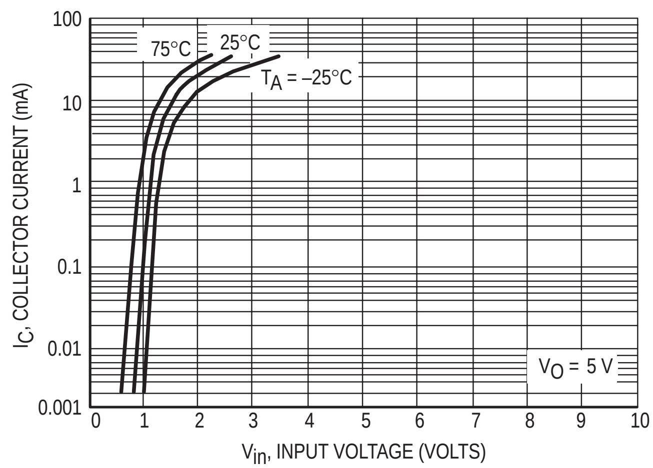


Figure 20. Output Current versus Input Voltage

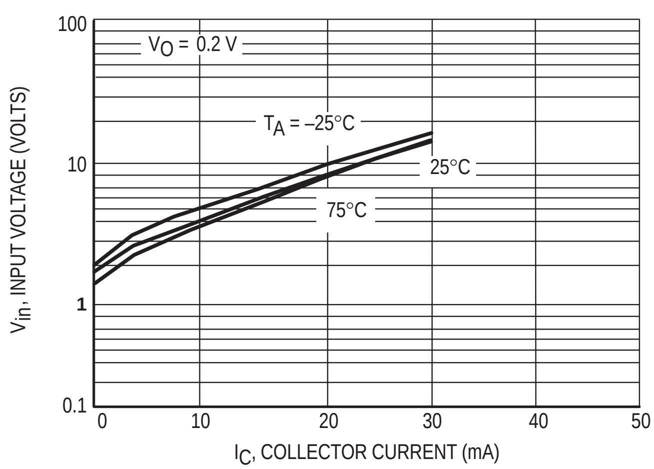


Figure 21. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5313DW1T1 NPN TRANSISTOR

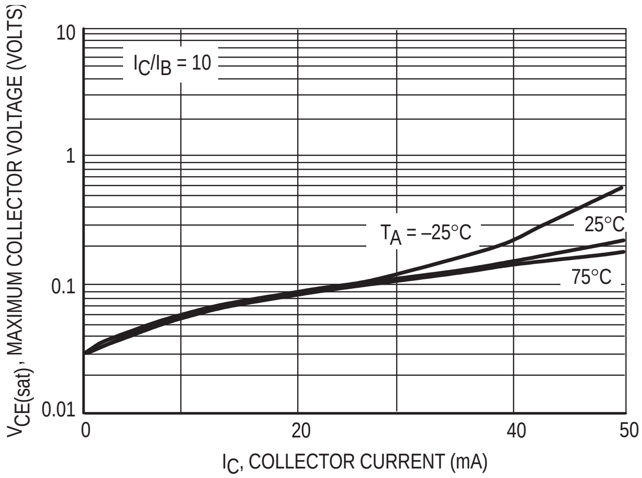


Figure 22. $V_{CE(sat)}$ versus I_C

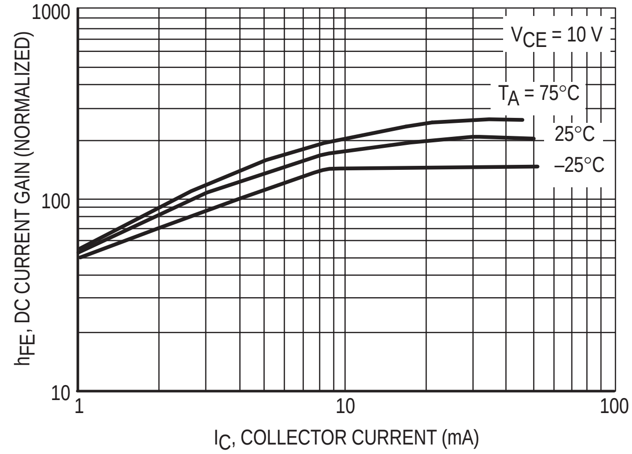


Figure 23. DC Current Gain

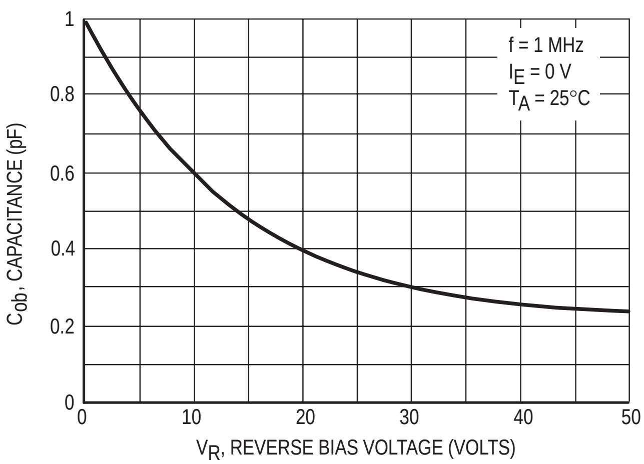


Figure 24. Output Capacitance

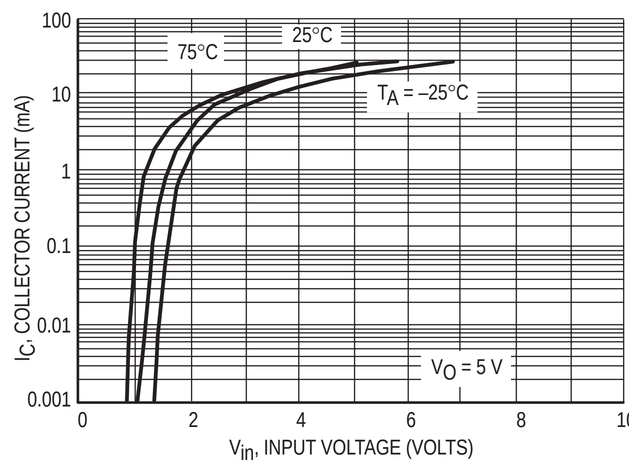


Figure 25. Output Current versus Input Voltage

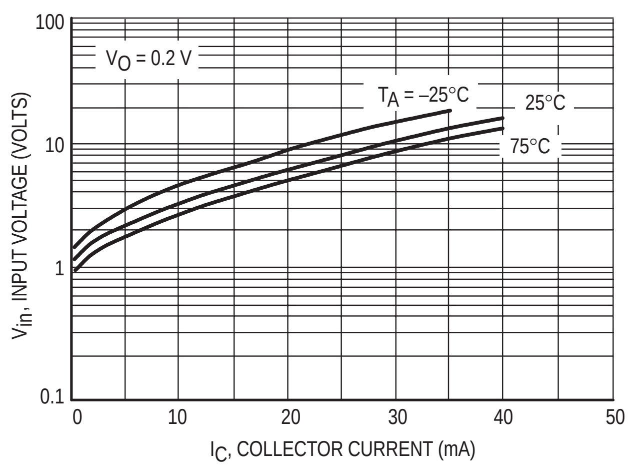


Figure 26. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5313DW1T1 PNP TRANSISTOR

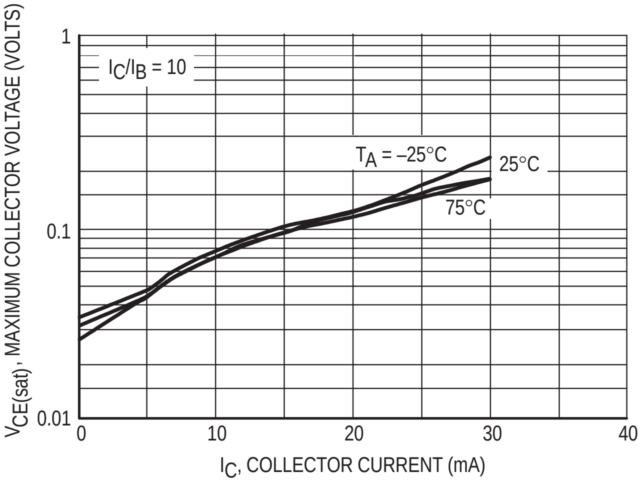


Figure 27. $V_{CE(sat)}$ versus I_C

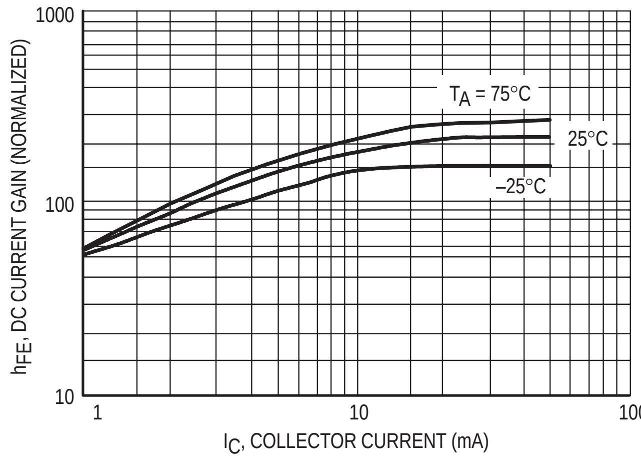


Figure 28. DC Current Gain

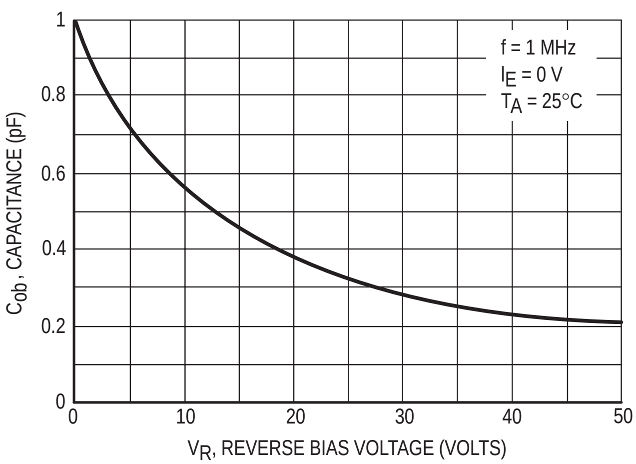


Figure 29. Output Capacitance

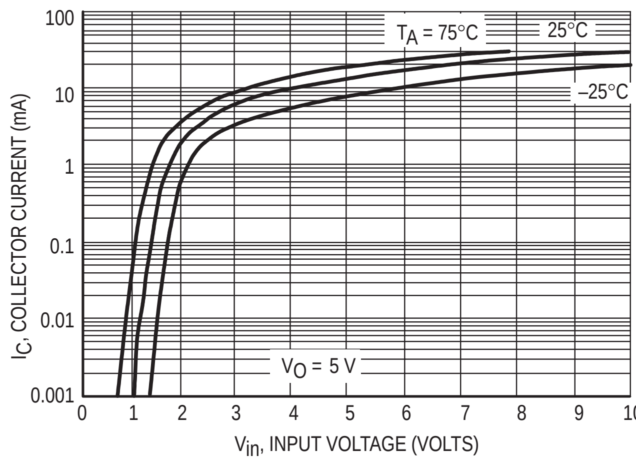


Figure 30. Output Current versus Input Voltage

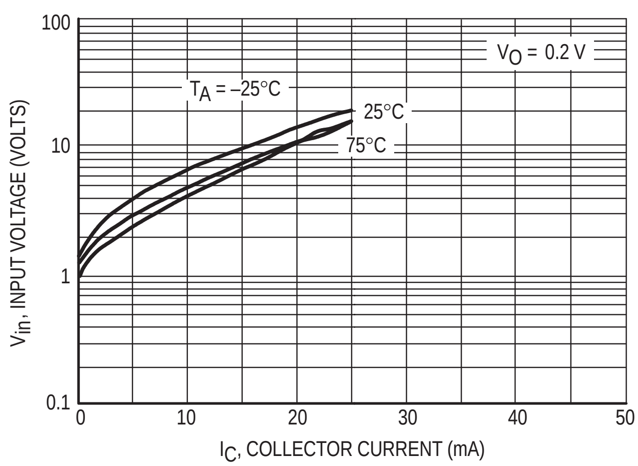


Figure 31. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5314DW1T1 NPN TRANSISTOR

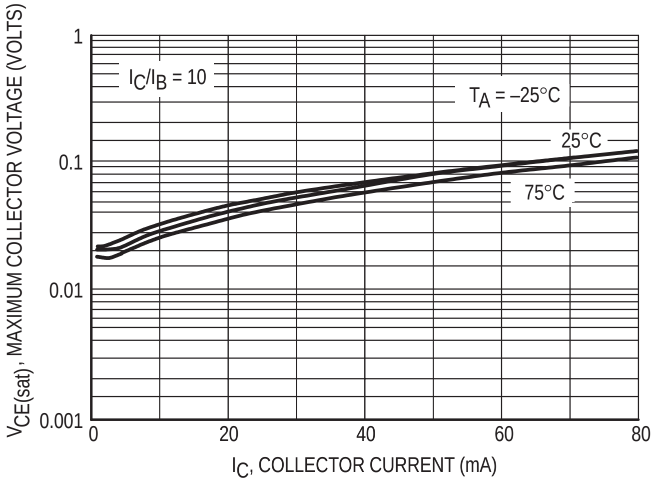


Figure 32. $V_{CE(sat)}$ versus I_C

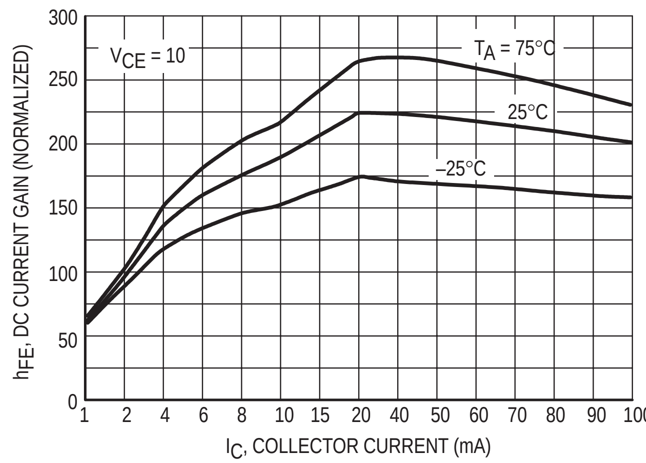


Figure 33. DC Current Gain

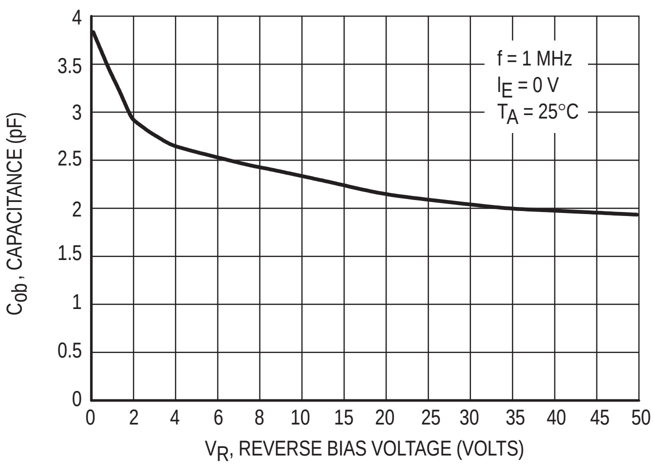


Figure 34. Output Capacitance

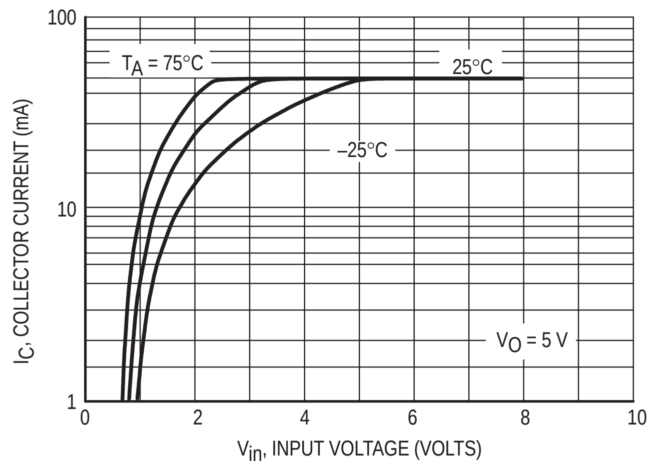


Figure 35. Output Current versus Input Voltage

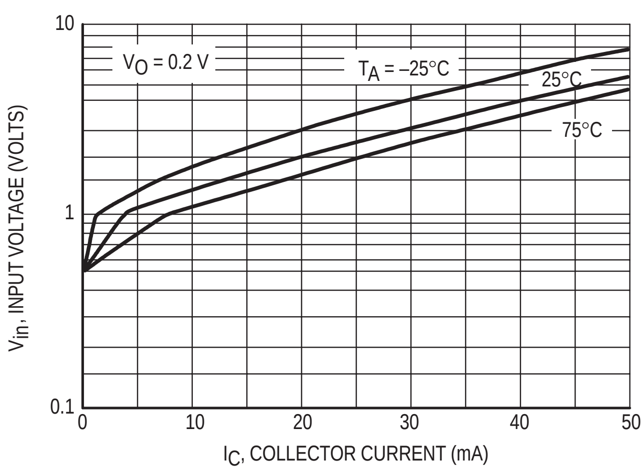


Figure 36. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5314DW1T1 PNP TRANSISTOR

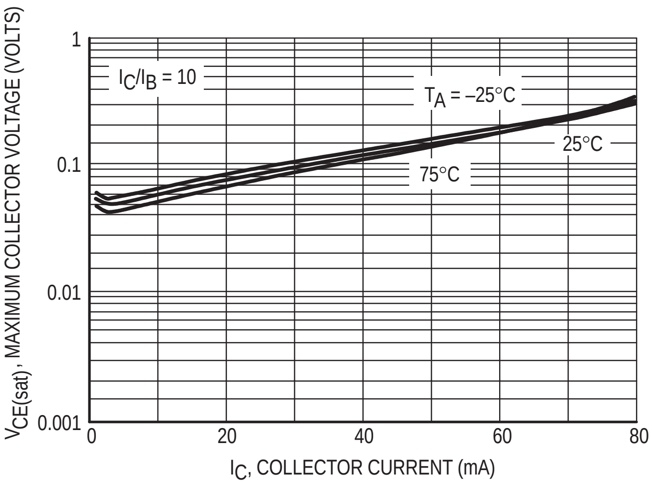


Figure 37. $V_{CE(sat)}$ versus I_C

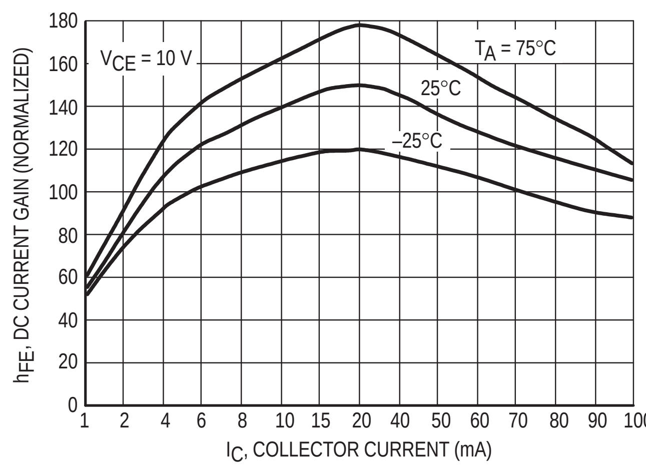


Figure 38. DC Current Gain

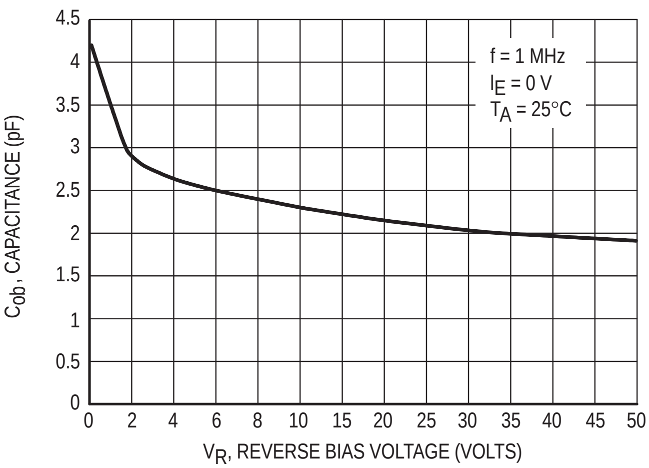


Figure 39. Output Capacitance

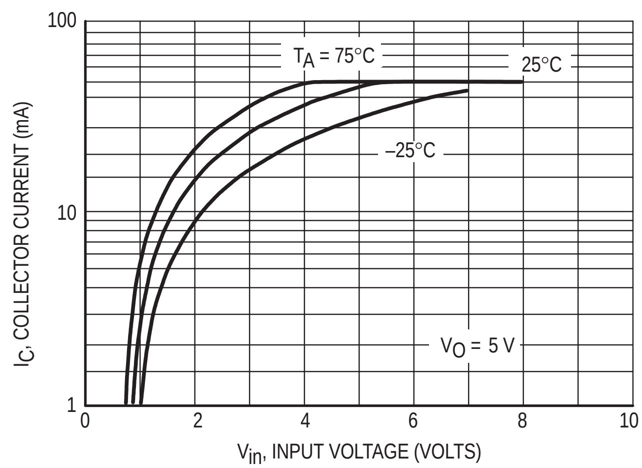


Figure 40. Output Current versus Input Voltage

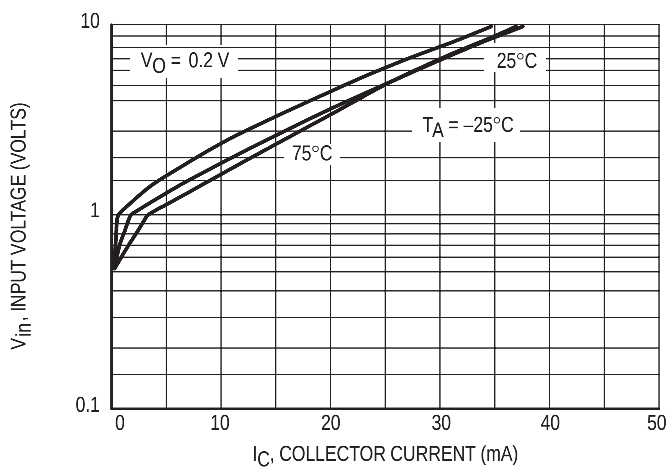


Figure 41. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5315DW1T1

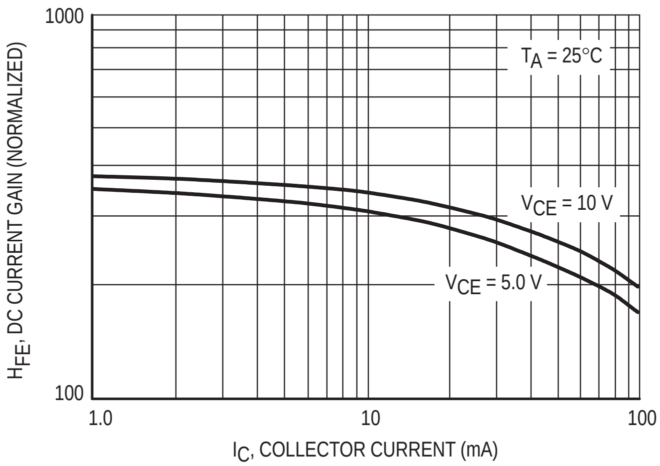


Figure 42. DC Current Gain — PNP

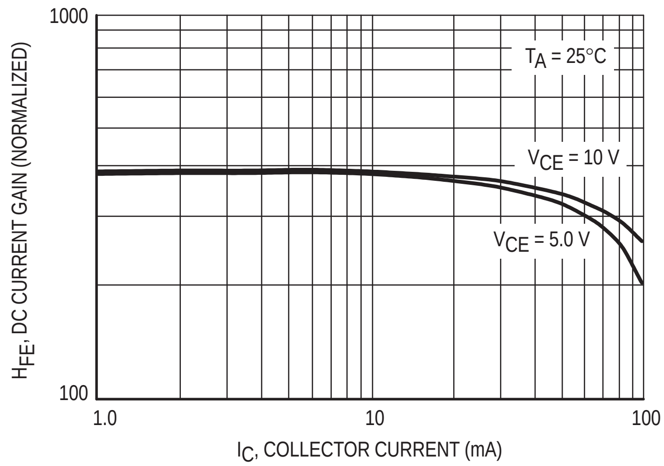


Figure 43. DC Current Gain — NPN

TYPICAL ELECTRICAL CHARACTERISTICS — MUN5316DW1T1

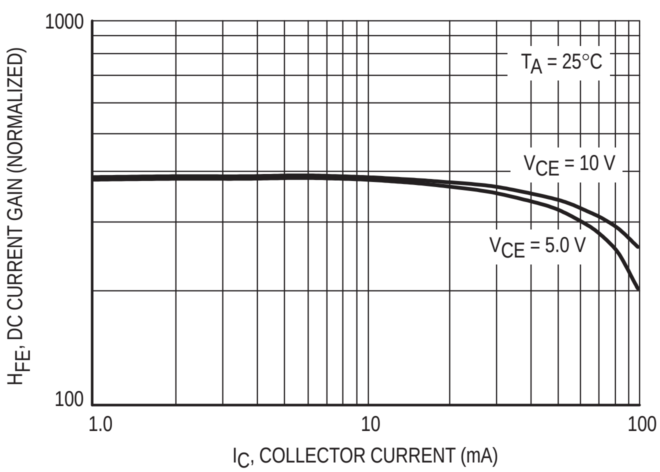


Figure 44. DC Current Gain — PNP

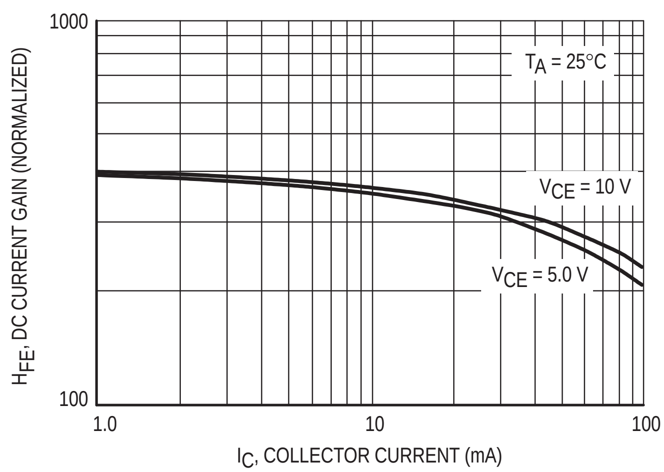
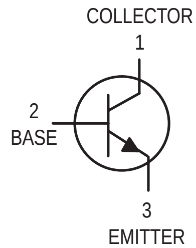


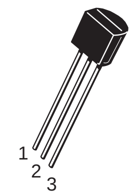
Figure 45. DC Current Gain — NPN

Amplifier Transistors

NPN Silicon

P2N2222A





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

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

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

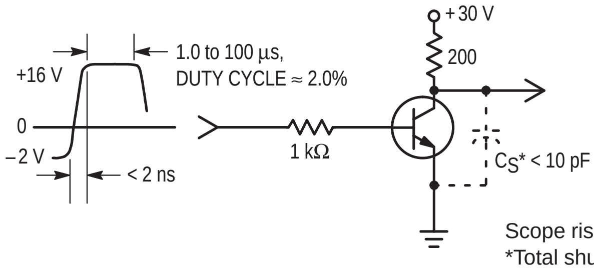
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = –55°C)		35	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)		100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)		50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)		40	—	
Collector–Emitter Saturation Voltage(1)	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	1.0	
Base–Emitter Saturation Voltage(1)	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	2.0	
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}			$X\ 10^{-4}$
(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

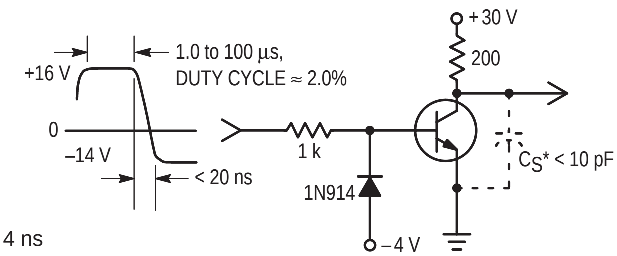
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = –2.0 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





Scope rise time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

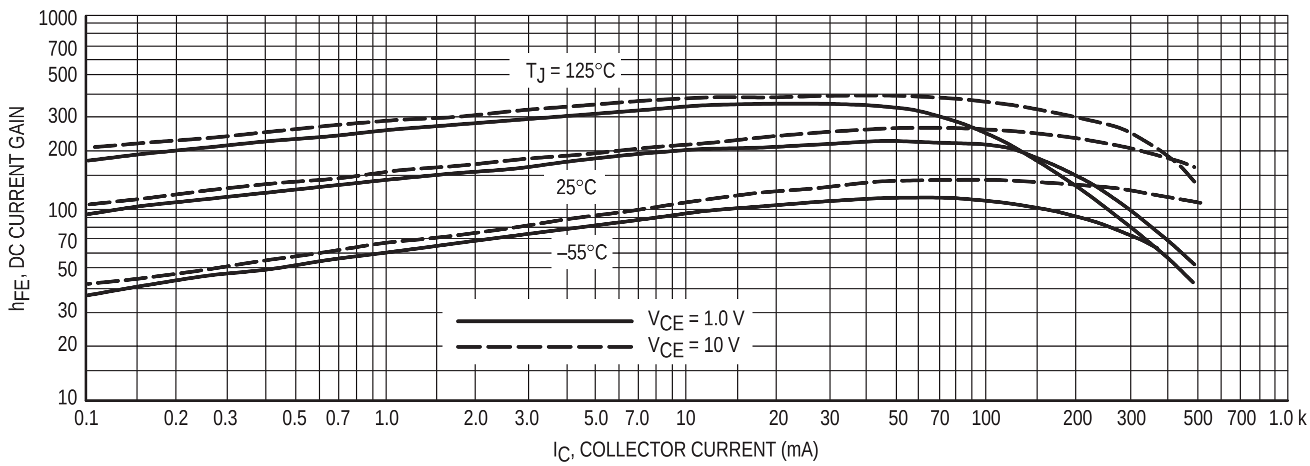


Figure 3. DC Current Gain

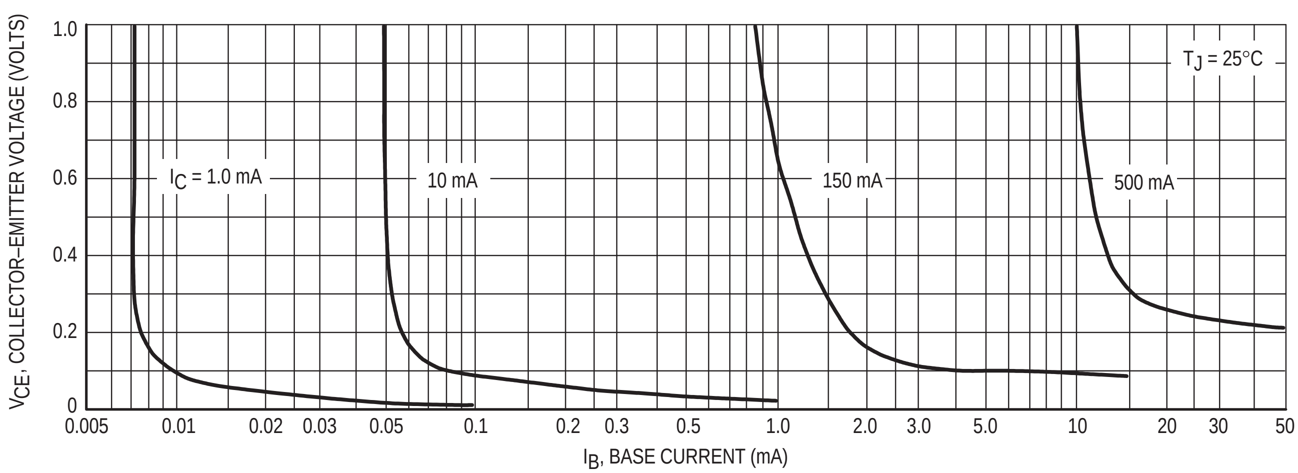


Figure 4. Collector Saturation Region

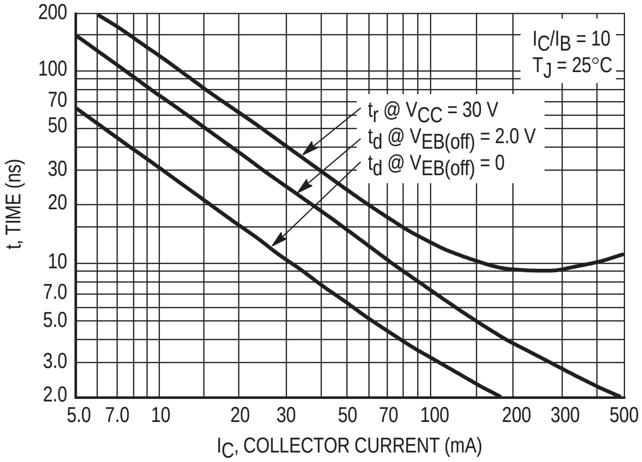


Figure 5. Turn–On Time

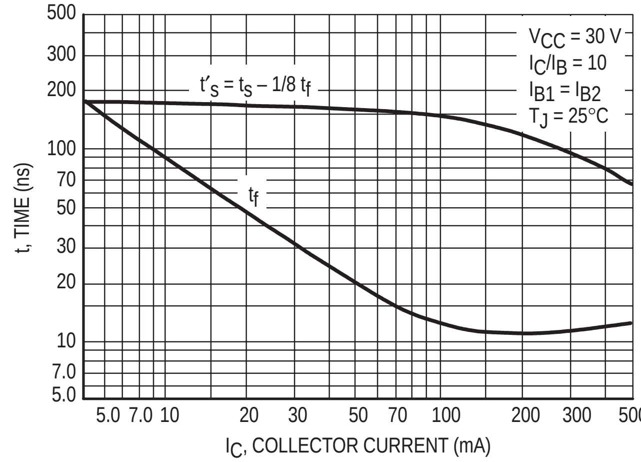


Figure 6. Turn–Off Time

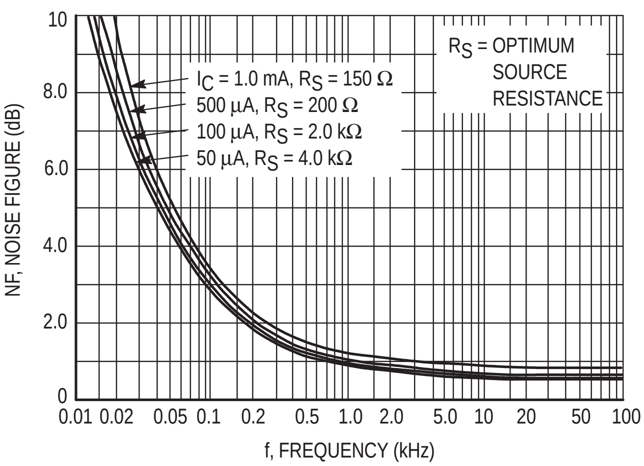


Figure 7. Frequency Effects

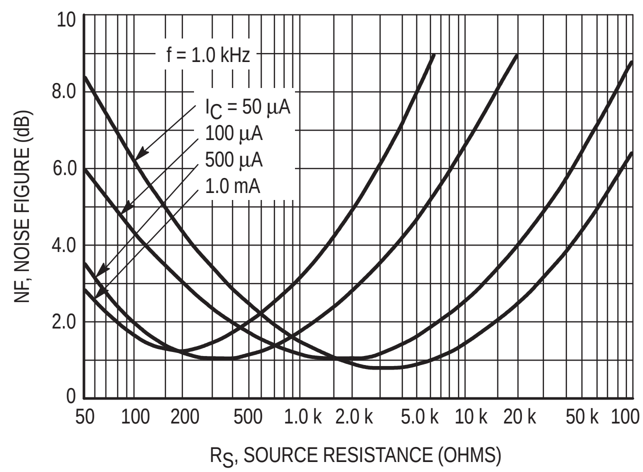


Figure 8. Source Resistance Effects

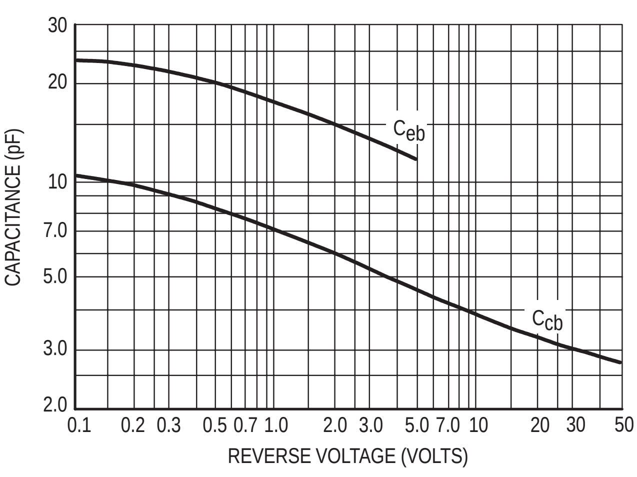


Figure 9. Capacitances

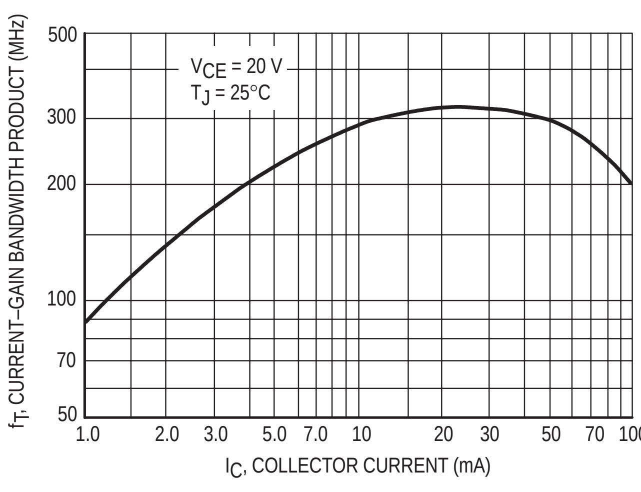


Figure 10. Current–Gain Bandwidth Product

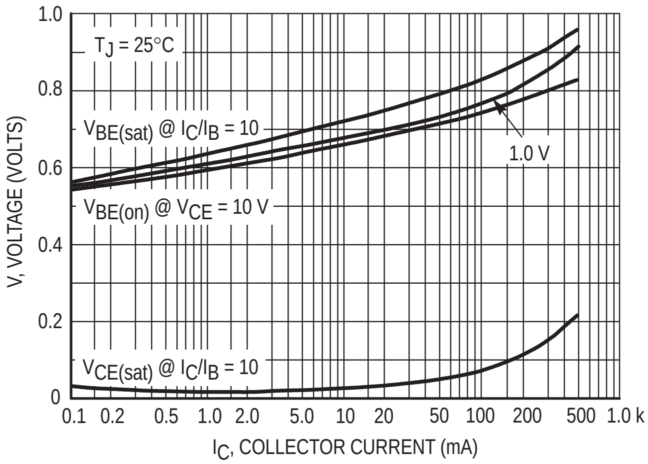


Figure 11. "On" Voltages

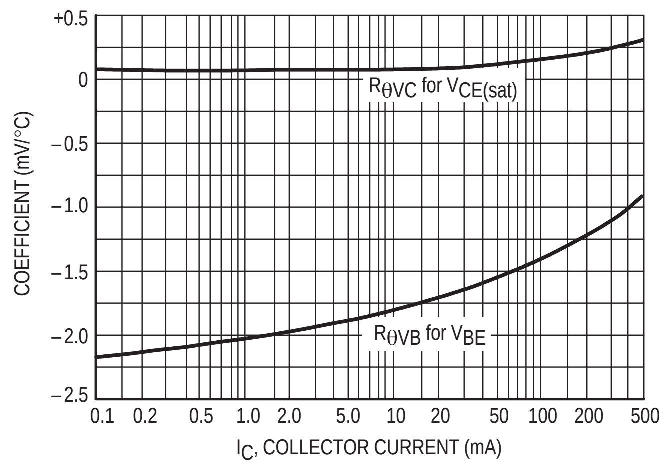
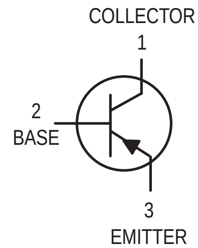
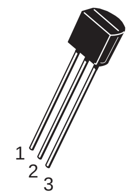


Figure 12. Temperature Coefficients

Amplifier Transistor
PNP Silicon

P2N2907A





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

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

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

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

Characteristic		Symbol	Min	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)(1)			100	300	
(I_C = –500 mAdc, V_{CE} = –10 Vdc)(1)			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(1)		$V_{BE(sat)}$			Vdc
(I_C = –150 mAdc, I_B = –15 mAdc)			—	–1.3	
(I_C = –500 mAdc, I_B = –50 mAdc)			—	–2.6	
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

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.

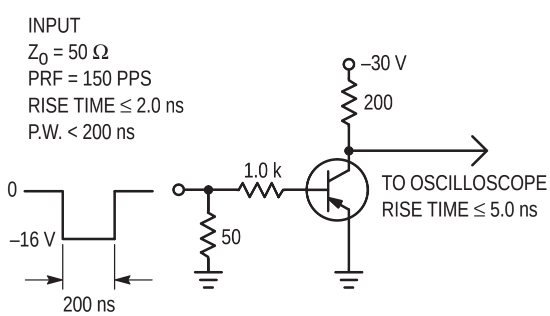


Figure 1. Delay and Rise Time Test Circuit

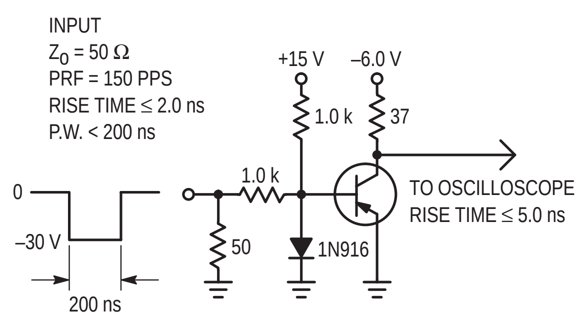


Figure 2. Storage and Fall Time Test Circuit

TYPICAL CHARACTERISTICS

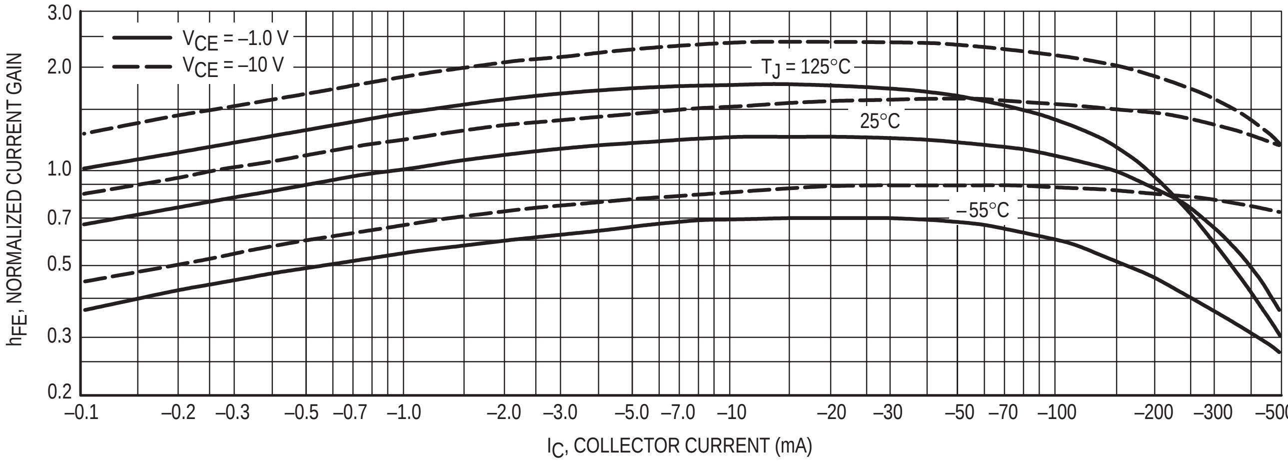


Figure 3. DC Current Gain

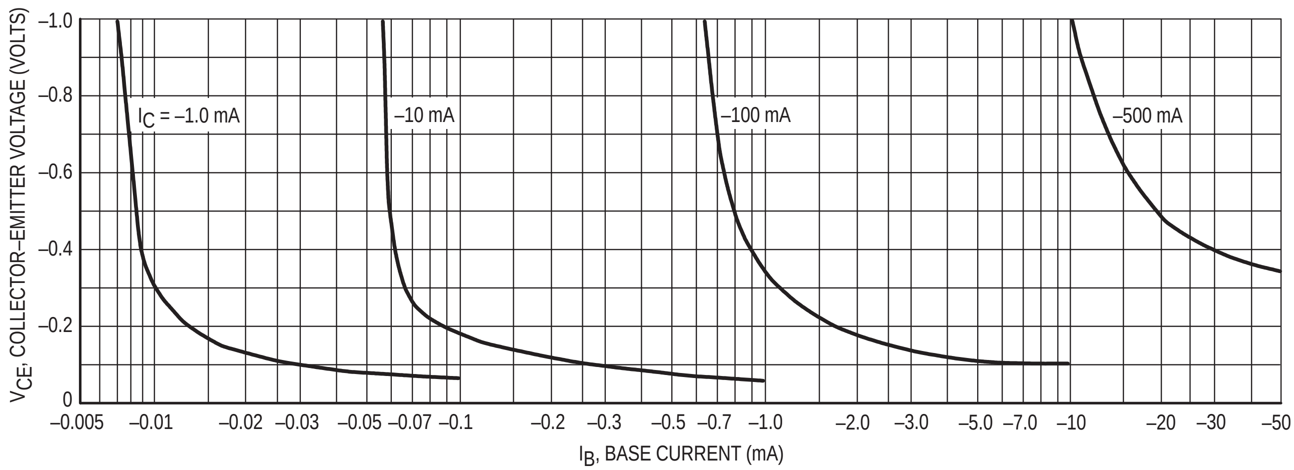


Figure 4. Collector Saturation Region

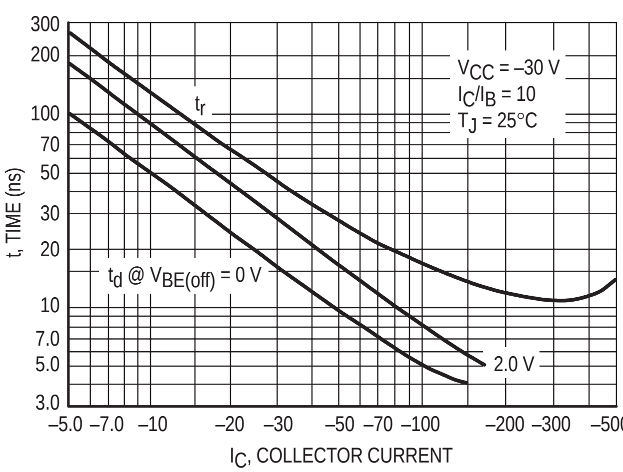


Figure 5. Turn–On Time

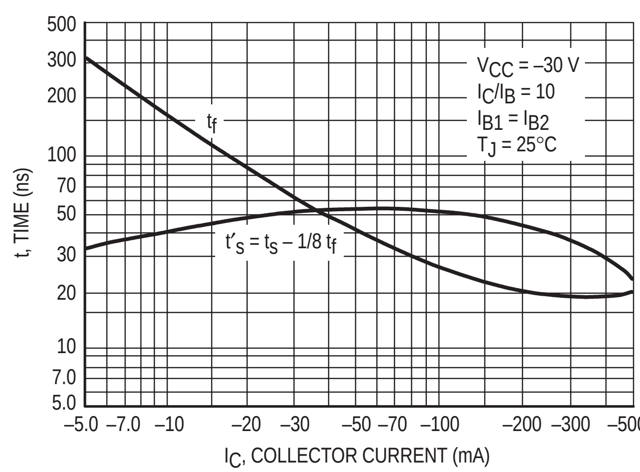


Figure 6. Turn–Off Time

TYPICAL SMALL–SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

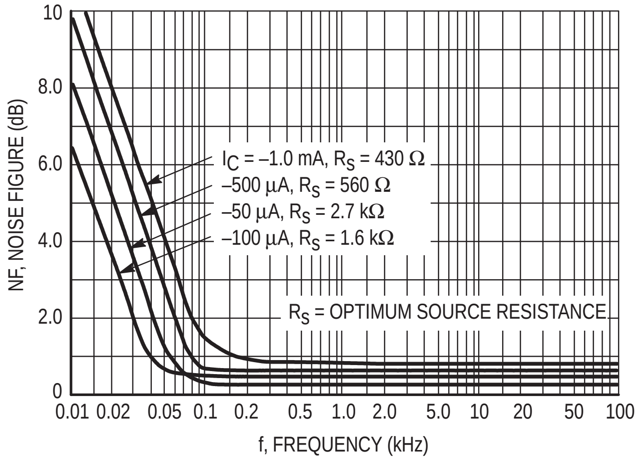


Figure 7. Frequency Effects

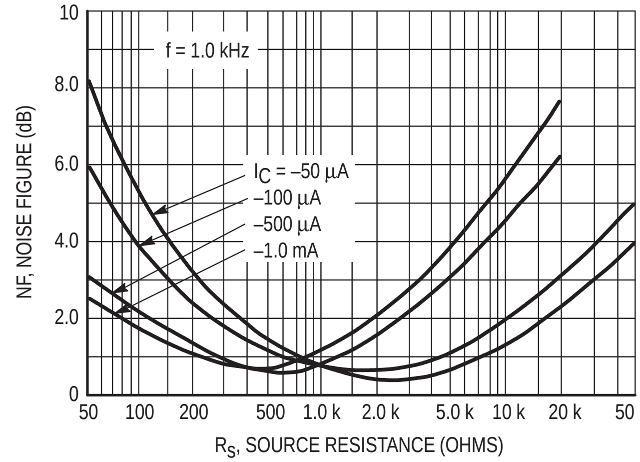


Figure 8. Source Resistance Effects

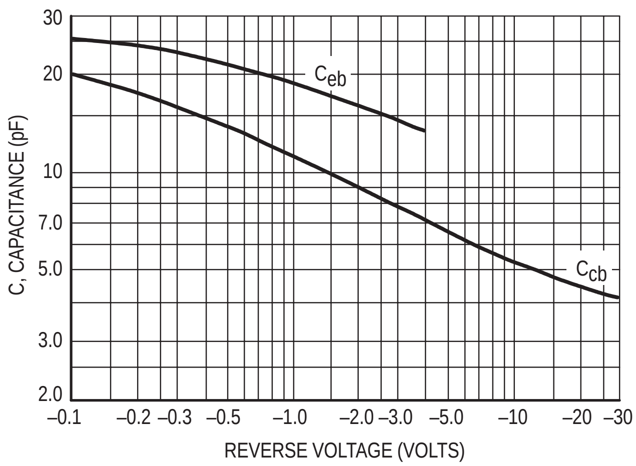


Figure 9. Capacitances

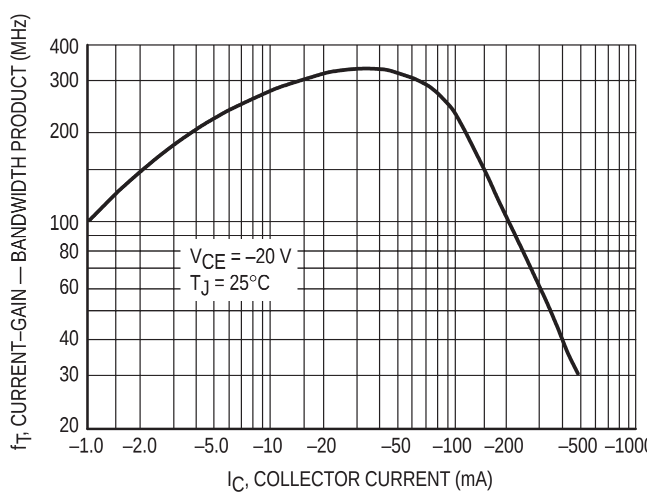


Figure 10. Current–Gain — Bandwidth Product

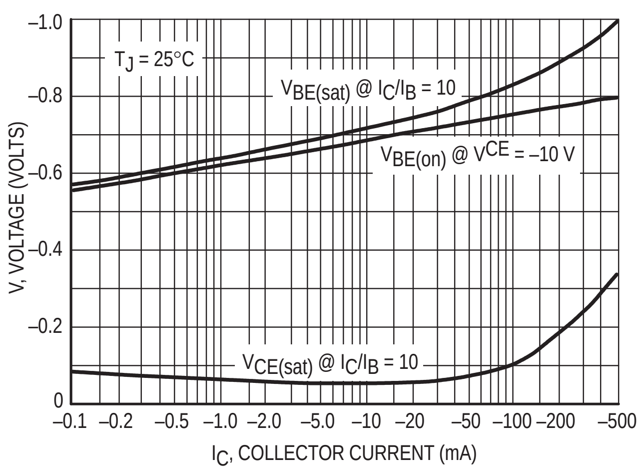


Figure 11. "On" Voltage

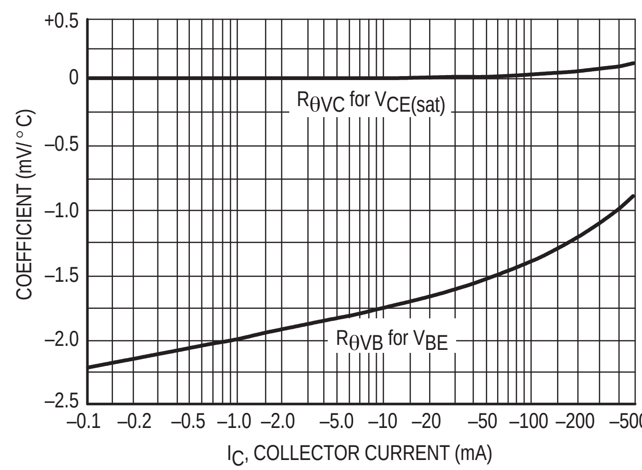


Figure 12. Temperature Coefficients

NPN Silicon Planar Epitaxial Transistor

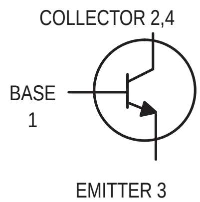
PZT651T1

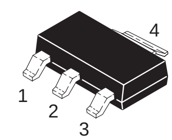
Motorola Preferred Device

**SOT–223 PACKAGE
HIGH CURRENT
NPN SILICON
TRANSISTOR
SURFACE MOUNT**

This NPN Silicon Epitaxial transistor is designed for use in industrial and consumer applications. The device is housed in the SOT–223 package which is designed for medium power surface mount applications.

- High Current: 2.0 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 PZT651T1 to order the 7 inch/1000 unit reel
  Use PZT651T3 to order the 13 inch/4000 unit reel
- PNP Complement is PZT751T1





**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}	80	Vdc
Emitter–Base Voltage	V_{EBO}	5.0	Vdc
Collector Current	I_C	2.0	Adc
Total Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	0.8 6.4	Watts mW/°C
Storage Temperature Range	T_{stg}	–65 to 150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

651

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance from Junction–to–Ambient in Free Air	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 10	°C Sec

1. Device mounted on a FR–4 glass epoxy printed circuit board using minimum recommended footprint.

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

REV 1

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

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	60	—	Vdc
Collector–Emitter 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
Base–Emitter Cutoff Current (V_{EB} = 4.0 Vdc)	I_{EBO}	—	0.1	µAdc
Collector–Base Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS (2)				
DC Current Gain	h_{FE}			—
(I_C = 50 mAdc, V_{CE} = 2.0 Vdc)		75	—	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		75	—	
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		75	—	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)		40	—	
Collector–Emitter Saturation Voltages	$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 200 mAdc)		—	0.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)		—	0.3	
Base–Emitter Voltages (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	—	1.0	Vdc
Base–Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	—	1.2	Vdc
Current–Gain — Bandwidth (I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	75	—	MHz

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

PNP Silicon Planar Epitaxial Transistor

PZT751T1

Motorola Preferred Device

**SOT–223 PACKAGE
HIGH CURRENT
PNP SILICON
TRANSISTOR
SURFACE MOUNT**

This PNP Silicon Epitaxial transistor is designed for use in industrial and consumer applications. The device is housed in the SOT–223 package which is designed for medium power surface mount applications.

- High Current: 2.0 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 PZT751T1 to order the 7 inch/1000 unit reel.
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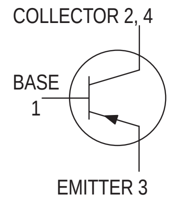
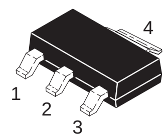
- NPN Complement is PZT651T1





**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}	80	Vdc
Emitter–Base Voltage	V_{EBO}	5.0	Vdc
Collector Current	I_C	2.0	Adc
Total Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	0.8 6.4	Watts mW/°C
Storage Temperature Range	T_{stg}	–65 to 150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

ZT751

THERMAL CHARACTERISTICS

Thermal Resistance from Junction–to–Ambient in Free Air	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes Time in Solder Bath	T_L	260 10	°C Sec

1. Device mounted on a FR–4 glass epoxy printed circuit board using minimum recommended footprint.

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

REV 1

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

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	60	—	Vdc
Collector–Emitter 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
Base–Emitter Cutoff Current (V_{EB} = 4.0 Vdc)	I_{EBO}	—	0.1	µAdc
Collector–Base Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS (2)				
DC Current Gain	h_{FE}			—
(I_C = 50 mAdc, V_{CE} = 2.0 Vdc)		75	—	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		75	—	
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		75	—	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)		40	—	
Collector–Emitter Saturation Voltages	$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 200 mAdc)		—	0.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)		—	0.3	
Base–Emitter Voltages (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	—	1.0	Vdc
Base–Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	—	1.2	Vdc
Current–Gain–Bandwidth (I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	75	—	MHz

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

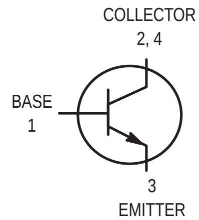
NPN Silicon Planar Epitaxial Transistor

PZT2222AT1

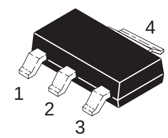
Motorola Preferred Device

This NPN 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.

- PNP Complement is PZT2907AT1
- 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 PZT2222AT1 to order the 7 inch/1000 unit reel.
  Use PZT2222AT3 to order the 13 inch/4000 unit reel.



SOT-223 PACKAGE
NPN SILICON
TRANSISTOR
SURFACE MOUNT



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

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(1)	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
Lead Temperature for Soldering, 0.0625″ from case Time in Solder Bath	T_L	260 10	°C Sec

DEVICE MARKING

P1F

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
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}	—	100	nAdc

1. 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 $inches^2$.

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

REV 2

ELECTRICAL CHARACTERISTICS — continued (T_A = 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	$\lvert h_{fe} \rvert$			—
(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	35	
(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, $V_{EB(off)}$ = 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	

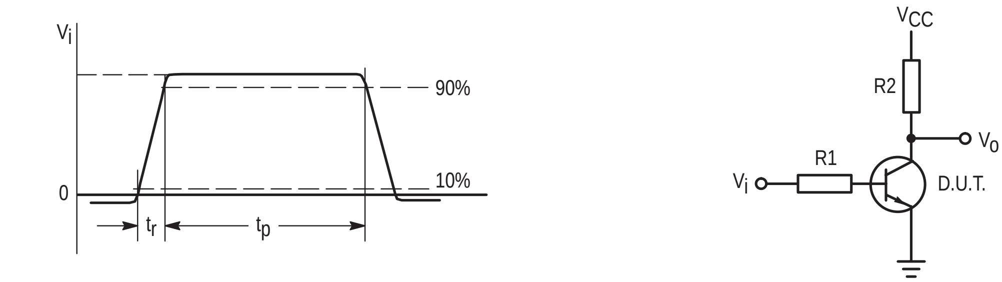


Figure 1. Input Waveform and Test Circuit for Determining Delay Time and Rise Time

V_i = – 0.5 V to +9.9 V, V_{CC} = +30 V, R1 = 619 Ω, R2 = 200 Ω.

PULSE GENERATOR:				OSCILLOSCOPE:			
PULSE DURATION	t_p	≤	200 ns	INPUT IMPEDANCE	Z_i	>	100 kΩ
RISE TIME	t_r	≤	2 ns	INPUT CAPACITANCE	C_i	<	12 pF
DUTY FACTOR	δ	=	0.02	RISE TIME	t_r	<	5 ns

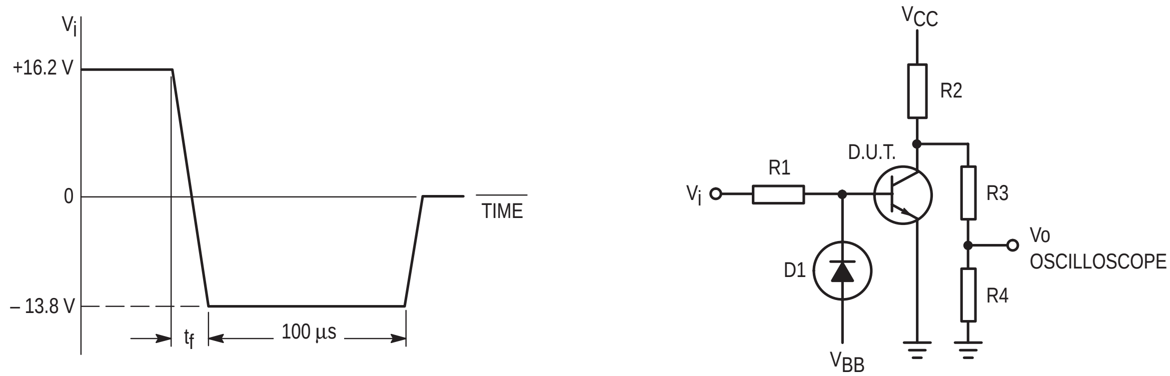


Figure 2. Input Waveform and Test Circuit for Determining Storage Time and Fall Time

PNP Silicon Epitaxial Transistor

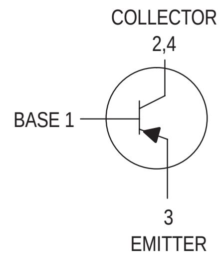
PZT2907AT1

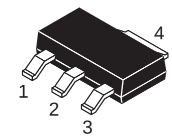
Motorola Preferred Device

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(1) 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 10	°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

1. 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.

REV 4

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS[2]						
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	

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

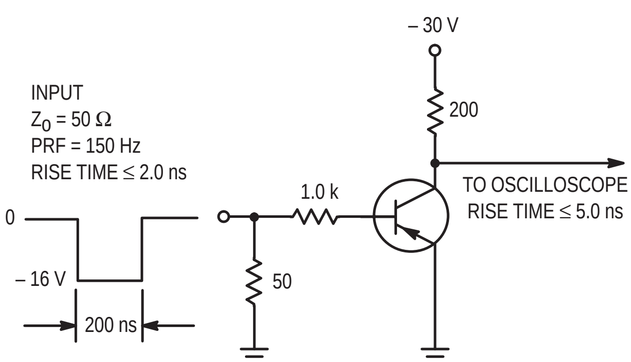


Figure 1. Delay and Rise Time Test Circuit

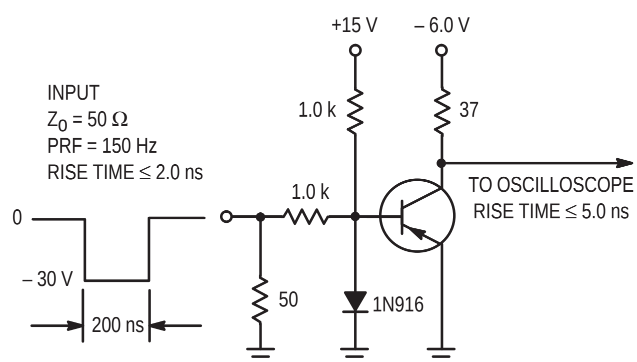


Figure 2. Storage and Fall Time Test Circuit

TYPICAL ELECTRICAL CHARACTERISTICS

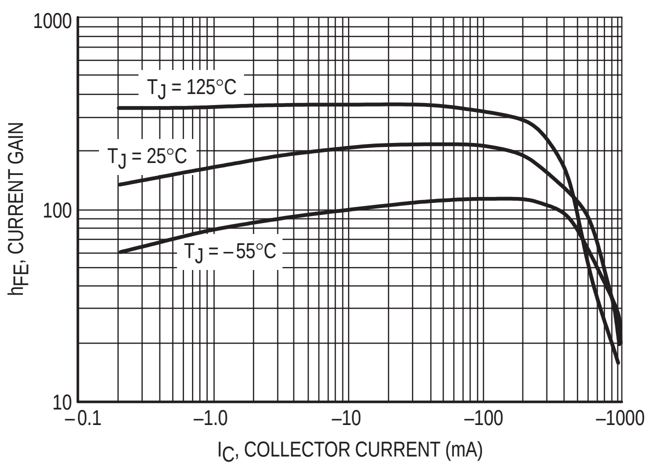


Figure 3. DC Current Gain

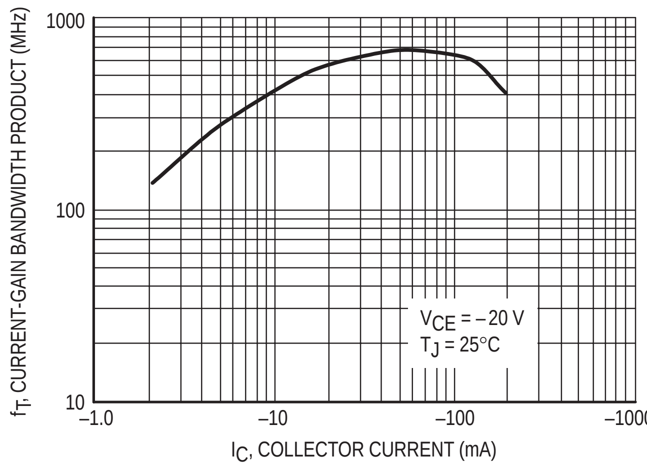


Figure 4. Current Gain Bandwidth Product

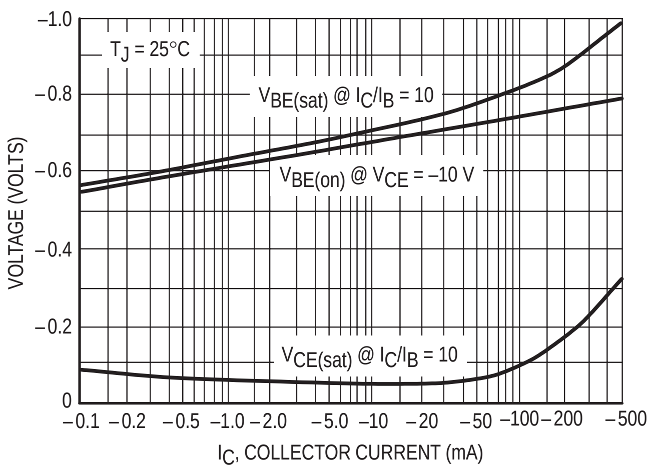


Figure 5. “ON” Voltage

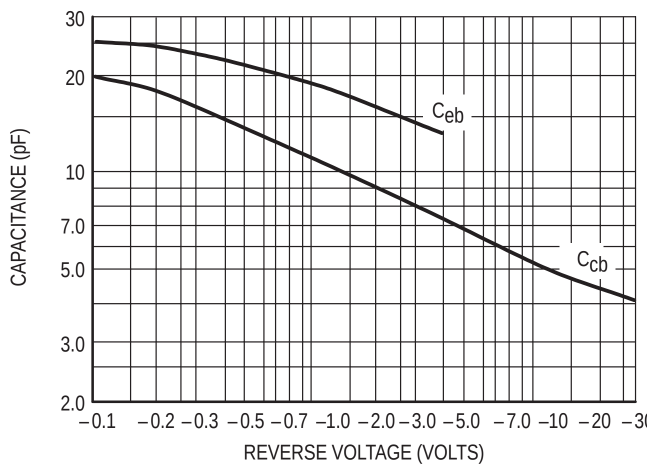


Figure 6. Capacitances

NPN Small-Signal Darlington Transistor

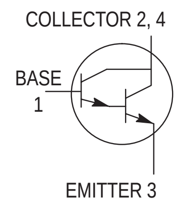
PZTA14T1

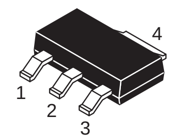
Motorola Preferred Device

**SOT–223 PACKAGE
MEDIUM POWER
NPN SILICON
DARLINGTON
TRANSISTOR
SURFACE MOUNT**

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





**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(1)	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 10	°C Sec

1. 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.

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

REV 1

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 (2)					
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

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

TYPICAL ELECTRICAL CHARACTERISTICS

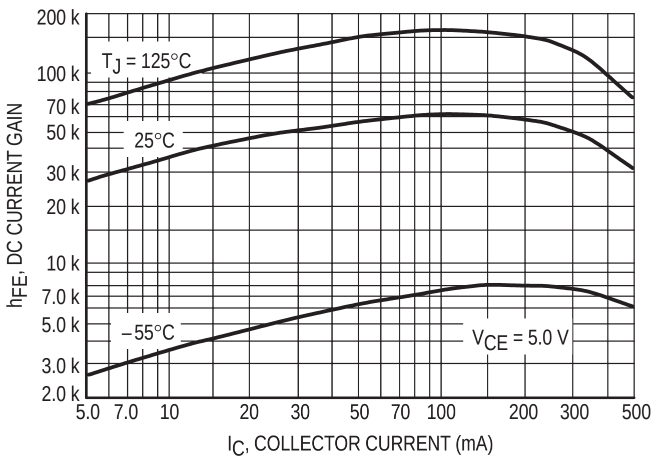


Figure 1. DC Current Gain

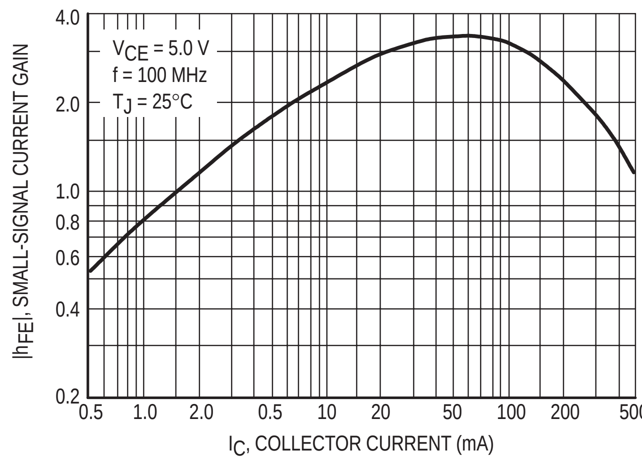


Figure 2. High Frequency Current Gain

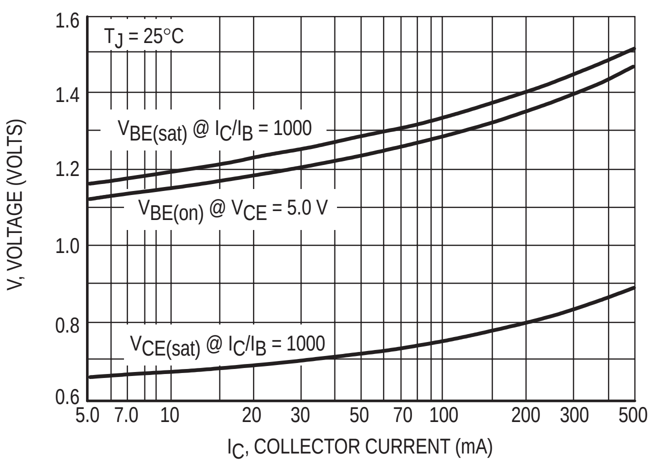


Figure 3. "On" Voltages

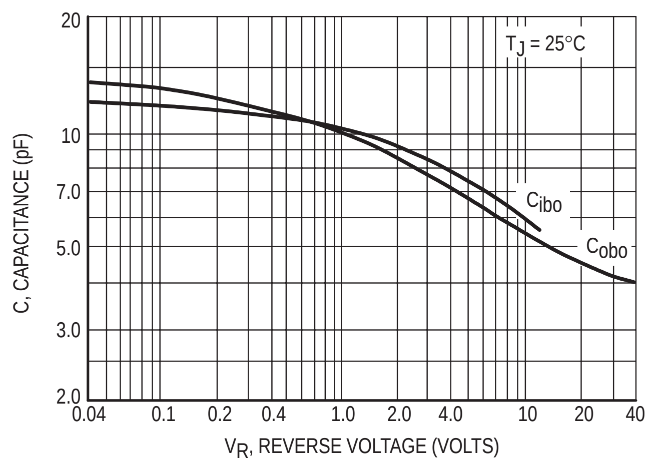


Figure 4. Capacitance

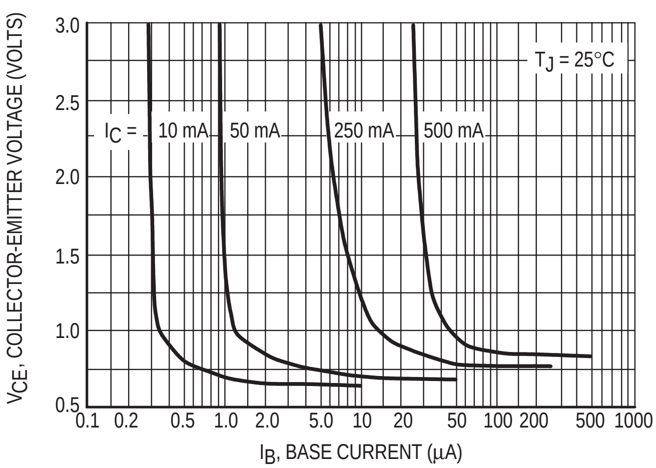


Figure 5. Collector Saturation Region

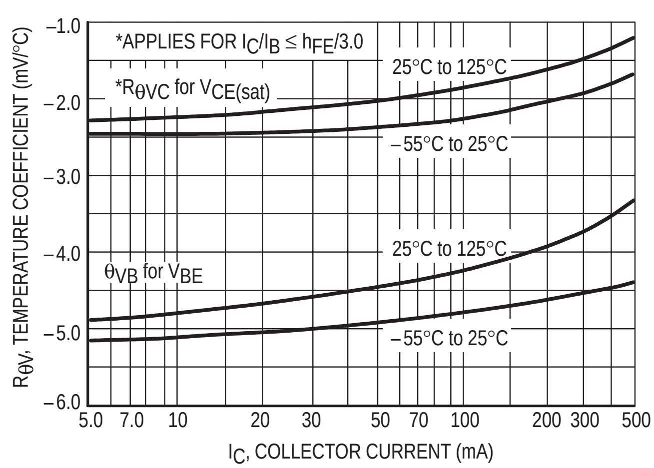


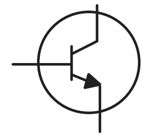
Figure 6. Temperature Coefficients

High Voltage Transistor Surface Mount

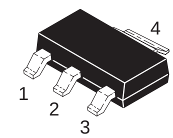
NPN Silicon

PZTA42T1

Motorola Preferred Device



SOT–223 PACKAGE
NPN SILICON
HIGH VOLTAGE
TRANSISTOR
SURFACE MOUNT



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

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 @ T_A = 25°C(1)	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

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction-to-Ambient(1)	$R_{\theta JA}$	83.3	°C/W

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

Characteristics	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 = 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

1. 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.
2. Pulse Test Conditions, t_p = 300 µs, δ = 0.02.

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

REV 2

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

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	 — — —	—

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

PNP Small-Signal Darlington Transistor

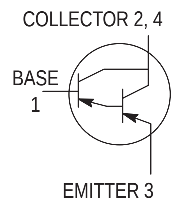
PZTA64T1

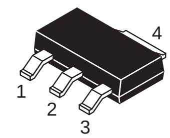
Motorola Preferred Device

SOT-223 PACKAGE PNP SILICON DARLINGTON TRANSISTOR SURFACE MOUNT

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





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(1)	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 10	°C Sec

1. 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.

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

REV 4

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(2)				
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 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

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

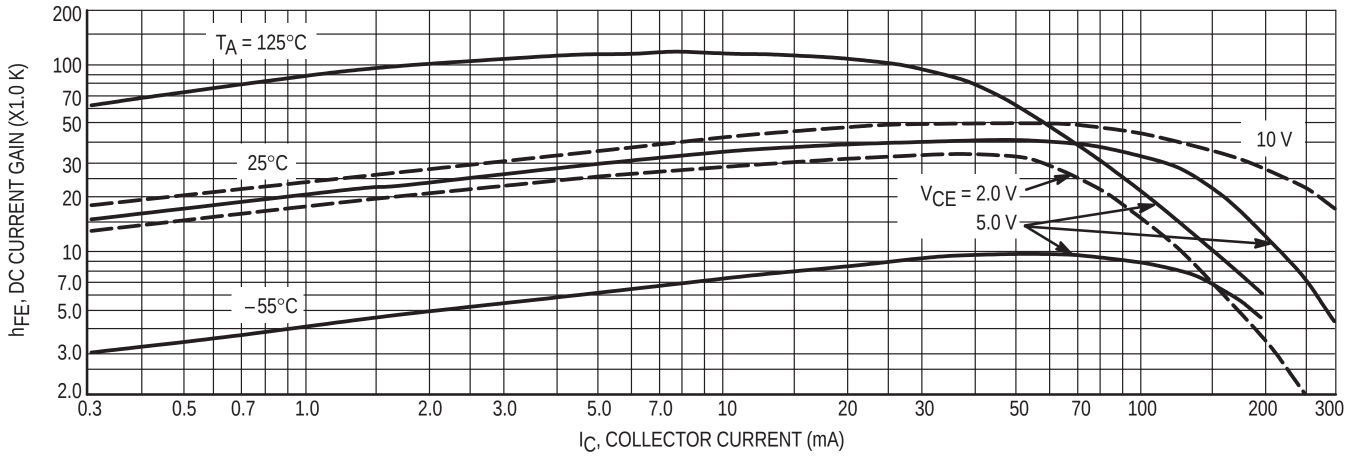


Figure 1. DC Current Gain

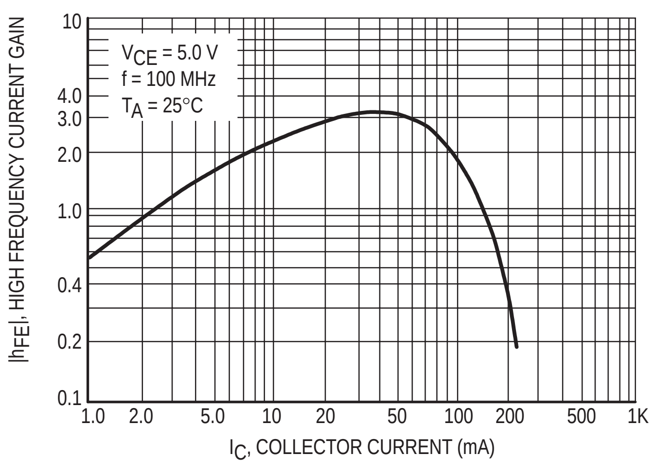


Figure 2. High Frequency Current Gain

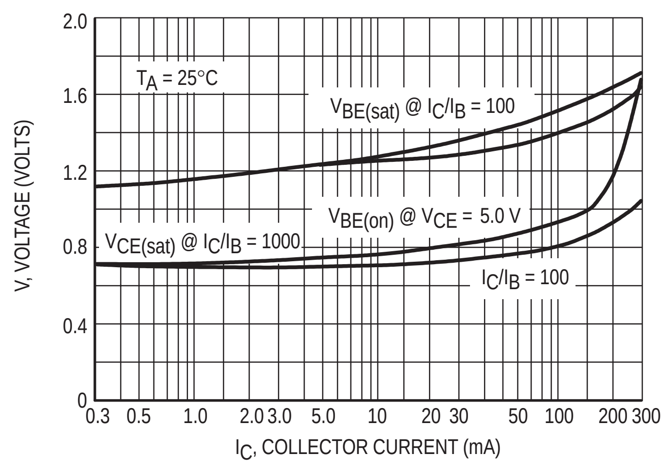


Figure 3. “On” Voltage

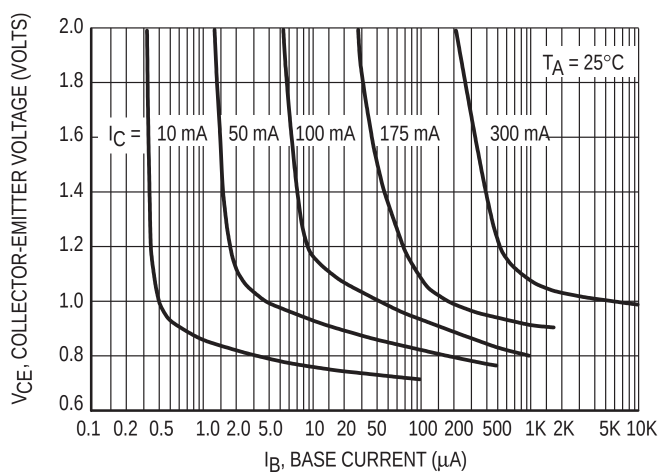
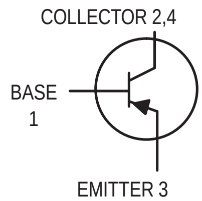


Figure 4. Collector Saturation Region

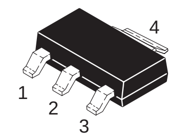
High Voltage Transistor
PNP Silicon



PZTA92T1

Motorola Preferred Device

**SOT–223 PACKAGE
PNP SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT**



**CASE 318E–04, STYLE 1
TO–261AA**

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(1)	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

Characteristic	Symbol	Max	Unit
Thermal Resistance from Junction to Ambient(1)	$R_{\theta JA}$	83.3	°C/W

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

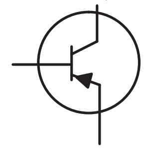
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = –1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	–300	—	Vdc
Collector–Base Breakdown Voltage (I_C = –100 μAdc, I_E = 0)	$V_{(BR)CBO}$	–300	—	Vdc
Emitter–Base Breakdown Voltage (I_E = –100 μAdc, I_C = 0)	$V_{(BR)EBO}$	–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(2)	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

1. 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.
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle = 2.0%.

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

REV 2

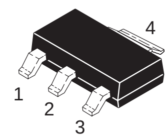
High Voltage Transistor
PNP Silicon



PZTA96T1

Motorola Preferred Device

SOT–223 PACKAGE
PNP SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT



CASE 318E–04, STYLE 1
TO–261AA

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(1)	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

Characteristic	Symbol	Max	Unit
Thermal Resistance from Junction to Ambient(1)	$R_{\theta JA}$	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(2) (I_C = –10 mAdc, V_{CE} = –10 Vdc)	h_{FE}	50	150	—
Saturation Voltages				Vdc
(I_C = –20 mAdc, I_B = –2.0 mAdc)	$V_{CE(sat)}$	—	–0.6	
(I_C = –20 mAdc, I_B = –2.0 mAdc)	$V_{BE(sat)}$	—	–1.0	

1. 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.
2. Pulse Test: Pulse Width ≤ 300 µs; Duty Cycle = 2.0%.

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

REV 1

Advance Information

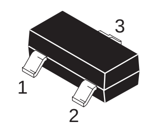
Integrated Relay/Solenoid Driver

MDC3105LT1

Motorola Preferred Device

RELAY/SOLENOID DRIVER SILICON MONOLITHIC CIRCUIT BLOCK

- Optimized to Switch 3 V to 5 V Relays from a 5 V Rail
- Compatible with "TX" and "TQ" Series Telecom Relays Rated up to 300 mW at 3 V to 5 V
- Features Low Input Drive Current
- Internal Zener Clamp Routes Induced Current to Ground Rather Than Back to Supply
- Guaranteed Off State with No Input Connection
- Supports Large Systems with Minimal Off–State Leakage
- ESD Resistant in Accordance with the 2000 V Human Body Model
- Provides a Robust Driver Interface Between Relay Coil and Sensitive Logic Circuits

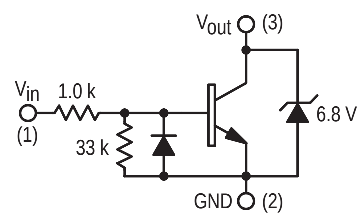


CASE 318–08, STYLE 6
SOT–23 (TO–236AB)

Applications include:

- Telecom Line Cards and Telephony
- Industrial Controls
- Security Systems
- Appliances and White Goods
- Automated Test Equipment
- Automotive Controls

INTERNAL CIRCUIT DIAGRAM



This device is intended to replace an array of three to six discrete components with an integrated SMT part. It is available in a SOT–23 package. It can be used to switch other 3 to 5 Vdc Inductive Loads such as solenoids and small DC motors.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{CC}	6.0	Vdc
Recommended Operating Supply Voltage	V_{CC}	2.0–5.5	Vdc
Input Voltage	$V_{in(fwd)}$	6.0	Vdc
Reverse Input Voltage	$V_{in(rev)}$	–0.5	Vdc
Output Sink Current — Continuous	I_O	300	mA
Junction Temperature	T_J	150	°C
Operating Ambient Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation(1) Derate above 25°C	P_D	225	mW
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W

1. FR–5 PCB of 1″ x 0.75″ x 0.062″, T_A = 25°C

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

This document contains information on a new product. Specifications and information herein are subject to change without notice.

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Output Zener Breakdown Voltage (@ IT = 10 mA Pulse)	$V_{(BRout)}$ $V_{(-BRout)}$	6.4 —	6.8 –0.7	7.2 —	V
Output Leakage Current @ 0 Input Voltage (V_{out} = 5.5 Vdc, V_{in} = O.C., T_A = 25°C) (V_{out} = 5.5 Vdc, V_{in} = O.C., T_A = 85°C)	I_{OO}	 — —	 — —	 5.0 30	µA
ON CHARACTERISTICS					
Input Bias Current @ V_{in} = 4.0 Vdc (I_O = 250 mA, V_{out} = 0.4 Vdc, T_A = –40°C) (correlated to a measurement @ 25°C)	I_{in}	—	2.5	—	mAdc
Output Saturation Voltage (I_O = 250 mA, V_{in} = 4.0 Vdc, T_A = –40°C) (correlated to a measurement @ 25°C)		—	0.2	0.4	Vdc
Output Sink Current — Continuous (T_A = –40°C, V_{CE} = 0.4 Vdc, V_{in} = 4.0 Vdc) (correlated to a measurement @ 25°C)	$I_{C(on)}$	250	—	—	mA

TYPICAL APPLICATION–DEPENDENT SWITCHING PERFORMANCE

SWITCHING CHARACTERISTICS

Characteristic	Symbol	V_{CC}	Min	Typ	Max	Units
Propagation Delay Times:						ns
High to Low Propagation Delay; Figures 1, 2 (5.0 V 74HC04)	t_{PHL}	5.5	—	55	—	
Low to High Propagation Delay; Figures 1, 2 (5.0 V 74HC04)	t_{PLH}	5.5	—	430	—	
High to Low Propagation Delay; Figures 1, 3 (3.0 V 74HC04)	t_{PHL}	5.5	—	85	—	
Low to High Propagation Delay; Figures 1, 3 (3.0 V 74HC04)	t_{PLH}	5.5	—	315	—	
High to Low Propagation Delay; Figures 1, 4 (5.0 V 74LS04)	t_{PHL}	5.5	—	55	—	
Low to High Propagation Delay; Figures 1, 4 (5.0 V 74LS04)	t_{PLH}	5.5	—	2385	—	
Transition Times:						ns
Fall Time; Figures 1, 2 (5.0 V 74HC04)	t_f	5.5	—	45	—	
Rise Time; Figures 1, 2 (5.0 V 74HC04)	t_r	5.5	—	160	—	
Fall Time; Figures 1, 3 (3.0 V 74HC04)	t_f	5.5	—	70	—	
Rise Time; Figures 1, 3 (3.0 V 74HC04)	t_r	5.5	—	195	—	
Fall Time; Figures 1, 4 (5.0 V 74LS04)	t_f	5.5	—	45	—	
Rise Time; Figures 1, 4 (5.0 V 74LS04)	t_r	5.5	—	2400	—	
Input Slew Rate(1)	$\Delta V/\Delta t$ in	5.5	TBD	—	—	V/ms

1. Minimum input slew rate must be followed to avoid overdissipating the device.

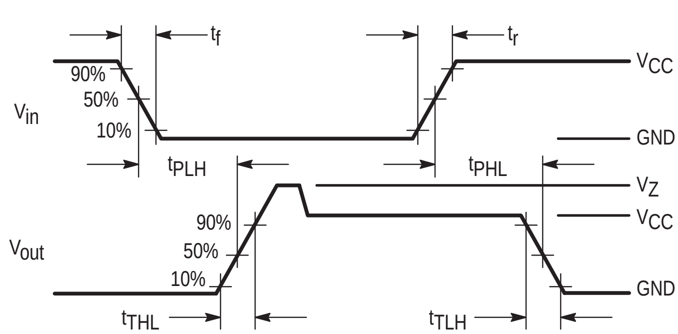


Figure 1. Switching Waveforms

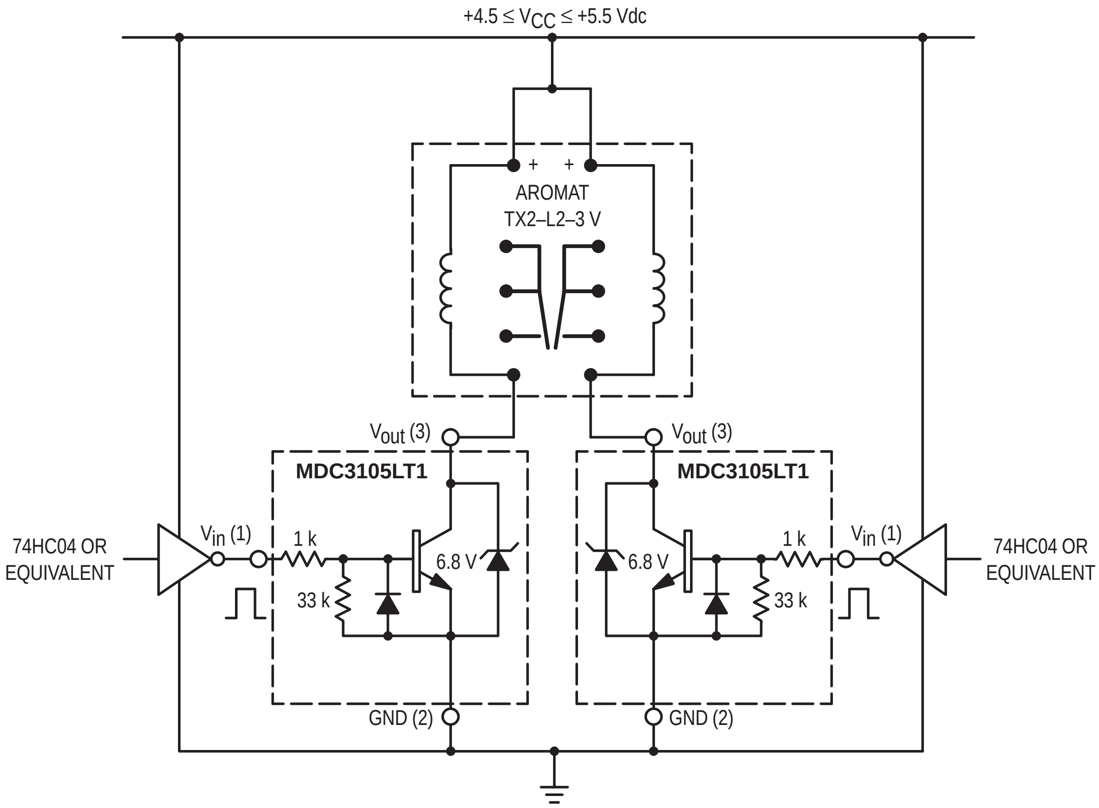


Figure 2. A 3.0–V, 200–mW Dual Coil Latching Relay Application with 5.0 V–HCMOS Interface

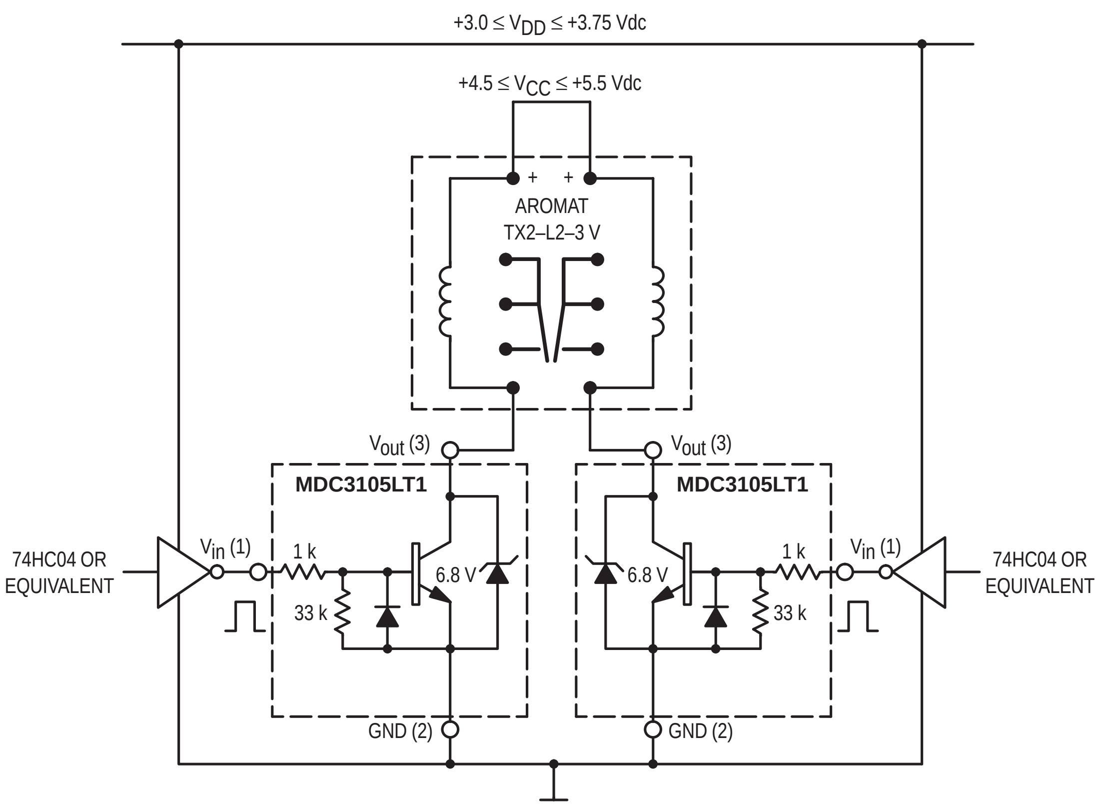


Figure 3. A 3.0–V, 200–mW Dual Coil Latching Relay Application with 3.0 V–HCMOS Interface

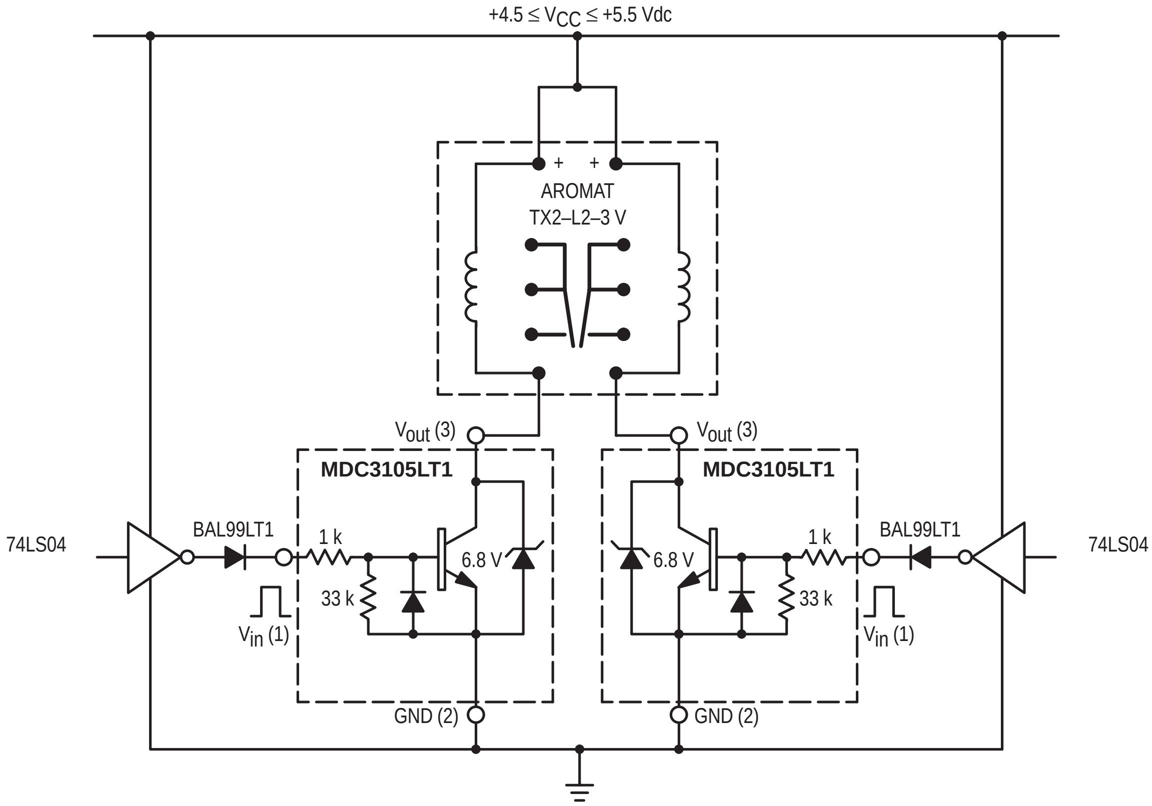
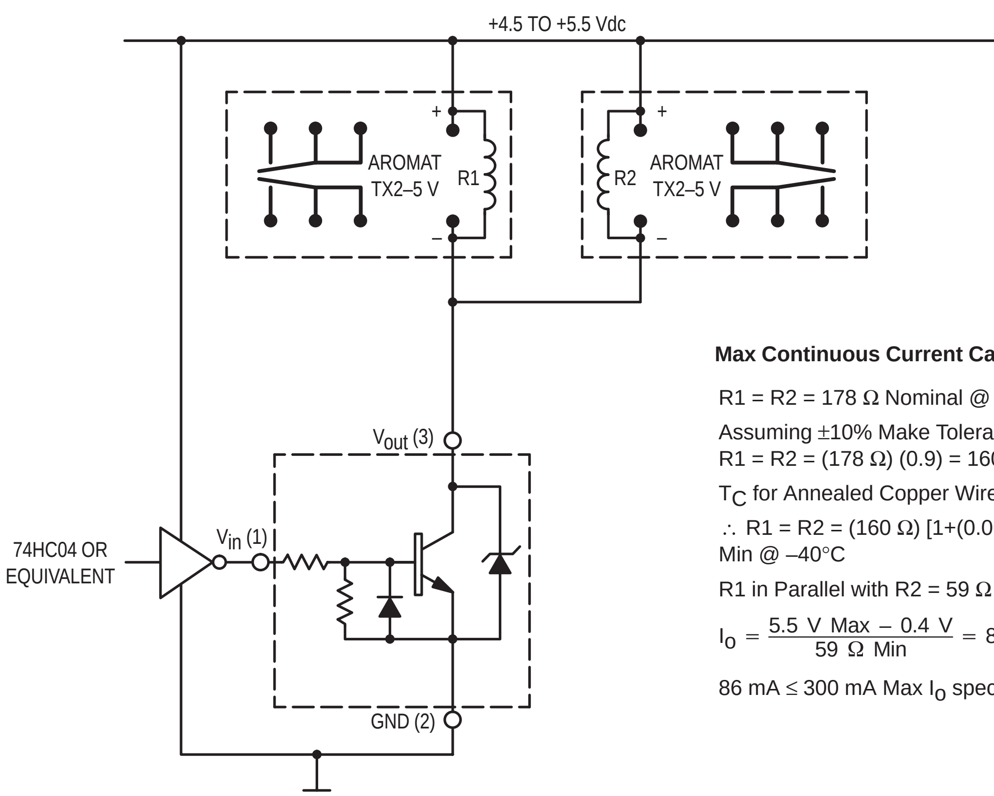


Figure 4. A 3.0–V, 200–mW Dual Coil Latching Relay Application with TTL Interface



Max Continuous Current Calculation

R1 = R2 = 178 Ω Nominal @ T_A = 25°C

Assuming ±10% Make Tolerance,
R1 = R2 = (178 Ω) (0.9) = 160 Ω Min @ T_A = 25°C

T_C for Annealed Copper Wire is 0.4%/°C

∴ R1 = R2 = (160 Ω) [1+(0.004) (–40°–25°)] = 118 Ω Min @ –40°C

R1 in Parallel with R2 = 59 Ω Min @ –40°C

$$I_O = \frac{5.5\ V\ Max - 0.4\ V}{59\ \Omega\ Min} = 86\ mA\ Max$$

86 mA ≤ 300 mA Max I_O spec.

Figure 5. Typical 5.0 V, 140 mW Coil Dual Relay Application

TYPICAL OPERATING WAVEFORMS

(Circuit of Figure 5)

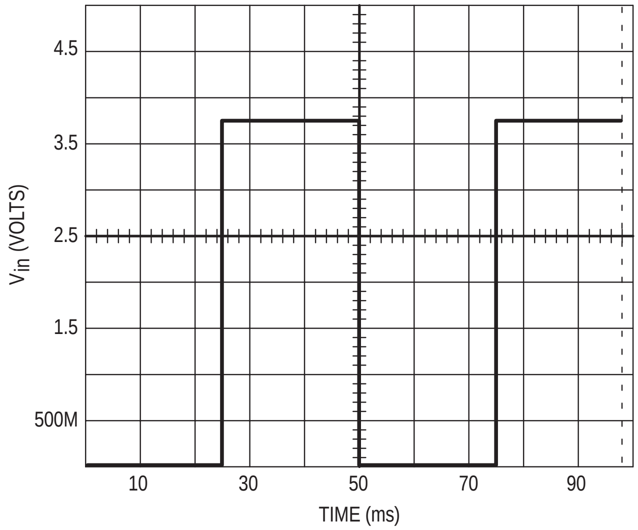


Figure 6. 20 Hz Square Wave Input

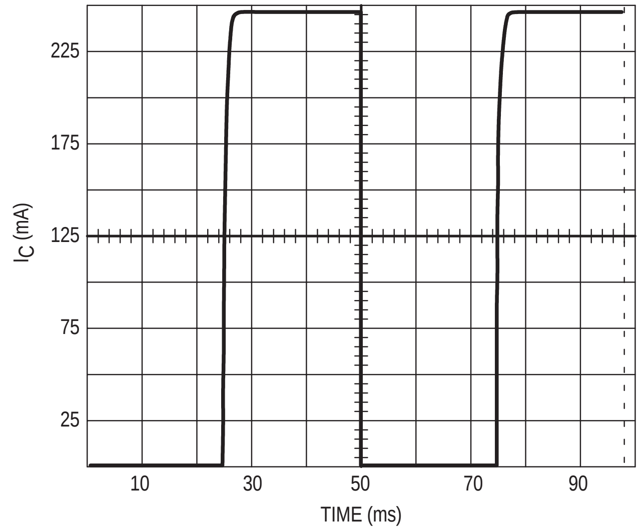


Figure 7. 20 Hz Square Wave Response

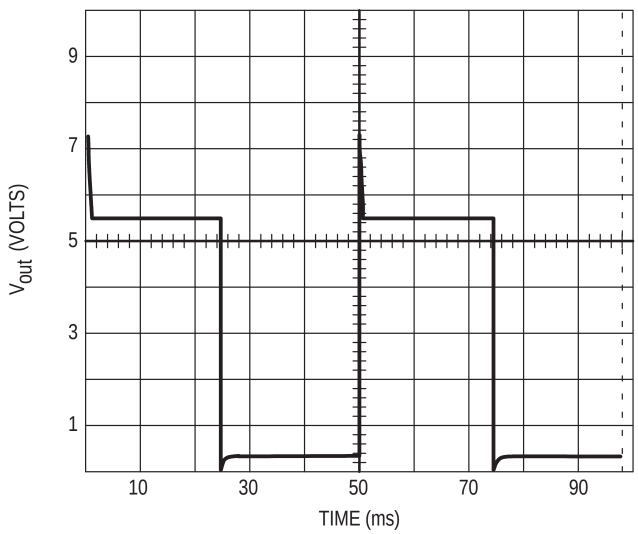


Figure 8. 20 Hz Square Wave Response

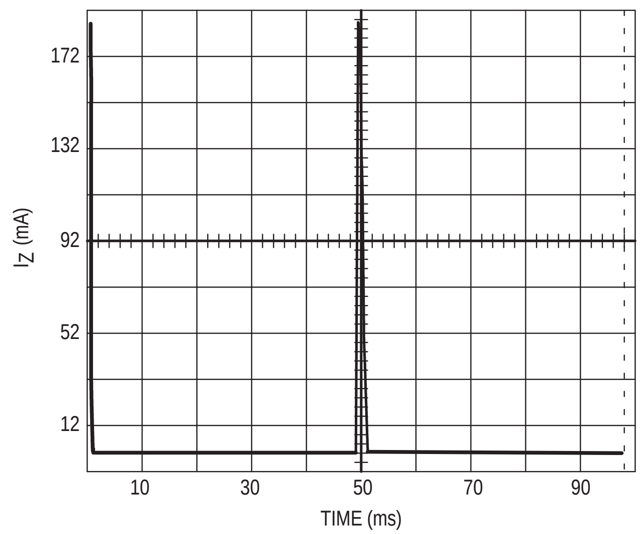


Figure 9. 20 Hz Square Wave Response

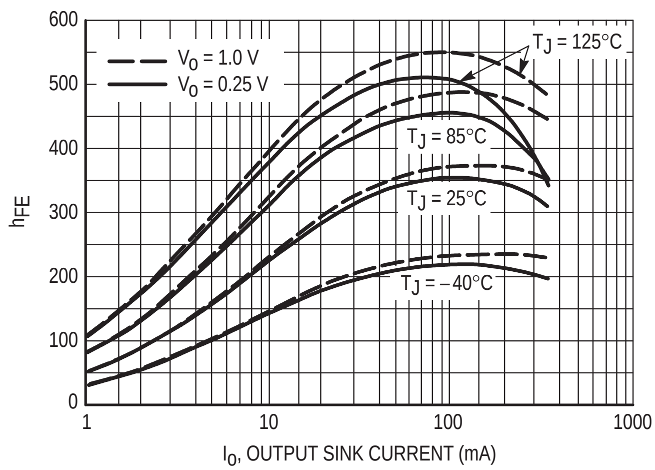


Figure 10. Pulsed Current Gain

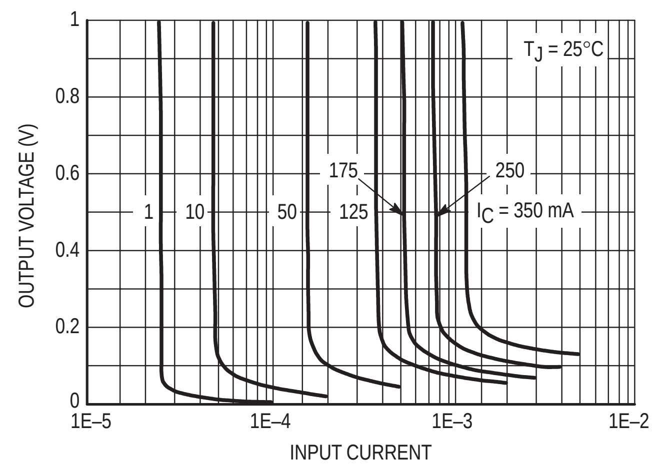
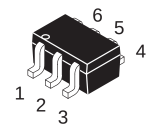


Figure 11. Collector Saturation Region

Low Voltage Bias Stabilizer with Enable

MDC5001T1

SILICON SMALLBLOCK™ INTEGRATED CIRCUIT



CASE 419B–01, Style 19
SOT–363

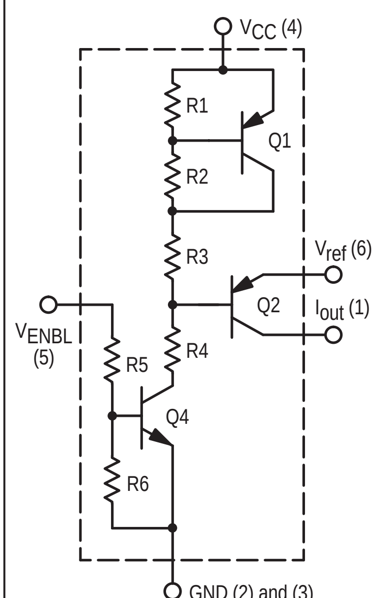
- Maintains Stable Bias Current in N–Type Discrete Bipolar Junction and Field Effect Transistors
- Provides Stable Bias Using a Single Component Without Use of Emitter Ballast and Bypass Components
- Operates Over a Wide Range of Supply Voltages Down to 1.8 Vdc
- Reduces Bias Current Variation Due to Temperature and Unit–to–Unit Parametric Changes
- Consumes $<$ 0.5 mW at V_{CC} = 2.75 V
- Active High Enable is CMOS Compatible

This device provides a reference voltage and acts as a DC feedback element around an external discrete, NPN BJT or N–Channel FET. It allows the external transistor to have its emitter/source directly grounded and still operate with a stable collector/drain DC current. It is primarily intended to stabilize the bias of discrete RF stages operating from a low voltage regulated supply, but can also be used to stabilize the bias current of any linear stage in order to eliminate emitter/source bypassing and achieve tighter bias regulation over temperature and unit variations. The “ENABLE” polarity nulls internal current, Enable current, and RF transistor current in “STANDBY.” This device is intended to replace a circuit of three to six discrete components.

The combination of low supply voltage, low quiescent current drain, and small package make the MDC5001T1 ideal for portable communications applications such as:

- Cellular Telephones
- Pagers
- PCN/PCS Portables
- GPS Receivers
- PCMCIA RF Modems
- Cordless Phones
- Broadband and Multiband Transceivers and Other Portable Wireless Products

INTERNAL CIRCUIT DIAGRAM



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{CC}	15	Vdc
Ambient Operating Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Junction Temperature	T_J	150	°C
Collector Emitter Voltage (Q2)	V_{CEO}	–15	V
Enable Voltage (Pin 5)	V_{ENBL}	V_{CC}	V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Power Dissipation (FR–5 PCB of 1″ × 0.75″ × 0.062″, T_A = 25°C) Derate above 25°C	P_D	 150 1.2	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	833	°C/W

REV 1

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

Characteristic	Symbol	Min	Typ	Max	Unit
Recommended Operating Supply Voltage	V_{CC}	1.8	2.75	10	Volts
Power Supply Current (V_{CC} = 2.75 V) V_{ref}, I_{out} are unterminated See Figure 8	I_{CC}	—	130	200	µA
Q2 Collector Emitter Breakdown Voltage (I_{C2} = 10 µA, I_{B2} = 0)	$V_{(BR)CEO2}$	15			Volts
Reference Voltage (V_{ENBL} = V_{CC} = 2.75 V, V_{out} = 0.7 V) (I_{out} = 30 µA) (I_{out} = 150 µA) See Figure 1	V_{ref}	 2.050 2.110	 2.075 2.135	 2.100 2.160	Volts
Reference Voltage (V_{ENBL} = V_{CC} = 2.75 V, V_{out} = 0.7 V, –40°C ≤ T_A ≤ +85°C) V_{CC} Pulse Width = 10 mS, Duty Cycle = 1% (I_{out} = 10 µA) (I_{out} = 30 µA) (I_{out} = 100 µA) See Figures 2 and 11	ΔV_{ref}		 ±5.0 ±15 ±25	 ±10 ±30 ±50	mV

The following SPICE models are provided as a convenience to the user and every effort has been made to insure their accuracy. However, no responsibility for their accuracy is assumed by Motorola.

.MODEL Q4 NPN

BF = 136	NE = 1.6
BR = 0.2	NF = 1.005
CJC = 318.6 f	RB = 140
CJE = 569.2 f	RBM = 70
CJS = 1.9 p	RC = 180
EG = 1.215	RE = 1.6
FC = 0.5	TF = 553.6 p
IKF = 24.41 m	TR = 10 n
IKR = 0.25	VAF = 267.6
IRB = 0.0004	VAR = 12
IS = 256E–18	VJC = 0.4172
ISC = 1 f	VJE = 0.7245
ISE = 500E–18	VJS = 0.39
ITF = 0.9018	VTF = 10
MJC = 0.2161	XTB = 1.5
MJE = 0.3373	XTF = 2.077
MJS = 0.13	XTI = 3
NC = 1.09	

.MODEL Q1, Q2 PNP

BF = 87	NK = 0.5
BR = 0.6	NR = 1.0
CJC = 800E–15	RB = 720
CJE = 46E–15	RBM = 470
EG = 1.215	RC = 180
FC = 0.5	RE = 26
IKF = 3.8E–04	TF = 15E–9
IKR = 2.0	TR = 50E–09
IRB = 0.9E–3	VAF = 54.93
IS = 1.027E–15	VAR = 20
ISC = 10E–18	VAR = 20
ISE = 1.8E–15	VJC = 0.4172
ITF = 2E–3	VJE = 0.4172
MJC = 0.2161	VTF = 10
MJE = 0.2161	XTB = 1.5
NC = 0.8	XTF = 2.0
NE = 1.38	XTI = 3
NF = 1.015	

RESISTOR VALUES

R1 = 12 K
R2 = 6 K
R3 = 3.4 K
R4 = 12 K
R5 = 20 K
R6 = 40 K

These models can be retrieved electronically by accessing the Motorola Web page at http://design–net.sps.mot.com/models and searching the section on SMALLBLOCK™ models

TYPICAL OPEN LOOP CHARACTERISTICS

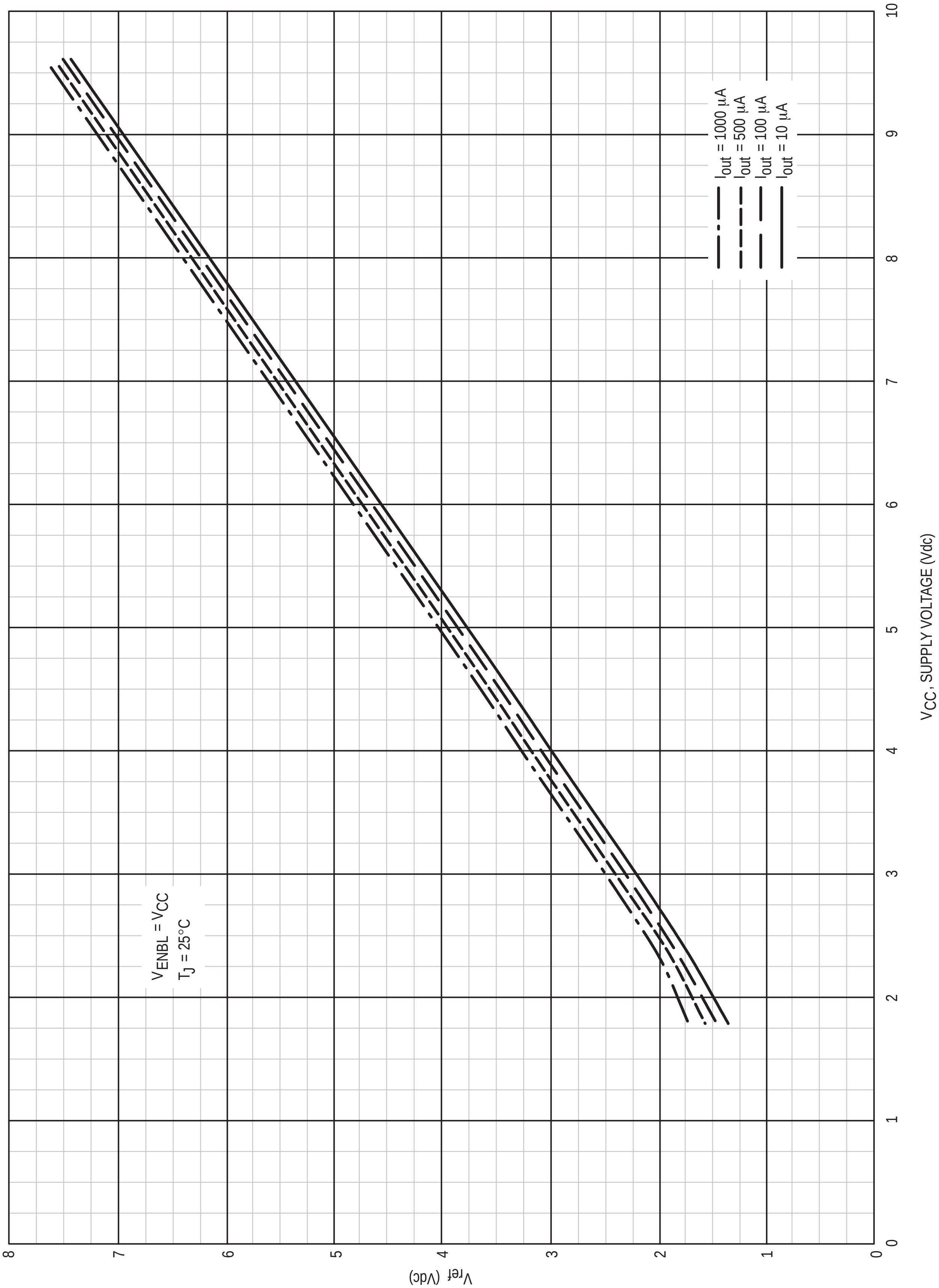


Figure 1. V_{ref} versus V_{CC} @ I_{out}

TYPICAL OPEN LOOP CHARACTERISTICS
(Refer to Circuits of Figures 10 through 15)

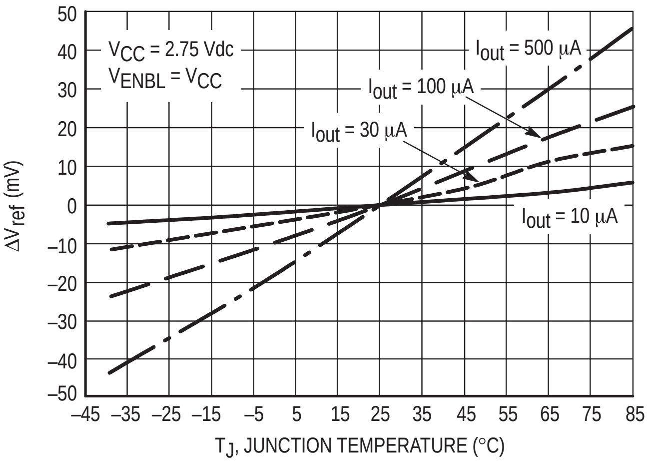


Figure 2. ΔV_{ref} versus T_J @ I_{out}

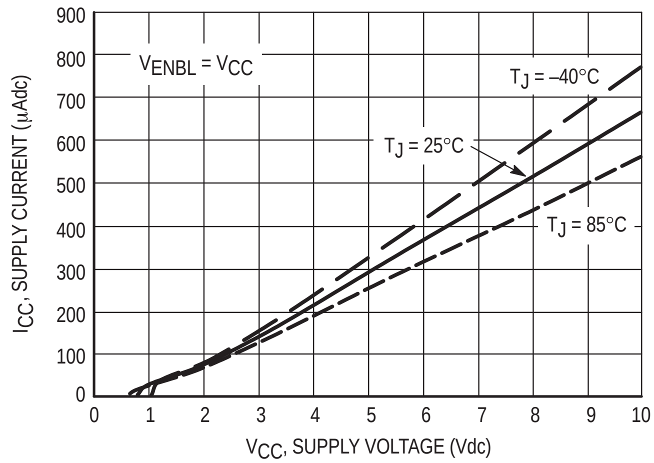


Figure 3. I_{CC} versus V_{CC} @ T_J

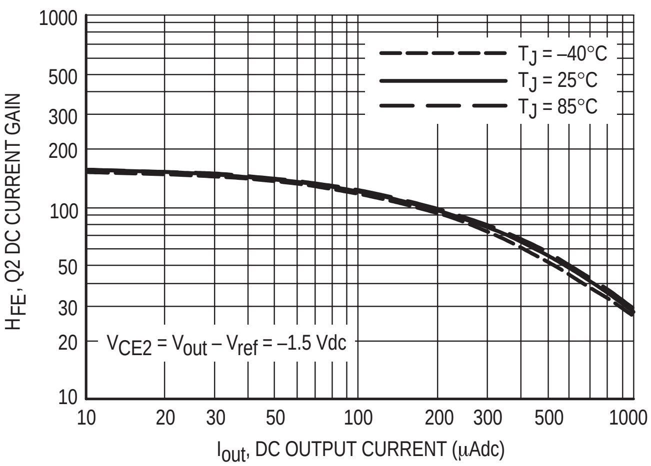


Figure 4. Q2 Current Gain versus Output Current @ T_J

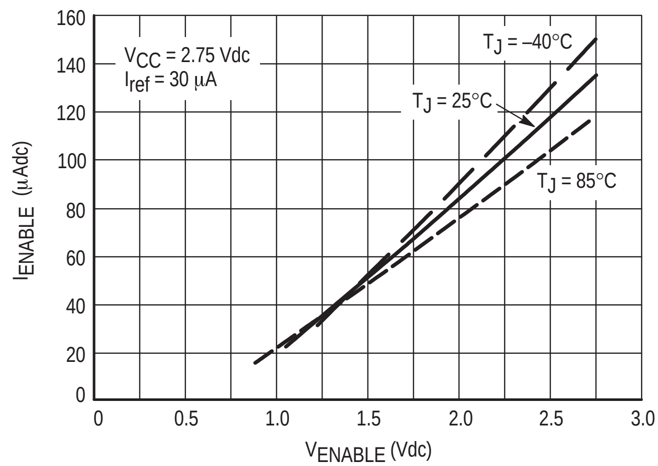


Figure 5. I_{enable} versus V_{enable}

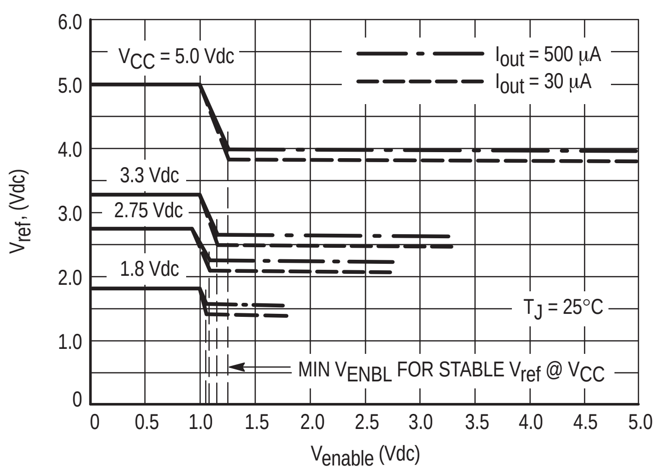


Figure 6. V_{ref} versus V_{enable} @ V_{CC} and I_{out}

TYPICAL CLOSED LOOP PERFORMANCE

(Refer to Circuits of Figures 16 & 17)

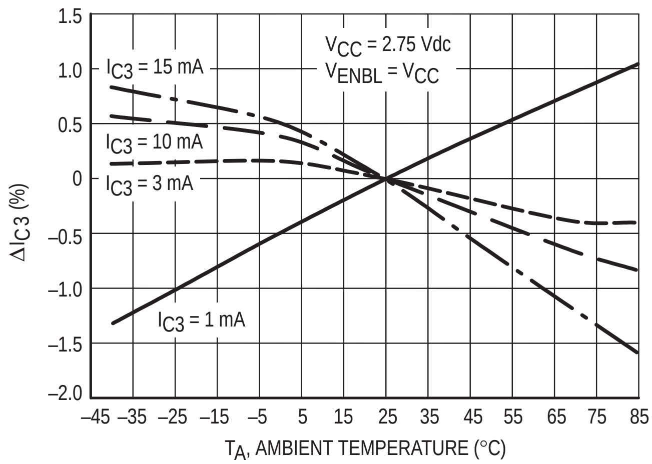


Figure 7. ΔI_{C3} versus T_A @ I_{C3}

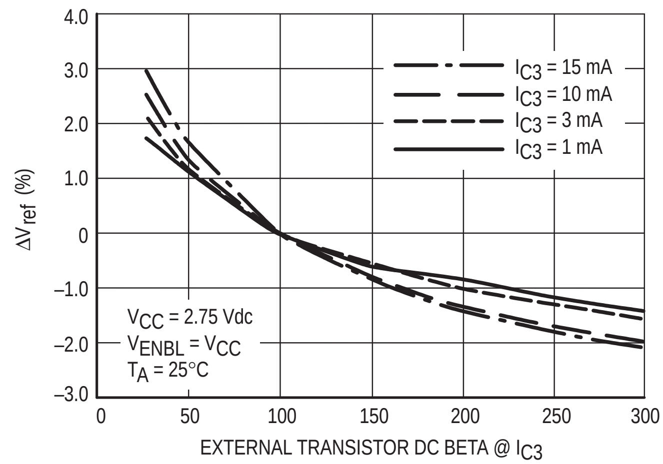


Figure 8. ΔV_{ref} versus External Transistor DC Beta @ I_{C3}

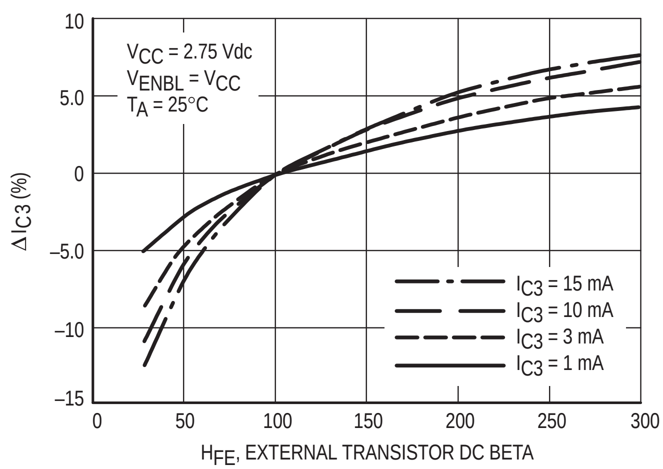


Figure 9. ΔI_{C3} versus External Transistor DC Beta @ I_{C3}

OPEN LOOP TEST CIRCUITS

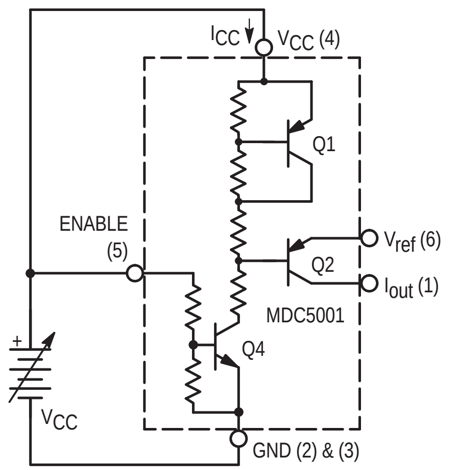
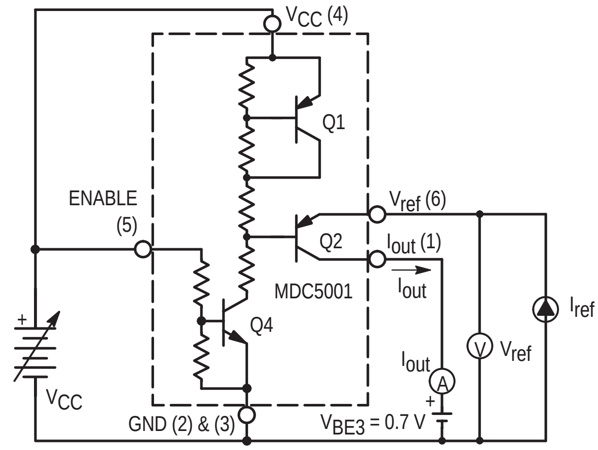
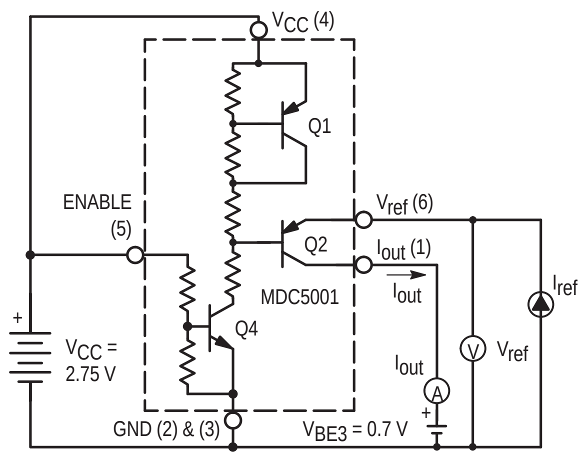


Figure 10. I_{CC} versus V_{CC} Test Circuit



See NOTE 1

Figure 11. V_{ref} versus V_{CC} Test Circuit



See NOTE 1

Figure 12. V_{ref} versus T_J Test Circuit

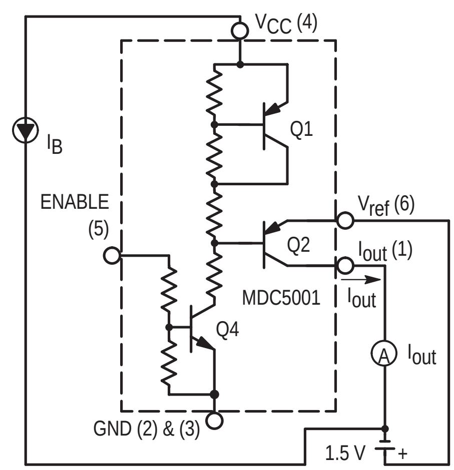


Figure 13. H_{FE} versus I_{out} Test Circuit

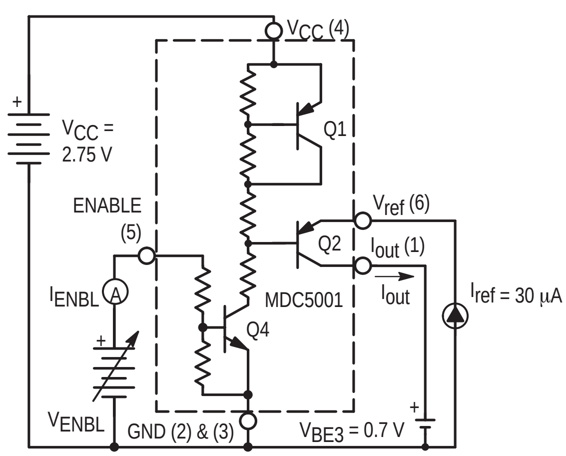
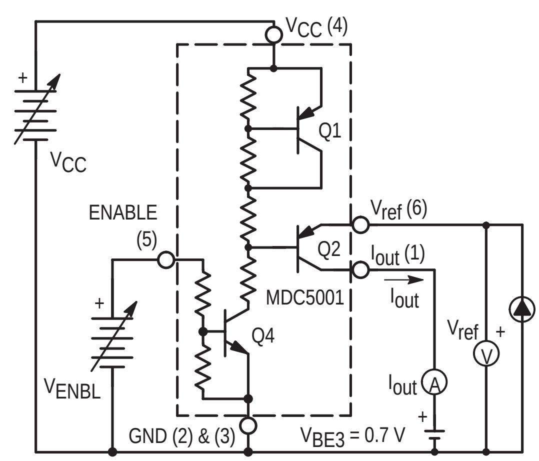


Figure 14. I_{ENBL} versus V_{ENBL} Test Circuit



See NOTE 1

Figure 15. V_{ref} versus V_{ENBL} Test Circuit

NOTE 1: V_{BE3} is used to simulate actual operating conditions that reduce V_{CE2} & H_{FE2}, and increase I_{B2} & V_{ref}.

CLOSED LOOP TEST CIRCUITS

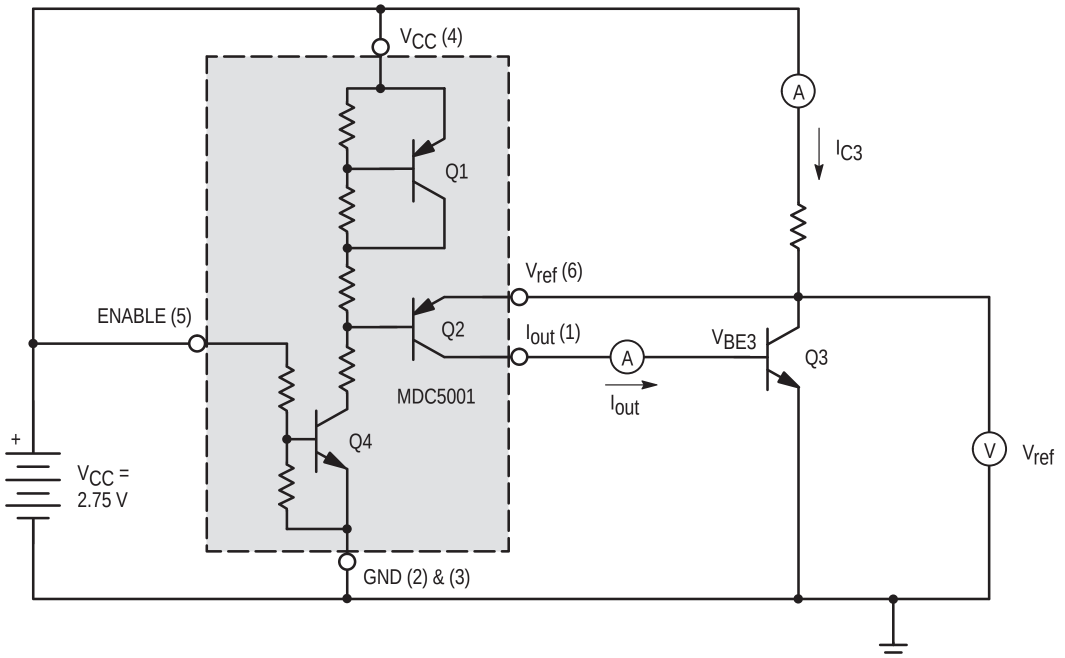
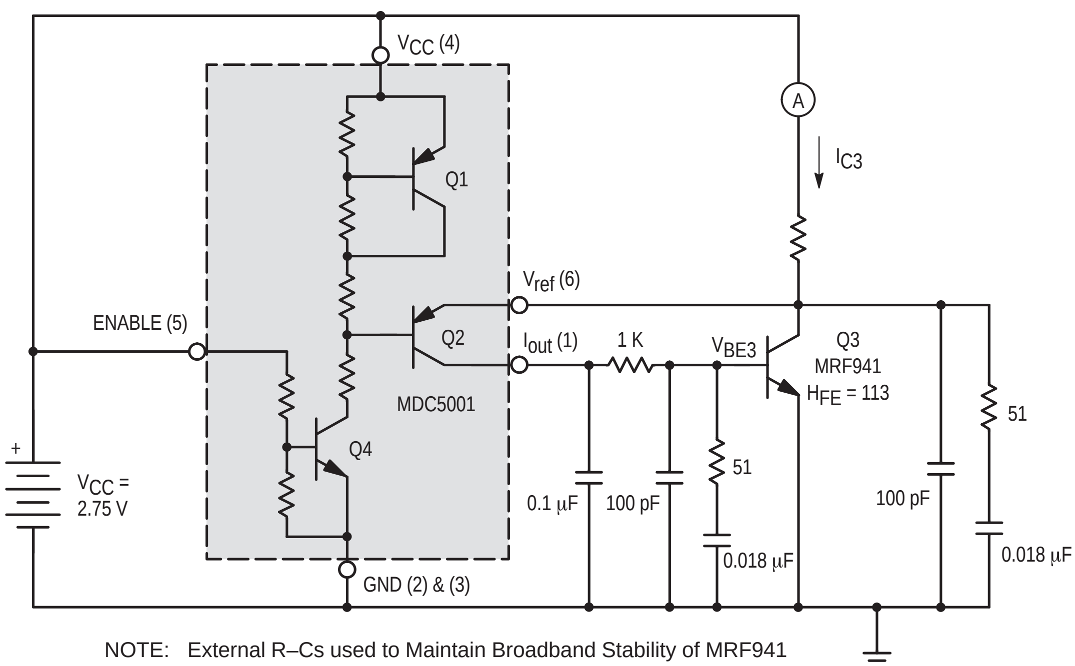


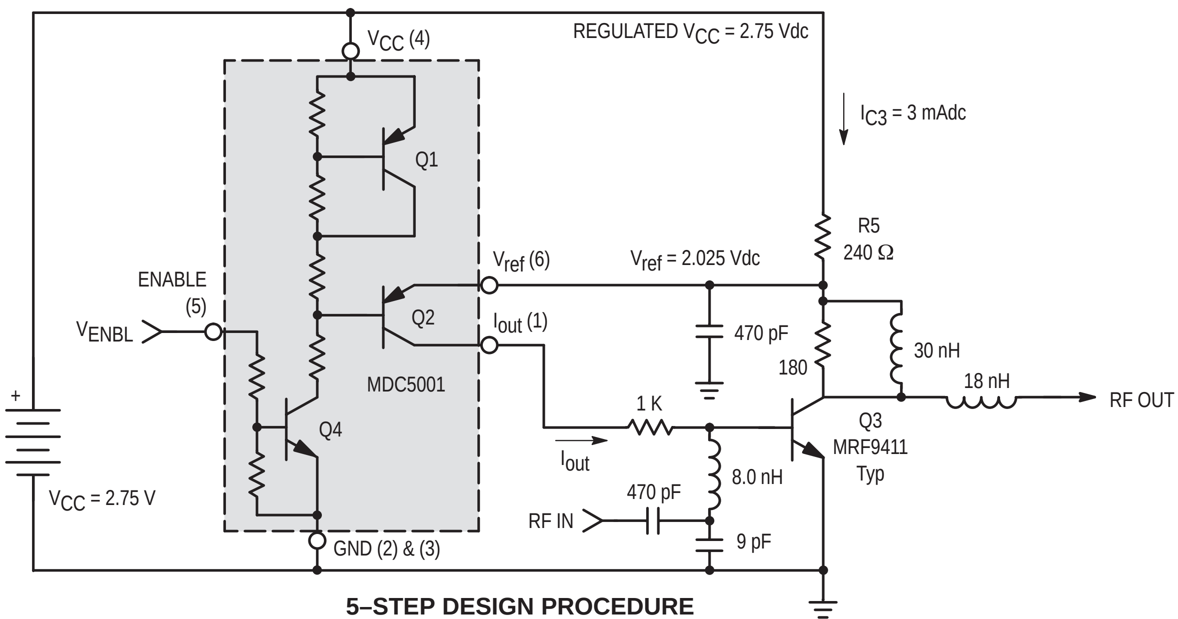
Figure 16. V_{ref} and RF Stage I_{C3} versus H_{FE3} Test Circuit



NOTE: External R–Cs used to Maintain Broadband Stability of MRF941

Figure 17. RF Stage I_{C3} versus T_A Test Circuit

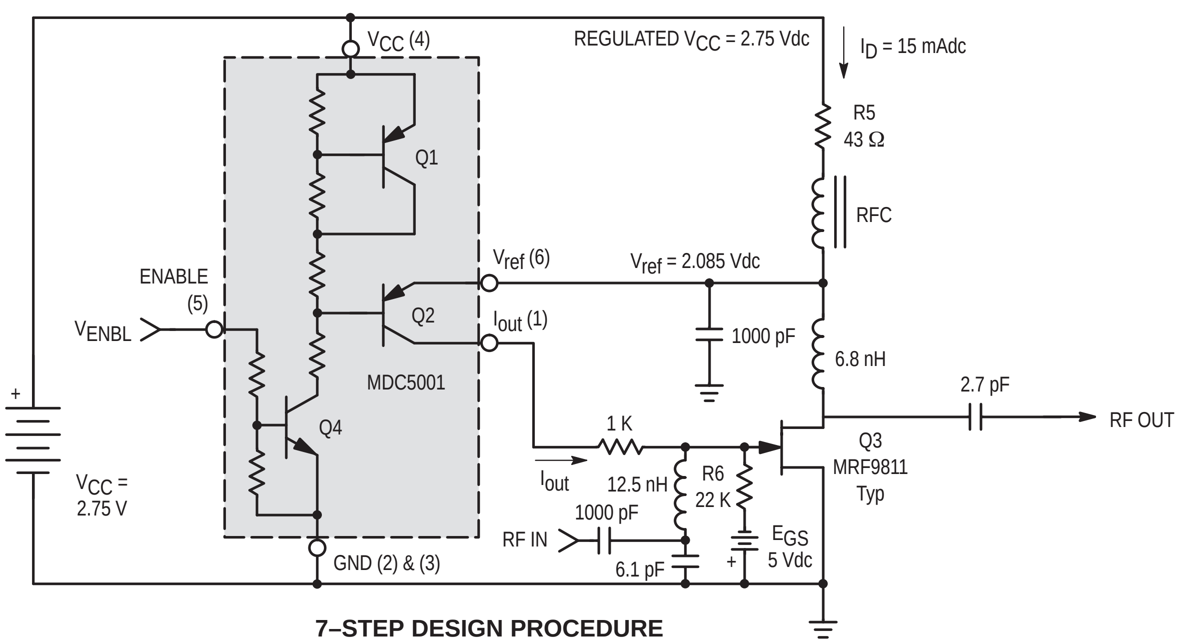
APPLICATION CIRCUITS



5–STEP DESIGN PROCEDURE

Step 1: Choose V_{CC} (1.8 V Min to 10 V Max)
Step 2: Insure that Min V_{ENBL} is ≥ minimum indicated in Figures 5 and 6.
Step 3: Choose bias current, I_{C3}, and calculate needed I_{out} from typ H_{FE3}
Step 4: From Figure 1, read V_{ref} for V_{CC} and I_{out} calculated.
Step 5: Calculate Nominal R5 = $(V_{CC} – V_{ref}) \div (I_{C3} + I_{out})$. Tweak as desired.

Figure 18. Class A Biasing of a Typical 900 MHz BJT Amplifier Application



7–STEP DESIGN PROCEDURE

Step 1: Choose V_{CC} (1.8 V Min to 10 V Max)
Step 2: Insure that Min V_{ENBL} is ≥ minimum indicated in Figures 5 and 6.
Step 3: Choose bias current, I_D, and determine needed gate–source voltage, V_{GS}.
Step 4: Choose I_{out} keeping in mind that too large an I_{out} can impair MDC5000 $\Delta V_{ref}/\Delta T_J$ performance (Figure 2) but too large an R6 can cause I_{DGO} & I_{GSO} to bias on the FET.
Step 5: Calculate R6 = $(V_{GS} + E_{GS}) \div I_{out}$
Step 6: From Figure 1, read V_{ref} for V_{CC} & I_{out} chosen
Step 7: Calculate Nominal R5 = $(V_{CC} – V_{ref}) \div (I_D + I_{out})$. Tweak as desired.

Figure 19. Class A Biasing of a Typical 890 MHz Depletion Mode GaAs FET Amplifier

Section 3

GreenLine™ Portfolio

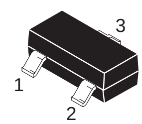
In Brief . . .

New in this revision is Motorola's GreenLine™ portfolio of devices. These devices feature energy–conserving traits superior to those of our existing line of standard parts for the same usage. GreenLine devices can actually help reduce the power demands of your products. In an increasingly power–hungry world, Motorola's GreenLine™ portfolio makes powerful sense. So much sense that we plan to continue adding devices to the portfolio. Chances are, there are Motorola GreenLine™ devices applicable to one or more of your products – ones that can help save energy, dollars – and the environment.

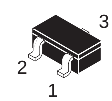
Currently, our portfolio consists of three families:

- **Low–Leakage Switching Diodes:** Reverse leakage specifications guaranteed to 500 pA. They help extend battery life and are ideal for small battery powered systems in which standby power is essential. Applications include ESD protection, reverse voltage protection, and steering logic.
- **Bipolar Output Driver Transistors:** Ultra–low collector saturation voltage. They deliver more energy to the intended load with less power wasted through dissipation loss. Especially effective in lower voltage battery powered applications and prolong battery life in portable and hand–held communications and personal digital equipment. Applications include low voltage display light drivers and general output drivers.
- **Small Signal HDTMOS™:** Lowest ever drain–source resistance versus package size. Lower $r_{DS(on)}$ means less wasted energy through dissipation loss. Especially effective for low–current applications where energy conservation is crucial. These small MOSFETs are ideal for space–sensitive power management circuitry. Applications include low current switchmode power supplies, uninterruptable power supplies (UPS), power management systems, and bias switching.

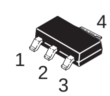
This chapter exclusively highlights the GreenLine devices, which are also listed in their respective Transistor, Diode and MOSFET chapters.



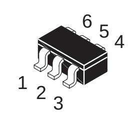
CASE 318-08
(TO-236AB)
SOT-23



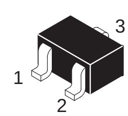
CASE 318D-04
SC–59



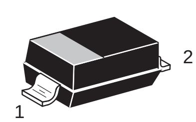
CASE 318E-04
(TO-261AA)
SOT-223



CASE 318G-02
TSOP–6



CASE 419-02
SC–70/SOT–323



CASE 425-04
SOD–123

GREEN LINE™

BSS84LT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

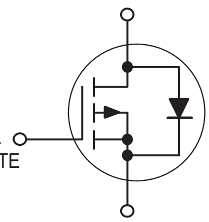
TMOS™

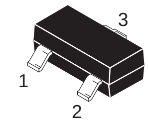
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET

Part of the Greenline™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Reduced power loss conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, load switching, power management in portable and battery–powered products such as computers, printers, cellular and cordless telephones.

- Energy Efficient
- Miniature SOT–23 Surface Mount Package Saves Board Space





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	50	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10$ µs)	I_D I_{DM}	130 520	mA
Total Power Dissipation @ T_A = 25°C	P_D	225	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	556	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

DEVICE MARKING

BSS84LT1 = PD

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
BSS84LT1	7″	8mm embossed tape	3000
BSS84LT3	13″	8mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 250 μAdc)	$V_{(BR)DSS}$	50	—	—	Vdc
Zero Gate Voltage Drain Current	I_{DSS}				μAdc
(V_{DS} = 25 Vdc, V_{GS} = 0 Vdc)		—	—	0.1	
(V_{DS} = 50 Vdc, V_{GS} = 0 Vdc)		—	—	15	
(V_{DS} = 50 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)		—	—	60	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	±60	μAdc
ON CHARACTERISTICS(1)					
Gate–Source Threaded 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} = 5.0 Vdc, I_D = 100 mAdc)	$r_{DS(on)}$	—	5.0	10	Ohms
Transfer Admittance (V_{DS} = 25 Vdc, I_D = 100 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	50	—	—	mS
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 5.0 Vdc)	C_{iss}	—	30	—	pF
Output Capacitance (V_{DS} = 5.0 Vdc)	C_{oss}	—	10	—	
Transfer Capacitance (V_{DG} = 5.0 Vdc)	C_{rss}	—	5.0	—	
SWITCHING CHARACTERISTICS(2)					
Turn–On Delay Time (V_{DD} = –15 Vdc, I_D = –2.5 Adc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time	t_r	—	1.0	—	
Turn–Off Delay Time	$t_{d(off)}$	—	16	—	
Fall Time	t_f	—	8.0	—	
Gate Charge	Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS					
Continuous Current	I_S	—	—	0.130	A
Pulsed Current	I_{SM}	—	—	0.520	
Forward Voltage(2)	V_{SD}	—	2.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

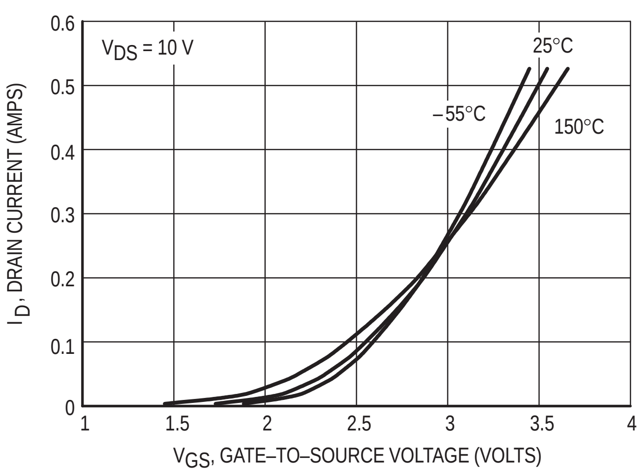


Figure 1. Transfer Characteristics

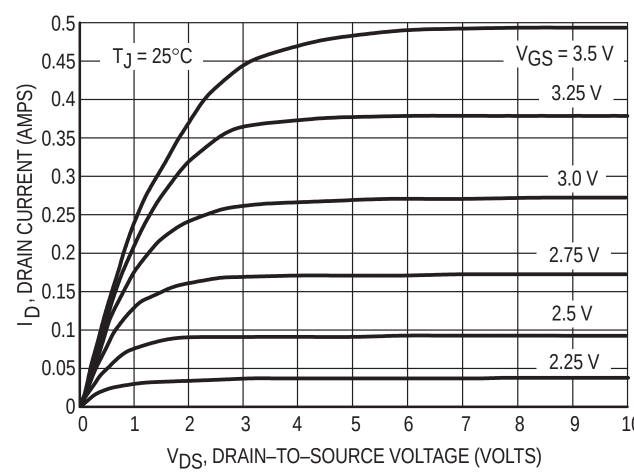


Figure 2. On–Region Characteristics

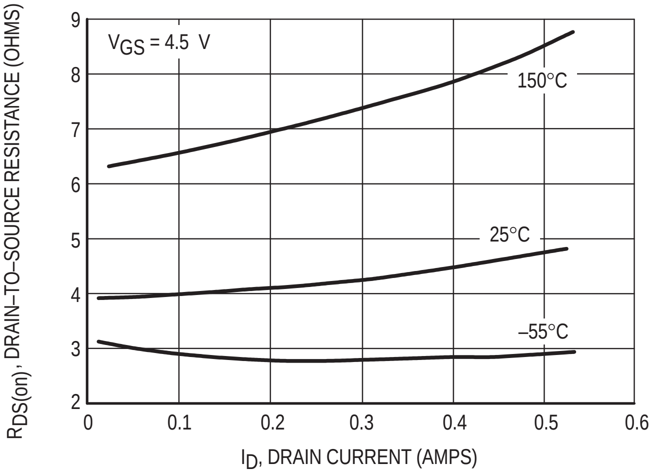


Figure 3. On–Resistance versus Drain Current

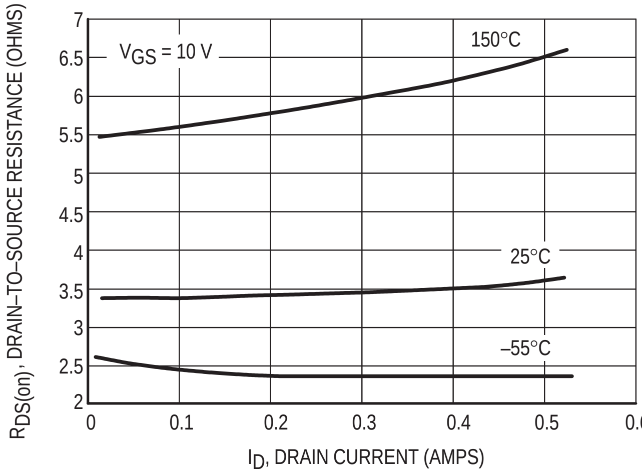


Figure 4. On–Resistance versus Drain Current

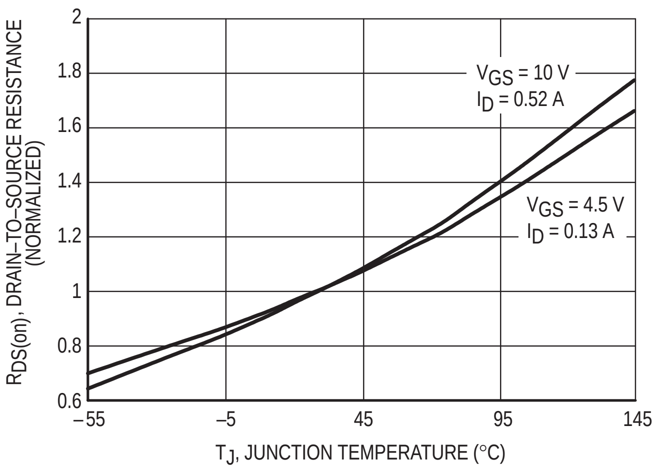


Figure 5. On–Resistance Variation with Temperature

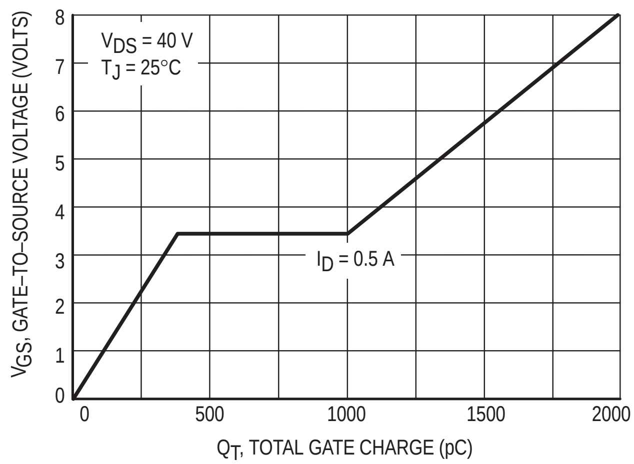


Figure 6. Gate Charge

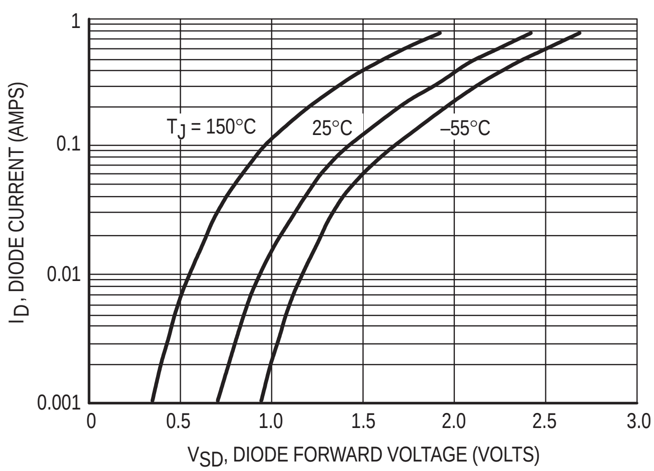


Figure 7. Body Diode Forward Voltage

GREEN LINE™

BSS138LT1

Motorola Preferred Device

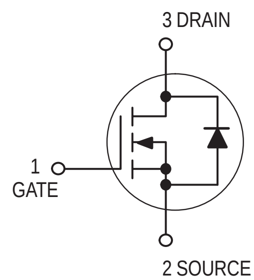
N-Channel Enhancement Mode Logic Level SOT-23 MOSFET

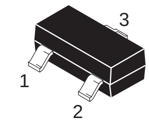
Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low Threshold Voltage ($V_{GS(th)}$: 0.5V...1.5V) makes it ideal for low voltage applications
- Miniature SOT–23 Surface Mount Package saves board space

TMOS™

**N–CHANNEL
LOGIC LEVEL
TMOS FET
TRANSISTOR**





**CASE 318–08, Style 21
SOT–23 (TO–236A)**

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	50	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_{DM}	200 800	mA
Total Power Dissipation @ T_A = 25°C	P_D	225	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	556	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

DEVICE MARKING

BSS138LT1 = J1

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
BSS138LT1	7″	8mm embossed tape	3000
BSS138LT3	13″	8mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 250 μAdc)		$V_{(BR)DSS}$	50	—	—	Vdc
Zero Gate Voltage Drain Current		I_{DSS}				μAdc
(V_{DS} = 25 Vdc, V_{GS} = 0 Vdc)			—	—	0.1	
(V_{DS} = 50 Vdc, V_{GS} = 0 Vdc)			—	—	0.5	
Gate–Source Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)		I_{GSS}	—	—	±0.1	μAdc
ON CHARACTERISTICS(1)						
Gate–Source Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)		$V_{GS(th)}$	0.5	—	1.5	Vdc
Static Drain–to–Source On–Resistance		$r_{DS(on)}$				Ohms
(V_{GS} = 2.75 Vdc, I_D < 200 mAdc, T_A = –40°C to +85°C)			—	5.6	10	
(V_{GS} = 5.0 Vdc, I_D = 200 mAdc)			—	—	3.5	
Forward Transconductance (V_{DS} = 25 Vdc, I_D = 200 mAdc, f = 1.0 kHz)		g_{fs}	100	—	—	mmhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 25 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	40	50	pF
Output Capacitance	(V_{DS} = 25 Vdc, V_{GS} = 0, f = 1 MHz)	C_{oss}	—	12	25	
Transfer Capacitance	(V_{DG} = 25 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	—	3.5	5.0	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 30 Vdc, I_D = 0.2 Adc,)	$t_{d(on)}$	—	—	20	ns
Turn–Off Delay Time		$t_{d(off)}$	—	—	20	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

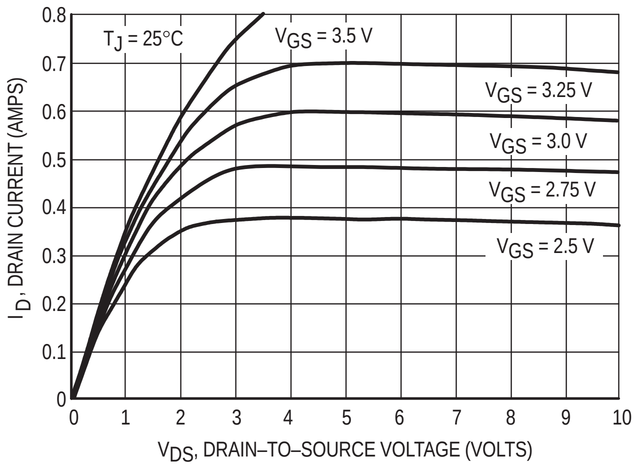


Figure 1. On–Region Characteristics

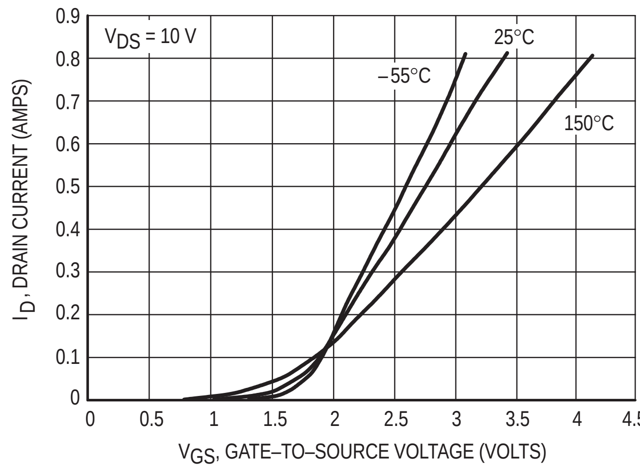


Figure 2. Transfer Characteristics

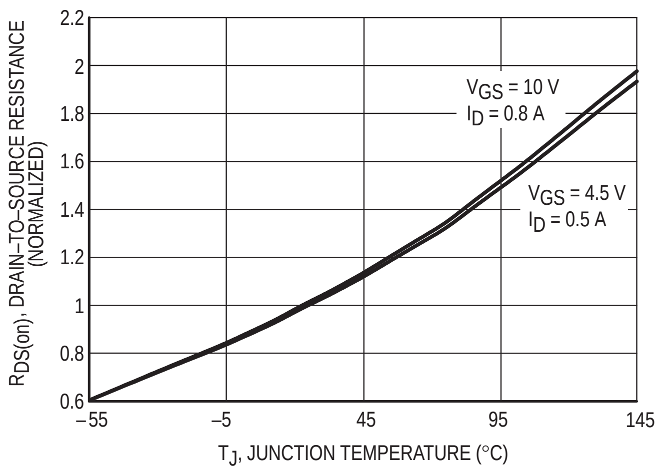


Figure 3. On–Resistance Variation with Temperature

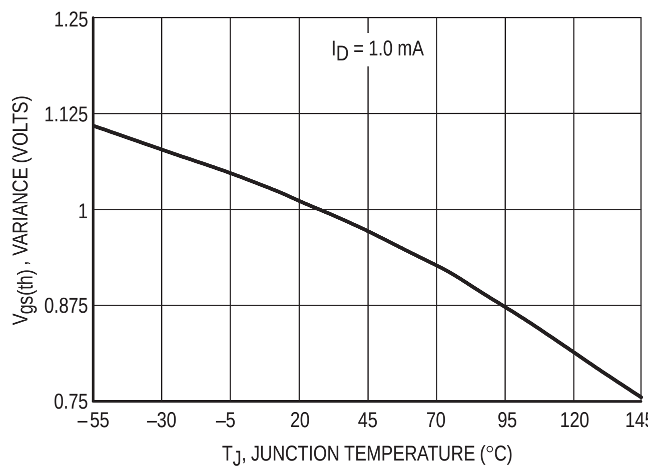


Figure 4. Threshold Voltage Variation with Temperature

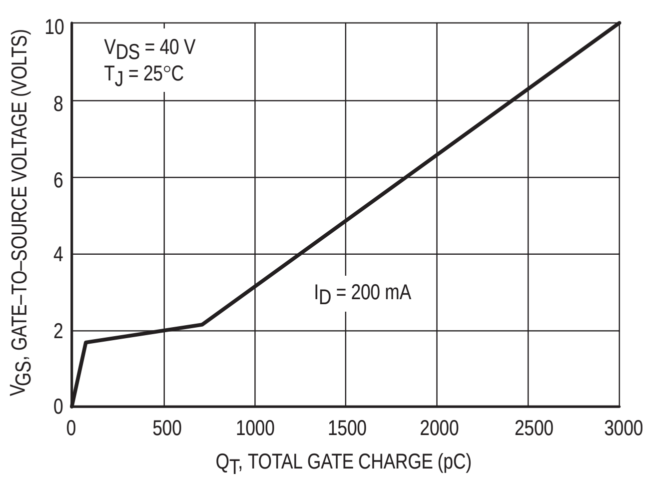


Figure 5. Gate Charge

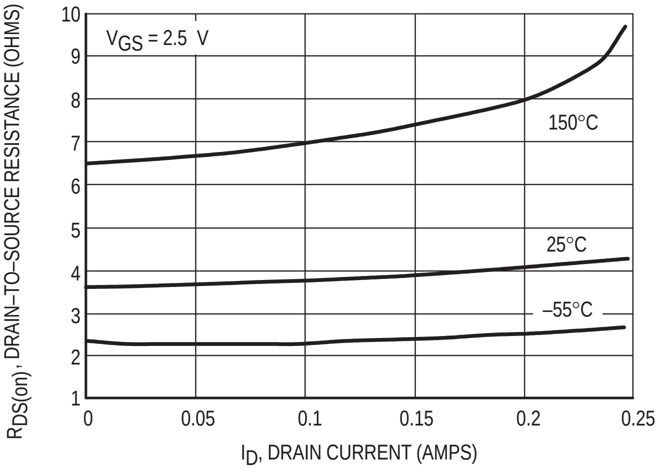


Figure 6. On–Resistance versus Drain Current

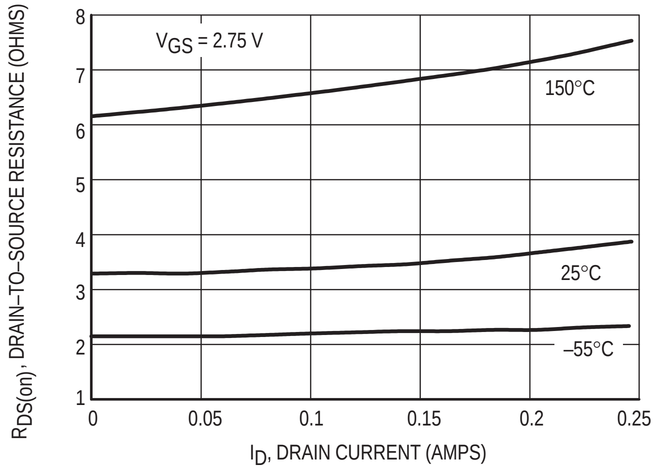


Figure 7. On–Resistance versus Drain Current

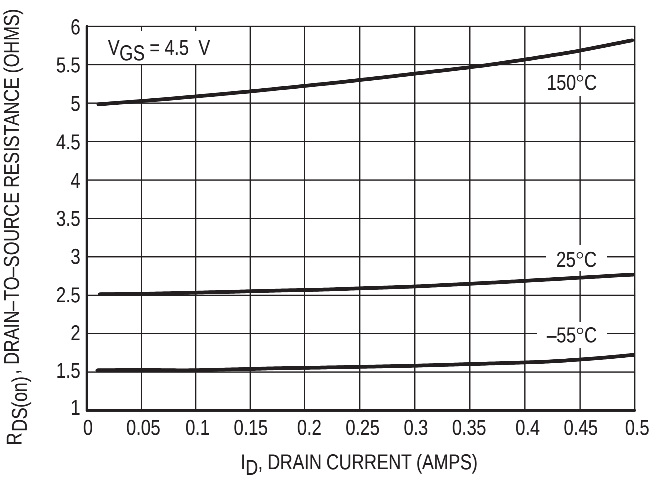


Figure 8. On–Resistance versus Drain Current

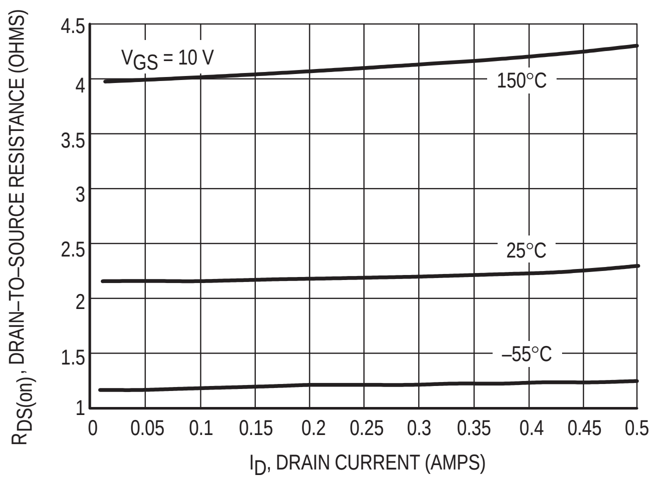


Figure 9. On–Resistance versus Drain Current

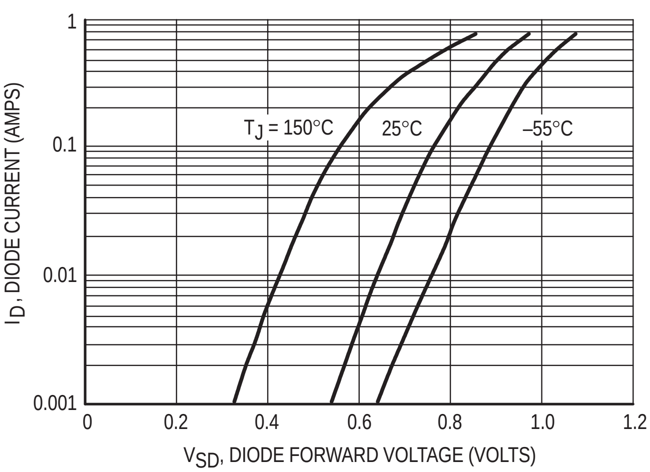


Figure 10. Body Diode Forward Voltage

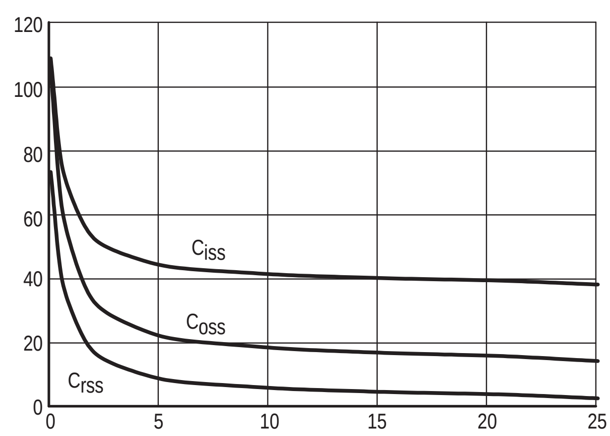


Figure 11. Capacitance

GREEN LINE™

MGSF1N02LT1

Motorola Preferred Device

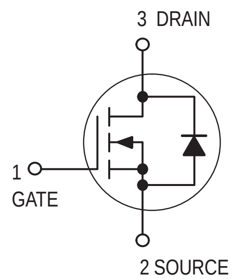
Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

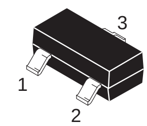
N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in space sensitive power management circuitry. Typical applications are dc–dc converters and power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current (t_p ≤ 10 μs)	I_D I_{DM}	750 2000	mA
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

Device Marking: NZ

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF1N02LT1	7″	8mm embossed tape	3000
MGSF1N02LT3	13″	8mm embossed tape	10,000

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

REV 2

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 Vdc, I_D = 10 μAdc)	$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current	I_{DSS}				μAdc
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc)		—	—	1.0	
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)		—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)	$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance	$r_{DS(on)}$				Ohms
(V_{GS} = 10 Vdc, I_D = 1.2 Adc)		—	0.075	0.090	
(V_{GS} = 4.5 Vdc, I_D = 1.0 Adc)		—	0.115	0.130	
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 5.0 Vdc)	C_{iss}	—	125	—	pF
Output Capacitance (V_{DS} = 5.0 Vdc)	C_{oss}	—	120	—	
Transfer Capacitance (V_{DG} = 5.0 Vdc)	C_{rss}	—	45	—	
SWITCHING CHARACTERISTICS(2) (V_{DD} = 15 Vdc, I_D = 1.0 Adc, R_L = 50 Ω)					
Turn–On Delay Time	$t_{d(on)}$	—	2.5	—	ns
Rise Time	t_r	—	1.0	—	
Turn–Off Delay Time	$t_{d(off)}$	—	16	—	
Fall Time	t_f	—	8.0	—	
Gate Charge (See Figure 6)	Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS					
Continuous Current	I_S	—	—	0.6	A
Pulsed Current	I_{SM}	—	—	0.75	
Forward Voltage(2)	V_{SD}	—	0.8	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

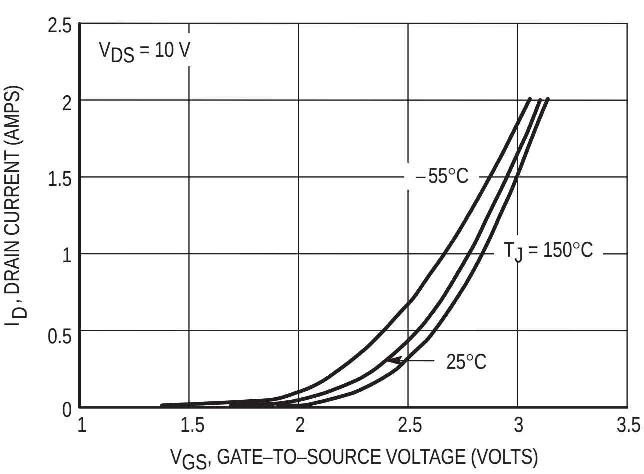


Figure 1. Transfer Characteristics

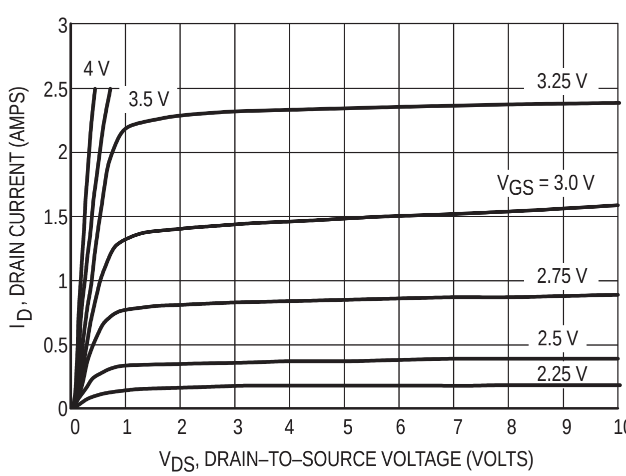


Figure 2. On–Region Characteristics

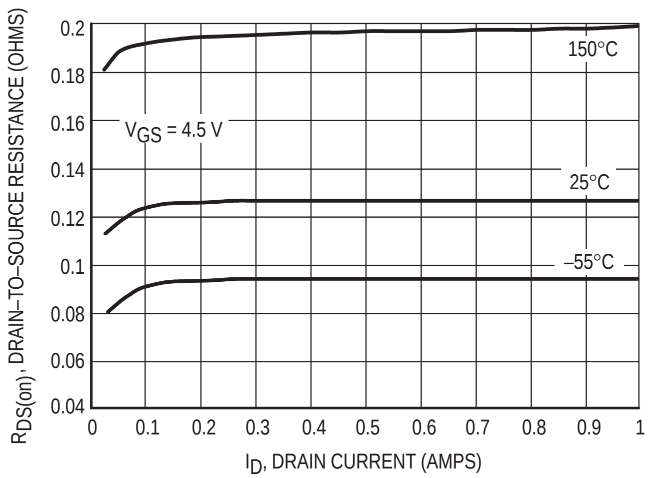


Figure 3. On–Resistance versus Drain Current

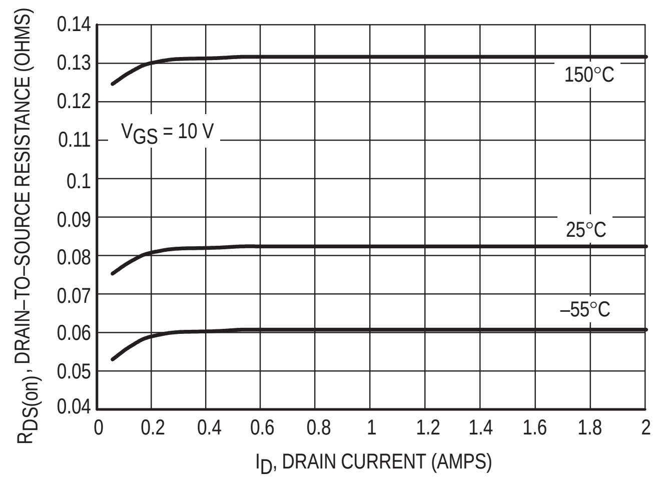


Figure 4. On–Resistance versus Drain Current

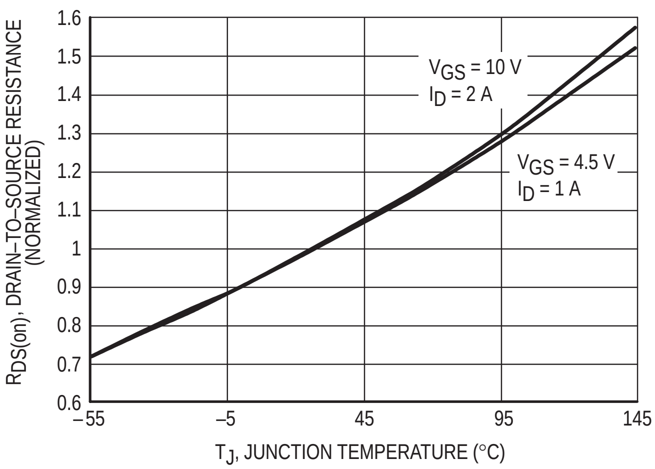


Figure 5. On–Resistance Variation with Temperature

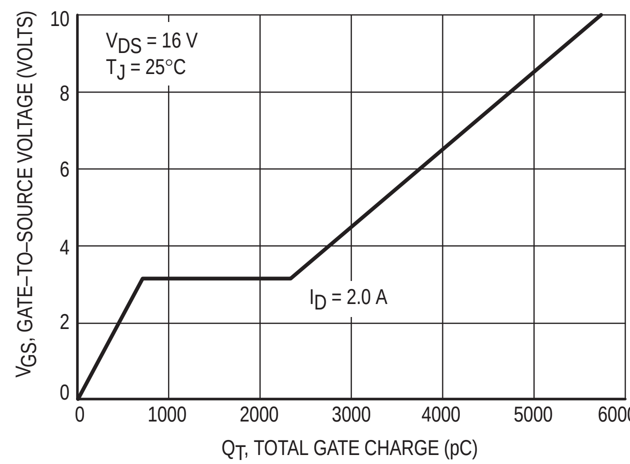


Figure 6. Gate Charge

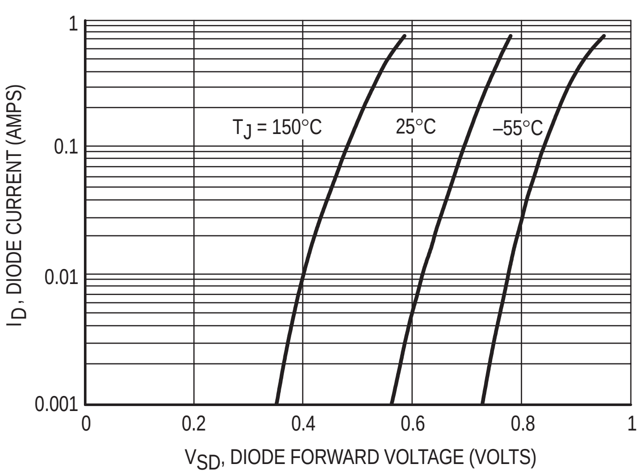


Figure 7. Body Diode Forward Voltage

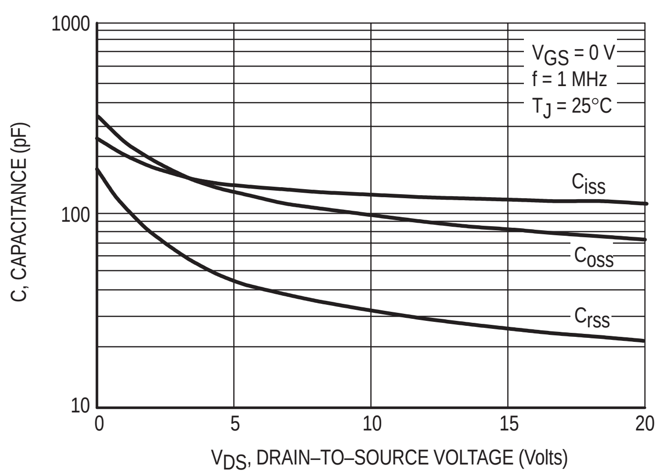


Figure 8. Capacitance

GREEN LINE™

MGSF1N03LT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

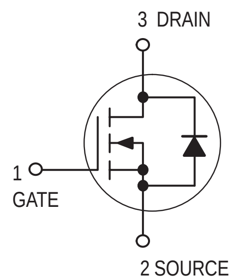
N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET

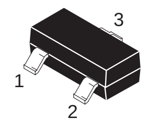
HD TMOS™

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in space sensitive power management circuitry. Typical applications are dc–dc converters and power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_{DM}	750 2000	mA
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

Device Marking: N3

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF1N03LT1	7″	8mm embossed tape	3000
MGSF1N03LT3	13″	8mm embossed tape	10,000

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

REV 4

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 Vdc, I_D = 10 μAdc)		$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 1.2 Adc)		$r_{DS(on)}$	—	0.08	0.10	Ohms
(V_{GS} = 4.5 Vdc, I_D = 1.0 Adc)			—	0.125	0.145	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 Vdc)	C_{iss}	—	140	—	pF
Output Capacitance	(V_{DS} = 5.0 Vdc)	C_{oss}	—	100	—	
Transfer Capacitance	(V_{DG} = 5.0 Vdc)	C_{rss}	—	40	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 Adc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 6)		Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.6	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	0.8	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

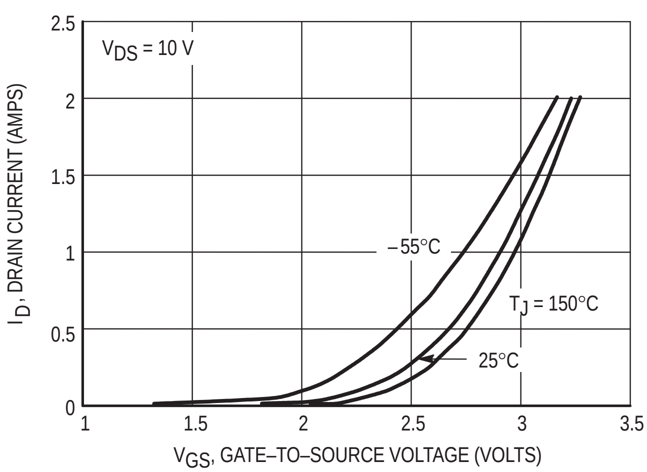


Figure 1. Transfer Characteristics

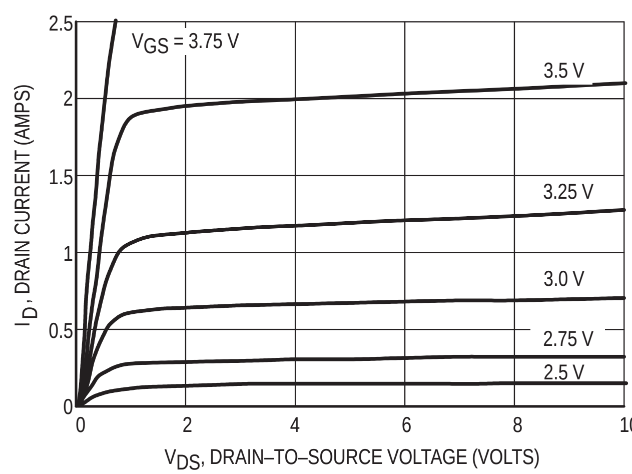


Figure 2. On–Region Characteristics

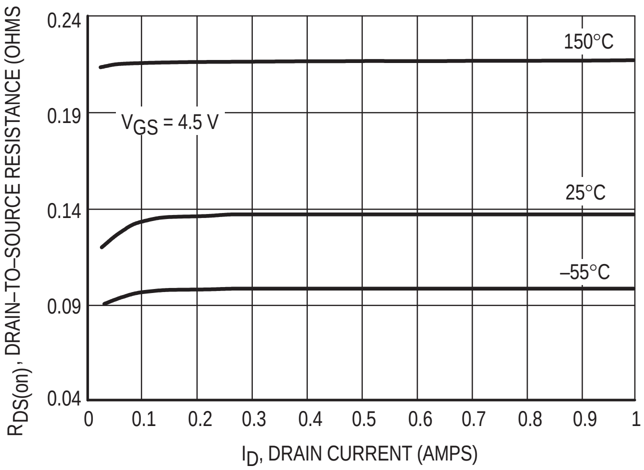


Figure 3. On–Resistance versus Drain Current

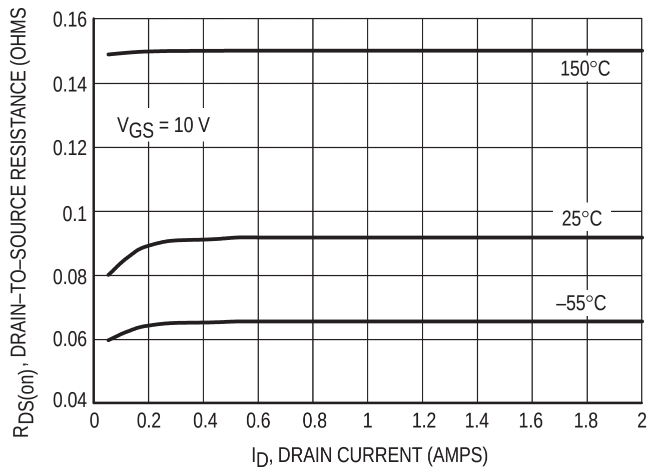


Figure 4. On–Resistance versus Drain Current

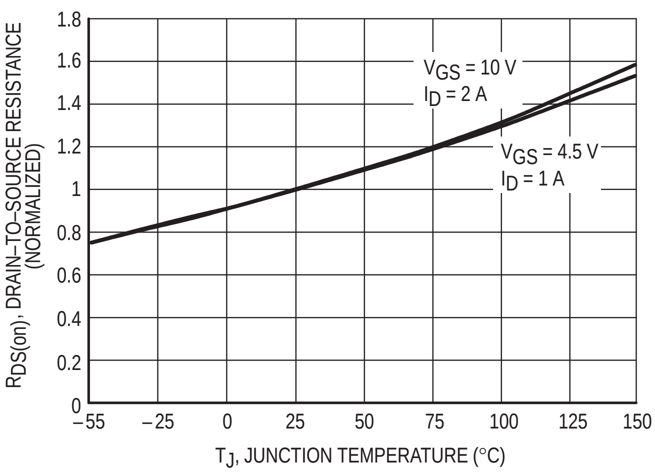


Figure 5. On–Resistance Variation with Temperature

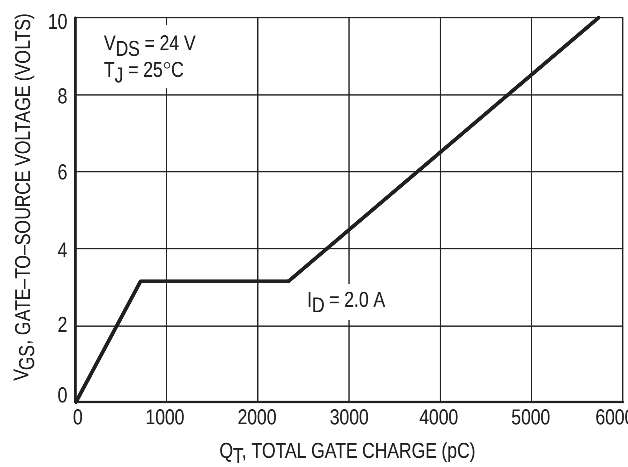


Figure 6. Gate Charge

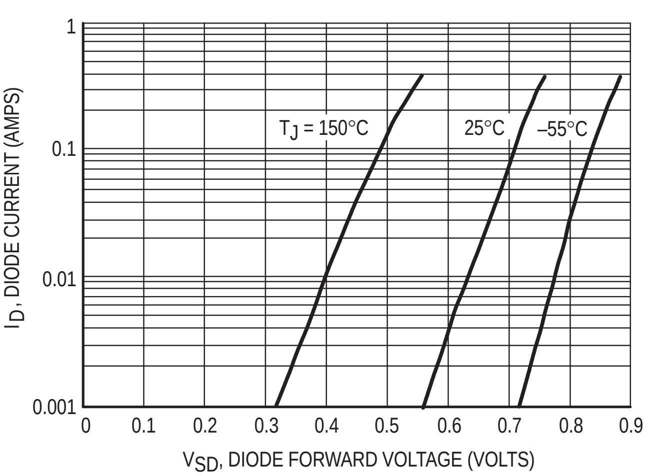


Figure 7. Body Diode Forward Voltage

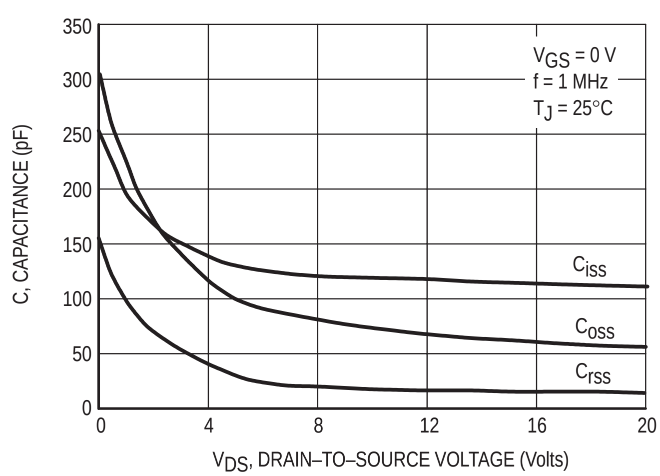


Figure 8. Capacitance

GREEN LINE™

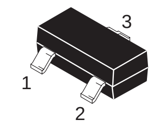
Preliminary Information

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

MGSF1P02ELT1

Motorola Preferred Device

P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET

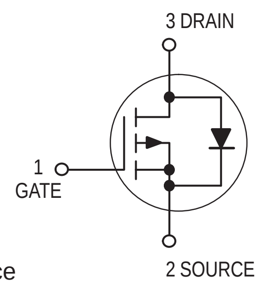


CASE 318–08, Style 21
SOT–23 (TO–236AB)

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in space sensitive power management circuitry. Typical applications are dc–dc converters and power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space



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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_{DM}	750 2000	mA
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

Device Marking: PC

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF1P02ELT1	7″	8mm embossed tape	3000
MGSF1P02ELT3	13″	8mm embossed tape	10,000

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 Vdc, I_D = 250 μAdc)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current		I_{DSS}				μAdc
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc)			—	—	1.0	
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0 Vdc)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	0.7	0.85	1.2	Vdc
Static Drain–to–Source On–Resistance		$r_{DS(on)}$				Ohms
(V_{GS} = 4.5 Vdc, I_D = 0.75 Adc)			—	0.20	0.26	
(V_{GS} = 2.5 Vdc, I_D = 0.5 Adc)			—	0.32	0.50	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 Vdc)	C_{iss}	—	130	—	pF
Output Capacitance	(V_{DS} = 5.0 Vdc)	C_{oss}	—	120	—	
Transfer Capacitance	(V_{DG} = 5.0 Vdc)	C_{rss}	—	60	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 Adc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 6)		Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.6	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	1.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

GREEN LINE™

MGSF1P02LT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

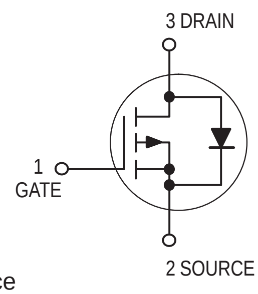
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET

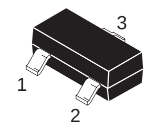
Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in space sensitive power management circuitry. Typical applications are dc–dc converters and power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space

TMOS™





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_{DM}	750 2000	mA
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

Device Marking: PC

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF1P02LT1	7″	8mm embossed tape	3000
MGSF1P02LT3	13″	8mm embossed tape	10,000

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

REV 2

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 Vdc, I_D = 10 μAdc)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 1.5 Adc)		$r_{DS(on)}$	—	0.235	0.350	Ohms
(V_{GS} = 4.5 Vdc, I_D = 0.75 Adc)			—	0.375	0.500	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 Vdc)	C_{iss}	—	130	—	pF
Output Capacitance	(V_{DS} = 5.0 Vdc)	C_{oss}	—	120	—	
Transfer Capacitance	(V_{DG} = 5.0 Vdc)	C_{rss}	—	60	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 Adc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 6)		Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.6	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	1.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

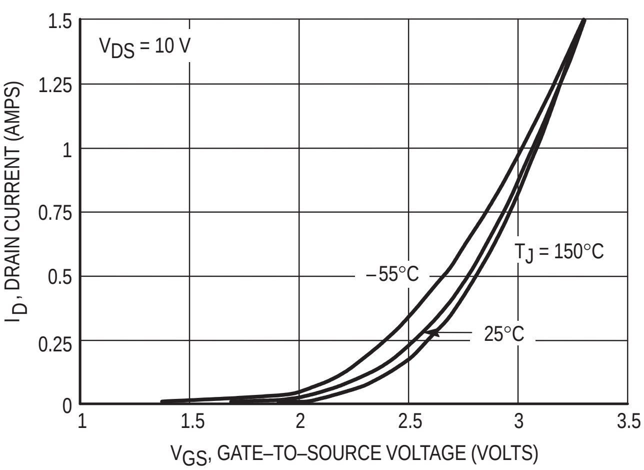


Figure 1. Transfer Characteristics

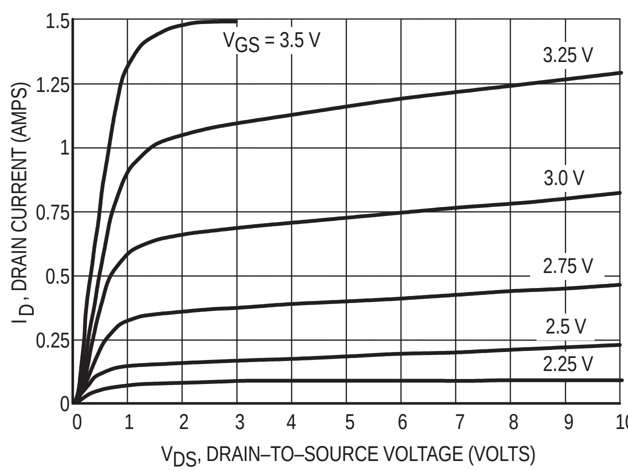


Figure 2. On–Region Characteristics

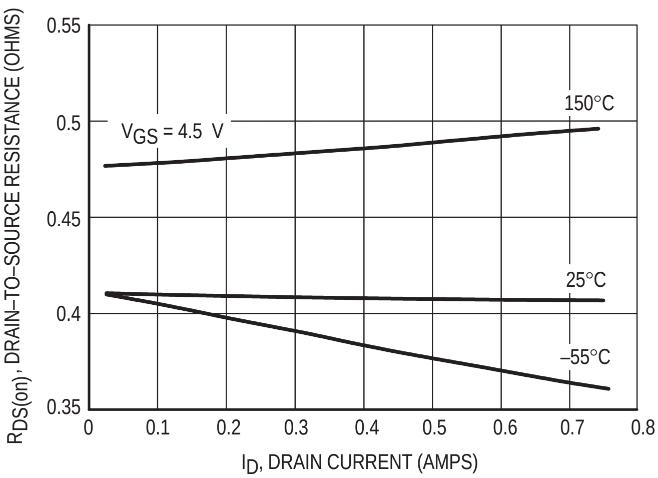


Figure 3. On–Resistance versus Drain Current

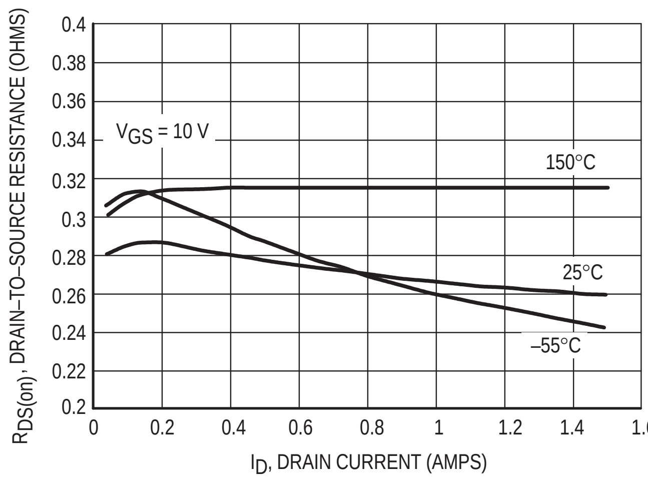


Figure 4. On–Resistance versus Drain Current

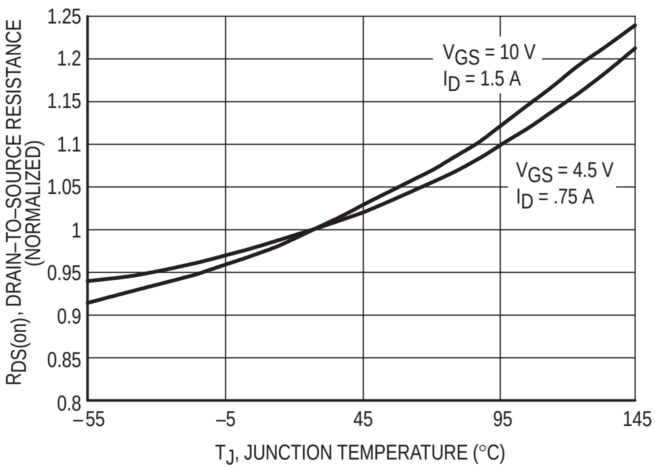


Figure 5. On–Resistance Variation with Temperature

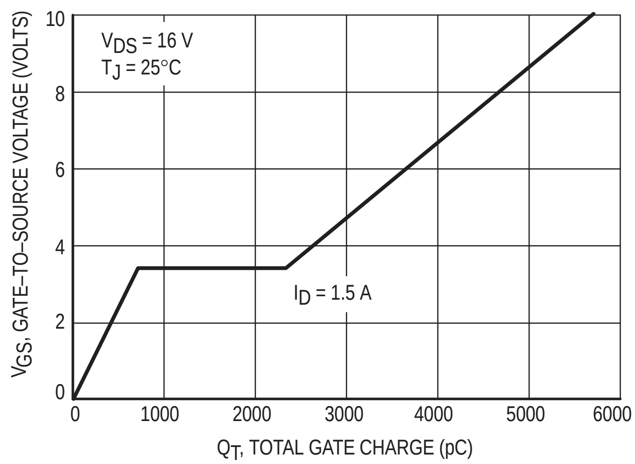


Figure 6. Gate Charge

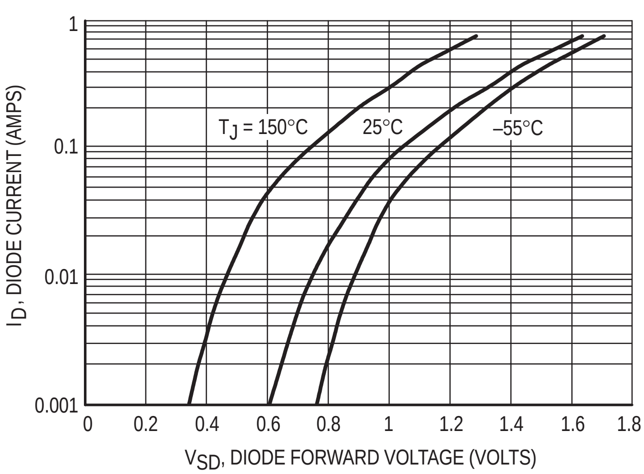


Figure 7. Body Diode Forward Voltage

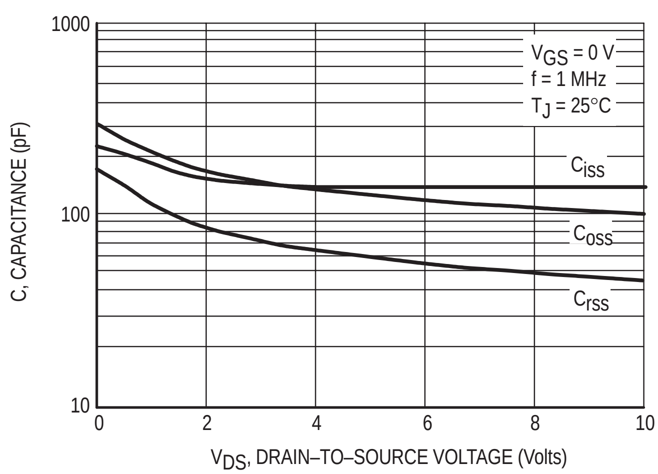


Figure 8. Capacitance

GREEN LINE™

Preliminary Information

MGSF3441VT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 78 mΩ (TYP)

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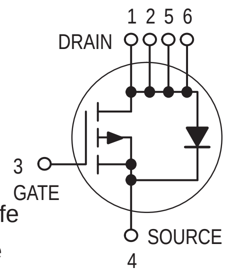

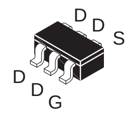

CASE 318G–02, Style 1
TSOP 6 PLASTIC

2.5V RATED

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10$ µs)	I_D I_{DM}	3.3 20	A
Total Power Dissipation @ T_A = 25°C Mounted on FR4 $t \le 5$ sec	P_D	2.0	W
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	128	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3441VT1	7″	8 mm embossed tape	3000
MGSF3441VT3	13″	8 mm embossed tape	10,000

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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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)			—	—	4.0	
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	0.45	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 4.5 Vdc, I_D = 3.3 A)		$r_{DS(on)}$	—	0.078	0.090	Ohms
(V_{GS} = 2.5 Vdc, I_D = 2.9 A)			—	0.110	0.135	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	27	50	ns
Rise Time		t_r	—	17	30	
Turn–Off Delay Time		$t_{d(off)}$	—	52	80	
Fall Time		t_f	—	45	70	
Gate Charge		Q_T	—	3000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	20	A
Forward Voltage(2)		V_{SD}	—	0.80	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

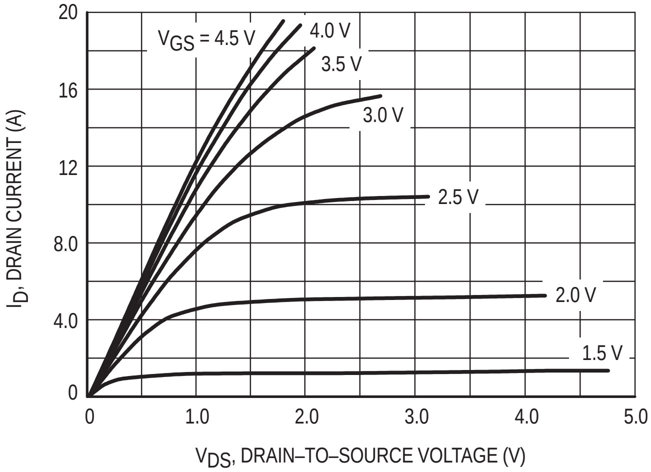

Figure 1. Output Characteristics

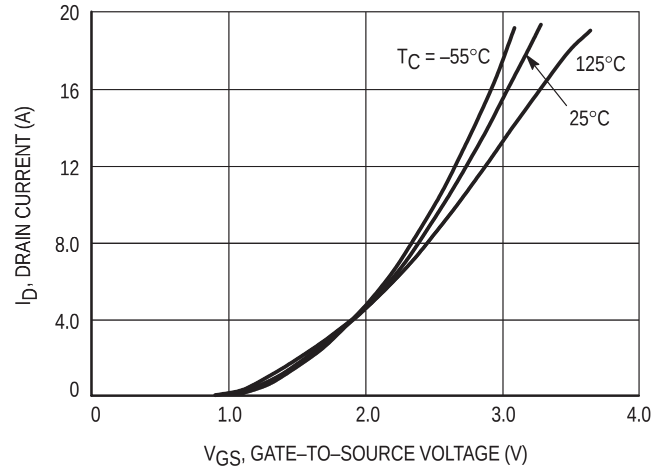

Figure 2. Transfer Characteristics

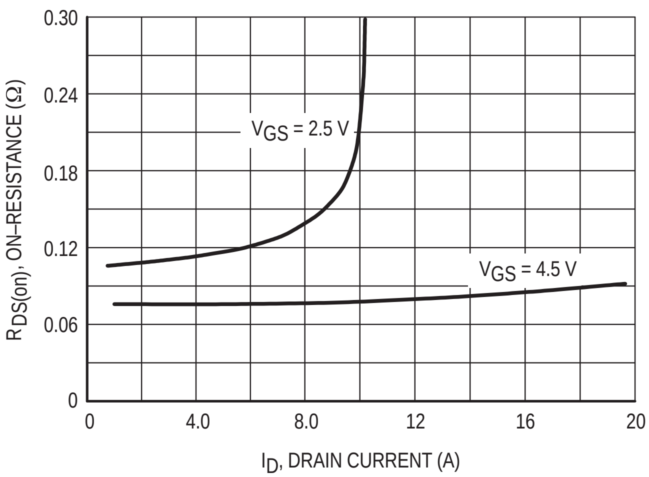

Figure 3. On–Resistance versus Drain Current

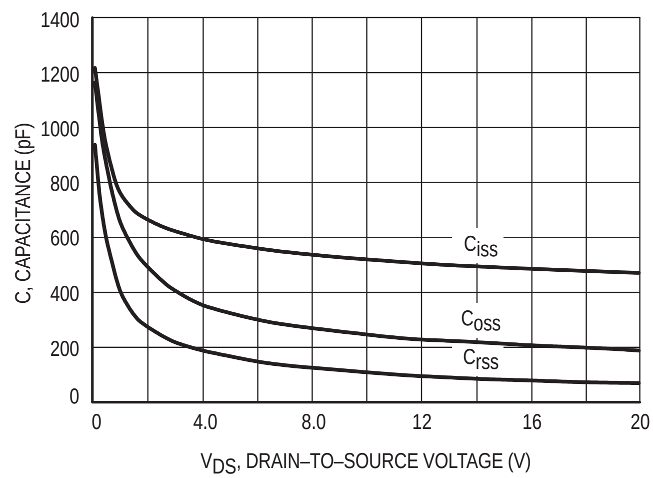

Figure 4. Capacitance

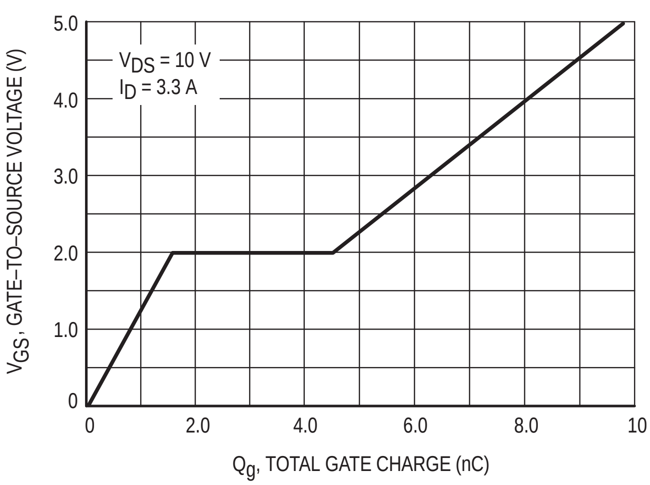

Figure 5. Gate Charge

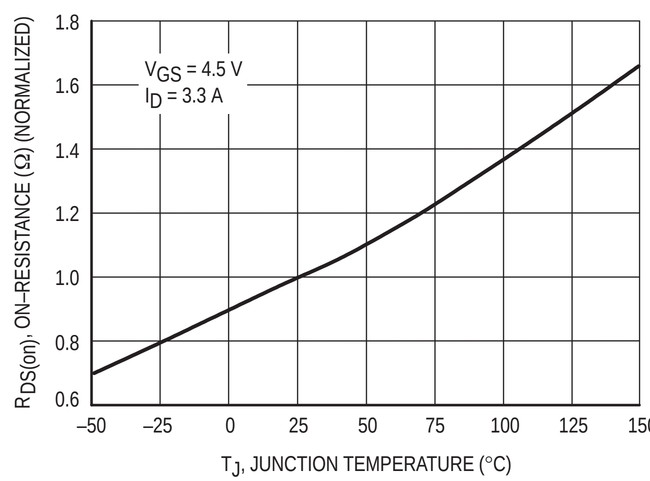

Figure 6. On–Resistance versus Junction Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

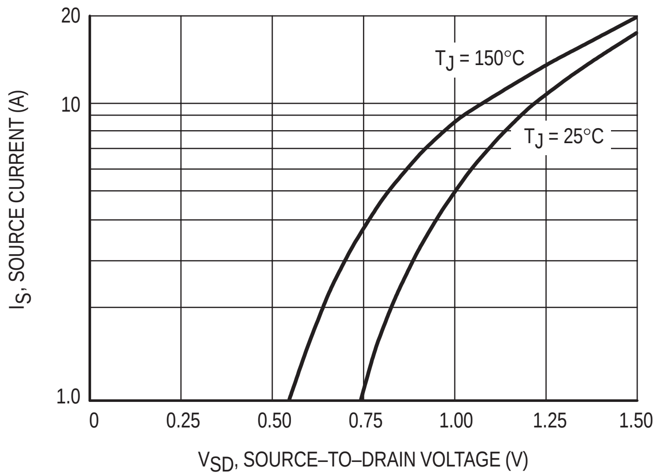

Figure 7. Source–Drain Diode Forward Voltage

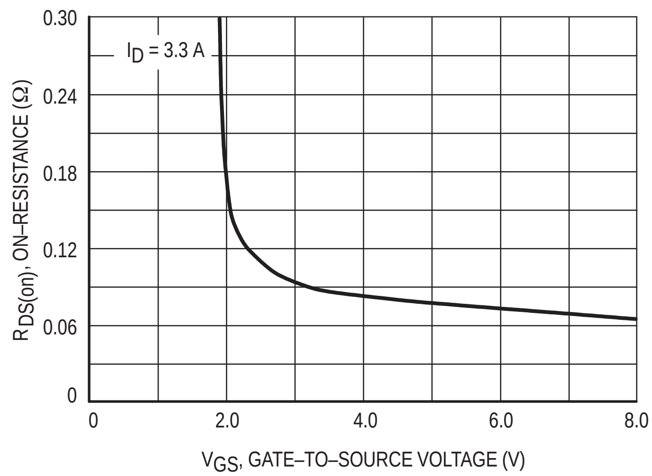

Figure 8. On–Resistance versus Gate–to–Source Voltage

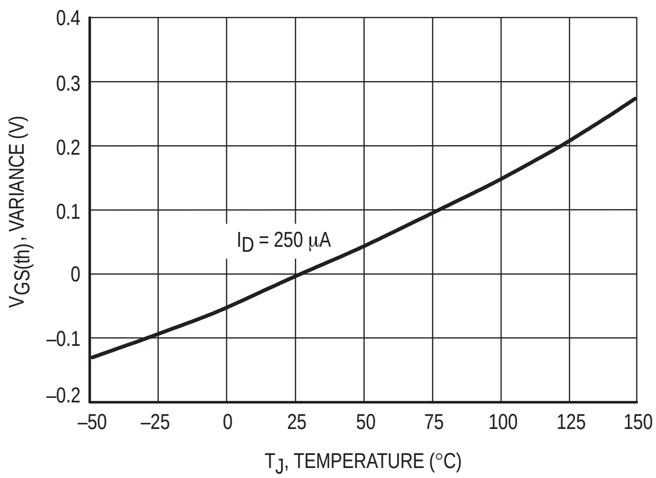

Figure 9. Threshold Voltage

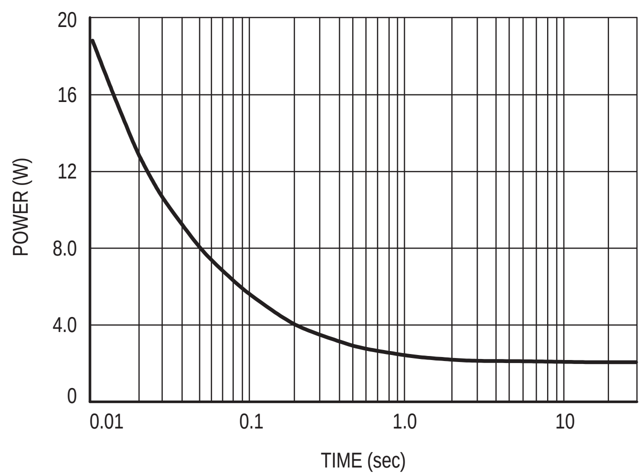

Figure 10. Single Pulse Power

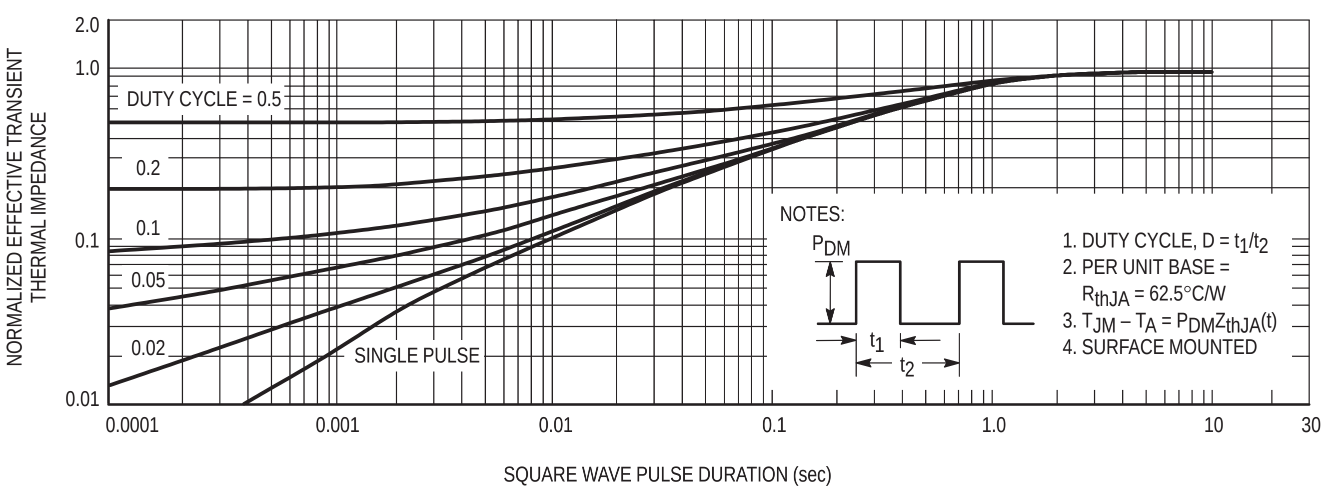

Figure 11. Normalized Thermal Transient Impedance, Junction–to–Ambient

GREEN LINE™

Preliminary Information

MGSF3441XT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 78 mΩ (TYP)

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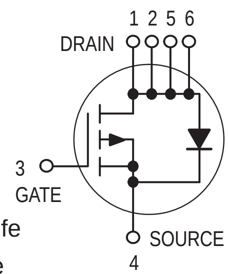

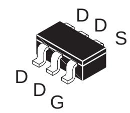

CASE 318G–02, Style 1
TSOP 6 PLASTIC

2.5V RATED

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10$ µs)	I_D I_{DM}	1.5 20	A
Total Power Dissipation @ T_A = 25°C	P_D	950	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	132	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3441XT1	7″	8 mm embossed tape	3000
MGSF3441XT3	13″	8 mm embossed tape	10,000

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

REV 2

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)		I_{DSS}	— —	— —	1.0 4.0	μAdc
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	0.45	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 4.5 Vdc, I_D = 1.5 A) (V_{GS} = 2.5 Vdc, I_D = 1.2 A)		$r_{DS(on)}$	— —	0.078 0.110	0.100 0.135	Ohms
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	27	50	ns
Rise Time		t_r	—	17	30	
Turn–Off Delay Time		$t_{d(off)}$	—	52	80	
Fall Time		t_f	—	45	70	
Gate Charge		Q_T	—	3000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	20	A
Forward Voltage(2)		V_{SD}	—	0.80	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

GREEN LINE™

Preliminary Information

MGSF3442VT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 58 mΩ (TYP)

HDTMOS™

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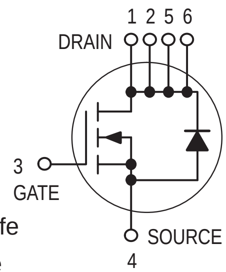

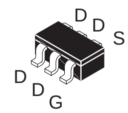

CASE 318G–02, Style 1
TSOP 6 PLASTIC

2.5V RATED

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_{DM}	4.0 20	A
Total Power Dissipation @ T_A = 25°C Mounted on FR4 $t \leq 5$ sec	P_D	2.0	W
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3442VT1	7″	8 mm embossed tape	3000
MGSF3442VT3	13″	8 mm embossed tape	10,000

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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 Vdc, I_D = 10 µA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)		I_{DSS}	— —	— —	1.0 5.0	µAdc
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 µAdc)		$V_{GS(th)}$	0.6	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 4.5 Vdc, I_D = 4.0 A) (V_{GS} = 2.5 Vdc, I_D = 3.4 A)		$r_{DS(on)}$	— —	0.058 0.072	0.070 0.095	Ohms
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 10 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	8.0	20	ns
Rise Time		t_r	—	24	40	
Turn–Off Delay Time		$t_{d(off)}$	—	36	60	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	—	—	nC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage(2)		V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

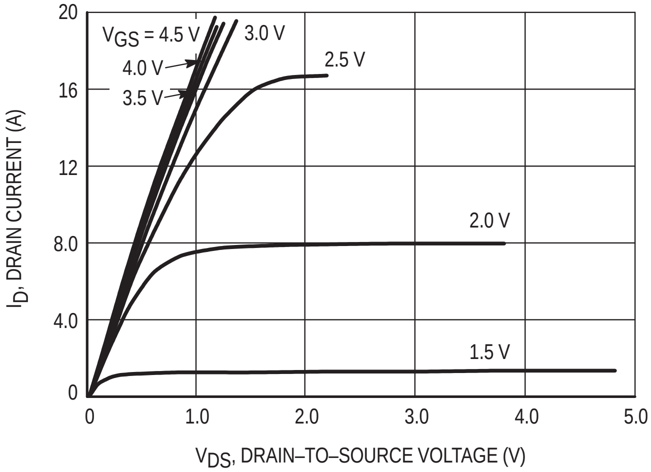

Figure 1. Output Characteristics

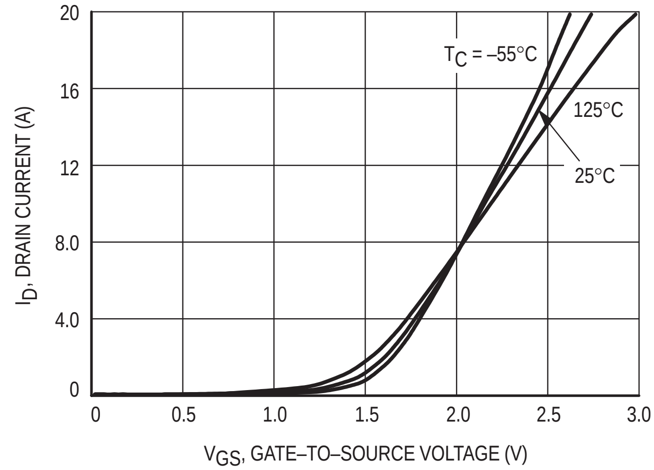

Figure 2. Transfer Characteristics

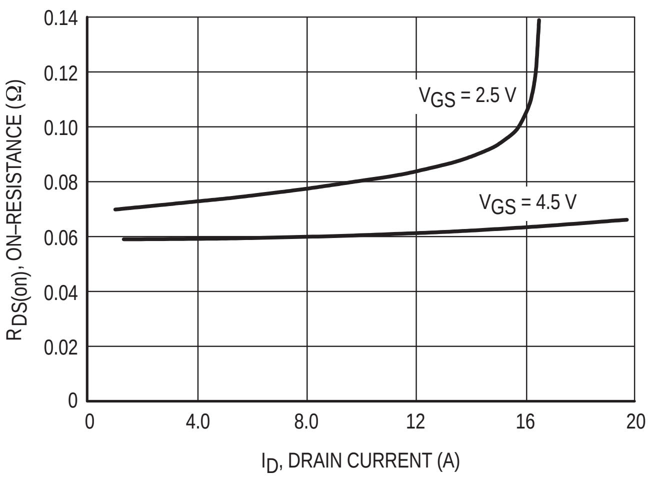

Figure 3. On–Resistance versus Drain Current

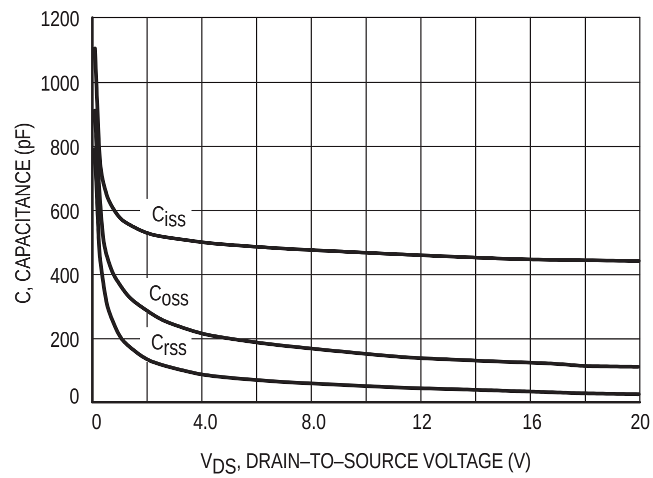

Figure 4. Capacitance

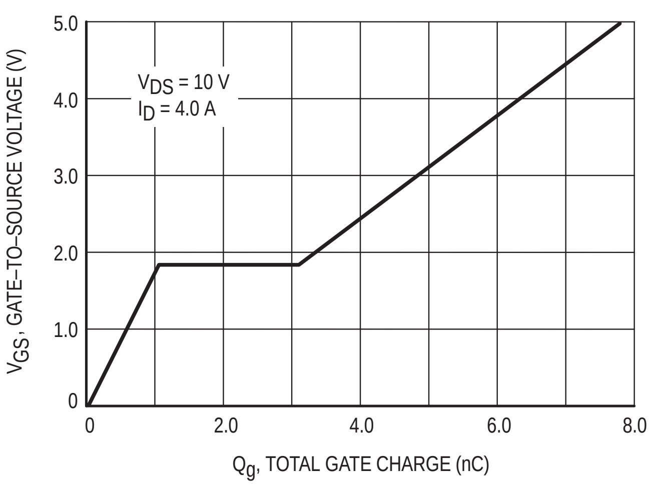

Figure 5. Gate Charge

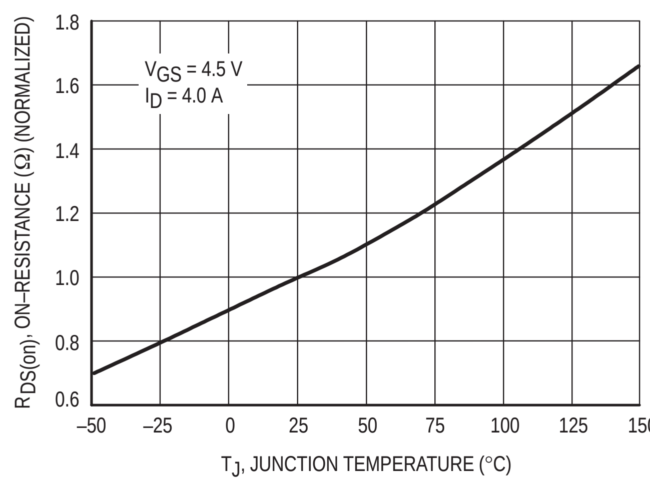

Figure 6. On–Resistance versus Junction Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

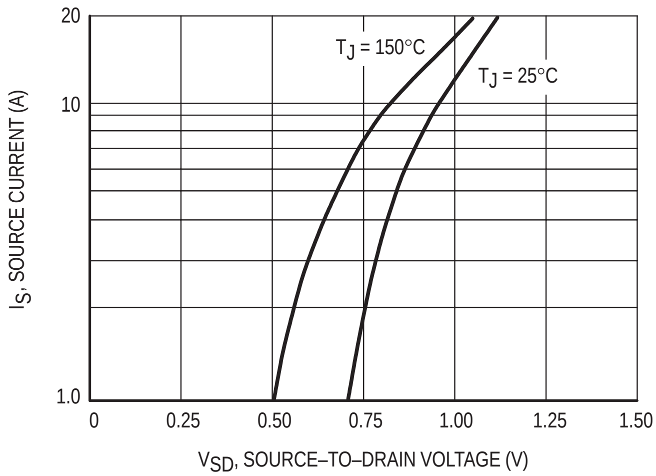

Figure 7. Source–Drain Diode Forward Voltage

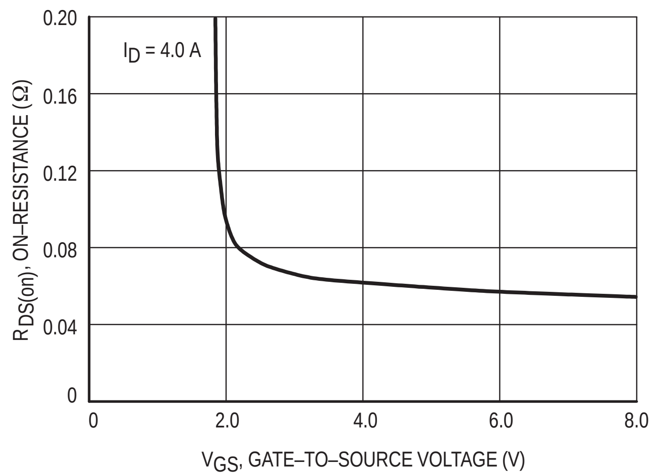

Figure 8. On–Resistance versus Gate–to–Source Voltage

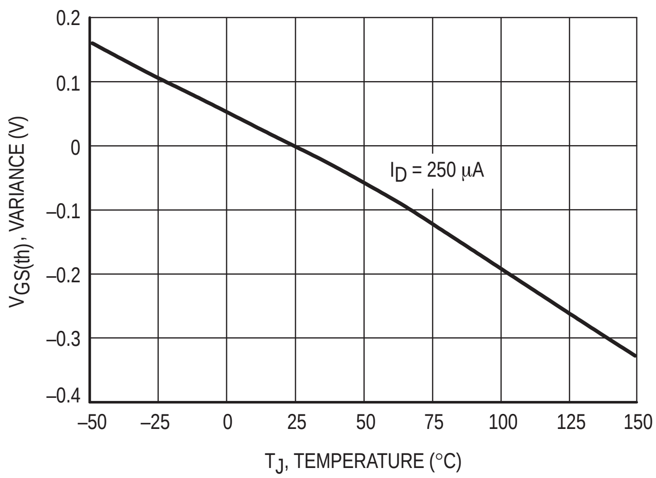

Figure 9. Threshold Voltage

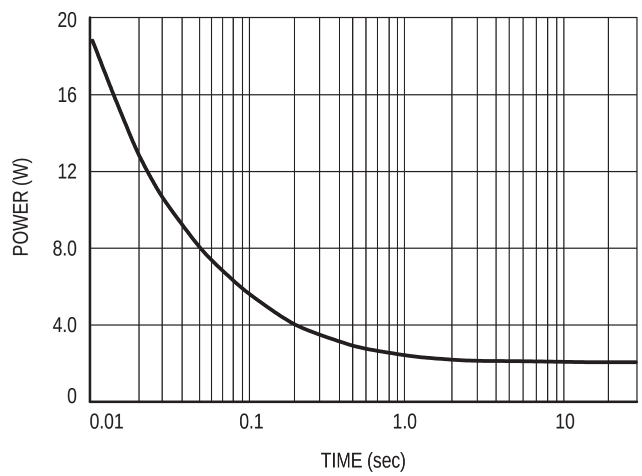

Figure 10. Single Pulse Power

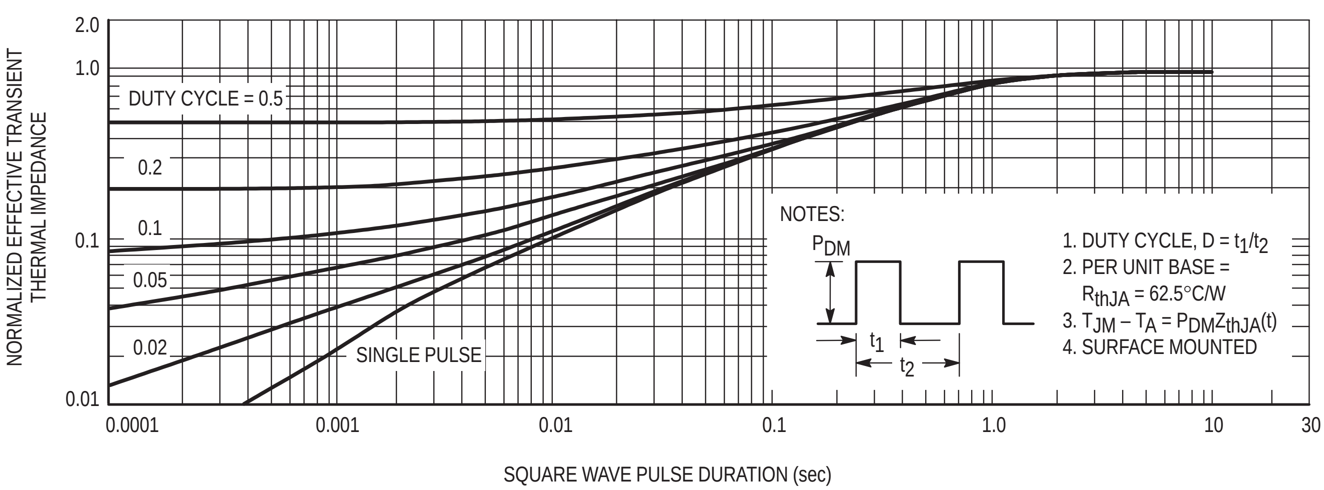

Figure 11. Normalized Thermal Transient Impedance, Junction–to–Ambient

GREEN LINE™

Preliminary Information

MGSF3442XT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 58 mΩ (TYP)

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

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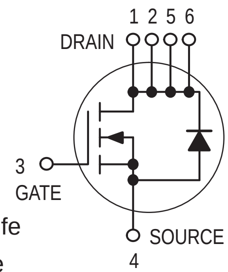

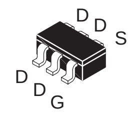

CASE 318G–02, Style 1
TSOP 6 PLASTIC

2.5V RATED

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_{DM}	1.7 20	A
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3442XT1	7″	8 mm embossed tape	3000
MGSF3442XT3	13″	8 mm embossed tape	10,000

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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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)			—	—	5.0	
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	0.6	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 4.5 Vdc, I_D = 1.7 A)		$r_{DS(on)}$	—	0.058	0.070	Ohms
(V_{GS} = 2.5 Vdc, I_D = 1.3 A)			—	0.072	0.095	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 10 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	8.0	20	ns
Rise Time		t_r	—	24	40	
Turn–Off Delay Time		$t_{d(off)}$	—	36	60	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	—	—	nC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage(2)		V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

GREEN LINE™

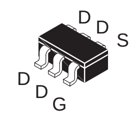
Preliminary Information

MGSF3454VT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 50 mΩ (TYP)



CASE 318G–02, Style 1
TSOP 6 PLASTIC

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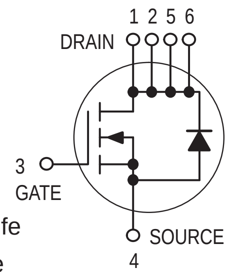

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MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le$ 10 µs)	I_D I_{DM}	4.2 20	A
Total Power Dissipation @ T_A = 25°C Mounted on FR4 t ≤ 5 sec	P_D	2.0	W
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3454VT1	7″	8 mm embossed tape	3000
MGSF3454VT3	13″	8 mm embossed tape	10,000

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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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)		I_{DSS}	— —	— —	1.0 25	μAdc
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 4.2 A) (V_{GS} = 4.5 Vdc, I_D = 3.4 A)		$r_{DS(on)}$	— —	0.05 0.07	0.065 0.095	Ohms
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 10 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	10	20	ns
Rise Time		t_r	—	15	30	
Turn–Off Delay Time		$t_{d(off)}$	—	20	35	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	—	15	nC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage(2)		V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

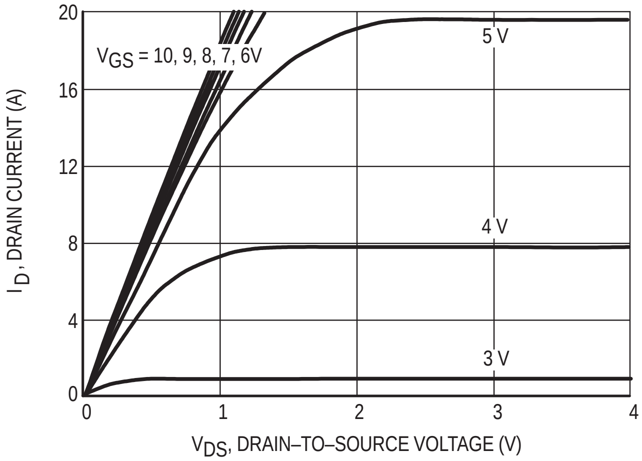

Figure 1. Output Characteristics

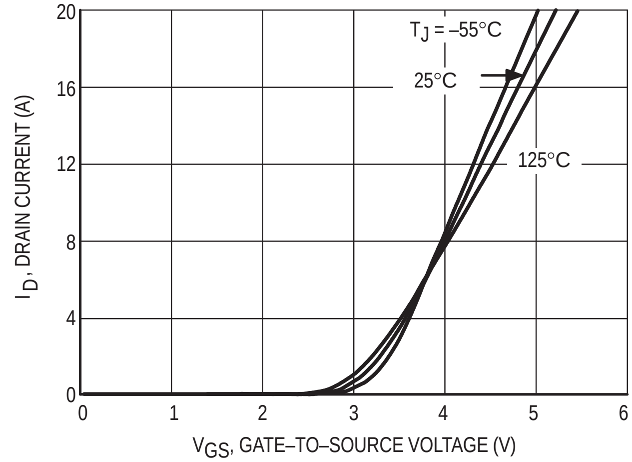

Figure 2. Transfer Characteristics

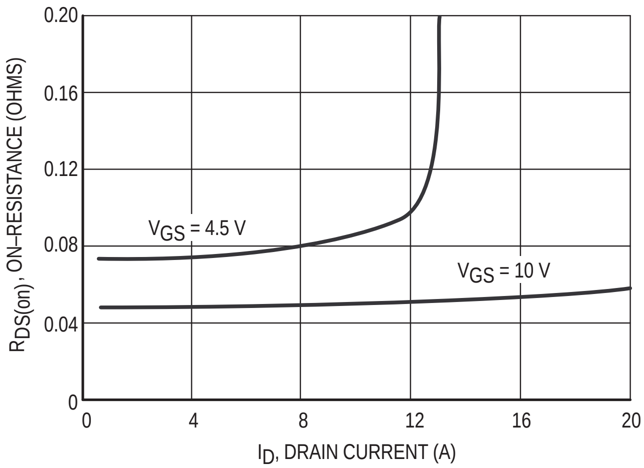

Figure 3. On–Resistance vs. Drain Current

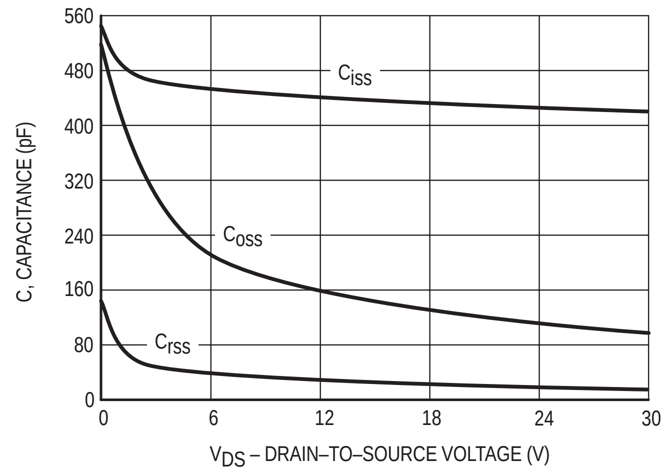

Figure 4. Capacitance

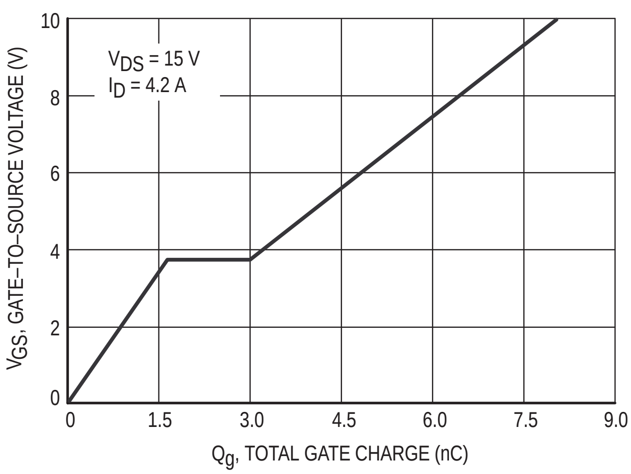

Figure 5. Gate Charge

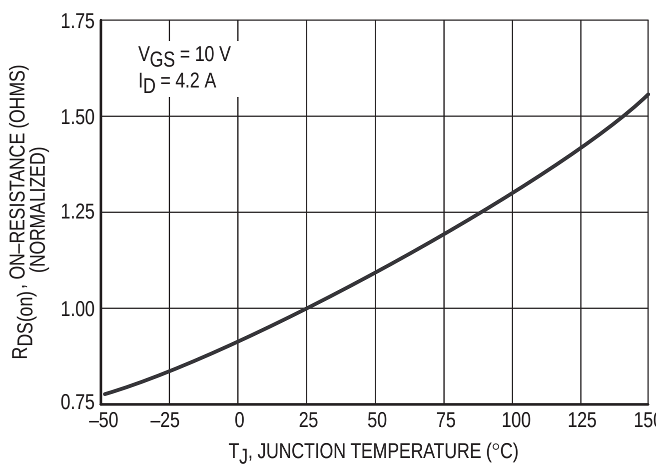

Figure 6. On–Resistance vs. Junction Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

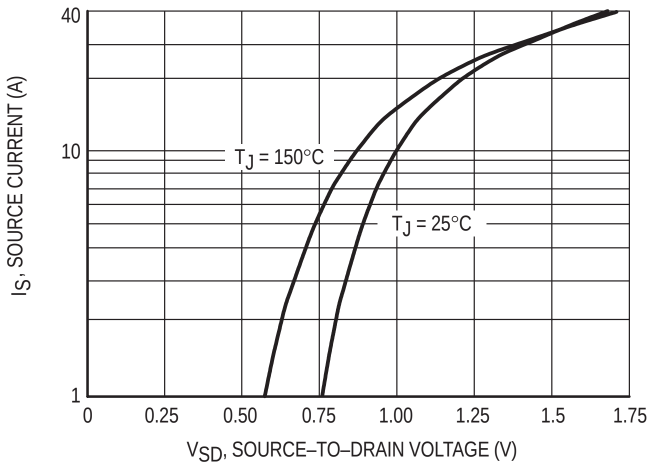

Figure 7. Source–Drain Diode Forward Voltage

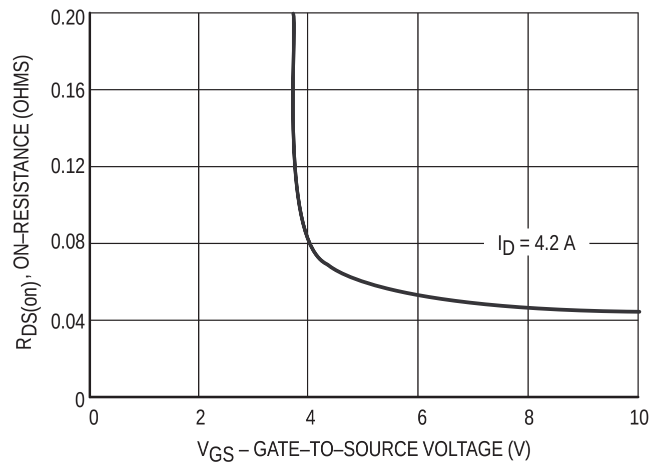

Figure 8. On–Resistance vs. Gate–to–Source Voltage

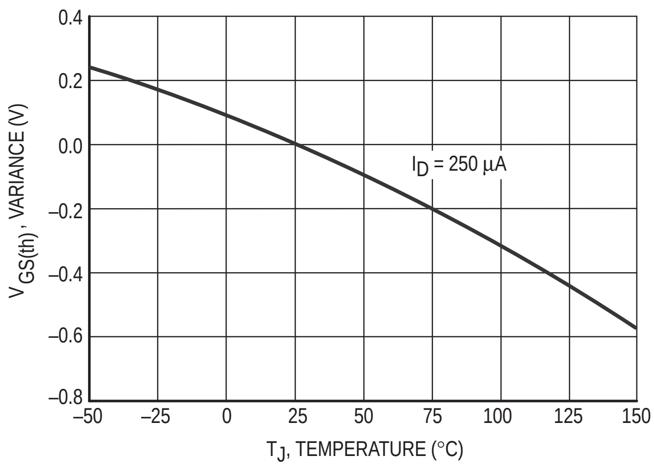

Figure 9. Threshold Voltage

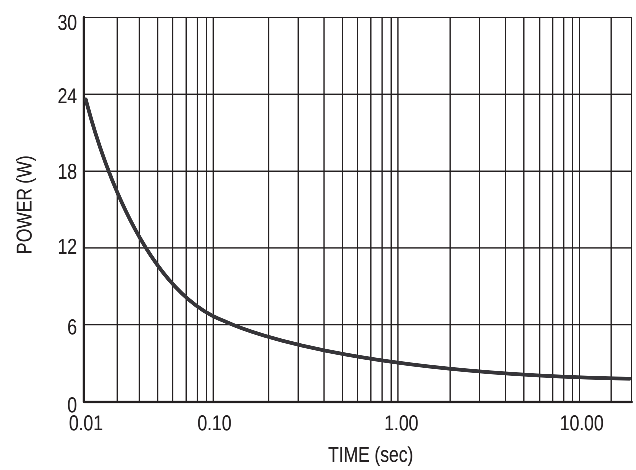

Figure 10. Single Pulse Power

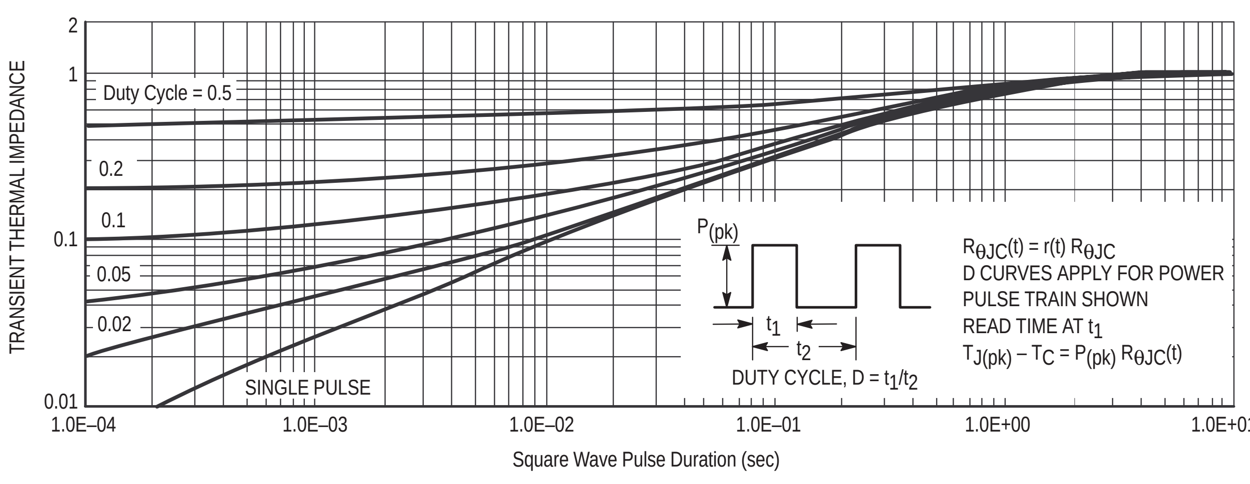

Figure 11. Normalized Thermal Transient Impedance, Junction–to–Ambient

Preliminary Information

MGSF3454XT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

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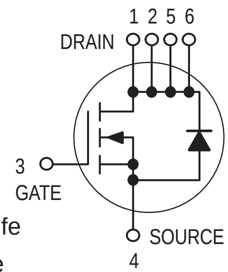

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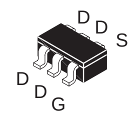

CASE 318G–02, Style 1
TSOP 6 PLASTIC

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_{DM}	1.75 20	A
Total Power Dissipation @ T_A = 25°C	P_D	950	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	250	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

Device Marking = 3G

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3454XT1	7″	8 mm embossed tape	3000
MGSF3454XT3	13″	8 mm embossed tape	10,000

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Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–to–Source Breakdown Voltage (V_{GS} = 0 Vdc, I_D = 10 μA)	$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)		—	—	25	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)	$V_{GS(th)}$	1.0	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 1.75 A)	$r_{DS(on)}$	—	0.05	0.065	Ohms
(V_{GS} = 4.5 Vdc, I_D = 1.5 A)		—	0.07	0.095	
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 5.0 V)	C_{iss}	—	345	—	pF
Output Capacitance (V_{DS} = 5.0 V)	C_{oss}	—	215	—	
Transfer Capacitance (V_{DG} = 5.0 V)	C_{rss}	—	140	—	
SWITCHING CHARACTERISTICS(2)					
Turn–On Delay Time (V_{DD} = 10 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	10	—	ns
Rise Time	t_r	—	15	—	
Turn–Off Delay Time	$t_{d(off)}$	—	20	—	
Fall Time	t_f	—	10	—	
Gate Charge	Q_T	—	—	15	nC
SOURCE–DRAIN DIODE CHARACTERISTICS					
Continuous Current	I_S	—	—	1.0	A
Pulsed Current	I_{SM}	—	—	5.0	A
Forward Voltage(2)	V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

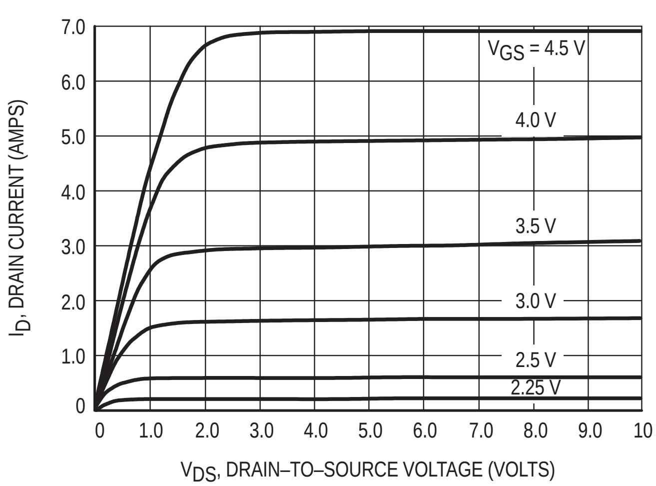


Figure 1. Output Characteristics

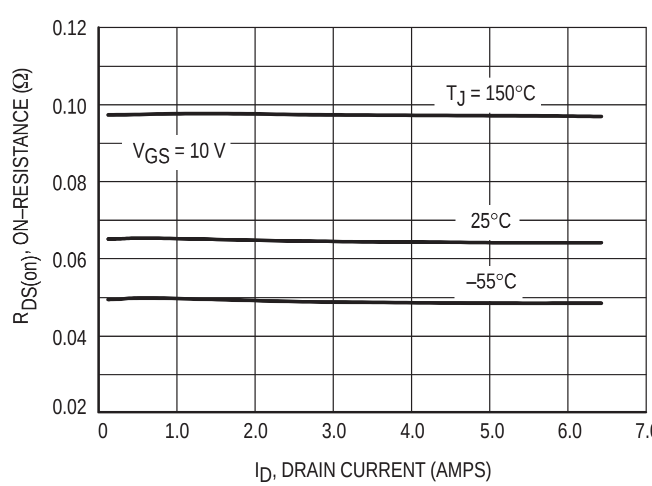


Figure 2. On–Resistance versus Drain Current

TYPICAL ELECTRICAL CHARACTERISTICS

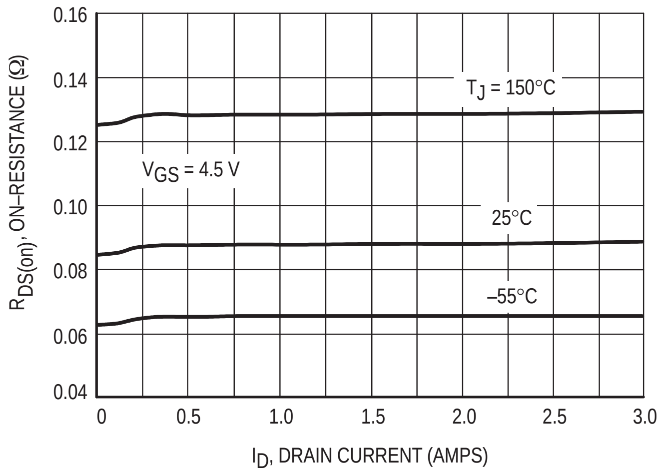


Figure 3. On–Resistance versus Drain Current

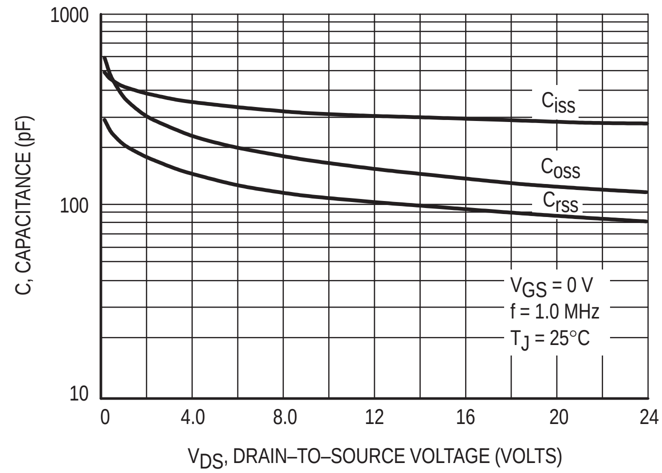


Figure 4. Capacitance

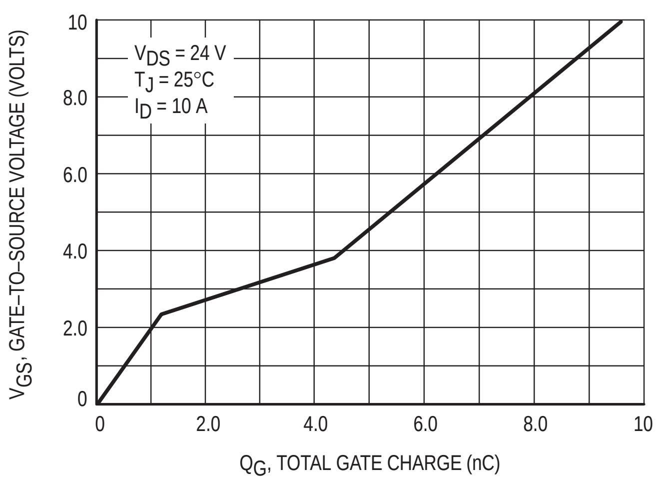


Figure 5. Gate Charge

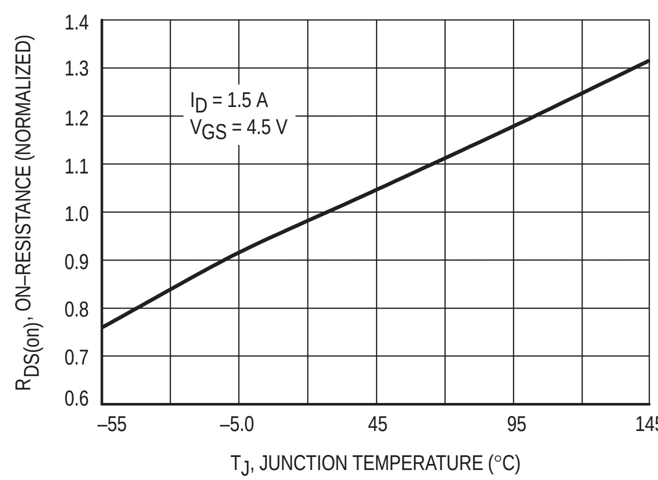


Figure 6. On–Resistance versus Junction Temperature

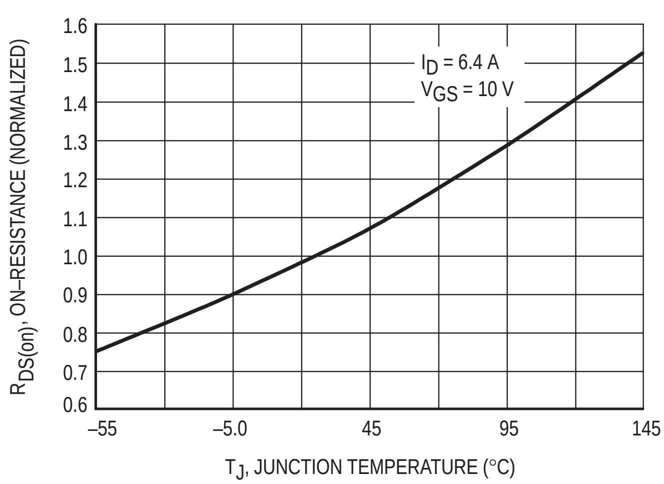


Figure 7. On–Resistance versus Junction Temperature

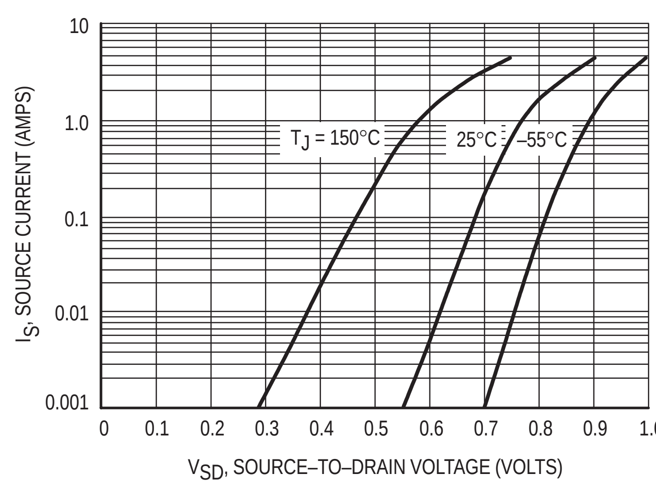


Figure 8. Source–Drain Diode Forward Voltage

TYPICAL ELECTRICAL CHARACTERISTICS

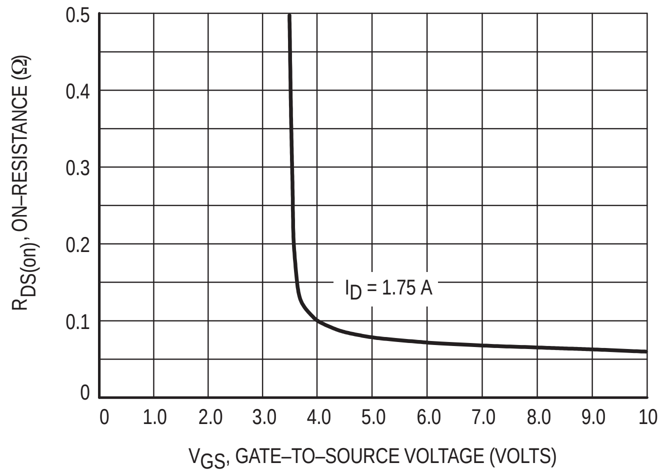


Figure 9. On–Resistance versus Gate–to–Source Voltage

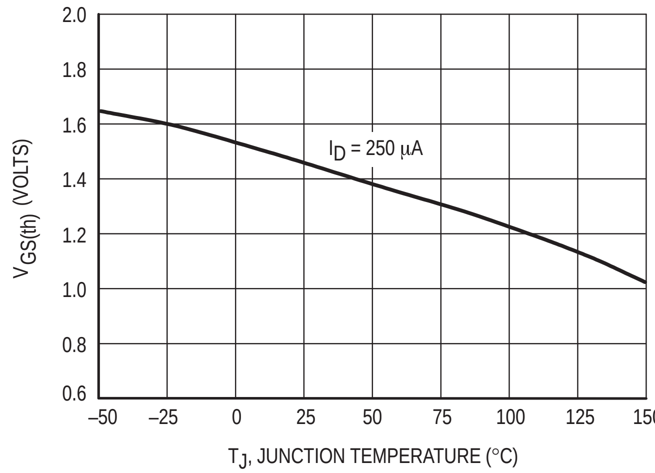


Figure 10. Threshold Voltage

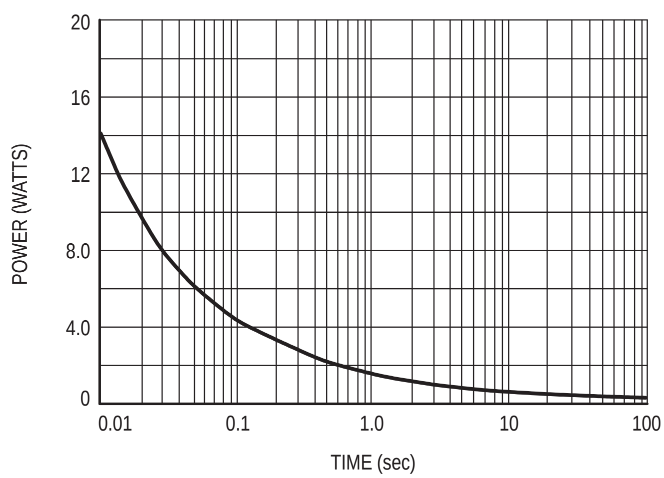


Figure 11. Single Pulse Power

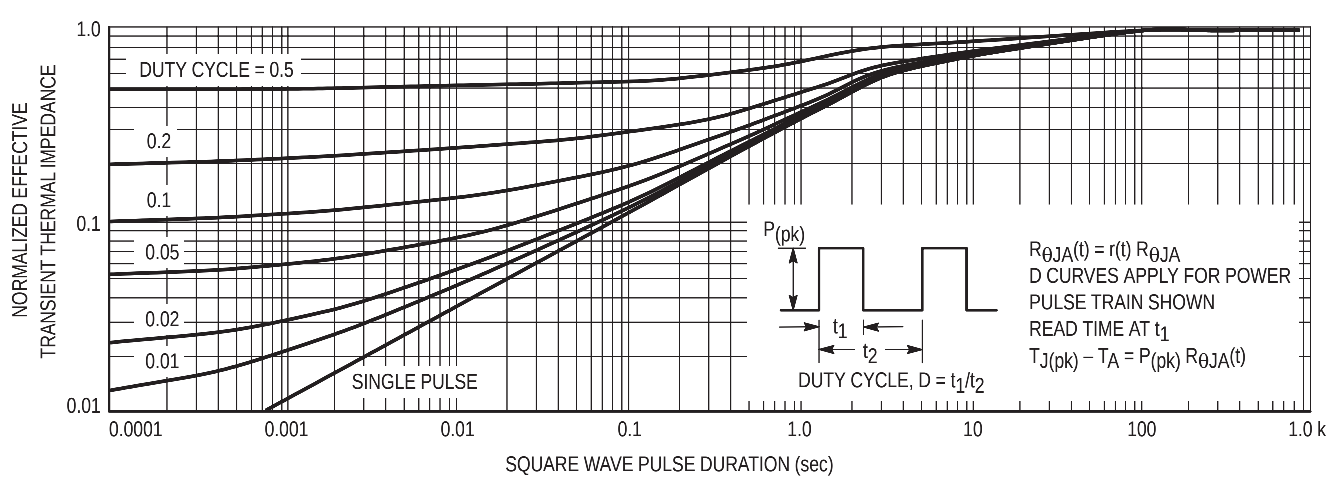


Figure 12. Normalized Thermal Transient Impedance, Junction–to–Ambient

GREEN LINE™

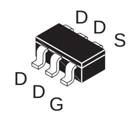
Preliminary Information

MGSF3455VT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

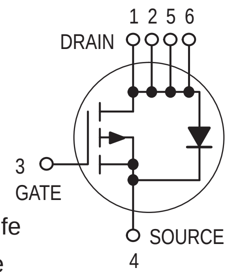
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 80 mΩ (TYP)



CASE 318G–02, Style 1
TSOP 6 PLASTIC

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.



- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature TSOP 6 Surface Mount Package Saves Board Space
- Visit our Web Site at http://www.mot–sps.com/ospd

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_{DM}	3.5 20	A
Total Power Dissipation @ T_A = 25°C Mounted on FR4 $t \leq 5$ sec	P_D	2.0	W
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3455VT1	7″	8 mm embossed tape	3000
MGSF3455VT3	13″	8 mm embossed tape	10,000

This document contains information on a product under development. Motorola reserves the right to change or discontinue this product without notice.

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 Vdc, I_D = 10 µA)		$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)		I_{DSS}	— —	— —	1.0 5.0	µAdc
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS[1]						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 µAdc)		$V_{GS(th)}$	1.0	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 3.5 A) (V_{GS} = 4.5 Vdc, I_D = 2.5 A)		$r_{DS(on)}$	— —	0.080 0.134	0.100 0.190	Ohms
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS[2]						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	10	20	ns
Rise Time		t_r	—	15	30	
Turn–Off Delay Time		$t_{d(off)}$	—	20	35	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	3000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage[2]		V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

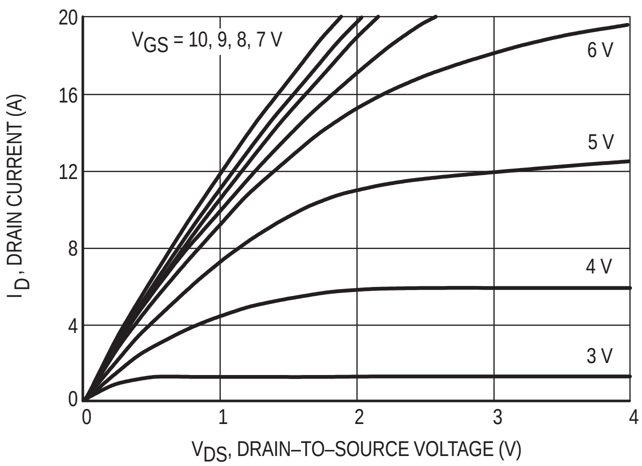


Figure 1. Output Characteristics

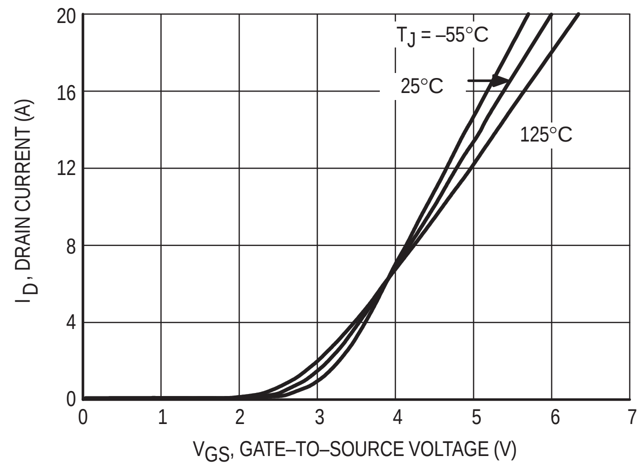


Figure 2. Transfer Characteristics

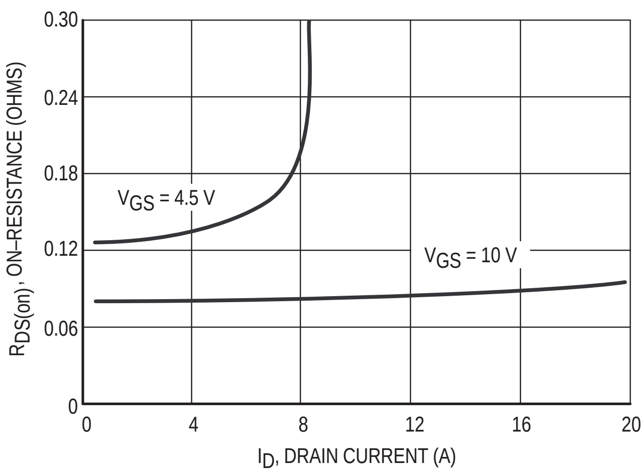


Figure 3. On–Resistance vs. Drain Current

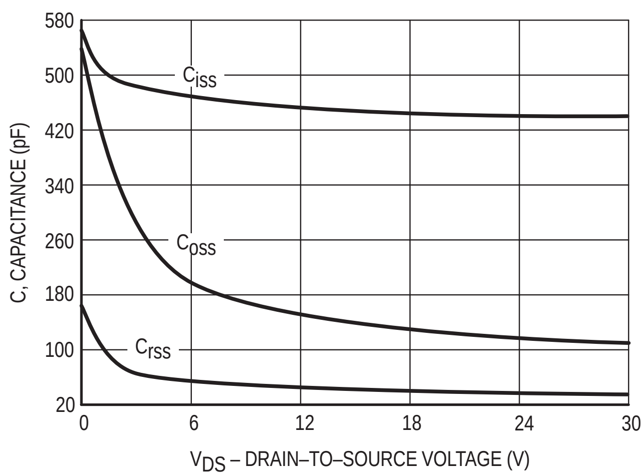


Figure 4. Capacitance

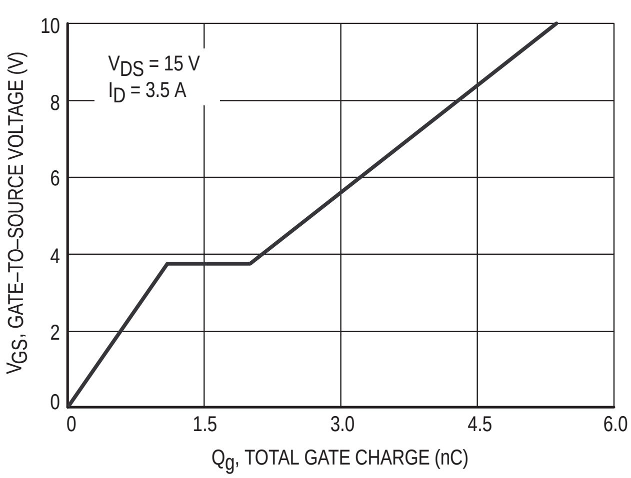


Figure 5. Gate Charge

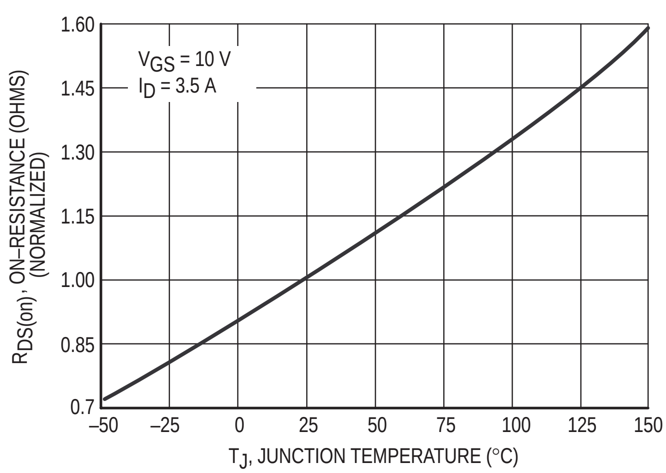


Figure 6. On–Resistance vs. Junction Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

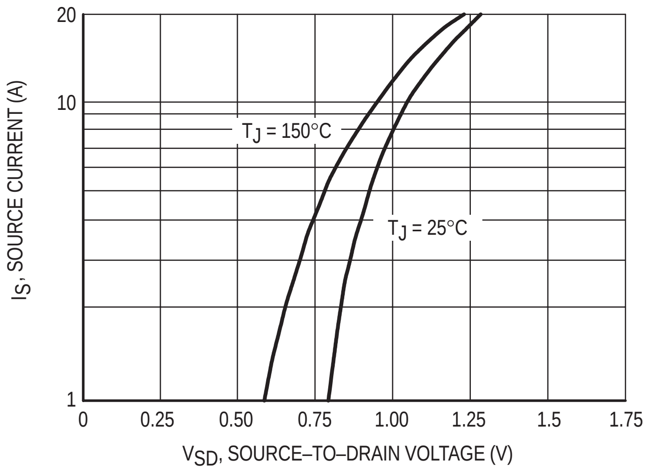


Figure 7. Source–Drain Diode Forward Voltage

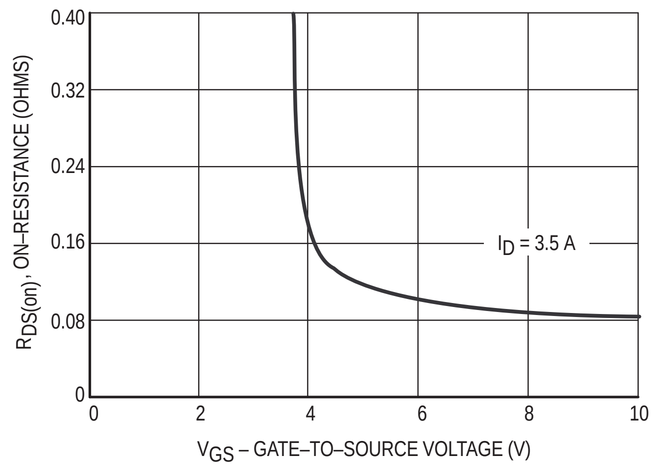


Figure 8. On–Resistance vs. Gate–to–Source Voltage

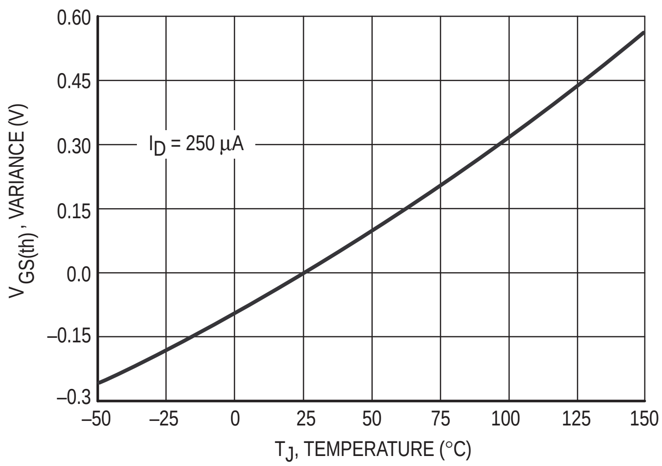


Figure 9. Threshold Voltage

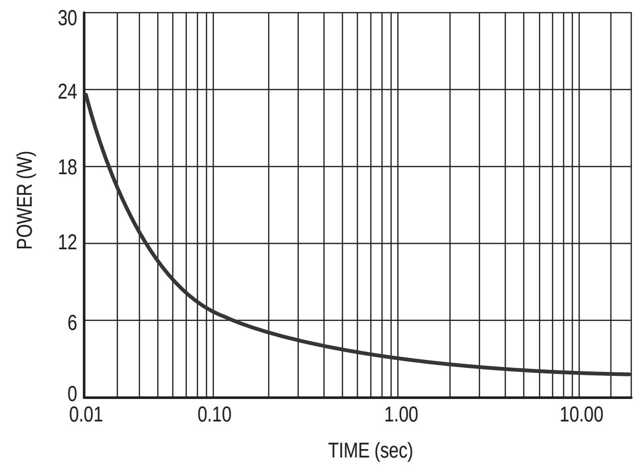


Figure 10. Single Pulse Power

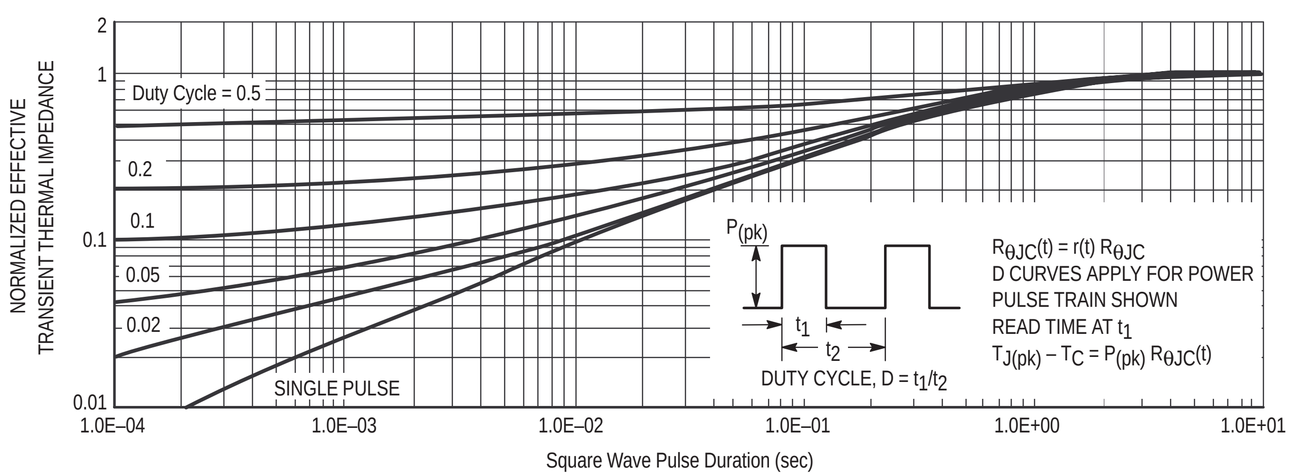


Figure 11. Normalized Thermal Transient Impedance, Junction–to–Ambient

GREEN LINE™

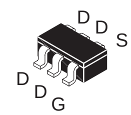
Preliminary Information

MGSF3455XT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 80 mΩ (TYP)

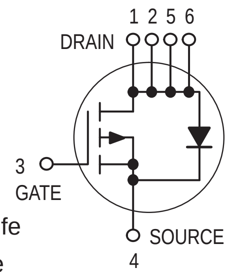


CASE 318G–02, Style 1
TSOP 6 PLASTIC

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature TSOP 6 Surface Mount Package Saves Board Space
- Visit our Web Site at http://www.mot–sps.com/ospd



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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_{DM}	1.45 10	A
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3455XT1	7″	8 mm embossed tape	3000
MGSF3455XT3	13″	8 mm embossed tape	10,000

This document contains information on a product under development. Motorola reserves the right to change or discontinue this product without notice.

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)			—	—	5.0	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS[1]						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 1.45 A)		$r_{DS(on)}$	—	0.080	0.100	Ohms
(V_{GS} = 4.5 Vdc, I_D = 1.2 A)			—	0.134	0.190	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS[2]						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	10	20	ns
Rise Time		t_r	—	15	30	
Turn–Off Delay Time		$t_{d(off)}$	—	20	35	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	3000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage[2]		V_{SD}	—	0.85	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

Switching Diode

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

This switching diode has the following features:

- Very Low Leakage (≤ 500 pA) promotes extended battery life by decreasing energy waste
- Offered in four Surface Mount package types
- Available in 8 mm Tape and Reel in quantities of 3,000

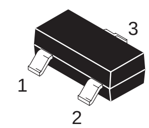
Applications

- ESD Protection
- Reverse Polarity Protection
- Steering Logic
- Medium–Speed Switching

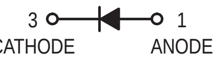
MMBD1000LT1
MMBD2000T1
MMBD3000T1
MMSD1000T1

Motorola Preferred Devices

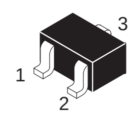
MMBD1000LT1



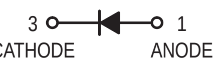
CASE 318-08, STYLE 8
SOT-23 (TO-236AB)



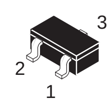
MMBD2000T1



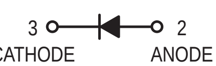
CASE 419-02, STYLE 2
SC–70/SOT–323



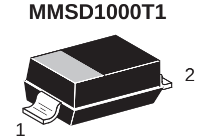
MMBD3000T1



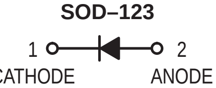
CASE 318D-04, STYLE 2
SC–59



MMSD1000T1



CASE 425-04, STYLE 1
SOD–123



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	30	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	I_{FM} (surge)	500	mA

DEVICE MARKING

MMBD1000LT1 = AY
MMBD2000T1 = DH
MMBD3000T1 = XP
MMSD1000T1 = 4K

THERMAL CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Total Device Dissipation FR-4 Board (1)		P_D		mW
T_A = 25°C	MMBD1000LT1, MMBD3000T1, MMSD1000T1		225	
	MMBD2000T1		150	
Derate above 25°C	MMBD1000LT1, MMBD3000T1, MMSD1000T1		1.8	mW/°C
	MMBD2000T1		1.2	
Thermal Resistance Junction to Ambient		$R_{\theta JA}$		°C/W
	MMBD1000LT1, MMBD3000T1, MMSD1000T1		556	
	MMBD2000T1		833	
Junction and Storage Temperature		T_J, T_{stg}	–55 to +150	°C

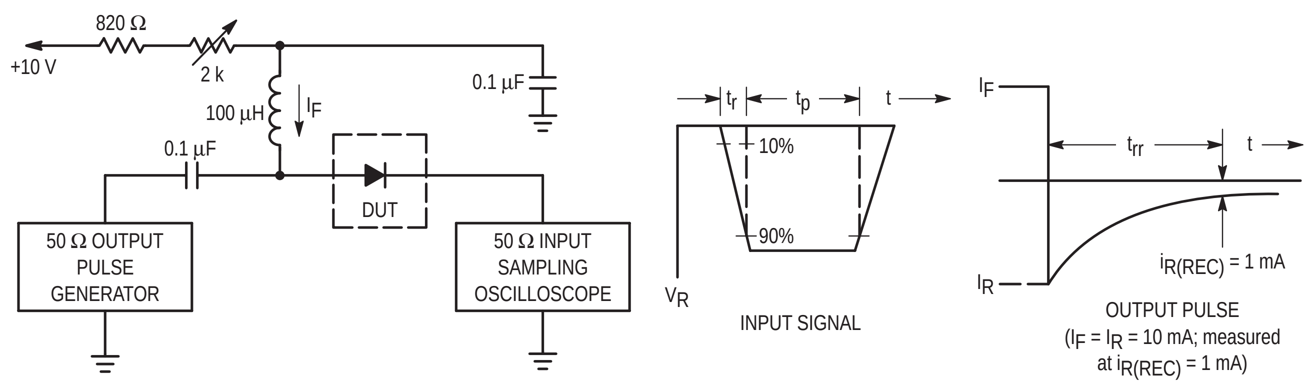
(1) Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

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

REV 1

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_{BR} = 100 μA)	$V_{(BR)}$	30	—	V
Reverse Voltage Leakage Current (V_R = 75 V)	I_R	—	500	pA
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA)	V_F	— —	850 950	mV
Diode Capacitance (V_R = 0 V, f = 1.0 MHz)	C_D	—	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mA) (Figure 1)	t_{rr}	—	3.0	μs



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 1. Recovery Time Equivalent Test Circuit

GREENLINE™

Switching Diode

MMBD1005LT1
MMBD2005T1
MMBD3005T1

Motorola Preferred Devices

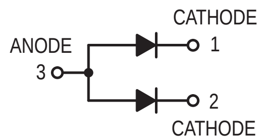
Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

This switching diode has the following features:

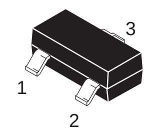
- Very Low Leakage (≤ 500 pA) promotes extended battery life by decreasing energy waste. Guaranteed leakage limit is for each diode in the pair contingent upon the other diode being in a non–forward–biased condition.
- Offered in four Surface Mount package types
- Available in 8 mm Tape and Reel in quantities of 3,000

Applications

- ESD Protection
- Reverse Polarity Protection
- Steering Logic
- Medium–Speed Switching

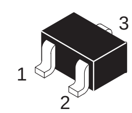


MMBD1005LT1



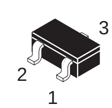
CASE 318-08, STYLE 12
SOT-23 (TO-236AB)

MMBD2005T1



CASE 419-02, STYLE 4
SC–70/SOT–323

MMBD3005T1



CASE 318D-04, STYLE 5
SC–59

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	30	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	I_{FM} (surge)	500	mA

DEVICE MARKING

MMBD1005LT1 = A3
MMBD2005T1 = DI
MMBD3005T1 = XQ

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-4 Board (1)	P_D		mW
T_A = 25°C MMBD1005LT1, MMBD3005T1		225	
MMBD2005T1		150	
Derate above 25°C MMBD1005LT1, MMBD3005T1		1.8	mW/°C
MMBD2005T1		1.2	
Thermal Resistance Junction to Ambient	$R_{\theta JA}$		°C/W
MMBD1005LT1, MMBD3005T1		556	
MMBD2005T1		833	
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

(1) Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

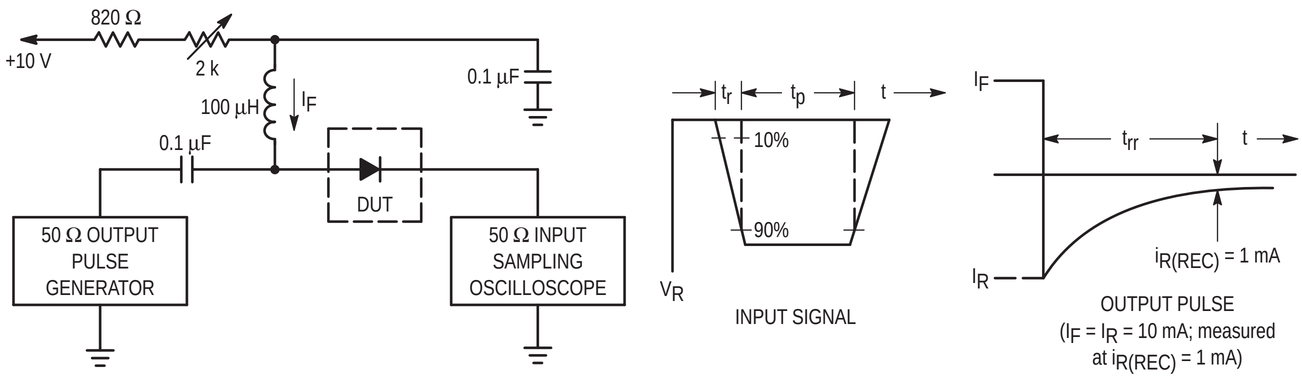
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_{BR} = 100 µA)	$V_{(BR)}$	30	—	V
Reverse Voltage Leakage Current (V_R = 75 V)(2)	I_R	—	500	pA
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA)	V_F	— —	850 950	mV
Diode Capacitance (V_R = 0 V, f = 1.0 MHz)	C_D	—	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mA) (Figure 1)	t_{rr}	—	3.0	µs

(2) Guaranteed leakage limit is for each diode in the pair contingent upon the other diode being in a non–forward–biased condition.



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 1. Recovery Time Equivalent Test Circuit

GREEN LINE™

Switching Diode

MMBD1010LT1
MMBD2010T1
MMBD3010T1

Motorola Preferred Devices

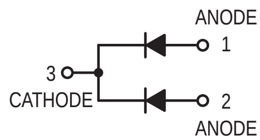
Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

This switching diode has the following features:

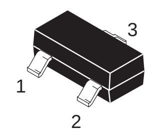
- Very Low Leakage (≤ 500 pA) promotes extended battery life by decreasing energy waste. Guaranteed leakage limit is for each diode in the pair contingent upon the other diode being in a non–forward–biased condition.
- Offered in four Surface Mount package types
- Available in 8 mm Tape and Reel in quantities of 3,000

Applications

- ESD Protection
- Reverse Polarity Protection
- Steering Logic
- Medium–Speed Switching

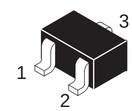


MMBD1010LT1



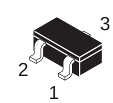
CASE 318-08, STYLE 9
SOT-23 (TO-236AB)

MMBD2010T1



CASE 419-02, STYLE 5
SC–70/SOT–323

MMBD3010T1



CASE 318D-04, STYLE 3
SC–59

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	30	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	I_{FM} (surge)	500	mA

DEVICE MARKING

MMBD1010LT1 = A5
MMBD2010T1 = DP
MMBD3010T1 = XS

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-4 Board (1)	P_D		mW
T_A = 25°C MMBD1010LT1, MMBD3010T1		225	
MMBD2010T1		150	
Derate above 25°C MMBD1010LT1, MMBD3010T1		1.8	mW/°C
MMBD2010T1		1.2	
Thermal Resistance Junction to Ambient	$R_{\theta JA}$		°C/W
MMBD1010LT1, MMBD3010T1		556	
MMBD2010T1		833	
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

(1) Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

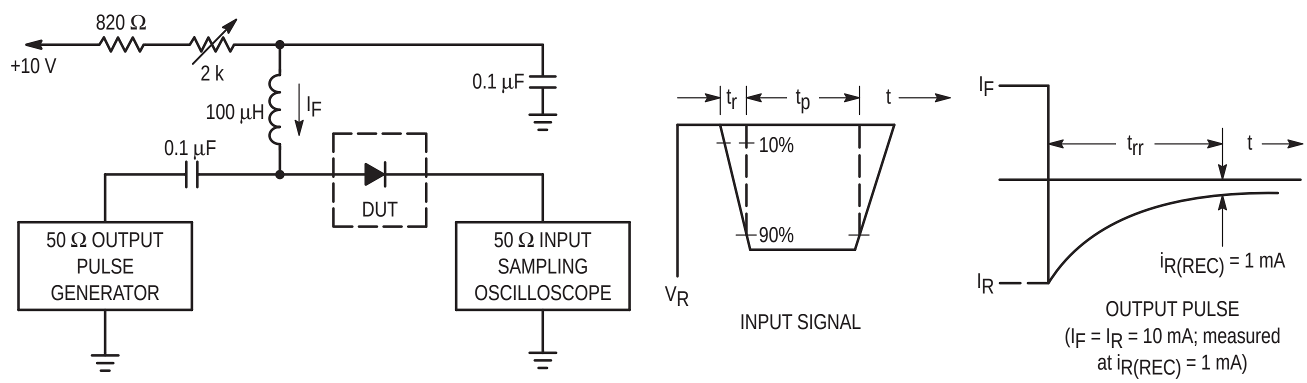
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_{BR} = 100 µA)	$V_{(BR)}$	30	—	V
Reverse Voltage Leakage Current (V_R = 75 V)(2)	I_R	—	500	pA
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA)	V_F	— —	850 950	mV
Diode Capacitance (V_R = 0 V, f = 1.0 MHz)	C_D	—	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mA) (Figure 1)	t_{rr}	—	3.0	µs

(2) Guaranteed leakage limit is for each diode in the pair contingent upon the other diode being in a non–forward–biased condition.



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 1. Recovery Time Equivalent Test Circuit

GREEN LINE™

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

MMBF0201NLT1

Motorola Preferred Device

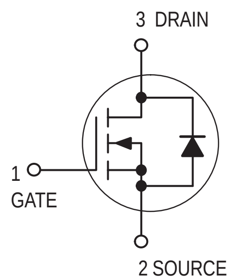
HD TMOS™

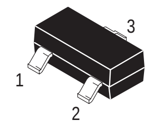
N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 1.0 OHM

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Continuous @ T_A = 70°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_D I_{DM}	300 240 750	mAdc
Total Power Dissipation @ T_A = 25°C(1)	P_D	225	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	556	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

DEVICE MARKING

N1

(1) Mounted on G10/FR4 glass epoxy board using minimum recommended footprint.

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMBF0201NLT1	7″	12 mm embossed tape	3000
MMBF0201NLT3	13″	12 mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current		I_{DSS}				μAdc
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc)			—	—	1.0	
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance		$r_{DS(on)}$				Ohms
(V_{GS} = 10 Vdc, I_D = 300 mAdc)			—	0.75	1.0	
(V_{GS} = 4.5 Vdc, I_D = 100 mAdc)			—	1.0	1.4	
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 200 mAdc)		g_{FS}	—	450	—	mMhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	45	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	25	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	5.0	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 300 mAdc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	2.5	—	
Turn–Off Delay Time		$t_{d(off)}$	—	15	—	
Fall Time		t_f	—	0.8	—	
Gate Charge (See Figure 5)		Q_T	—	1400	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.3	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	0.85	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

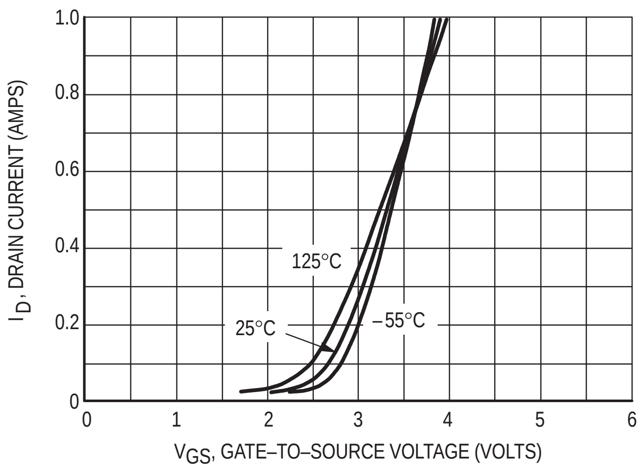


Figure 1. Transfer Characteristics

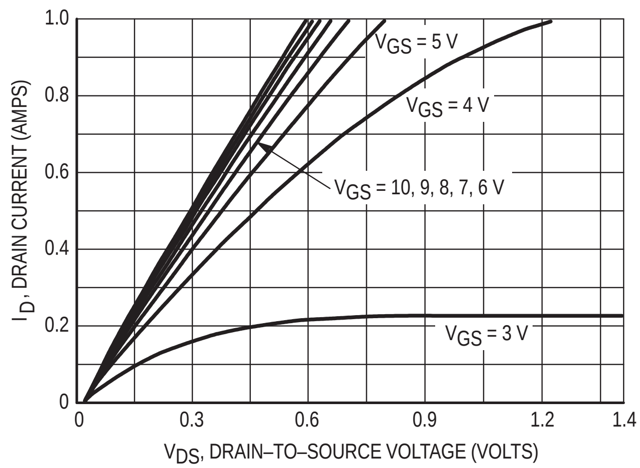


Figure 2. On–Region Characteristics

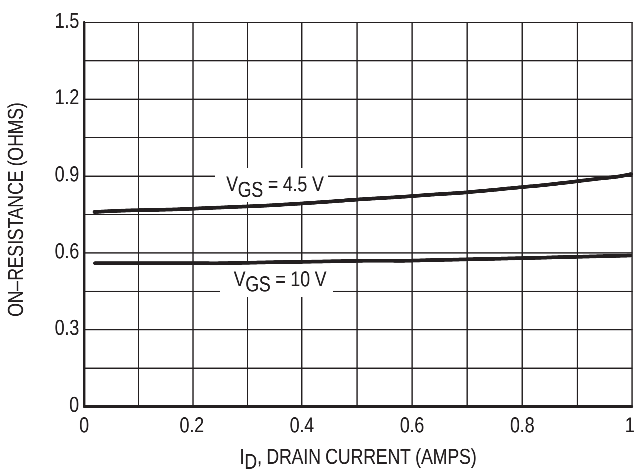


Figure 3. On–Resistance versus Drain Current

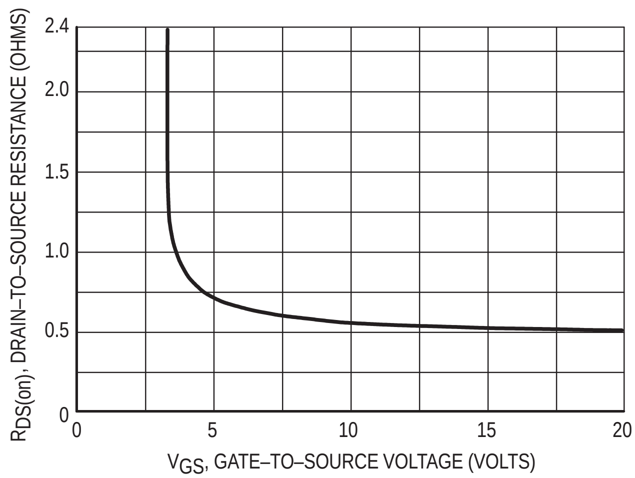


Figure 4. On–Resistance versus Gate–to–Source Voltage

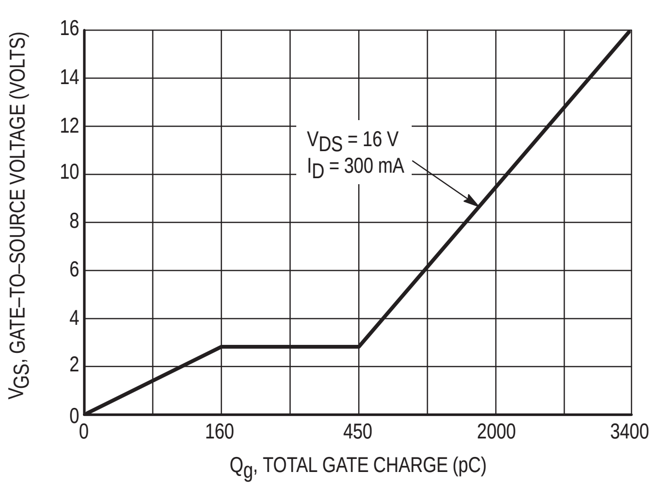


Figure 5. Gate Charge

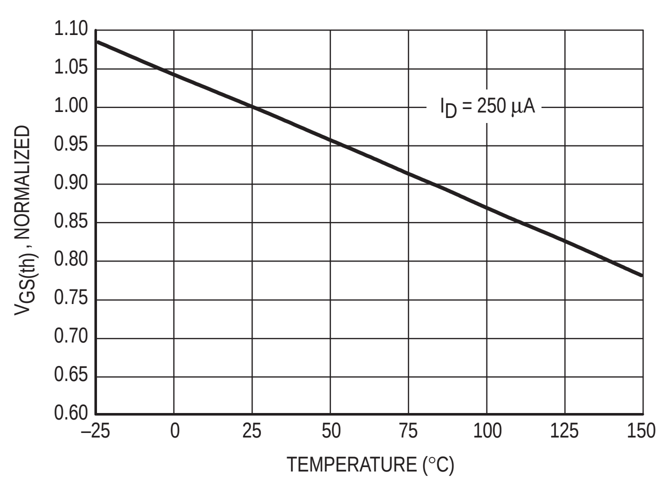


Figure 6. Threshold Voltage Variance Over Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

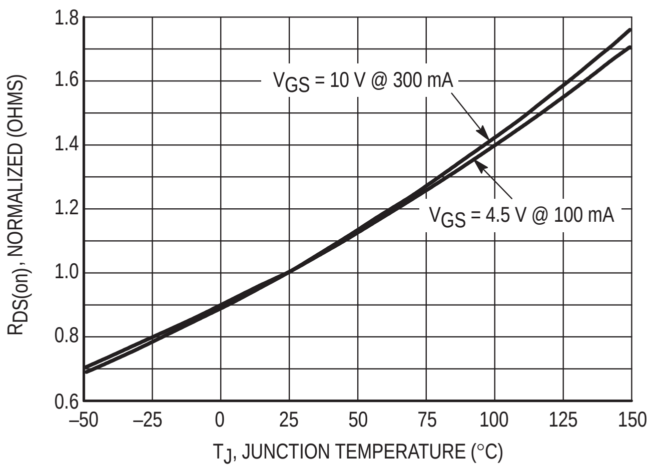


Figure 7. On–Resistance versus Junction Temperature

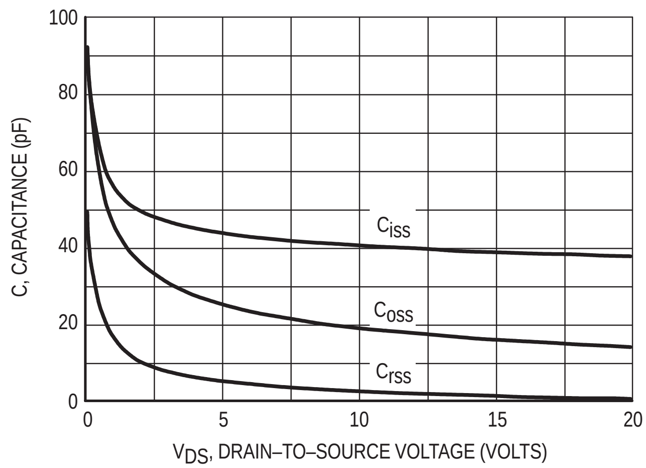


Figure 8. Capacitance

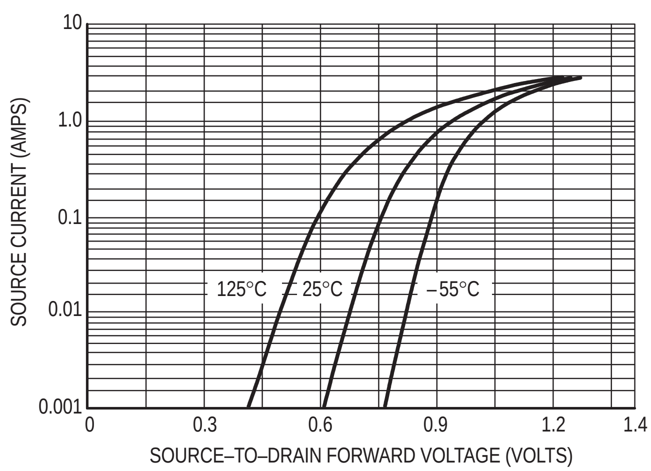


Figure 9. Source–to–Drain Forward Voltage versus Continuous Current (I_S)

GREEN LINE™

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

MMBF0202PLT1

Motorola Preferred Device

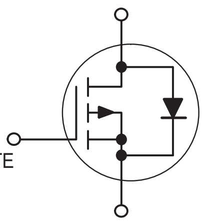
Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

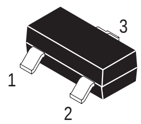
These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space

HD TMOS™

P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 1.4 OHM





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Continuous @ T_A = 70°C — Pulsed Drain Current (t_p ≤ 10 µs)	I_D I_D I_{DM}	300 240 750	mAdc
Total Power Dissipation @ T_A = 25°C(1)	P_D	225	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	625	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

DEVICE MARKING

P3

(1) Mounted on G10/FR4 glass epoxy board using minimum recommended footprint.

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMBF0202PLT1	7″	12 mm embossed tape	3000
MMBF0202PLT3	13″	12 mm embossed tape	10,000

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

(Replaces MMBF0202P/D)

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 16 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 200 mAdc)		$r_{DS(on)}$	—	0.9	1.4	Ohms
(V_{GS} = 4.5 Vdc, I_D = 50 mAdc)			—	2.0	3.5	
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 200 mAdc)		g_{FS}	—	600	—	mMhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	50	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	45	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	20	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = –15 Vdc, R_L = 75 Ω, I_D = 200 mAdc, V_{GEN} = –10 V, R_G = 6.0 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 5)	(V_{DS} = 16 V, V_{GS} = 10 V, I_D = 200 mA)	Q_T	—	2700	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.3	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	1.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

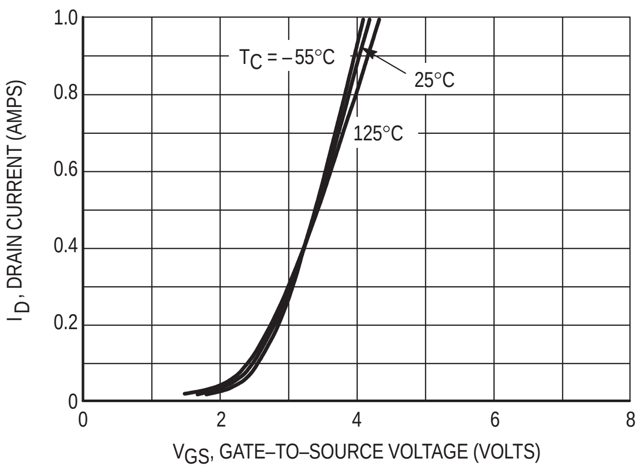


Figure 1. Transfer Characteristics

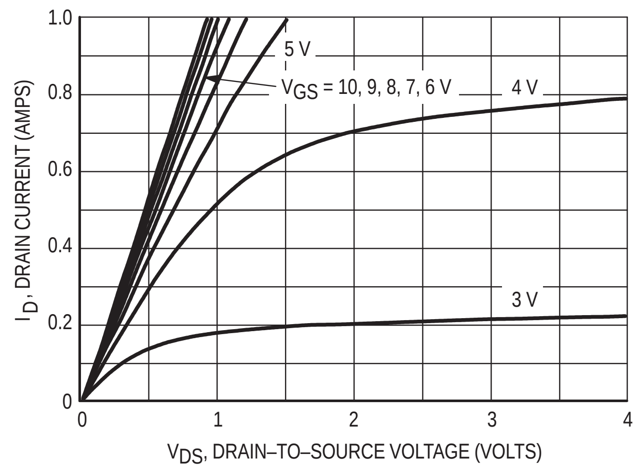


Figure 2. On–Region Characteristics

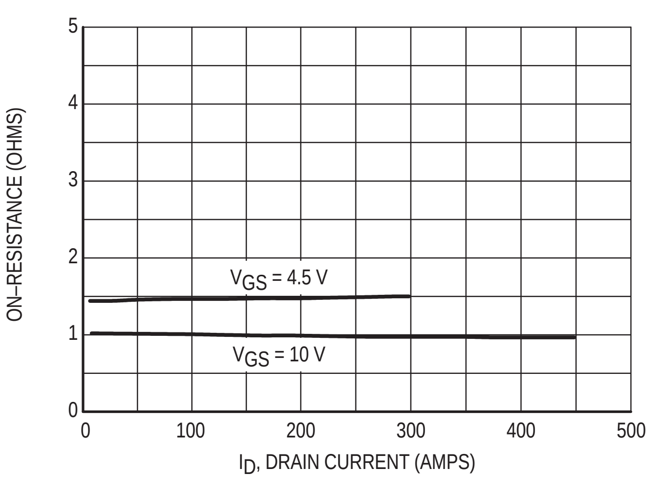


Figure 3. On–Resistance versus Drain Current

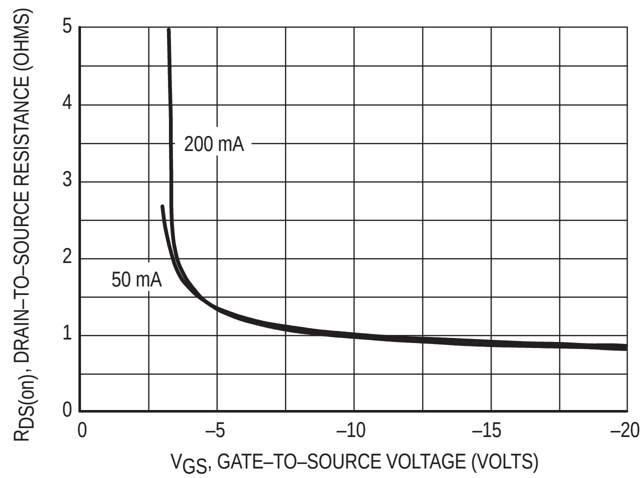


Figure 4. On–Resistance versus Gate–to–Source Voltage

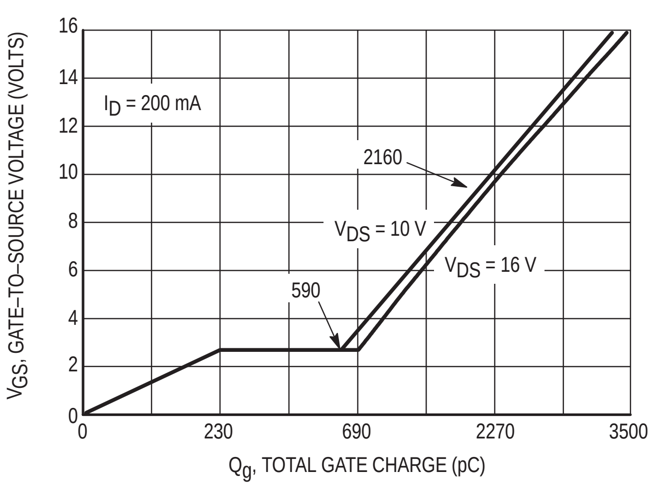


Figure 5. Gate Charge

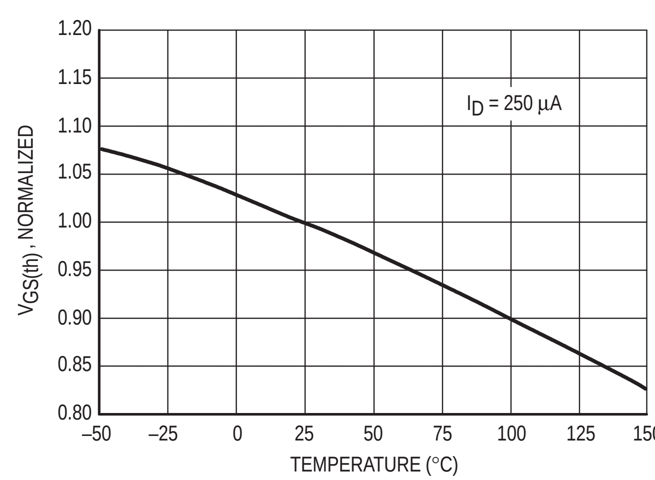


Figure 6. Threshold Voltage Variance Over Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

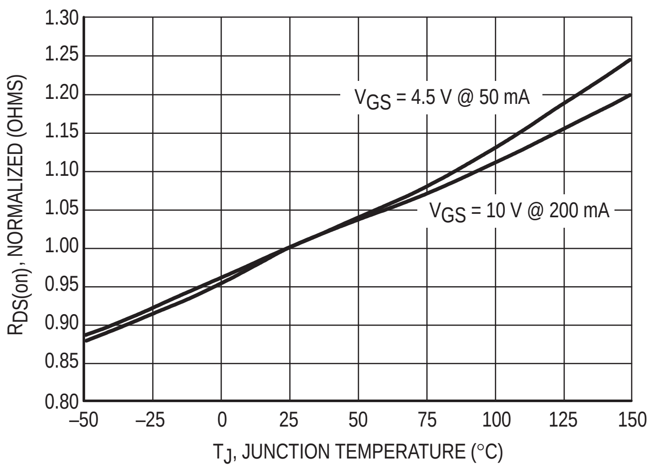


Figure 7. On–Resistance versus Junction Temperature

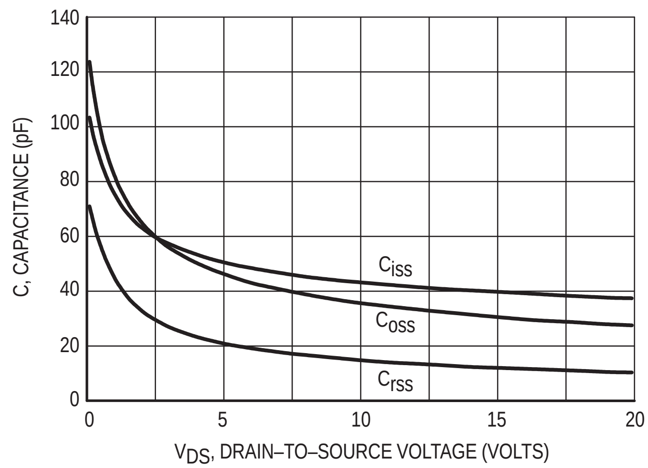


Figure 8. Capacitance

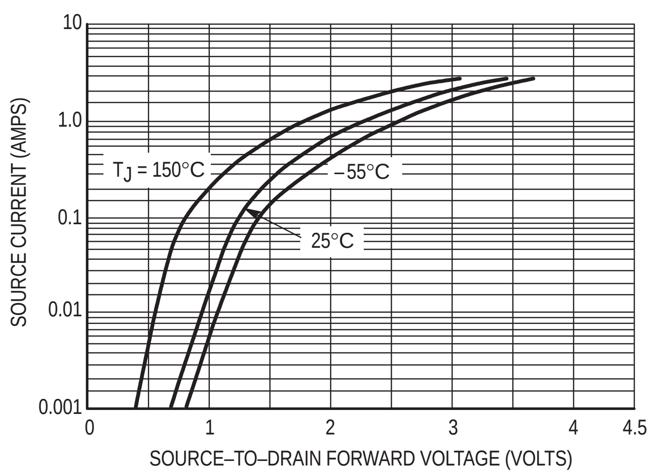


Figure 9. Source–to–Drain Forward Voltage versus Continuous Current (I_S)

GREEN LINE™

MMBF2201NT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

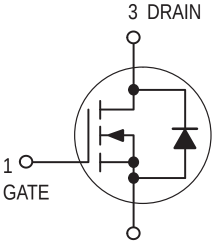
TMOS™

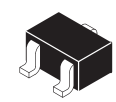
N – CHANNEL ENHANCEMENT – MODE TMOS MOSFET $r_{DS(on)}$ = 1.0 OHM

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SC–70 / SOT– 323 Surface Mount Package Saves Board Space





CASE 419–02, Style 7
SC–70/SOT–323

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Continuous @ T_A = 70°C — Pulsed Drain Current (t_p ≤ 10 µs)	I_D I_D I_{DM}	300 240 750	mAdc
Total Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	150 1.2	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	833	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

DEVICE MARKING

N1

(1) Mounted on G10/FR4 glass epoxy board using minimum recommended footprint.

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMBF2201NT1	7″	8 mm embossed tape	3000
MMBF2201NT3	13″	8 mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 16 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)		I_{DSS}	— —	— —	1.0 10	μAdc
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 300 mAdc) (V_{GS} = 4.5 Vdc, I_D = 100 mAdc)		$r_{DS(on)}$	— —	0.75 1.0	1.0 1.4	Ohms
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 200 mAdc)		g_{FS}	—	450	—	mMhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	45	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	25	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	5.0	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 300 mAdc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	2.5	—	
Turn–Off Delay Time		$t_{d(off)}$	—	15	—	
Fall Time		t_f	—	0.8	—	
Gate Charge (See Figure 5)		Q_T	—	1400	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.3	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	0.85	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL CHARACTERISTICS

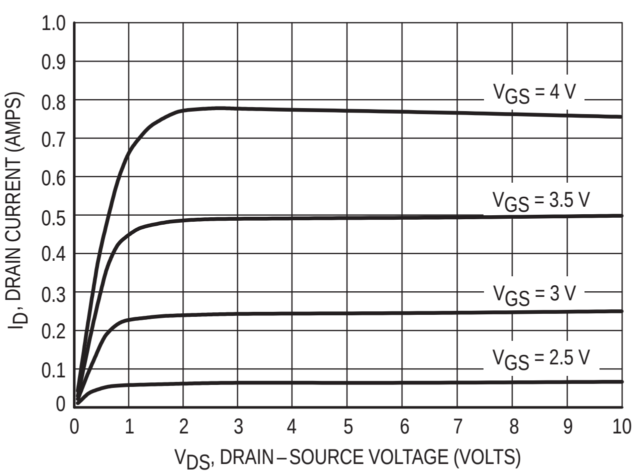


Figure 1. Typical Drain Characteristics

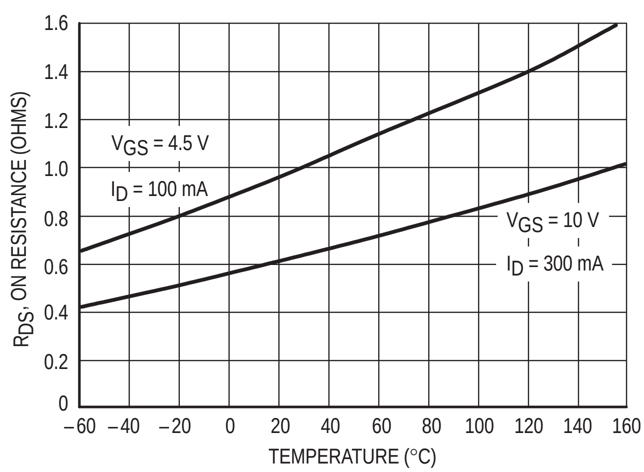


Figure 2. On Resistance versus Temperature

TYPICAL CHARACTERISTICS

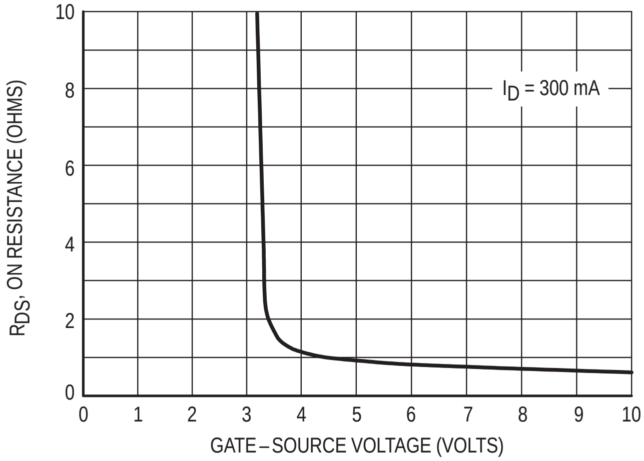


Figure 3. On Resistance versus Gate – Source Voltage

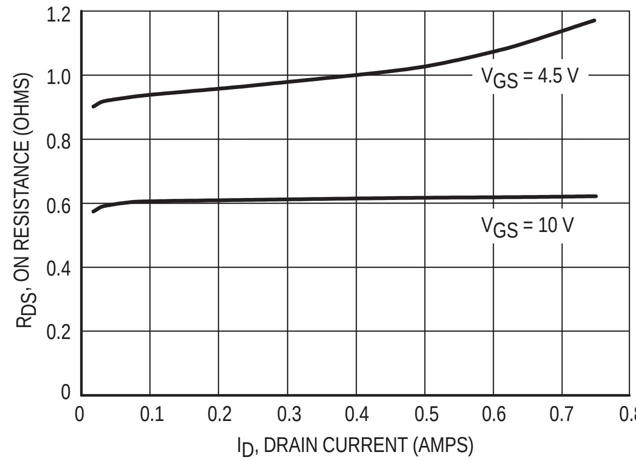


Figure 4. On Resistance versus Drain Current

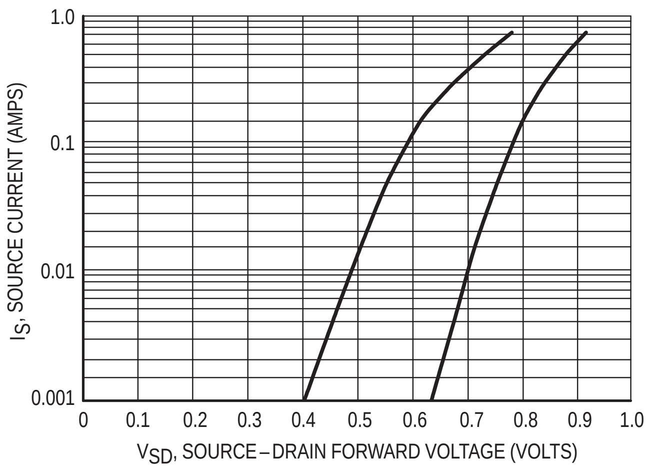


Figure 5. Source – Drain Forward Voltage

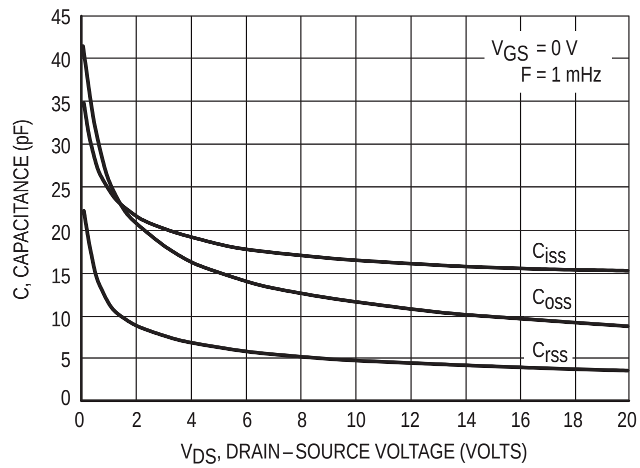


Figure 6. Capacitance Variation

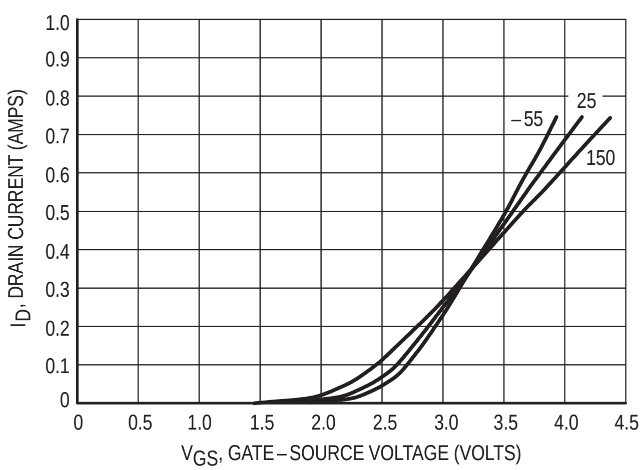


Figure 7. Transfer Characteristics

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

MMBF2202PT1

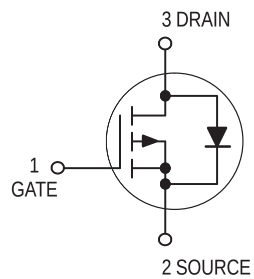
Motorola Preferred Device

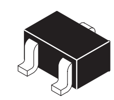
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 2.2 OHM

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola’s High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SC–70/SOT–323 Surface Mount Package Saves Board Space





CASE 419–02, STYLE 7
SC–70/SOT–323

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Continuous @ T_A = 70°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_D I_{DM}	300 240 750	mAdc
Total Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	150 1.2	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	833	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

DEVICE MARKING

P3

(1) Mounted on G10/FR4 glass epoxy board using minimum recommended footprint.

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMBF2202PT1	7″	8 mm embossed tape	3000
MMBF2202PT3	13″	8 mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current		I_{DSS}				μAdc
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc)			—	—	1.0	
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance		$r_{DS(on)}$				Ohms
(V_{GS} = 10 Vdc, I_D = 200 mAdc)			—	1.5	2.2	
(V_{GS} = 4.5 Vdc, I_D = 50 mAdc)			—	2.0	3.5	
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 200 mAdc)		g_{FS}	—	600	—	mMhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	50	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	45	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	20	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = –15 Vdc, R_L = 75 Ω, I_D = 200 mAdc, V_{GEN} = –10 V, R_G = 6.0 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 5)	(V_{DS} = 16 V, V_{GS} = 10 V, I_D = 200 mA)	Q_T	—	2700	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.3	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	1.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL CHARACTERISTICS

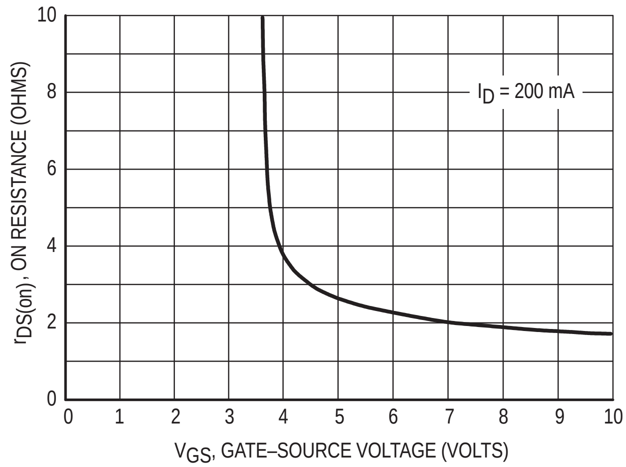


Figure 1. On Resistance versus Gate–Source Voltage

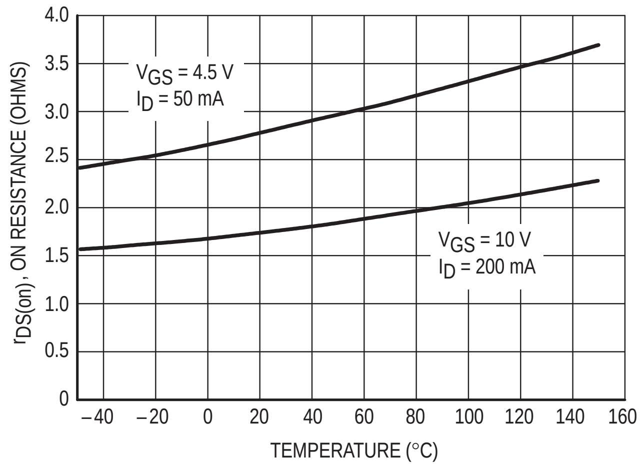


Figure 2. On Resistance versus Temperature

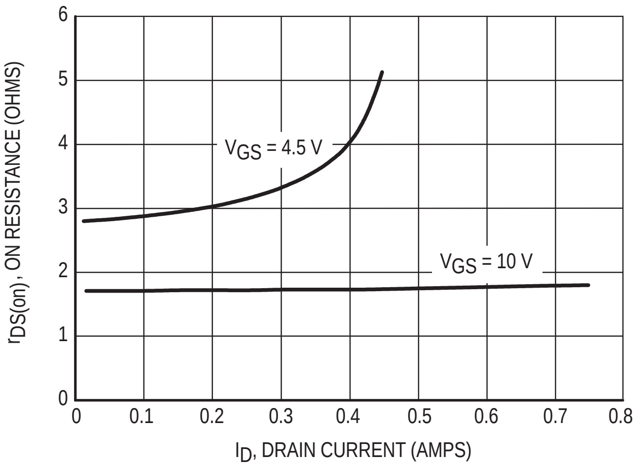


Figure 3. On Resistance versus Drain Current

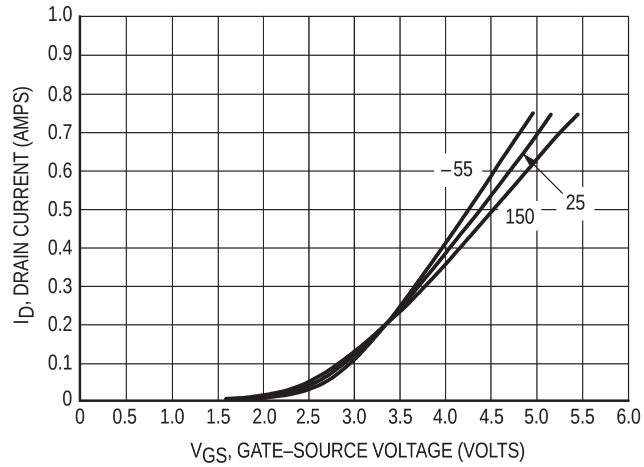


Figure 4. Transfer Characteristics

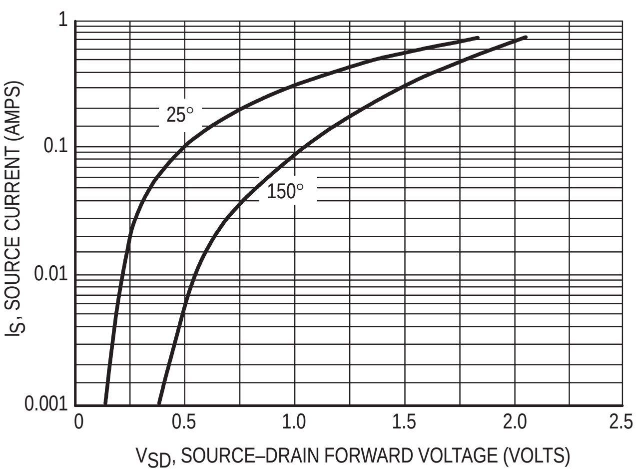


Figure 5. Source–Drain Forward Voltage

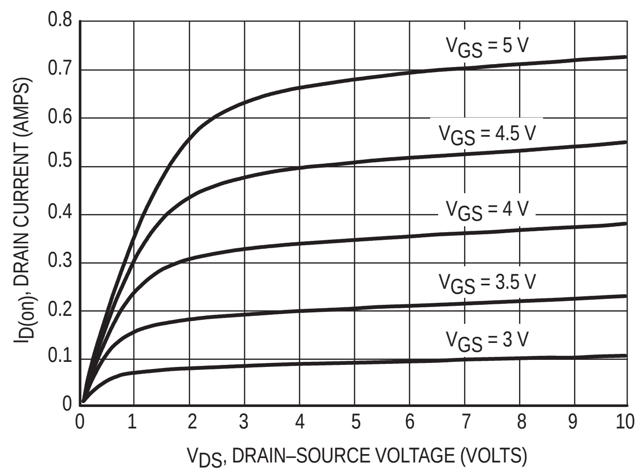


Figure 6. On Region Characteristics

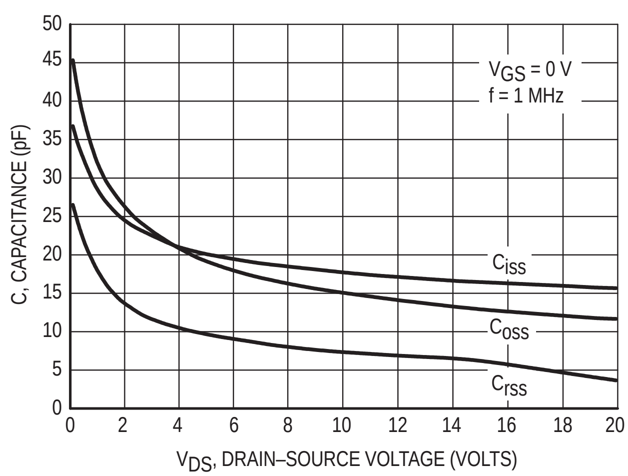


Figure 7. Capacitance Variation

GREEN LINE™

MMBT1010LT1
MSD1010T1

Motorola Preferred Devices

Low Saturation Voltage PNP Silicon Driver Transistors

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

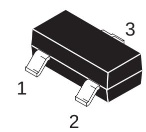
This PNP Silicon Epitaxial Planar Transistor is designed to conserve energy in general purpose driver applications. This device is housed in the SOT-23 and SC–59 packages which are designed for low power surface mount applications.

- Low $V_{CE(sat)}$, < 0.1 V at 50 mA

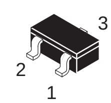
Applications

- LCD Backlight Driver
- Annunciator Driver
- General Output Device Driver

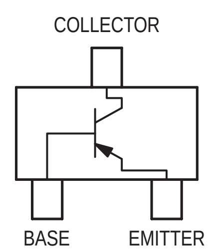
PNP GENERAL PURPOSE DRIVER TRANSISTORS SURFACE MOUNT



CASE 318–08, STYLE 6
SOT-23



CASE 318D–04, STYLE 1
SC-59



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	45	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	15	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

DEVICE MARKING

MMBT1010LT1 = GLP
MSD1010T1 = GLP

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation T_A = 25°C Derate above 25°C	P_D(1)	250 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ +150	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 10 mA, I_B = 0	15	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 µA, I_E = 0	5.0	—	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}(2)	V_{CE} = 5 V, I_C = 100 mA	300	600	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$(2)	I_C = 10 mA, I_B = 1.0 mA I_C = 50 mA, I_B = 5.0 mA I_C = 100 mA, I_B = 10 mA	— —	0.1 0.1 0.19	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$(2)	I_C = 100 mA, I_B = 10 mA	—	1.1	Vdc

(1) Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.
(2) Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

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

REV 2

Section 4

Small–Signal Field–Effect Transistors and MOSFETs

In Brief . . .

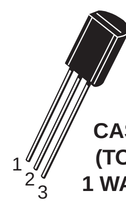
The data sheets on the following pages are designed to emphasize those FETs that by virtue of widespread industry use, ease of manufacture, and low relative cost, merit first consideration for new equipment design.

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.

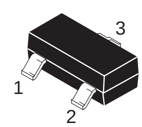
Motorola believes it is important to extend any emphasizing note of cautiousness when handling and testing *ANY* FET product. Precautions include, but are not limited to, the implementation of static safe workstations and proper handling techniques. Additionally, it is very important to keep FET devices 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.

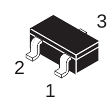


CASE 29-05
(TO-226AE)
1 WATT TO-92

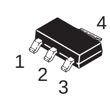
CASE 29-04
(TO-226AA)
TO-92



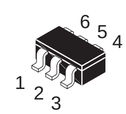
CASE 318-08
(TO-236AB)
SOT-23



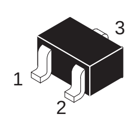
CASE 318D-04
SC–59



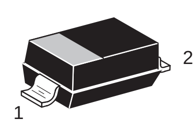
CASE 318E-04
(TO-261AA)
SOT-223



CASE 318G-02
TSOP–6



CASE 419-02
SC–70/SOT–323



CASE 425-04
SOD–123

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 6 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 6 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.

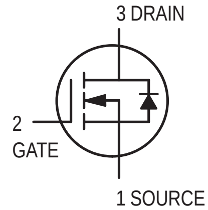
ABCD

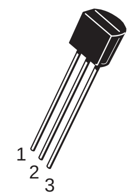
The “D” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

TMOS FET Transistor
N–Channel — Enhancement

2N7000

Motorola Preferred Device





CASE 29–04, STYLE 22
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain Source Voltage	V_{DSS}	60	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	60	Vdc
Gate–Source Voltage — Continuous — Non–repetitive ($t_p \le 50$ µs)	 V_{GS} V_{GSM}	 ±20 ±40	 Vdc Vpk
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	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°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 µAdc)	$V_{(BR)DSS}$	60	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 48 Vdc, V_{GS} = 0) (V_{DS} = 48 Vdc, V_{GS} = 0, T_J = 125°C)	I_{DSS}	 — —	 1.0 1.0	 µAdc mAdc
Gate–Body Leakage Current, Forward (V_{GSF} = 15 Vdc, V_{DS} = 0)	I_{GSSF}	—	–10	nAdc
ON CHARACTERISTICS(1)				
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)	$V_{GS(th)}$	0.8	3.0	Vdc
Static Drain–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 0.5 Adc) (V_{GS} = 4.5 Vdc, I_D = 75 mAdc)	$r_{DS(on)}$	 — —	 5.0 6.0	Ohm
Drain–Source On–Voltage (V_{GS} = 10 Vdc, I_D = 0.5 Adc) (V_{GS} = 4.5 Vdc, I_D = 75 mAdc)	$V_{DS(on)}$	 — —	 2.5 0.45	Vdc

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

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

REV 3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted) (Continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS(1) (continued)				
On–State Drain Current (V_{GS} = 4.5 Vdc, V_{DS} = 10 Vdc)	$I_{d(on)}$	75	—	mAdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 200 mAdc)	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(1)				
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%.

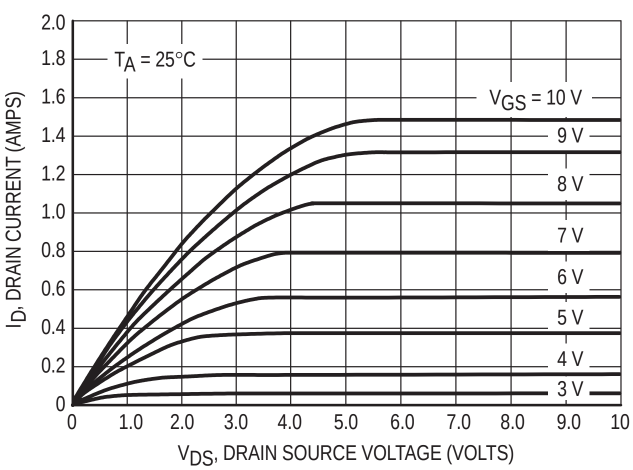


Figure 1. Ohmic Region

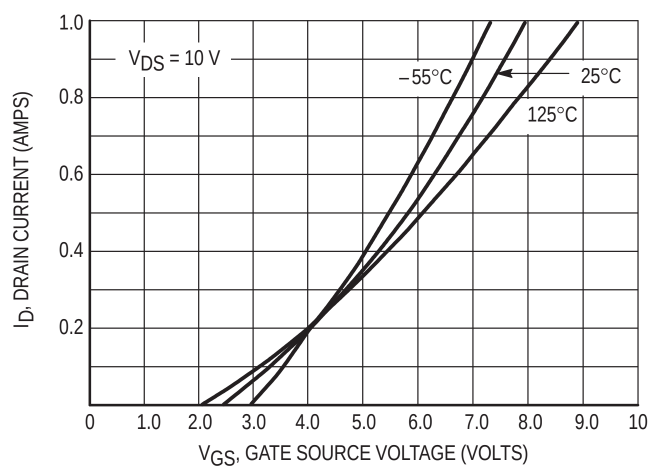


Figure 2. Transfer Characteristics

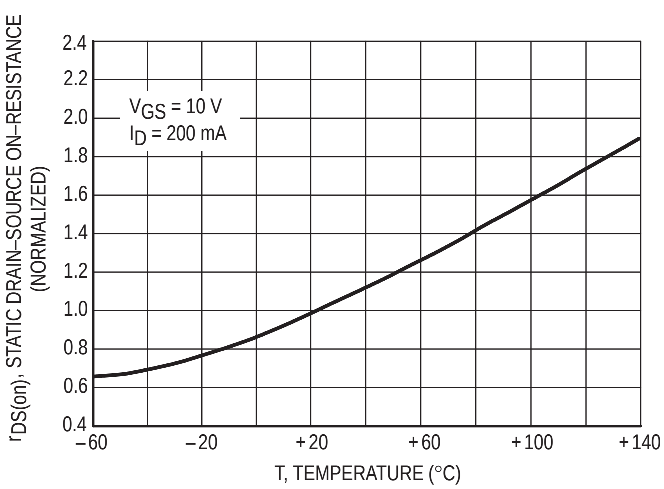


Figure 3. Temperature versus Static Drain–Source On–Resistance

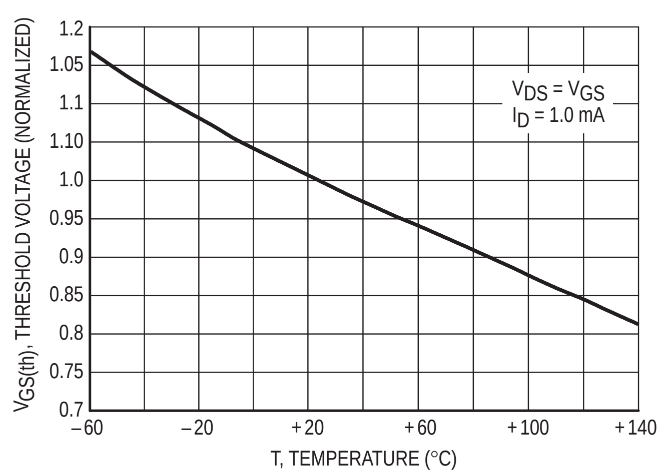
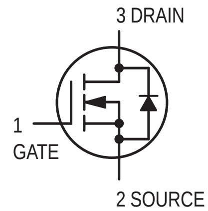


Figure 4. Temperature versus Gate Threshold Voltage

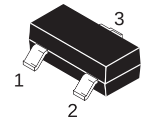
TMOS FET Transistor

N–Channel Enhancement



2N7002LT1

Motorola Preferred Device



CASE 318 – 08, STYLE 21
SOT– 23 (TO – 236AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	60	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 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	mAdc
Gate–Source Voltage — Continuous — Non–repetitive (t_p ≤ 50 µs)	 V_{GS} V_{GSM}	 ±20 ±40	 Vdc Vpk

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board,[(3)] 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,[(4)] 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

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 µAdc)	$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current T_J = 25°C (V_{GS} = 0, V_{DS} = 60 Vdc) 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 Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
3. FR–5 = 1.0 x 0.75 x 0.062 in.
4. Alumina = 0.4 x 0.3 x 0.025 in 99.5% alumina.

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

REV 2

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 µAdc)	$V_{GS(th)}$	1.0	—	2.5	Vdc
On–State Drain Current (V_{DS} ≥ 2.0 $V_{DS(on)}$, V_{GS} = 10 Vdc)	$I_{D(on)}$	500	—	—	mA
Static Drain–Source On–State Voltage	$V_{DS(on)}$				Vdc
(V_{GS} = 10 Vdc, I_D = 500 mAdc)		—	—	3.75	
(V_{GS} = 5.0 Vdc, I_D = 50 mAdc)		—	—	0.375	
Static Drain–Source On–State Resistance	$r_{DS(on)}$				Ohms
(V_{GS} = 10 V, I_D = 500 mAdc) T_C = 25°C		—	—	7.5	
T_C = 125°C		—	—	13.5	
(V_{GS} = 5.0 Vdc, I_D = 50 mAdc) T_C = 25°C		—	—	7.5	
T_C = 125°C		—	—	13.5	
Forward Transconductance (V_{DS} ≥ 2.0 $V_{DS(on)}$, I_D = 200 mAdc)	g_{FS}	80	—	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	—	50	pF
Output Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	—	25	pF
Reverse Transfer Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	—	5.0	pF
SWITCHING CHARACTERISTICS(2)					
Turn–On Delay Time (V_{DD} = 25 Vdc, I_D ≅ 500 mAdc, R_G = 25 Ω, R_L = 50 Ω)	$t_{d(on)}$	—	—	30	ns
Turn–Off Delay Time (V_{DD} = 25 Vdc, I_D ≅ 500 mAdc, R_G = 25 Ω, R_L = 50 Ω)	$t_{d(off)}$	—	—	40	ns
BODY–DRAIN DIODE RATINGS					
Diode Forward On–Voltage (I_S = 11.5 mAdc, V_{GS} = 0 V)	V_{SD}	—	—	–1.5	Vdc
Source Current Continuous (Body Diode)	I_S	—	—	–115	mAdc
Source Current Pulsed	I_{SM}	—	—	–800	mAdc

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

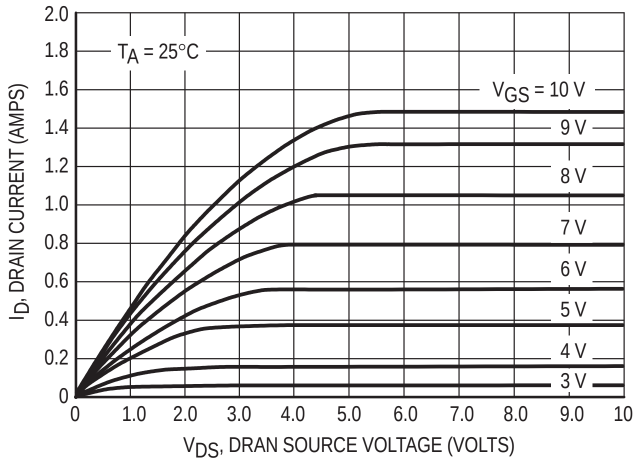


Figure 1. Ohmic Region

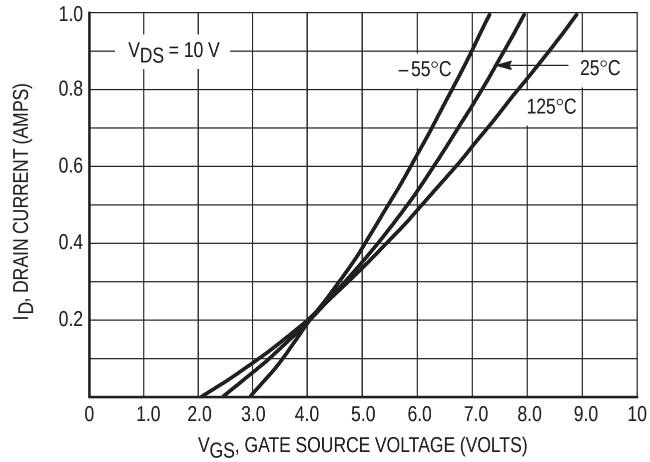


Figure 2. Transfer Characteristics

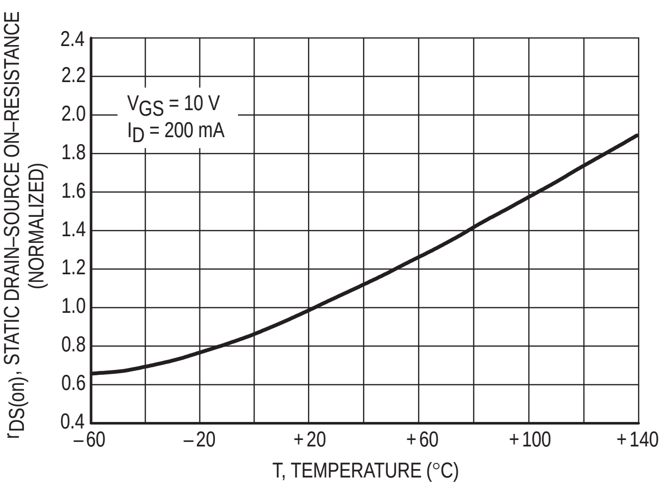


Figure 3. Temperature versus Static Drain–Source On–Resistance

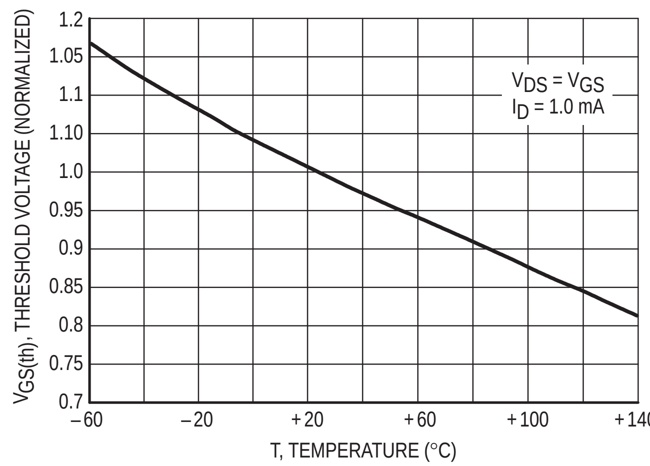
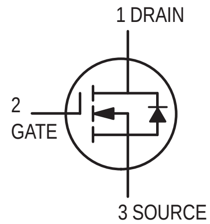


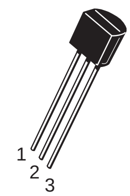
Figure 4. Temperature versus Gate Threshold Voltage

TMOS Switching

N–Channel — Enhancement



BS107
BS107A



CASE 29–04, STYLE 30
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DS}	200	Vdc
Gate–Source Voltage — Continuous — Non–repetitive ($t_p \leq 50\ \mu s$)	 V_{GS} V_{GSM}	 ±20 ±30	 Vdc Vpk
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

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 Vdc, V_{GS} = 0)	I_{DSS}	—	—	30	nAdc
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 µAdc)	$V_{(BR)DSX}$	200	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
ON CHARACTERISTICS(2)					
Gate Threshold Voltage (I_D = 1.0 mAdc, V_{DS} = V_{GS})	$V_{GS(Th)}$	1.0	—	3.0	Vdc
Static Drain–Source On Resistance BS107 (V_{GS} = 2.6 Vdc, I_D = 20 mAdc) (V_{GS} = 10 Vdc, I_D = 200 mAdc) BS107A (V_{GS} = 10 Vdc) (I_D = 100 mAdc) (I_D = 250 mAdc)	$r_{DS(on)}$	 — — — —	 — — 4.5 4.8	 28 14 6.0 6.4	Ohms
SMALL–SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	6.0	—	pF
Output Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	30	—	pF
Forward Transconductance (V_{DS} = 25 Vdc, I_D = 250 mAdc)	g_{fs}	200	400	—	mmhos
SWITCHING CHARACTERISTICS					
Turn–On Time	t_{on}	—	6.0	15	ns
Turn–Off Time	t_{off}	—	12	15	ns

1. The Power Dissipation of the package may result in a lower continuous drain current.
2. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

REV 1

RESISTIVE SWITCHING

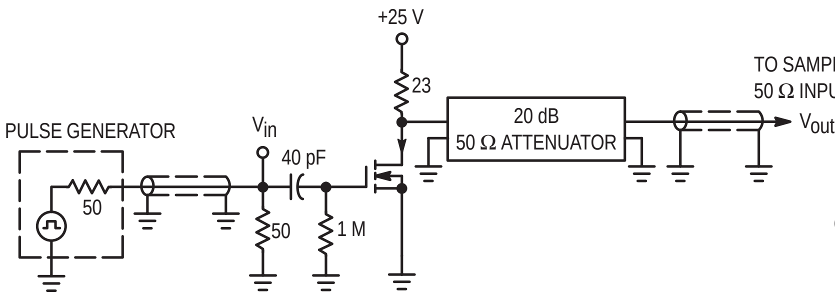


Figure 1. Switching Test Circuit

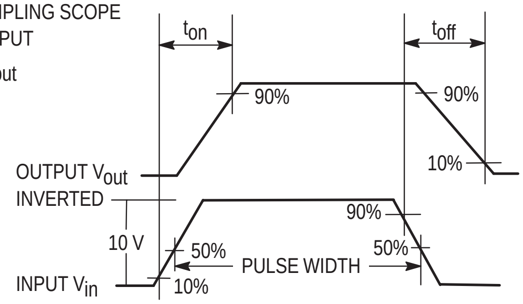


Figure 2. Switching Waveforms

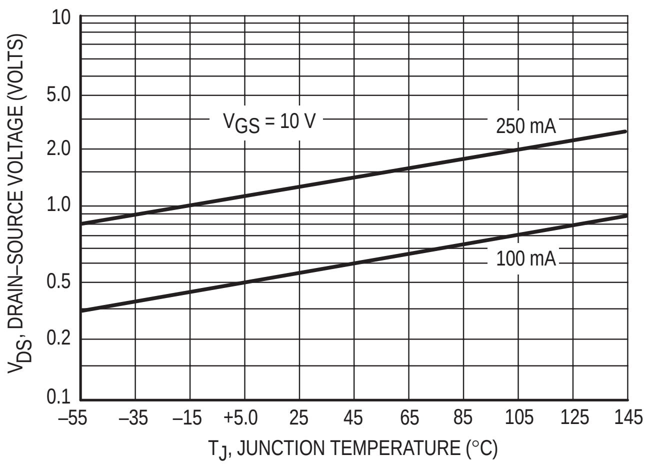


Figure 3. On Voltage versus Temperature

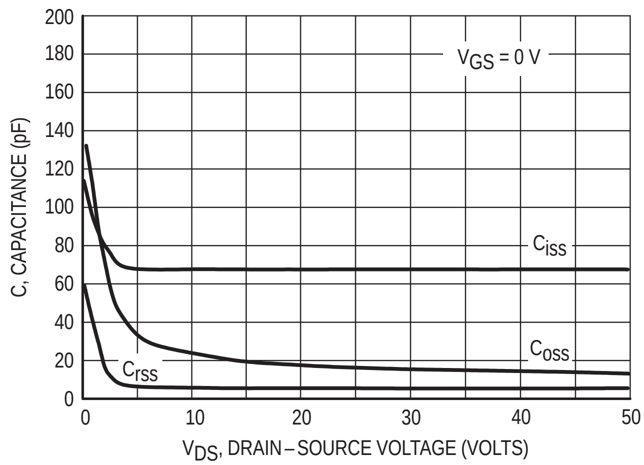


Figure 4. Capacitance Variation

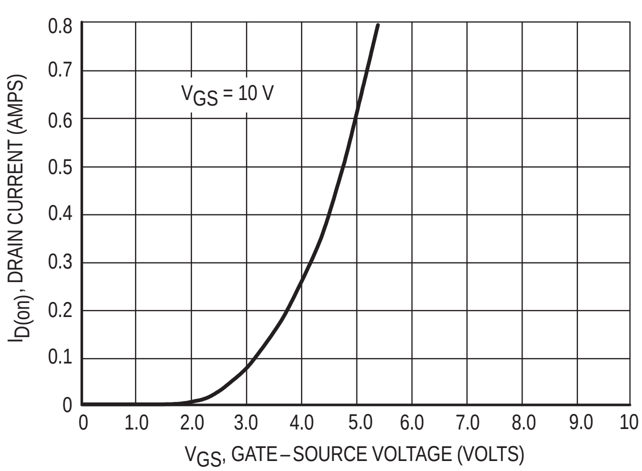


Figure 5. Transfer Characteristic

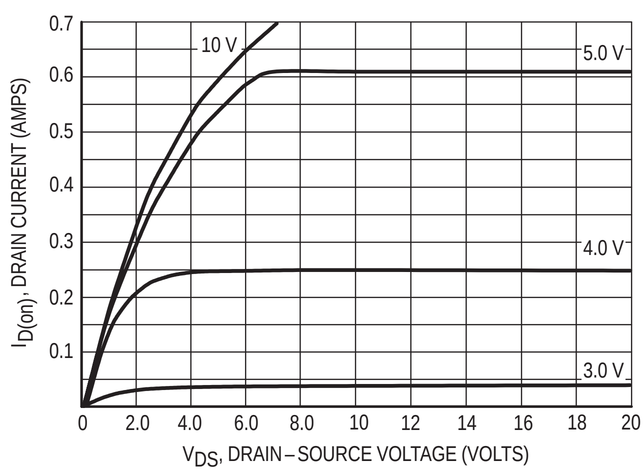


Figure 6. Output Characteristic

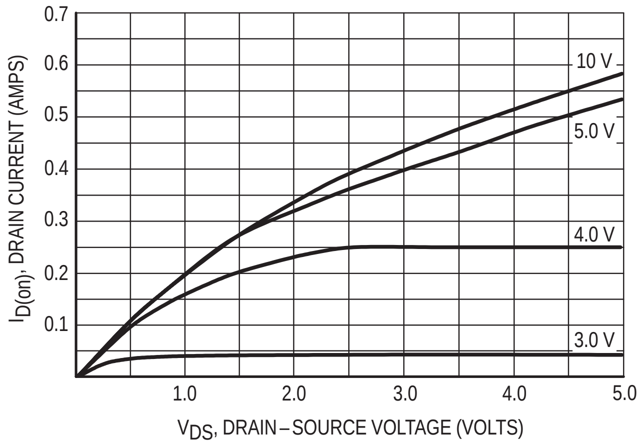
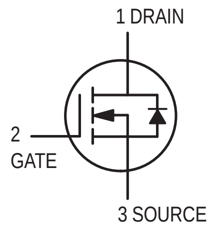


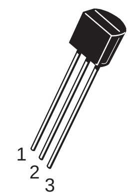
Figure 7. Saturation Characteristic

TMOS FET Switching

N–Channel — Enhancement

BS170





CASE 29–04, STYLE 30
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DS}	60	Vdc
Gate–Source Voltage — Continuous — Non–repetitive ($t_p \leq 50$ µs)	 V_{GS} V_{GSM}	 ±20 ±40	 Vdc Vpk
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

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 µAdc)	$V_{(BR)DSS}$	60	90	—	Vdc
ON CHARACTERISTICS(2)					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)	$V_{GS(Th)}$	0.8	2.0	3.0	Vdc
Static Drain–Source On Resistance (V_{GS} = 10 Vdc, I_D = 200 mAdc)	$r_{DS(on)}$	—	1.8	5.0	Ω
Drain Cutoff Current (V_{DS} = 25 Vdc, V_{GS} = 0 Vdc)	$I_{D(off)}$	—	—	0.5	µA
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 250 mAdc)	g_{fs}	—	200	—	mmhos
SMALL–SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	—	60	pF
SWITCHING CHARACTERISTICS					
Turn–On Time (I_D = 0.2 Adc) See Figure 1	t_{on}	—	4.0	10	ns
Turn–Off Time (I_D = 0.2 Adc) See Figure 1	t_{off}	—	4.0	10	ns

1. The Power Dissipation of the package may result in a lower continuous drain current.
2. Pulse Test: Pulse Width $\leq$ 300 µs, Duty Cycle $\leq$ 2.0%.

REV 1

RESISTIVE SWITCHING

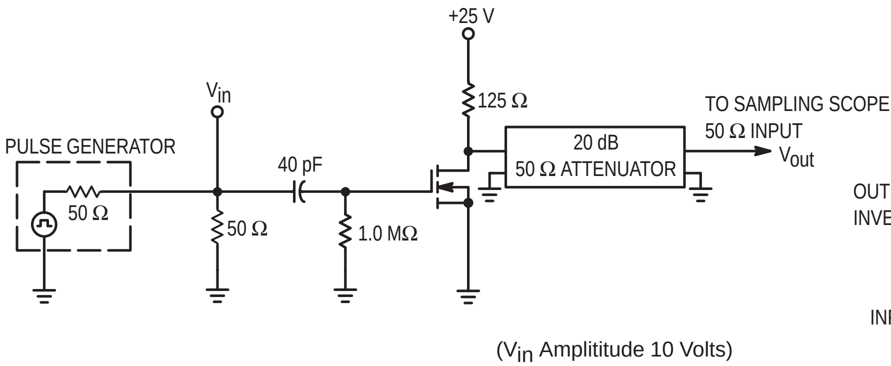


Figure 1. Switching Test Circuit

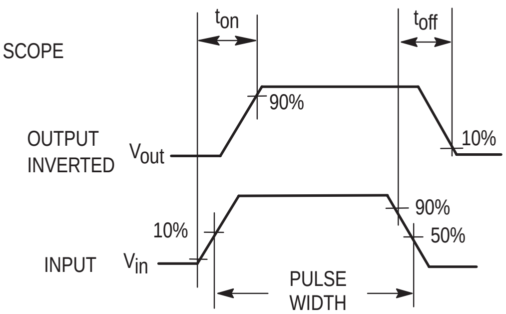


Figure 2. Switching Waveforms

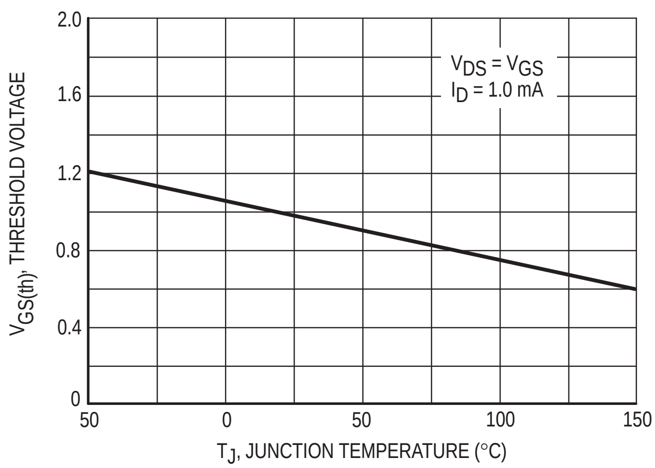


Figure 3. $V_{GS(th)}$ Normalized versus Temperature

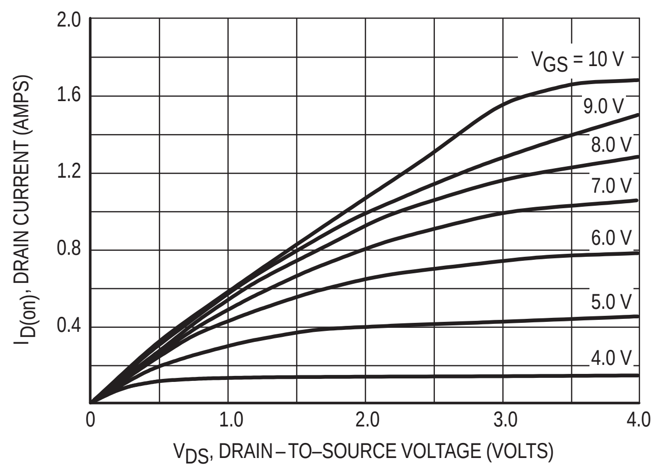


Figure 4. On–Region Characteristics

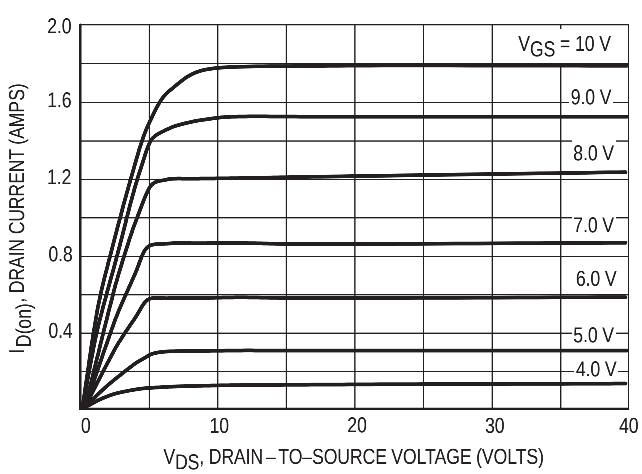


Figure 5. Output Characteristics

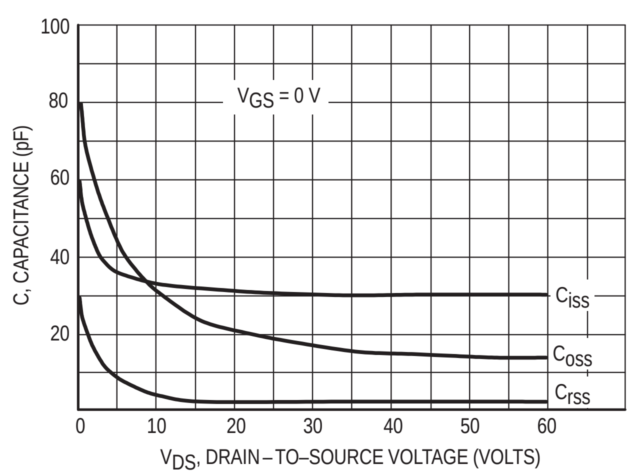


Figure 6. Capacitance versus Drain–To–Source Voltage

BSS84LT1

Motorola Preferred Device

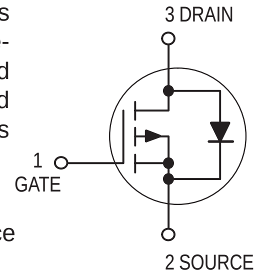
Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

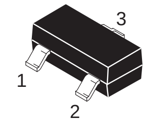
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET

Part of the Greenline™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Reduced power loss conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, load switching, power management in portable and battery–powered products such as computers, printers, cellular and cordless telephones.

- Energy Efficient
- Miniature SOT–23 Surface Mount Package Saves Board Space





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	50	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_{DM}	130 520	mA
Total Power Dissipation @ T_A = 25°C	P_D	225	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	556	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

DEVICE MARKING

BSS84LT1 = PD

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
BSS84LT1	7″	8mm embossed tape	3000
BSS84LT3	13″	8mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 250 μAdc)		$V_{(BR)DSS}$	50	—	—	Vdc
Zero Gate Voltage Drain Current		I_{DSS}				μAdc
(V_{DS} = 25 Vdc, V_{GS} = 0 Vdc)			—	—	0.1	
(V_{DS} = 50 Vdc, V_{GS} = 0 Vdc)			—	—	15	
(V_{DS} = 50 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	60	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)		I_{GSS}	—	—	±60	μAdc
ON CHARACTERISTICS(1)						
Gate–Source Threaded 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} = 5.0 Vdc, I_D = 100 mAdc)		$r_{DS(on)}$	—	5.0	10	Ohms
Transfer Admittance (V_{DS} = 25 Vdc, I_D = 100 mAdc, f = 1.0 kHz)		$\|y_{fs}\|$	50	—	—	mS
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 Vdc)	C_{iss}	—	30	—	pF
Output Capacitance	(V_{DS} = 5.0 Vdc)	C_{oss}	—	10	—	
Transfer Capacitance	(V_{DG} = 5.0 Vdc)	C_{rss}	—	5.0	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = –15 Vdc, I_D = –2.5 Adc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge		Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.130	A
Pulsed Current		I_{SM}	—	—	0.520	
Forward Voltage(2)		V_{SD}	—	2.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

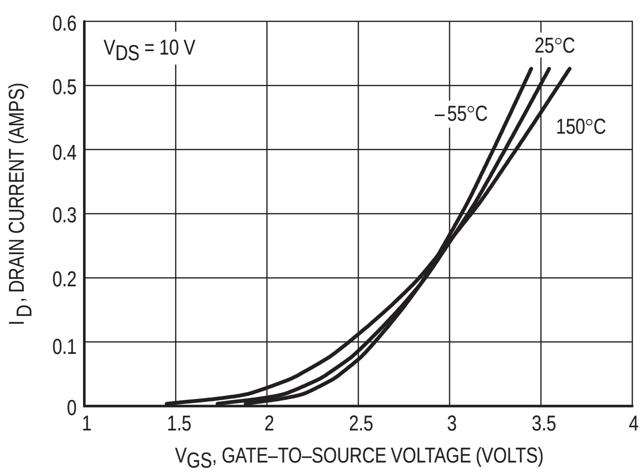


Figure 1. Transfer Characteristics

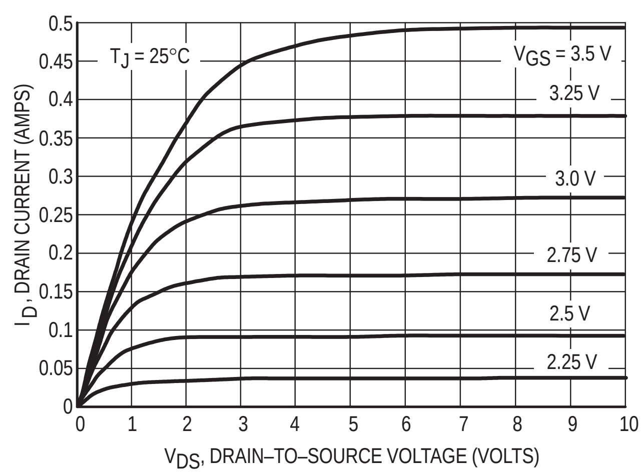


Figure 2. On–Region Characteristics

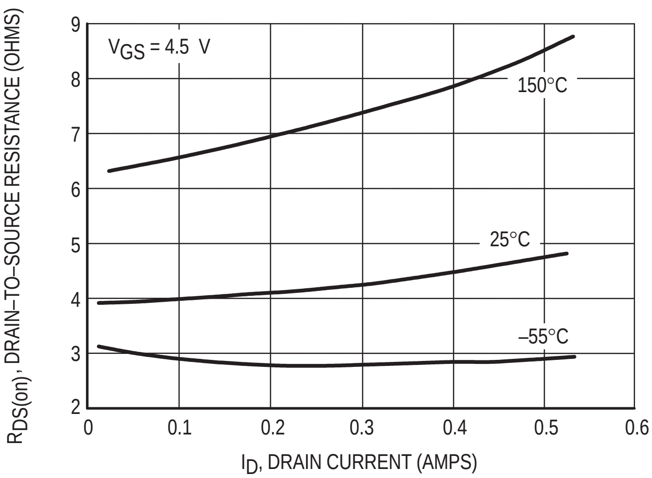


Figure 3. On–Resistance versus Drain Current

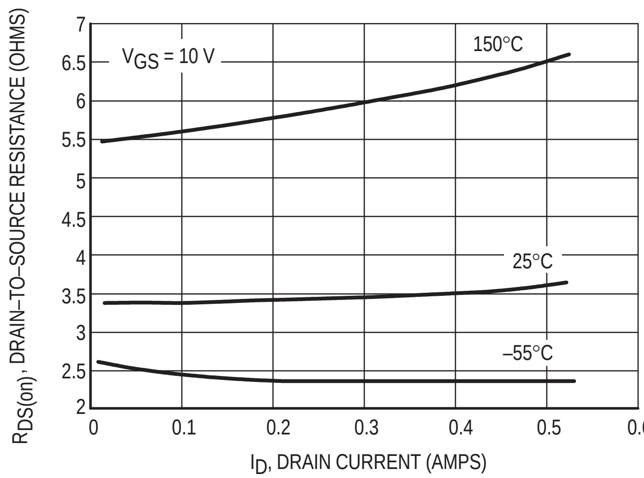


Figure 4. On–Resistance versus Drain Current

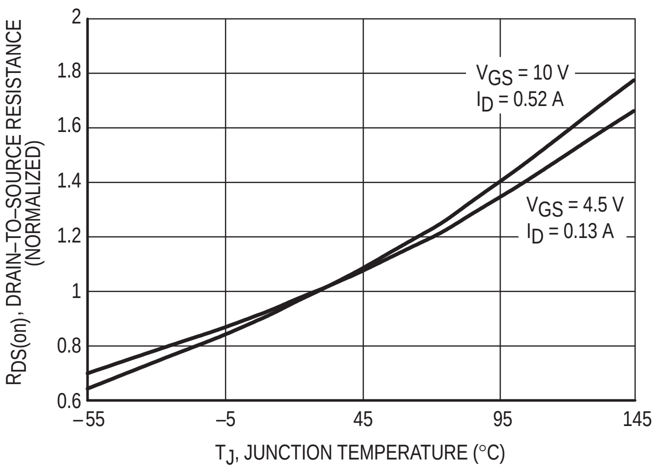


Figure 5. On–Resistance Variation with Temperature

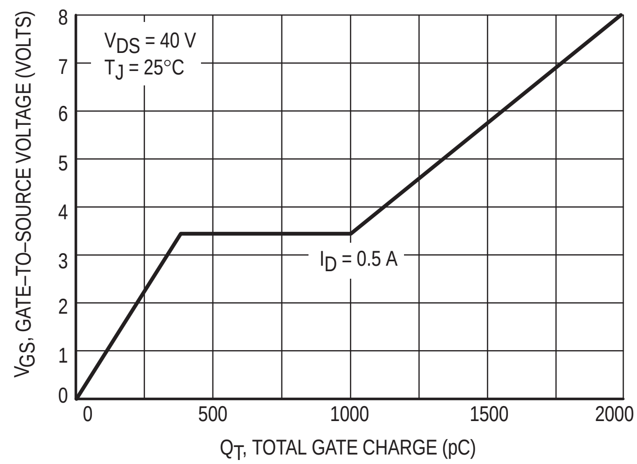


Figure 6. Gate Charge

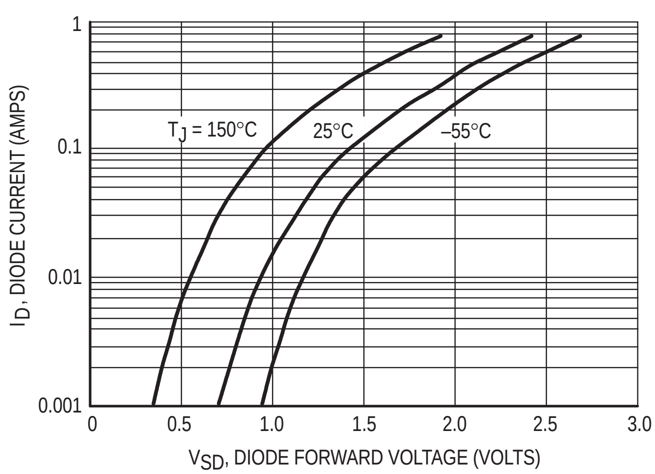
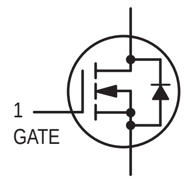


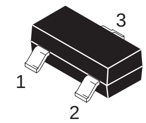
Figure 7. Body Diode Forward Voltage

TMOS FET Transistor
N–Channel

BSS123LT1

Motorola Preferred Device





CASE 318–08, STYLE 21
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	100	Vdc
Gate–Source Voltage — Continuous — Non–repetitive ($t_p \leq 50$ µs)	 V_{GS} V_{GSM}	 ±20 ±40	 Vdc Vpk
Drain Current Continuous(1) Pulsed(2)	 I_D I_{DM}	 0.17 0.68	Adc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(3) 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

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 µAdc)	$V_{(BR)DSS}$	100	—	—	Vdc
Zero Gate Voltage Drain Current (V_{GS} = 0, V_{DS} = 100 Vdc) T_J = 25°C T_J = 125°C	I_{DSS}	 — —	 — —	 15 60	µAdc
Gate–Body Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS(4)					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)	$V_{GS(th)}$	0.8	—	2.8	Vdc
Static Drain–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 100 mAdc)	$r_{DS(on)}$	—	5.0	6.0	Ω
Forward Transconductance (V_{DS} = 25 Vdc, I_D = 100 mAdc)	g_{fs}	80	—	—	mmhos

1. The Power Dissipation of the package may result in a lower continuous drain current.
2. Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
3. FR–5 = 1.0 × 0.75 × 0.062 in.
4. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

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

REV 2

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

Characteristic		Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	20	—	pF
Output Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	9.0	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	4.0	—	pF
SWITCHING CHARACTERISTICS(4)						
Turn–On Delay Time	(V_{CC} = 30 Vdc, I_C = 0.28 Adc, V_{GS} = 10 Vdc, R_{GS} = 50 Ω)	$t_{d(on)}$	—	20	—	ns
Turn–Off Delay Time		$t_{d(off)}$	—	40	—	ns
REVERSE DIODE						
Diode Forward On–Voltage (I_D = 0.34 Adc, V_{GS} = 0 Vdc)		V_{SD}	—	—	1.3	V

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

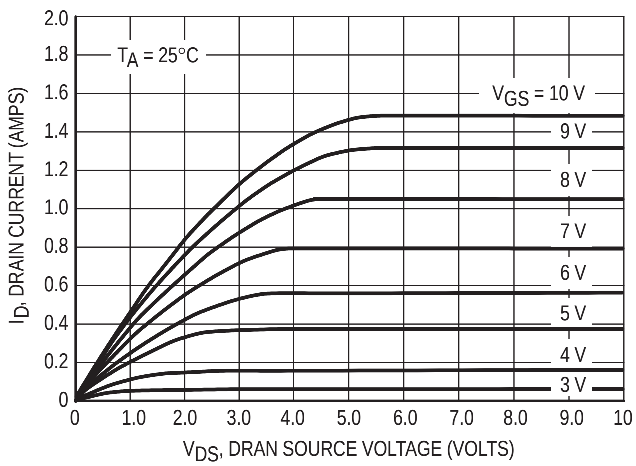


Figure 1. Ohmic Region

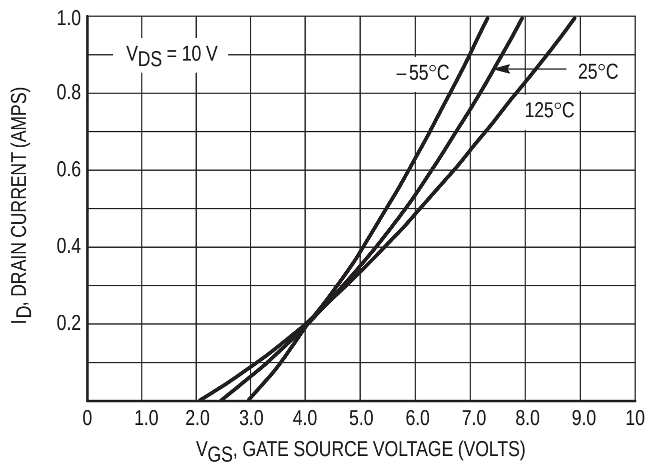


Figure 2. Transfer Characteristics

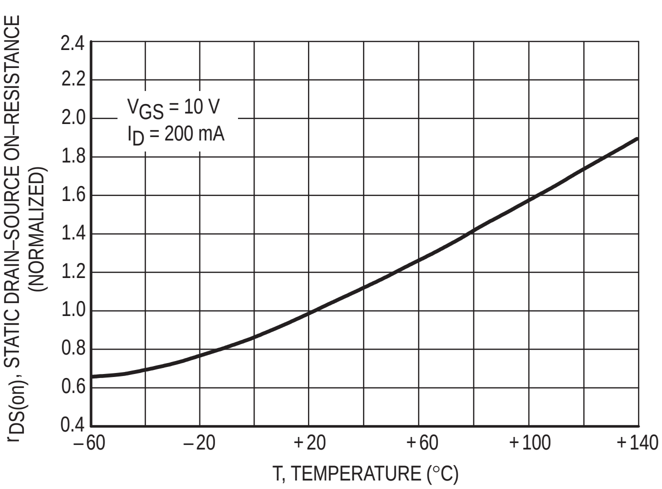


Figure 3. Temperature versus Static Drain–Source On–Resistance

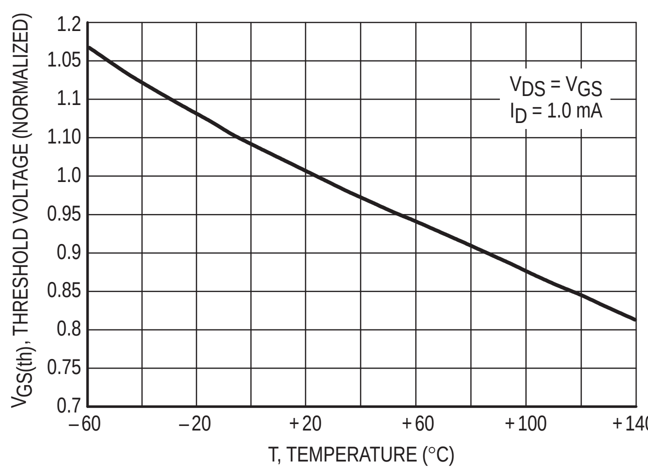


Figure 4. Temperature versus Gate Threshold Voltage

GREEN LINE™

BSS138LT1

Motorola Preferred Device

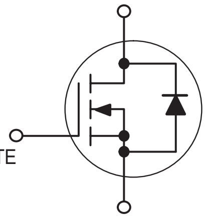
N-Channel Enhancement Mode Logic Level SOT-23 MOSFET

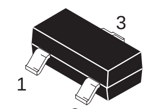
N–CHANNEL LOGIC LEVEL TMOS FET TRANSISTOR

Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low Threshold Voltage ($V_{GS(th)}$: 0.5V...1.5V) makes it ideal for low voltage applications
- Miniature SOT–23 Surface Mount Package saves board space

TMOS™





CASE 318–08, Style 21
SOT–23 (TO–236A)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	50	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_{DM}	200 800	mA
Total Power Dissipation @ T_A = 25°C	P_D	225	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	556	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

DEVICE MARKING

BSS138LT1 = J1

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
BSS138LT1	7″	8mm embossed tape	3000
BSS138LT3	13″	8mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 250 μAdc)		$V_{(BR)DSS}$	50	—	—	Vdc
Zero Gate Voltage Drain Current		I_{DSS}				μAdc
(V_{DS} = 25 Vdc, V_{GS} = 0 Vdc)			—	—	0.1	
(V_{DS} = 50 Vdc, V_{GS} = 0 Vdc)			—	—	0.5	
Gate–Source Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)		I_{GSS}	—	—	±0.1	μAdc
ON CHARACTERISTICS(1)						
Gate–Source Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)		$V_{GS(th)}$	0.5	—	1.5	Vdc
Static Drain–to–Source On–Resistance		$r_{DS(on)}$				Ohms
(V_{GS} = 2.75 Vdc, I_D < 200 mAdc, T_A = –40°C to +85°C)			—	5.6	10	
(V_{GS} = 5.0 Vdc, I_D = 200 mAdc)			—	—	3.5	
Forward Transconductance (V_{DS} = 25 Vdc, I_D = 200 mAdc, f = 1.0 kHz)		g_{fs}	100	—	—	mmhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 25 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	40	50	pF
Output Capacitance	(V_{DS} = 25 Vdc, V_{GS} = 0, f = 1 MHz)	C_{oss}	—	12	25	
Transfer Capacitance	(V_{DG} = 25 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	—	3.5	5.0	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 30 Vdc, I_D = 0.2 Adc,)	$t_{d(on)}$	—	—	20	ns
Turn–Off Delay Time		$t_{d(off)}$	—	—	20	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

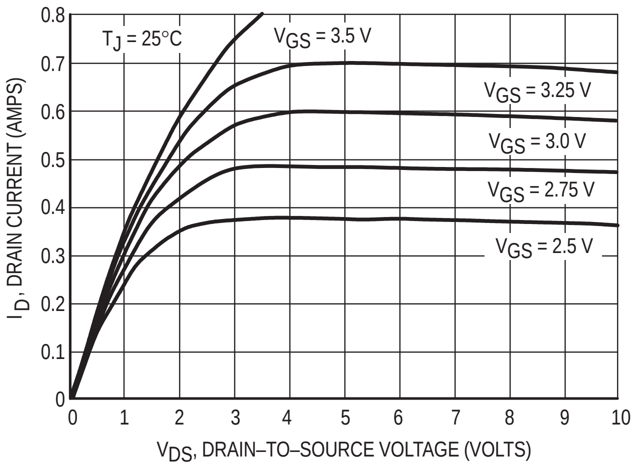


Figure 1. On–Region Characteristics

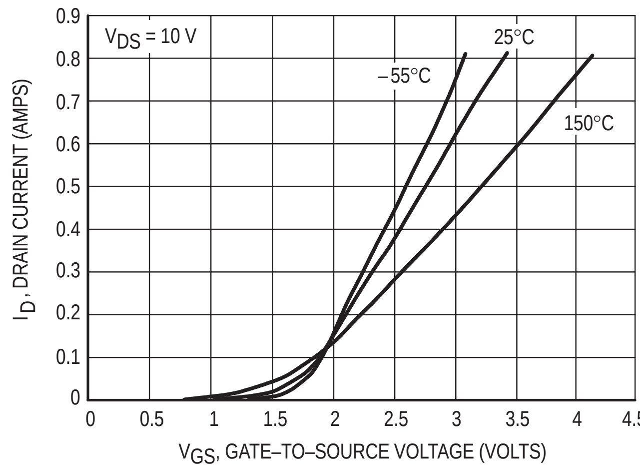


Figure 2. Transfer Characteristics

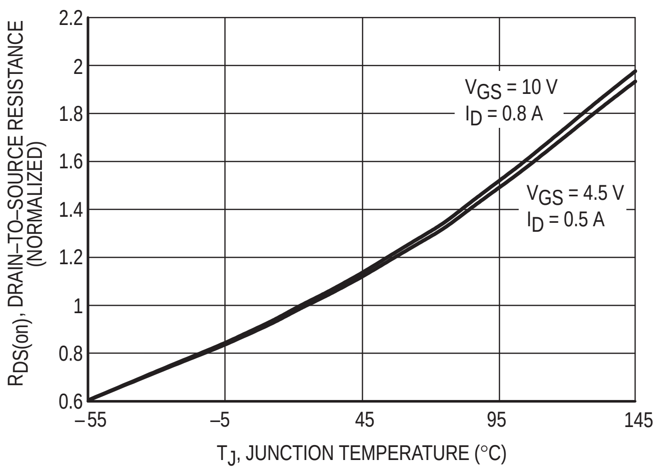


Figure 3. On–Resistance Variation with Temperature

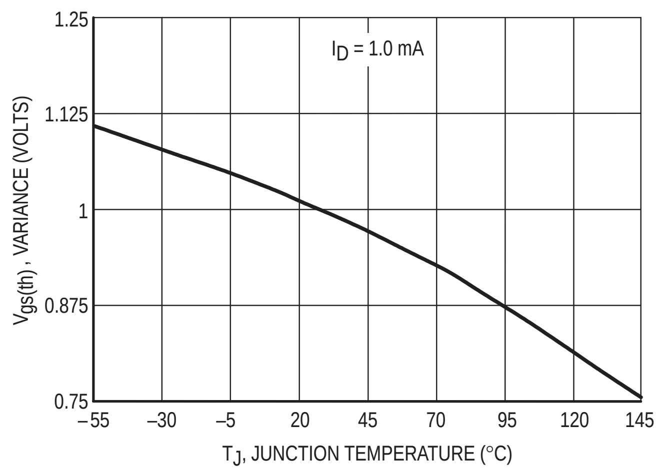


Figure 4. Threshold Voltage Variation with Temperature

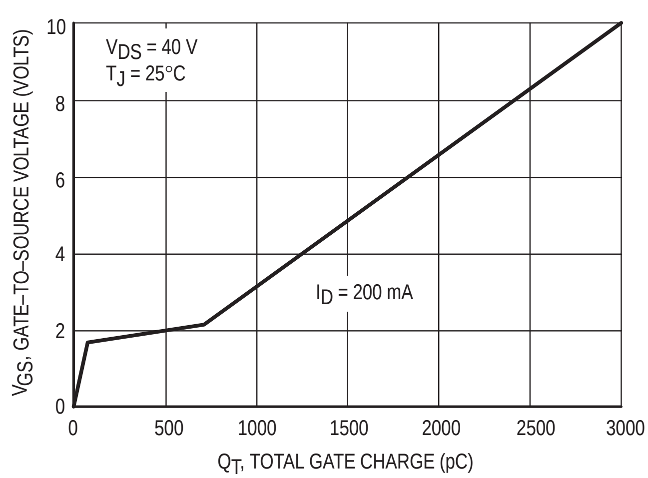


Figure 5. Gate Charge

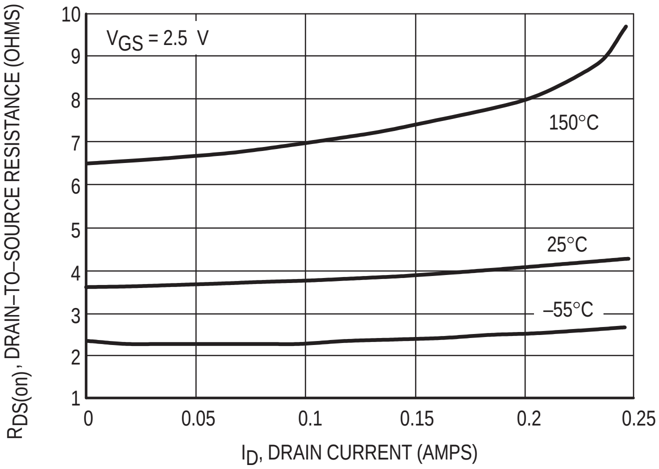


Figure 6. On–Resistance versus Drain Current

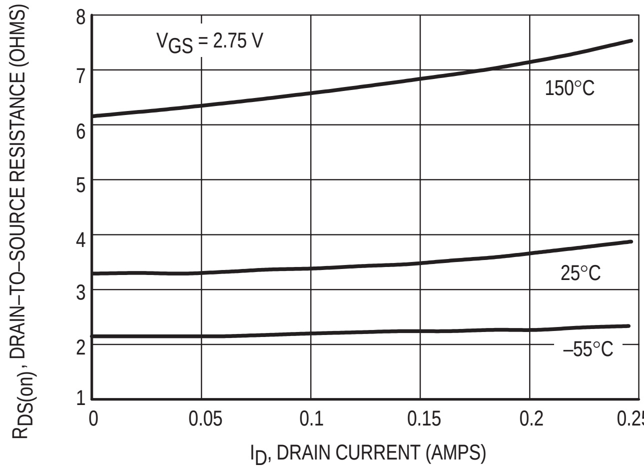


Figure 7. On–Resistance versus Drain Current

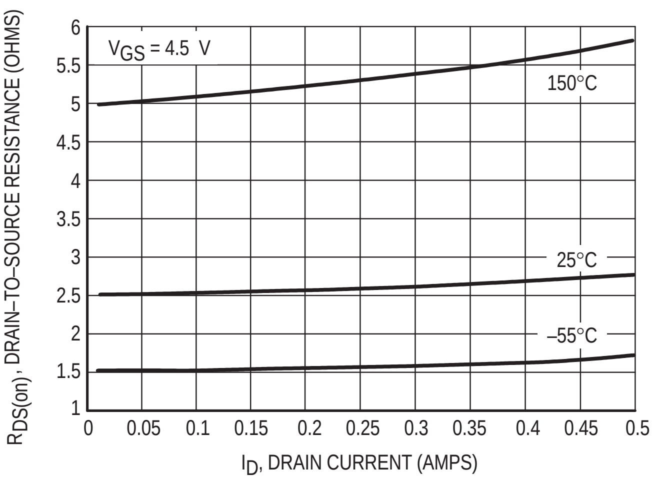


Figure 8. On–Resistance versus Drain Current

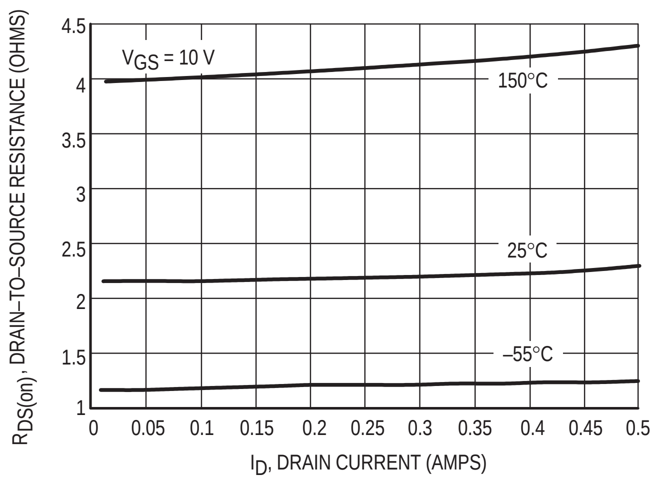


Figure 9. On–Resistance versus Drain Current

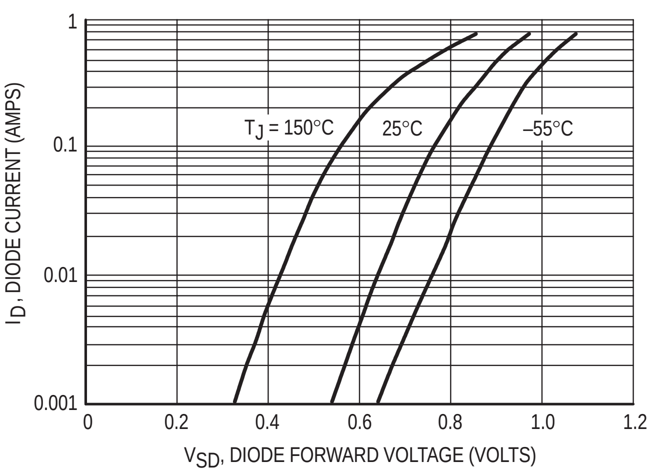


Figure 10. Body Diode Forward Voltage

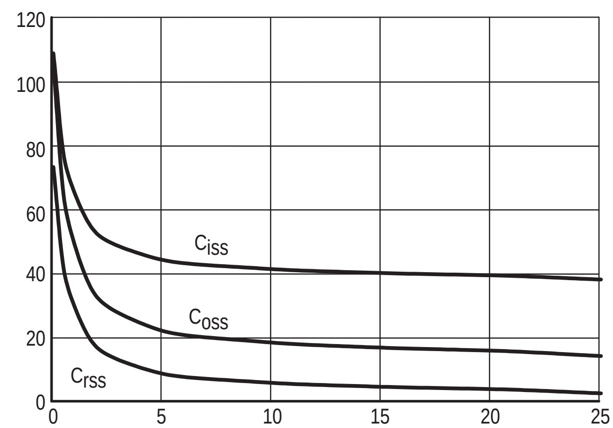


Figure 11. Capacitance

GREEN LINE™

MGSF1N02LT1

Motorola Preferred Device

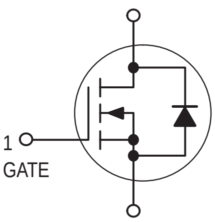
Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

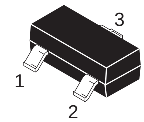
These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in space sensitive power management circuitry. Typical applications are dc–dc converters and power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space

HD TMOS™



N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET



CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq$ 10 µs)	I_D I_{DM}	750 2000	mA
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

Device Marking: NZ

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF1N02LT1	7″	8mm embossed tape	3000
MGSF1N02LT3	13″	8mm embossed tape	10,000

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

REV 2

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 Vdc, I_D = 10 μAdc)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 1.2 Adc)		$r_{DS(on)}$	—	0.075	0.090	Ohms
(V_{GS} = 4.5 Vdc, I_D = 1.0 Adc)			—	0.115	0.130	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 Vdc)	C_{iss}	—	125	—	pF
Output Capacitance	(V_{DS} = 5.0 Vdc)	C_{oss}	—	120	—	
Transfer Capacitance	(V_{DG} = 5.0 Vdc)	C_{rss}	—	45	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 Adc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 6)		Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.6	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	0.8	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

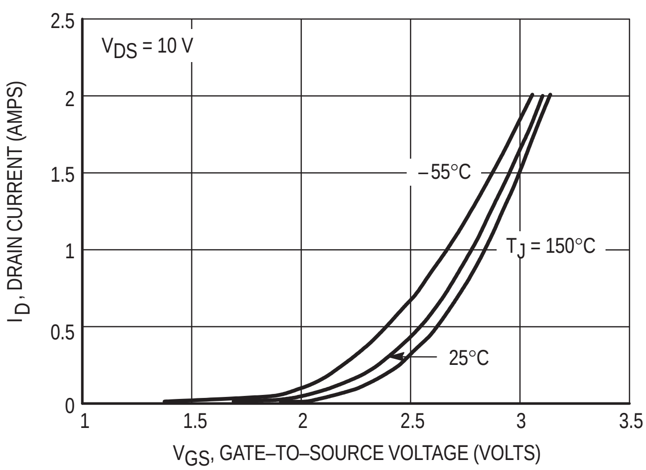


Figure 1. Transfer Characteristics

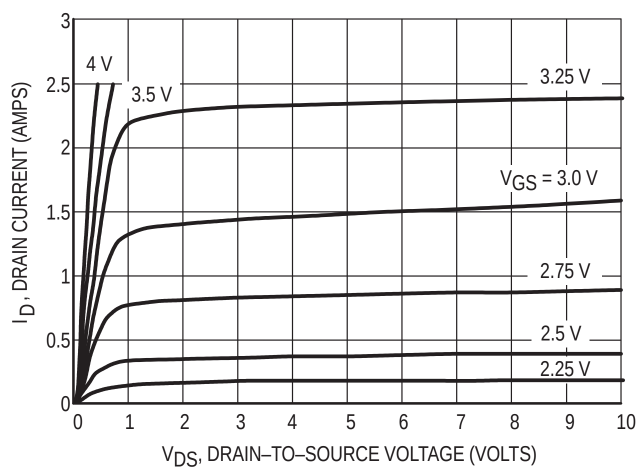


Figure 2. On–Region Characteristics

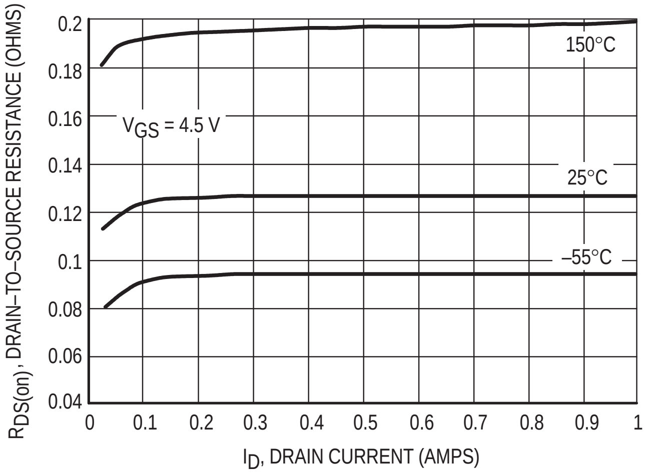


Figure 3. On–Resistance versus Drain Current

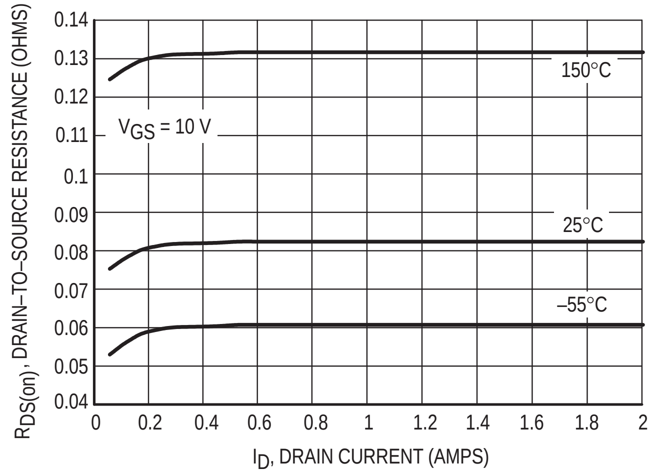


Figure 4. On–Resistance versus Drain Current

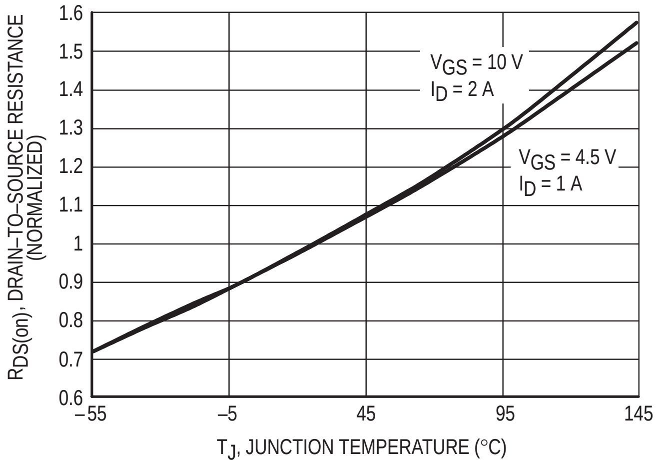


Figure 5. On–Resistance Variation with Temperature

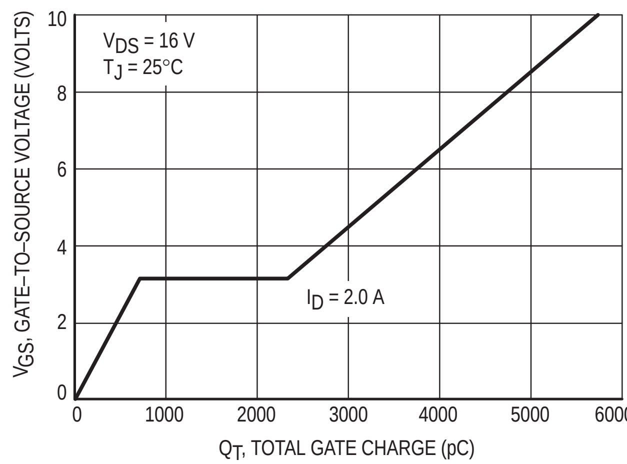


Figure 6. Gate Charge

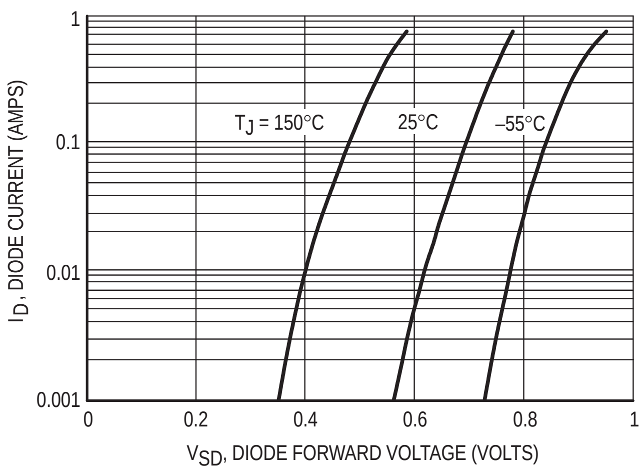


Figure 7. Body Diode Forward Voltage

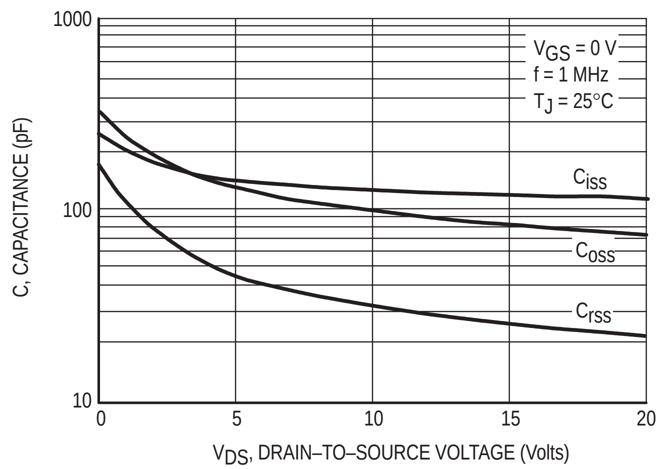


Figure 8. Capacitance

GREEN LINE™

MGSF1N03LT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

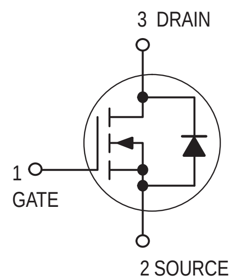
N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET

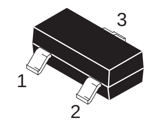
HD TMOS™

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in space sensitive power management circuitry. Typical applications are dc–dc converters and power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_{DM}	750 2000	mA
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

Device Marking: N3

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF1N03LT1	7″	8mm embossed tape	3000
MGSF1N03LT3	13″	8mm embossed tape	10,000

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

REV 4

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 Vdc, I_D = 10 μAdc)	$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)	I_{DSS}	 — —	 — —	 1.0 10	μAdc
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)	$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 1.2 Adc) (V_{GS} = 4.5 Vdc, I_D = 1.0 Adc)	$r_{DS(on)}$	 — —	 0.08 0.125	 0.10 0.145	Ohms
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 5.0 Vdc)	C_{iss}	—	140	—	pF
Output Capacitance (V_{DS} = 5.0 Vdc)	C_{oss}	—	100	—	
Transfer Capacitance (V_{DG} = 5.0 Vdc)	C_{rss}	—	40	—	
SWITCHING CHARACTERISTICS(2)					
Turn–On Delay Time (V_{DD} = 15 Vdc, I_D = 1.0 Adc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time	t_r	—	1.0	—	
Turn–Off Delay Time	$t_{d(off)}$	—	16	—	
Fall Time	t_f	—	8.0	—	
Gate Charge (See Figure 6)	Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS					
Continuous Current	I_S	—	—	0.6	A
Pulsed Current	I_{SM}	—	—	0.75	
Forward Voltage(2)	V_{SD}	—	0.8	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

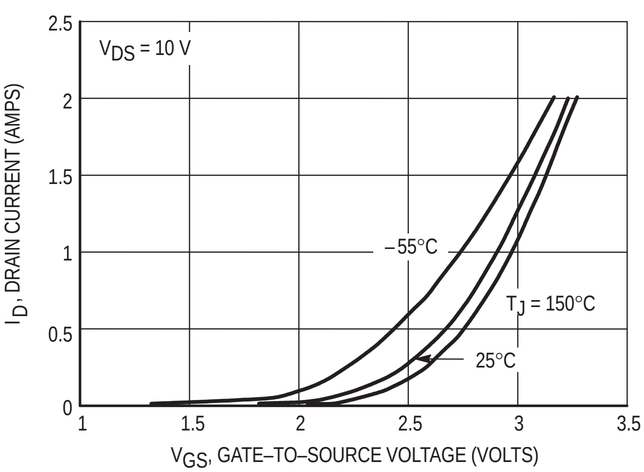


Figure 1. Transfer Characteristics

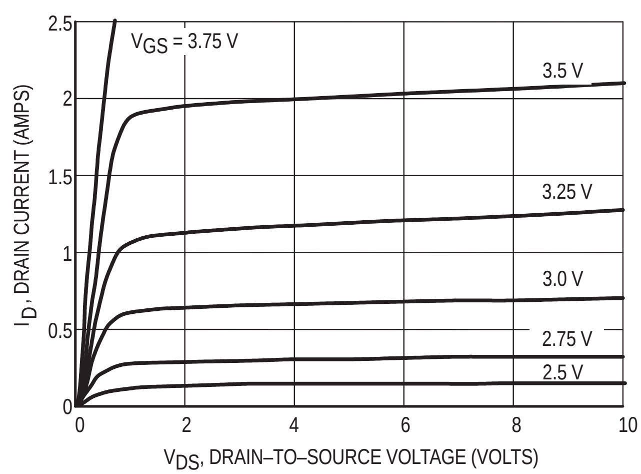


Figure 2. On–Region Characteristics

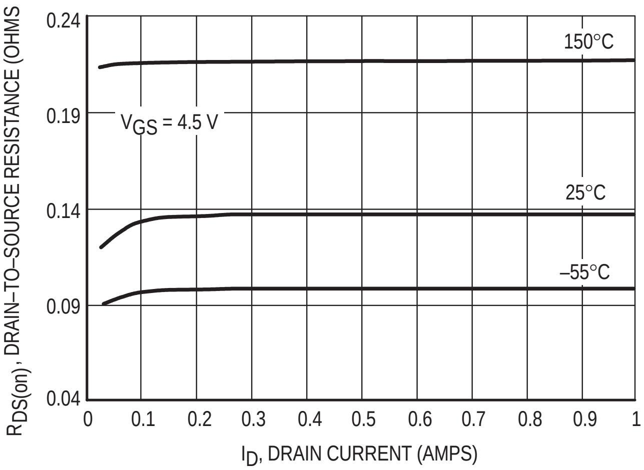


Figure 3. On–Resistance versus Drain Current

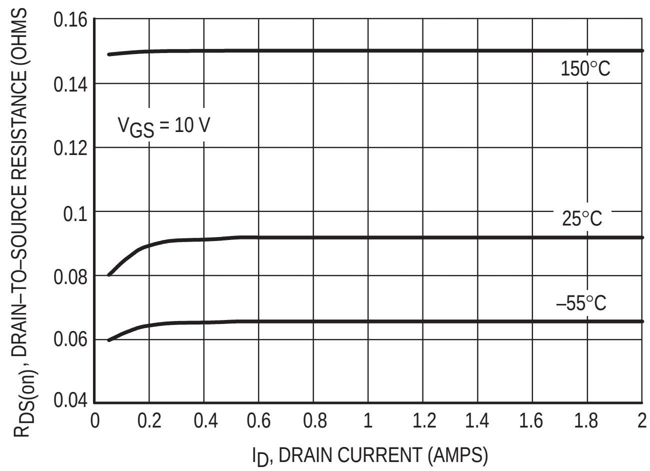


Figure 4. On–Resistance versus Drain Current

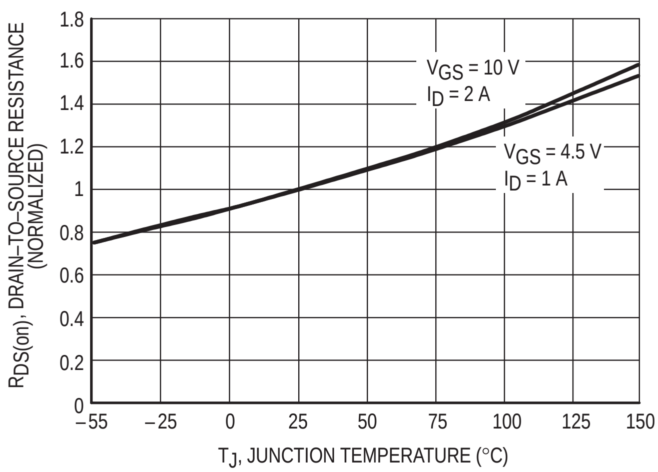


Figure 5. On–Resistance Variation with Temperature

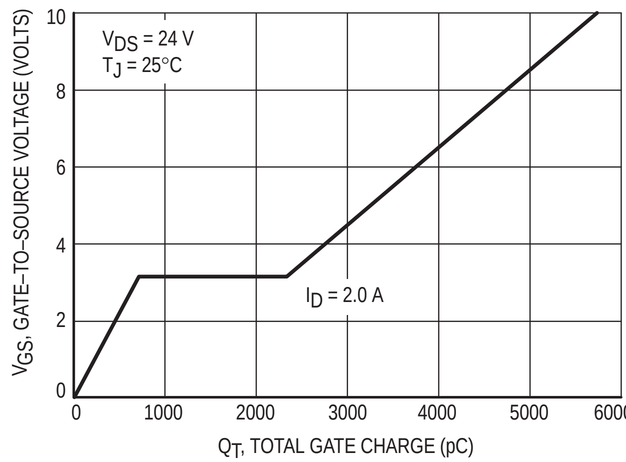


Figure 6. Gate Charge

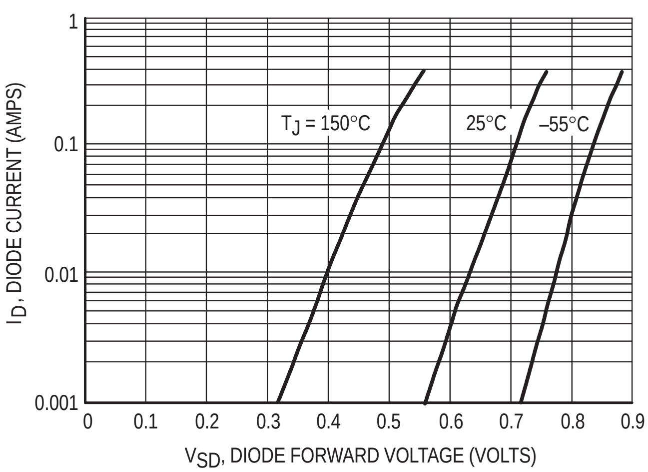


Figure 7. Body Diode Forward Voltage

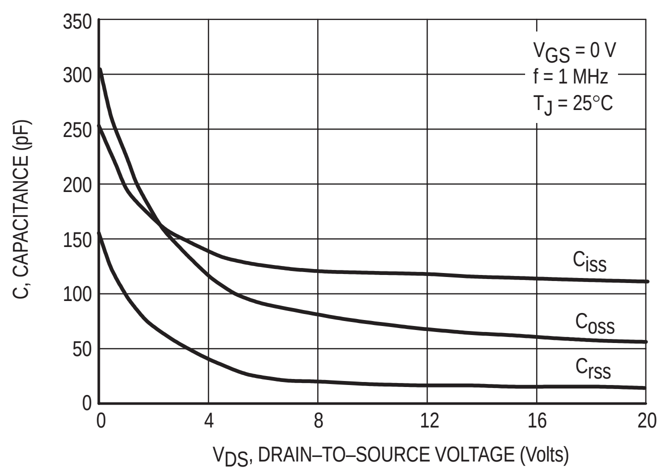


Figure 8. Capacitance

GREEN LINE™

Preliminary Information

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

MGSF1P02ELT1

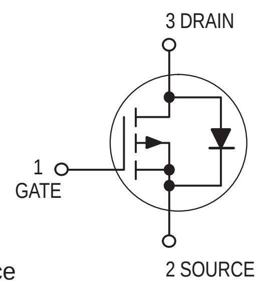
Motorola Preferred Device

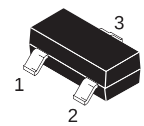
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in space sensitive power management circuitry. Typical applications are dc–dc converters and power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10$ µs)	I_D I_{DM}	750 2000	mA
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

Device Marking: PC

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF1P02ELT1	7″	8mm embossed tape	3000
MGSF1P02ELT3	13″	8mm embossed tape	10,000

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 Vdc, I_D = 250 μAdc)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current		I_{DSS}				μAdc
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc)			—	—	1.0	
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0 Vdc)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	0.7	0.85	1.2	Vdc
Static Drain–to–Source On–Resistance		$r_{DS(on)}$				Ohms
(V_{GS} = 4.5 Vdc, I_D = 0.75 Adc)			—	0.20	0.26	
(V_{GS} = 2.5 Vdc, I_D = 0.5 Adc)			—	0.32	0.50	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 Vdc)	C_{iss}	—	130	—	pF
Output Capacitance	(V_{DS} = 5.0 Vdc)	C_{oss}	—	120	—	
Transfer Capacitance	(V_{DG} = 5.0 Vdc)	C_{rss}	—	60	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 Adc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 6)		Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.6	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	1.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

MGSF1P02LT1

Motorola Preferred Device

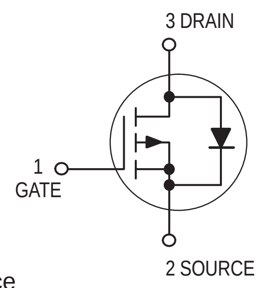
Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

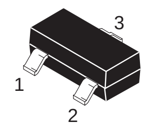
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in space sensitive power management circuitry. Typical applications are dc–dc converters and power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_{DM}	750 2000	mA
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

Device Marking: PC

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF1P02LT1	7″	8mm embossed tape	3000
MGSF1P02LT3	13″	8mm embossed tape	10,000

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

REV 2

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 Vdc, I_D = 10 μAdc)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0 Vdc)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 1.5 Adc)		$r_{DS(on)}$	—	0.235	0.350	Ohms
(V_{GS} = 4.5 Vdc, I_D = 0.75 Adc)			—	0.375	0.500	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 Vdc)	C_{iss}	—	130	—	pF
Output Capacitance	(V_{DS} = 5.0 Vdc)	C_{oss}	—	120	—	
Transfer Capacitance	(V_{DG} = 5.0 Vdc)	C_{rss}	—	60	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 Adc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 6)		Q_T	—	6000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.6	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	1.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

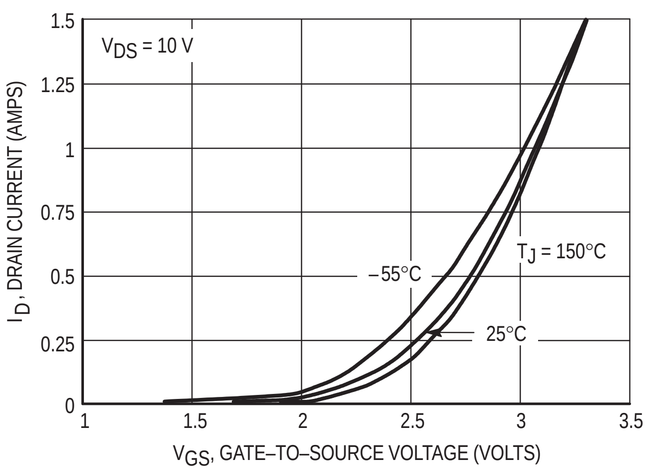


Figure 1. Transfer Characteristics

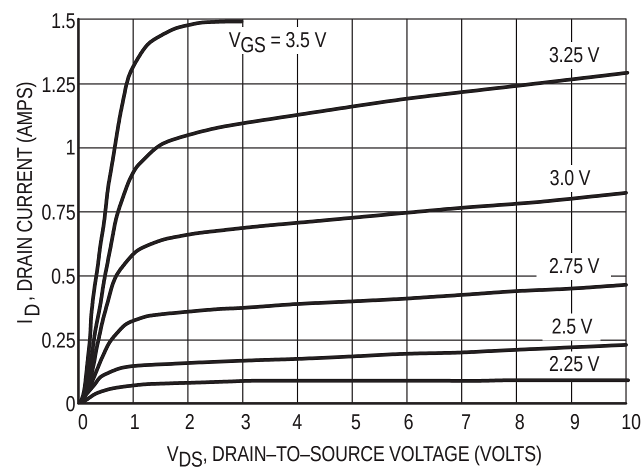


Figure 2. On–Region Characteristics

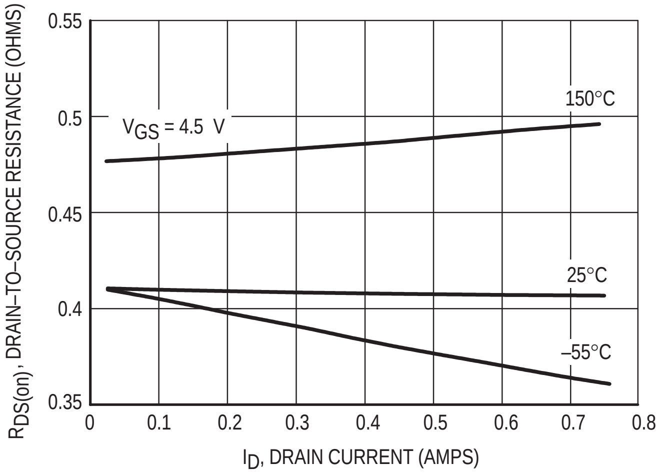


Figure 3. On–Resistance versus Drain Current

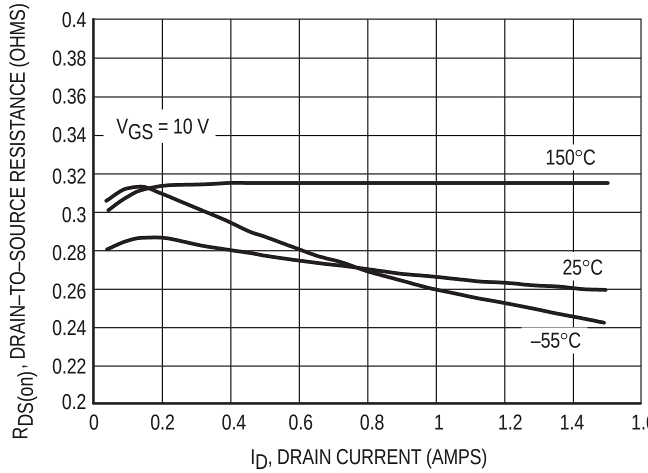


Figure 4. On–Resistance versus Drain Current

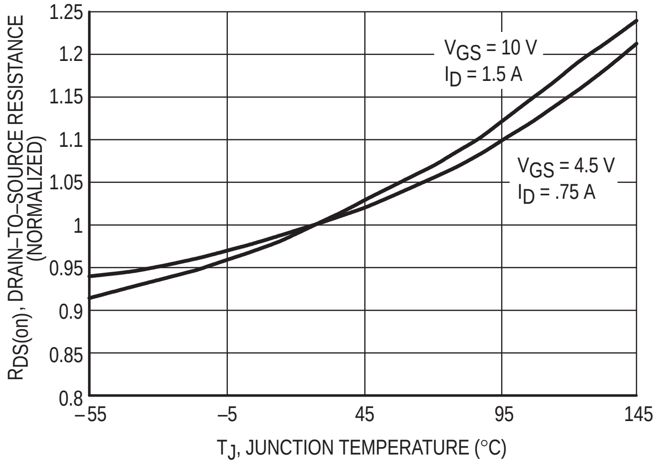


Figure 5. On–Resistance Variation with Temperature

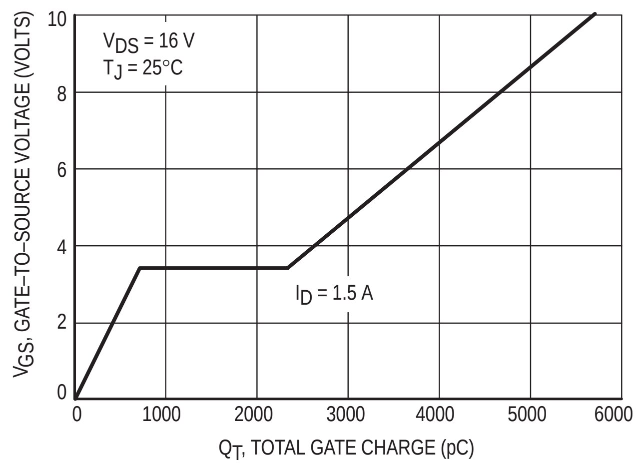


Figure 6. Gate Charge

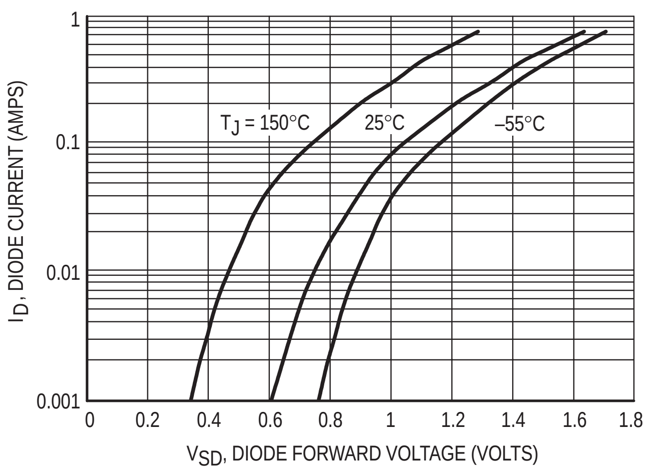


Figure 7. Body Diode Forward Voltage

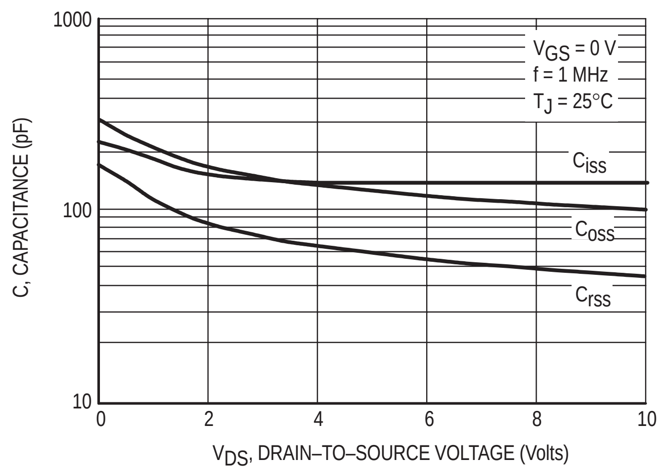


Figure 8. Capacitance

GREEN LINE™

Preliminary Information

MGSF3441VT1

Motorola Preferred Device

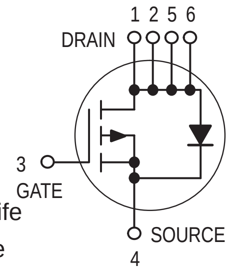
Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

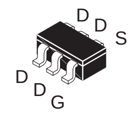
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 78 mΩ (TYP)

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature TSOP 6 Surface Mount Package Saves Board Space
- Visit our Web Site at http://www.mot–sps.com/ospd





CASE 318G–02, Style 1
TSOP 6 PLASTIC

2.5V RATED

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10$ μs)	I_D I_{DM}	3.3 20	A
Total Power Dissipation @ T_A = 25°C Mounted on FR4 t ≤ 5 sec	P_D	2.0	W
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	128	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3441VT1	7″	8 mm embossed tape	3000
MGSF3441VT3	13″	8 mm embossed tape	10,000

This document contains information on a product under development. Motorola reserves the right to change or discontinue this product without notice.

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)			—	—	4.0	
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	0.45	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 4.5 Vdc, I_D = 3.3 A)		$r_{DS(on)}$	—	0.078	0.090	Ohms
(V_{GS} = 2.5 Vdc, I_D = 2.9 A)			—	0.110	0.135	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	27	50	ns
Rise Time		t_r	—	17	30	
Turn–Off Delay Time		$t_{d(off)}$	—	52	80	
Fall Time		t_f	—	45	70	
Gate Charge		Q_T	—	3000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	20	A
Forward Voltage(2)		V_{SD}	—	0.80	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

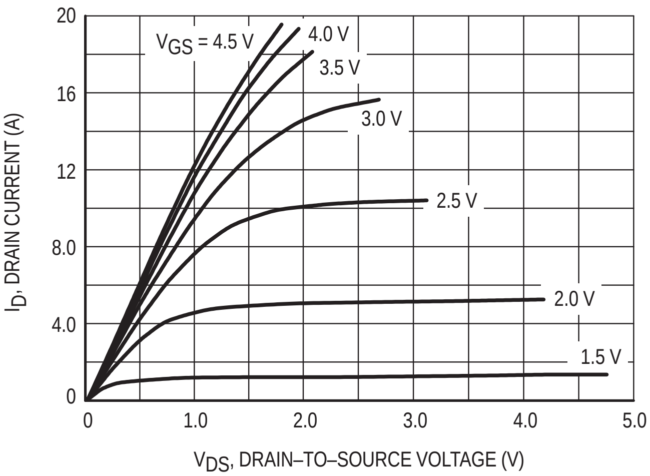


Figure 1. Output Characteristics

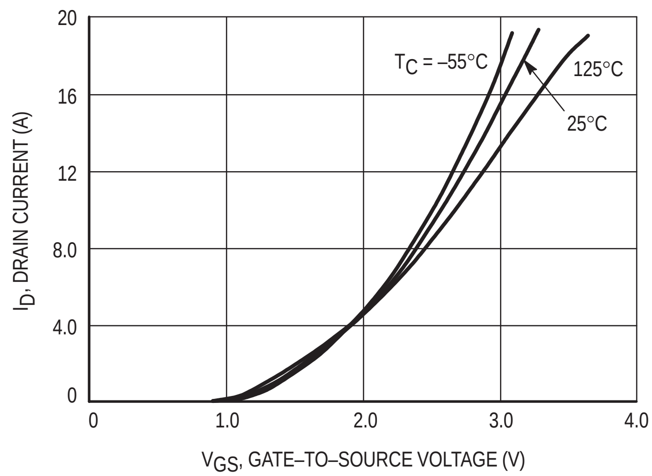


Figure 2. Transfer Characteristics

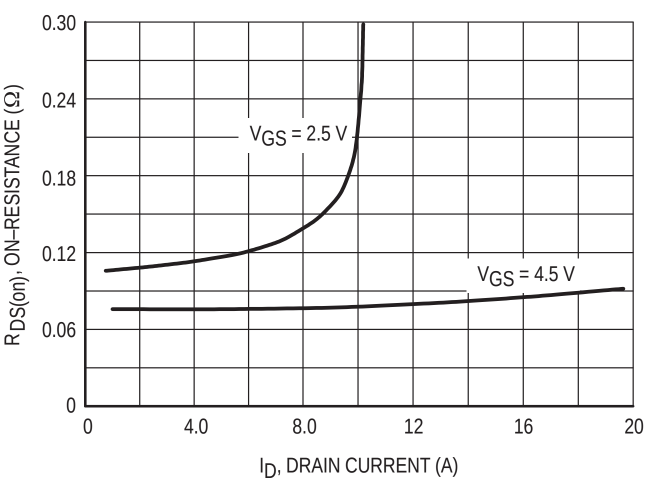


Figure 3. On–Resistance versus Drain Current

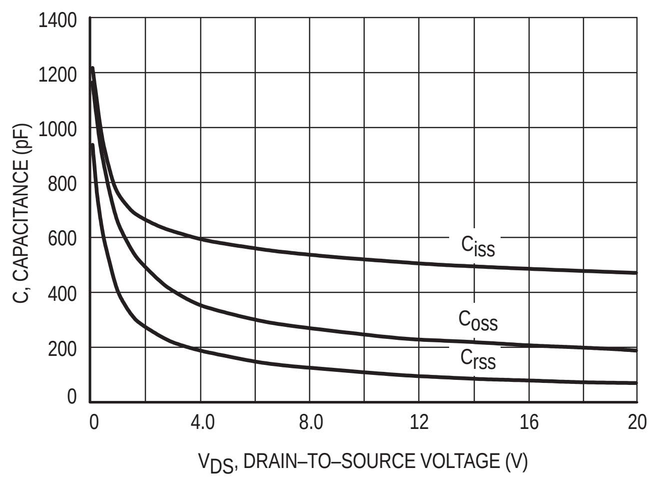


Figure 4. Capacitance

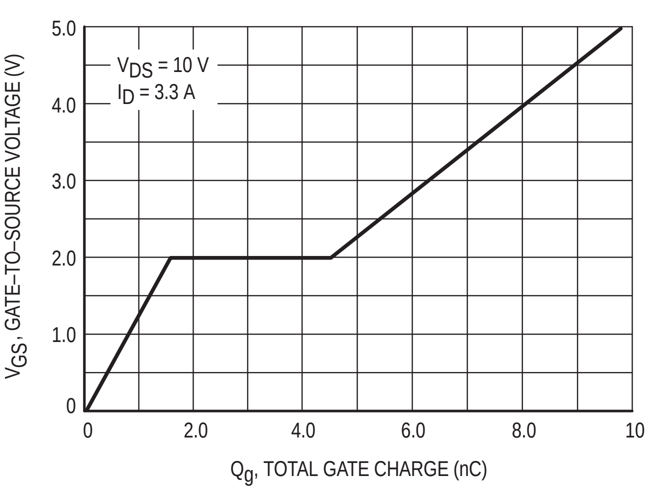


Figure 5. Gate Charge

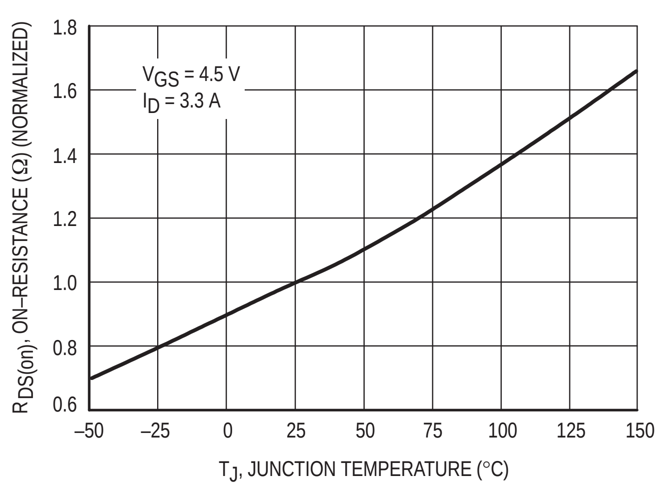


Figure 6. On–Resistance versus Junction Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

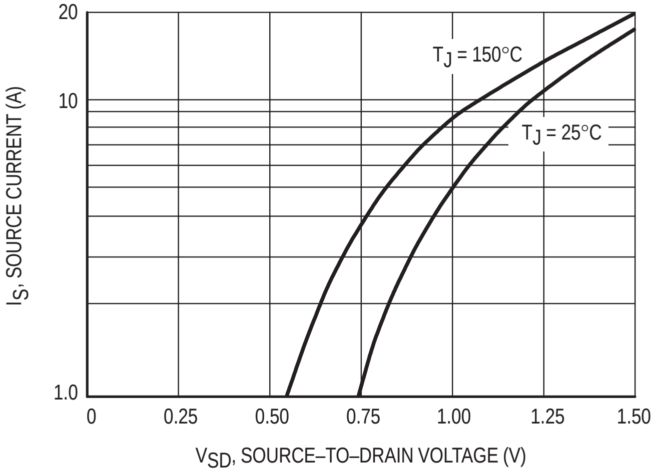


Figure 7. Source–Drain Diode Forward Voltage

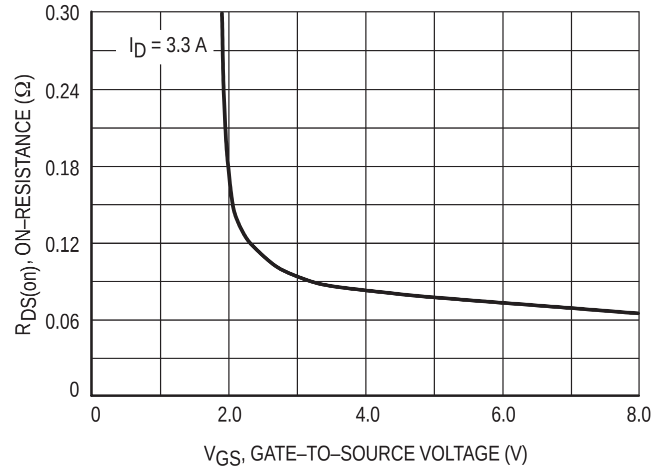


Figure 8. On–Resistance versus Gate–to–Source Voltage

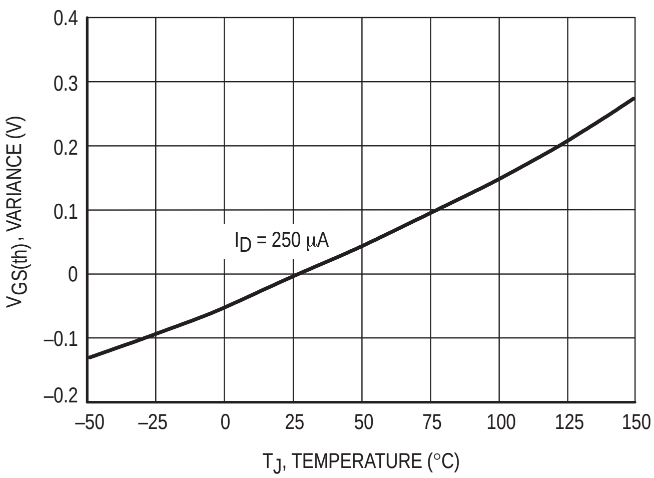


Figure 9. Threshold Voltage

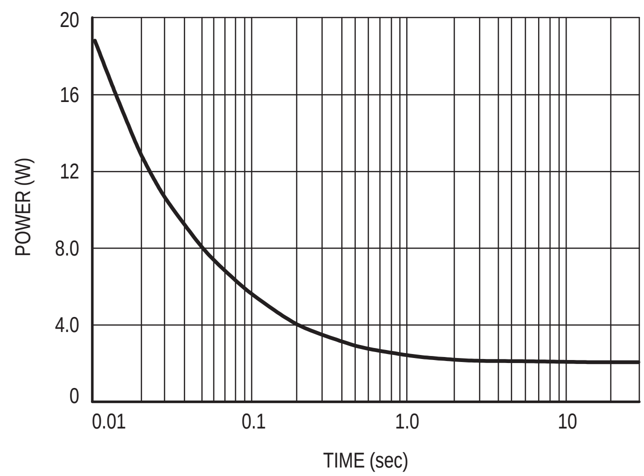


Figure 10. Single Pulse Power

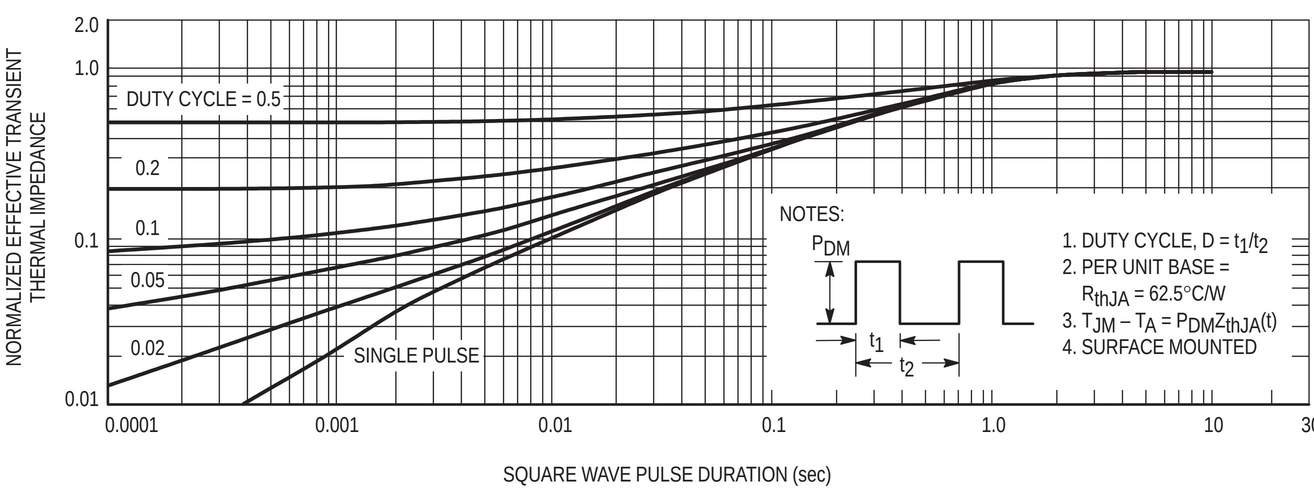


Figure 11. Normalized Thermal Transient Impedance, Junction–to–Ambient

GREEN LINE™

Preliminary Information

MGSF3441XT1

Motorola Preferred Device

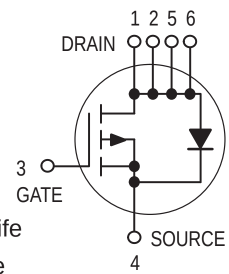
Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

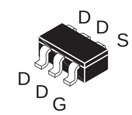
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 78 mΩ (TYP)

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature TSOP 6 Surface Mount Package Saves Board Space
- Visit our Web Site at http://www.mot–sps.com/ospd





CASE 318G–02, Style 1
TSOP 6 PLASTIC

2.5V RATED

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10$ µs)	I_D I_{DM}	1.5 20	A
Total Power Dissipation @ T_A = 25°C	P_D	950	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	132	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3441XT1	7″	8 mm embossed tape	3000
MGSF3441XT3	13″	8 mm embossed tape	10,000

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

REV 2

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 Vdc, I_D = 10 µA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)		I_{DSS}	— —	— —	1.0 4.0	µAdc
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 µAdc)		$V_{GS(th)}$	0.45	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 4.5 Vdc, I_D = 1.5 A) (V_{GS} = 2.5 Vdc, I_D = 1.2 A)		$r_{DS(on)}$	— —	0.078 0.110	0.100 0.135	Ohms
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	27	50	ns
Rise Time		t_r	—	17	30	
Turn–Off Delay Time		$t_{d(off)}$	—	52	80	
Fall Time		t_f	—	45	70	
Gate Charge		Q_T	—	3000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	20	A
Forward Voltage(2)		V_{SD}	—	0.80	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

GREEN LINE™

Preliminary Information

MGSF3442VT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

HDTMOS™

N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 58 mΩ (TYP)

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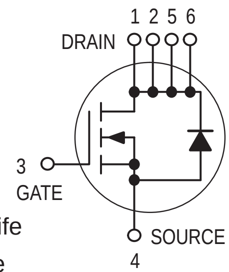

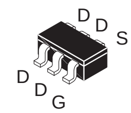

CASE 318G–02, Style 1
TSOP 6 PLASTIC

2.5V RATED

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq$ 10 µs)	I_D I_{DM}	4.0 20	A
Total Power Dissipation @ T_A = 25°C Mounted on FR4 t ≤ 5 sec	P_D	2.0	W
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3442VT1	7″	8 mm embossed tape	3000
MGSF3442VT3	13″	8 mm embossed tape	10,000

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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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)			—	—	5.0	
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	0.6	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 4.5 Vdc, I_D = 4.0 A)		$r_{DS(on)}$	—	0.058	0.070	Ohms
(V_{GS} = 2.5 Vdc, I_D = 3.4 A)			—	0.072	0.095	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 10 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	8.0	20	ns
Rise Time		t_r	—	24	40	
Turn–Off Delay Time		$t_{d(off)}$	—	36	60	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	—	—	nC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage(2)		V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

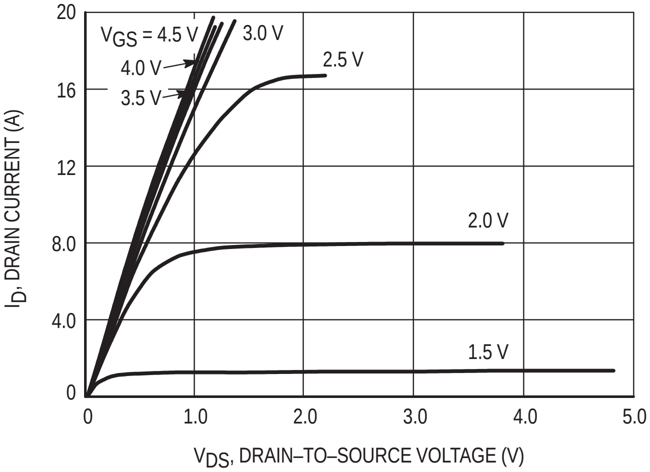

Figure 1. Output Characteristics

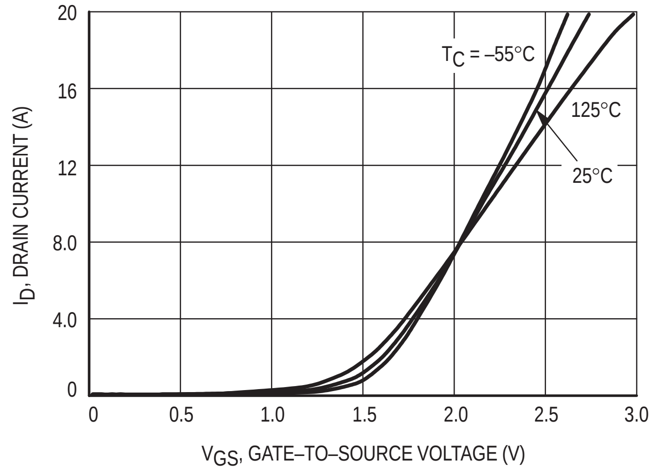

Figure 2. Transfer Characteristics

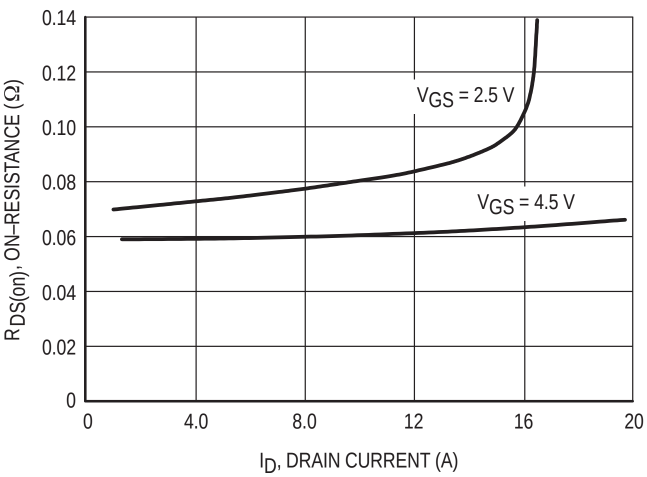

Figure 3. On–Resistance versus Drain Current

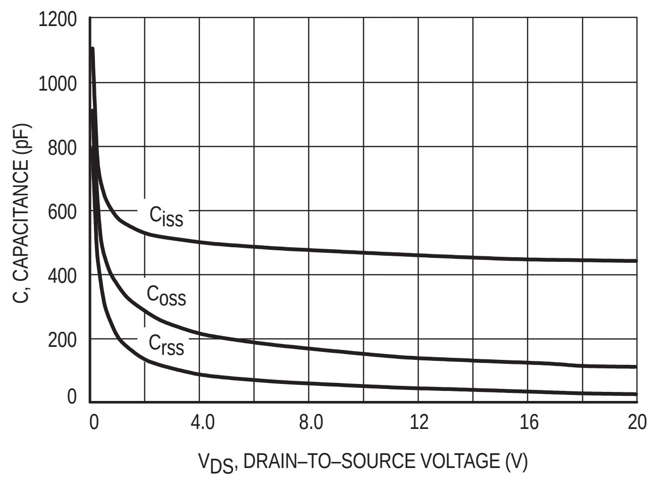

Figure 4. Capacitance

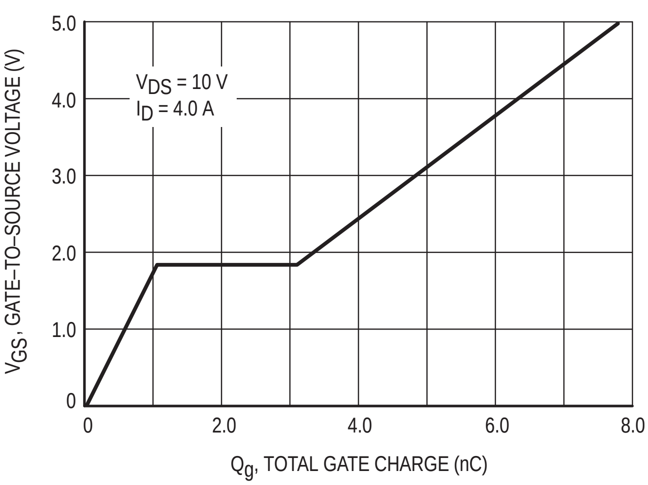

Figure 5. Gate Charge

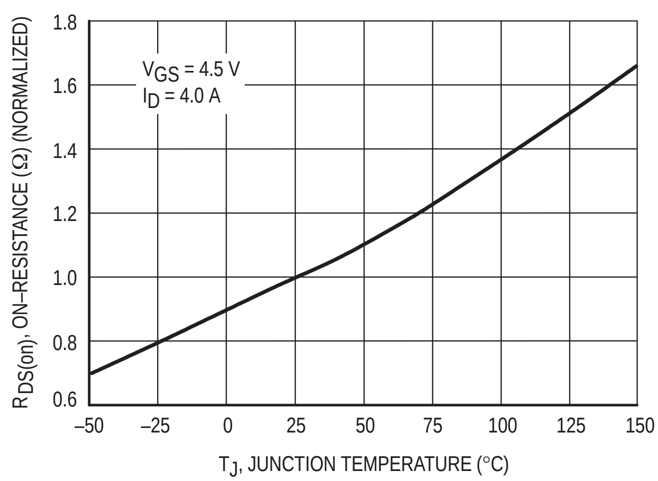

Figure 6. On–Resistance versus Junction Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

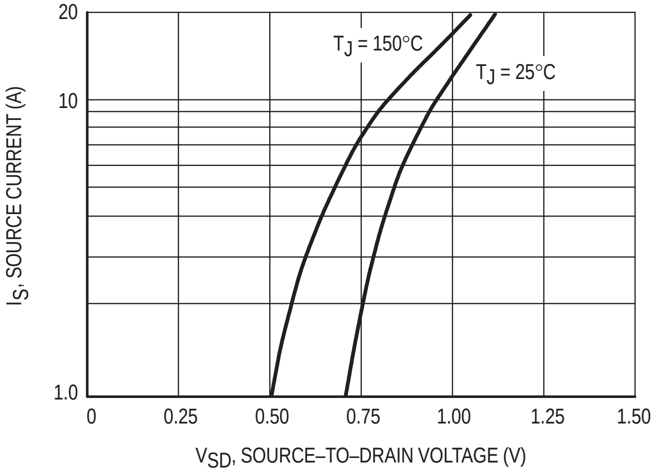

Figure 7. Source–Drain Diode Forward Voltage

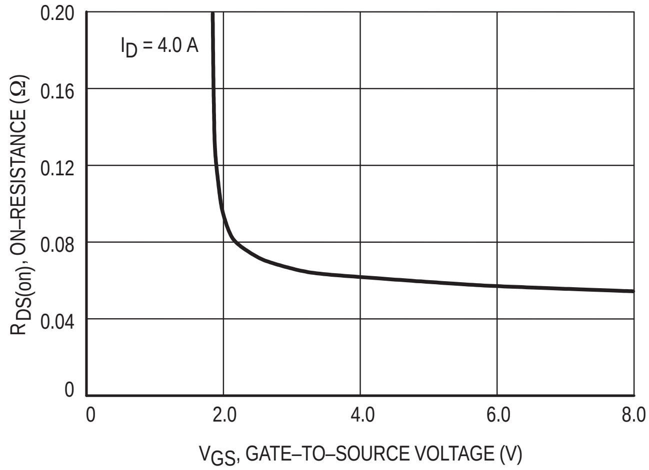

Figure 8. On–Resistance versus Gate–to–Source Voltage

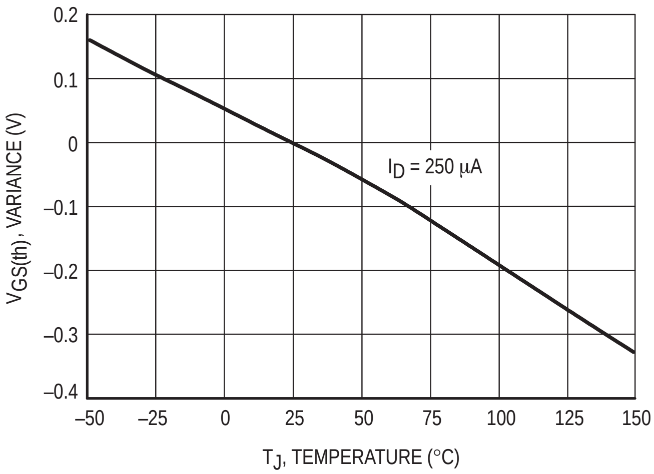

Figure 9. Threshold Voltage

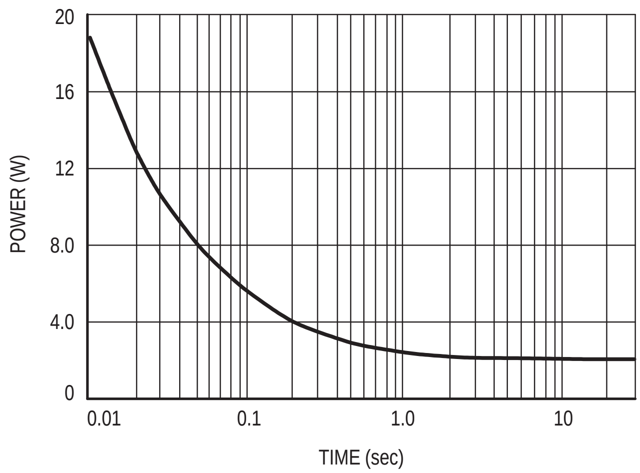

Figure 10. Single Pulse Power

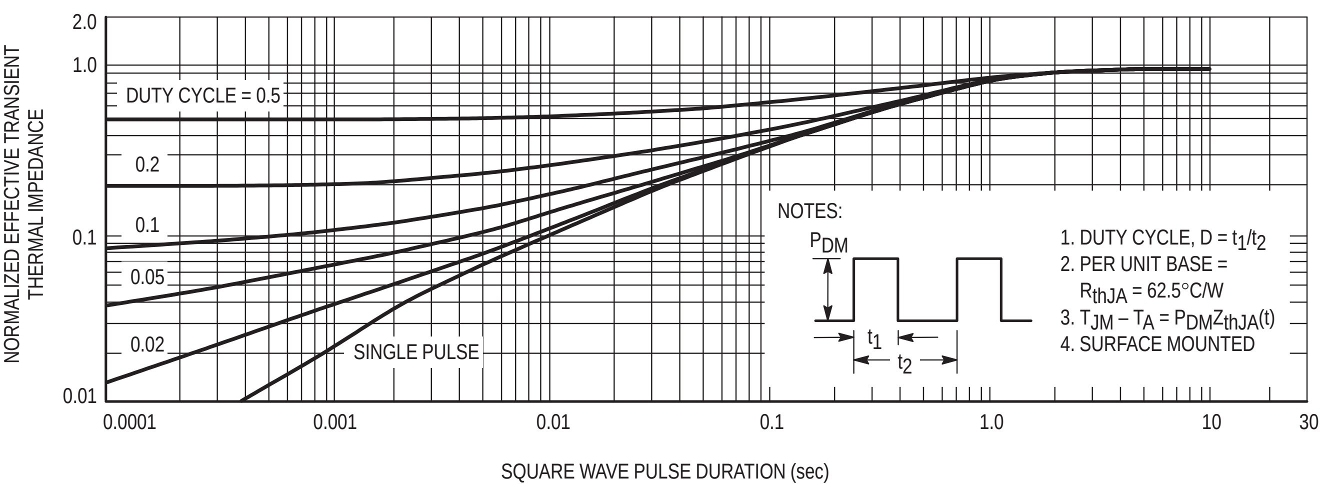

Figure 11. Normalized Thermal Transient Impedance, Junction–to–Ambient

GreenLine™

Preliminary Information

MGSF3442XT1

Motorola Preferred Device

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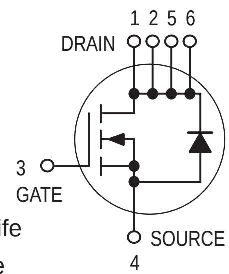

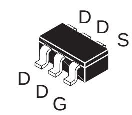

CASE 318G–02, Style 1
TSOP 6 PLASTIC

2.5V RATED

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 8.0	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_{DM}	1.7 20	A
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3442XT1	7″	8 mm embossed tape	3000
MGSF3442XT3	13″	8 mm embossed tape	10,000

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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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 20 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)			—	—	5.0	
Gate–Body Leakage Current (V_{GS} = ± 8.0 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	0.6	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 4.5 Vdc, I_D = 1.7 A)		$r_{DS(on)}$	—	0.058	0.070	Ohms
(V_{GS} = 2.5 Vdc, I_D = 1.3 A)			—	0.072	0.095	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 10 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	8.0	20	ns
Rise Time		t_r	—	24	40	
Turn–Off Delay Time		$t_{d(off)}$	—	36	60	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	—	—	nC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage(2)		V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
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GREEN LINE™

Preliminary Information

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

MGSF3454VT1

Motorola Preferred Device

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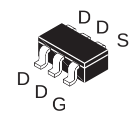
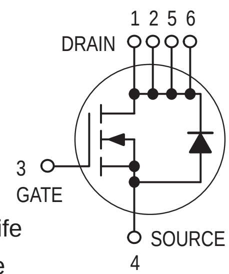


CASE 318G–02, Style 1
TSOP 6 PLASTIC

HDTMOS™

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.



- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature TSOP 6 Surface Mount Package Saves Board Space
- Visit our Web Site at http://www.mot–sps.com/ospd

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current (t_p ≤ 10 μs)	I_D I_{DM}	4.2 20	A
Total Power Dissipation @ T_A = 25°C Mounted on FR4 t ≤ 5 sec	P_D	2.0	W
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3454VT1	7″	8 mm embossed tape	3000
MGSF3454VT3	13″	8 mm embossed tape	10,000

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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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)		I_{DSS}	— —	— —	1.0 25	μAdc
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 4.2 A) (V_{GS} = 4.5 Vdc, I_D = 3.4 A)		$r_{DS(on)}$	— —	0.05 0.07	0.065 0.095	Ohms
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 10 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	10	20	ns
Rise Time		t_r	—	15	30	
Turn–Off Delay Time		$t_{d(off)}$	—	20	35	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	—	15	nC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage(2)		V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

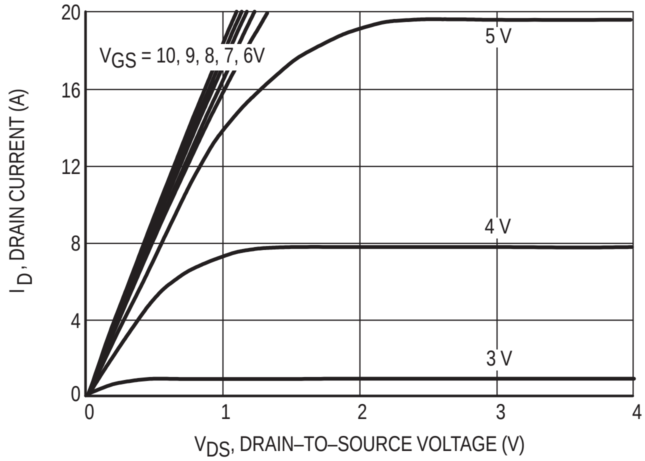

Figure 1. Output Characteristics

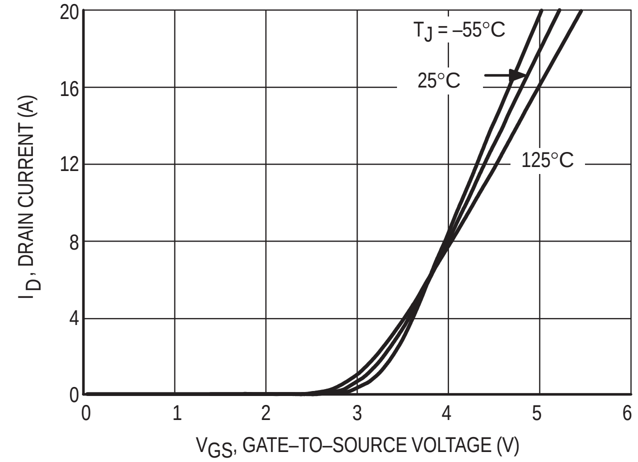

Figure 2. Transfer Characteristics

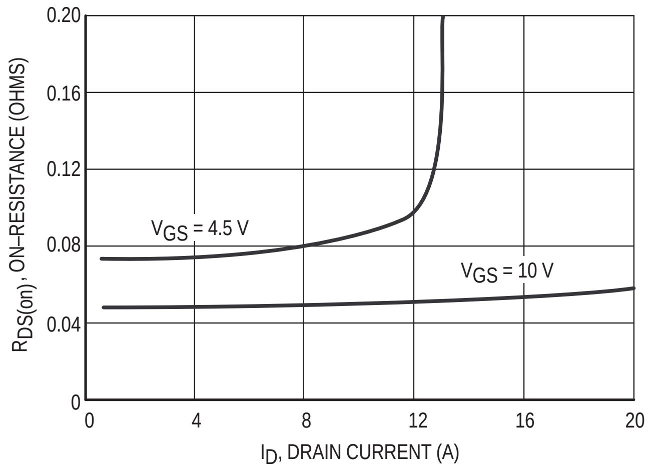

Figure 3. On–Resistance vs. Drain Current

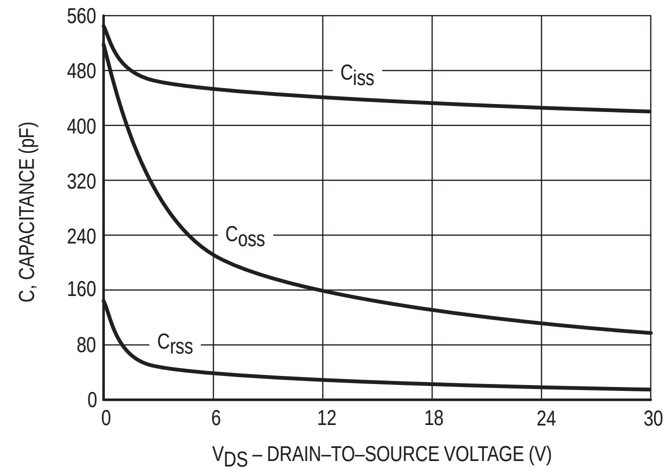

Figure 4. Capacitance

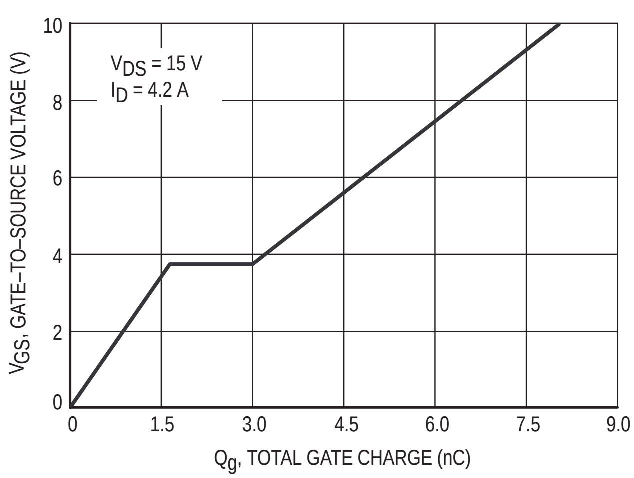

Figure 5. Gate Charge

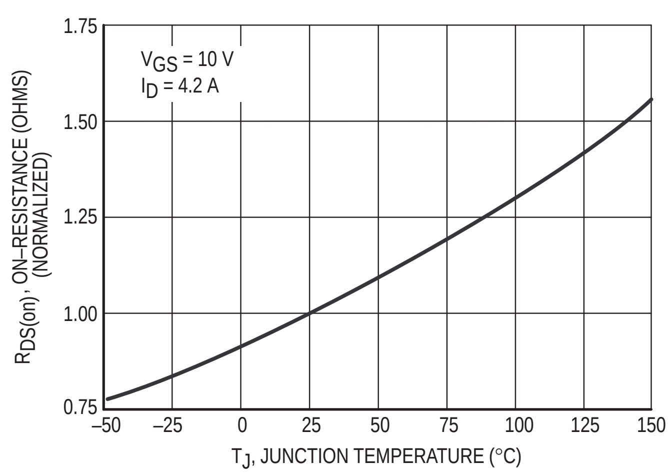

Figure 6. On–Resistance vs. Junction Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

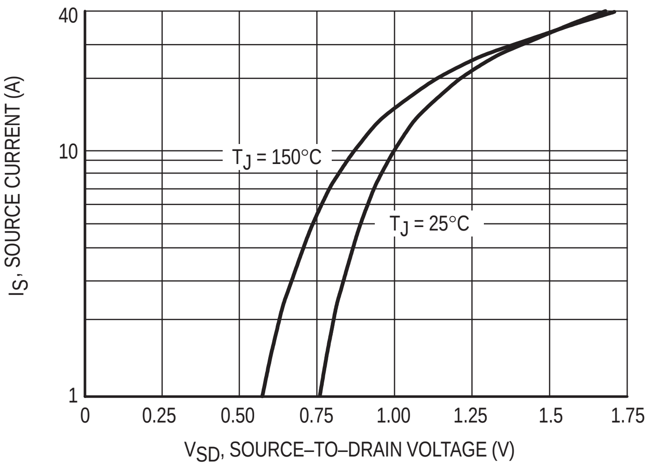

Figure 7. Source–Drain Diode Forward Voltage

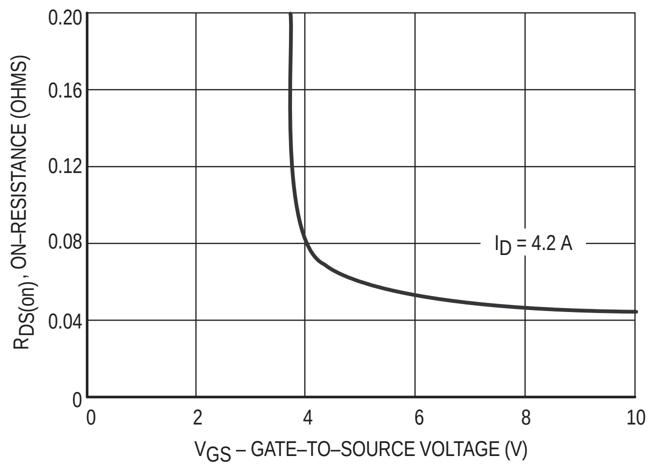

Figure 8. On–Resistance vs. Gate–to–Source Voltage

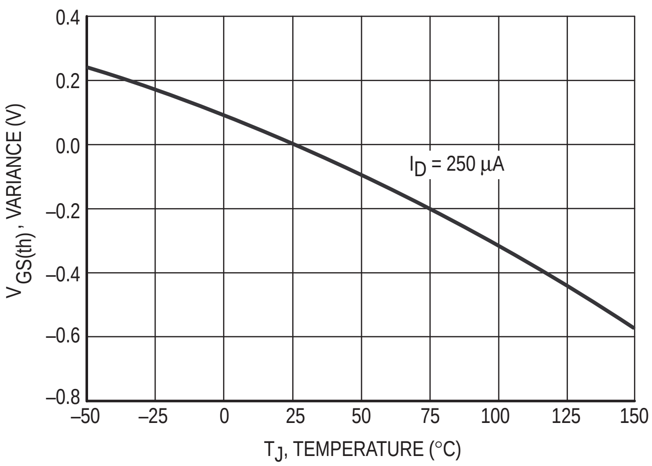

Figure 9. Threshold Voltage

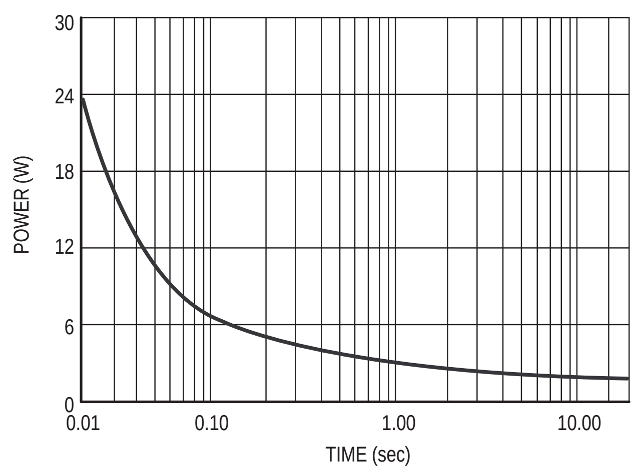

Figure 10. Single Pulse Power

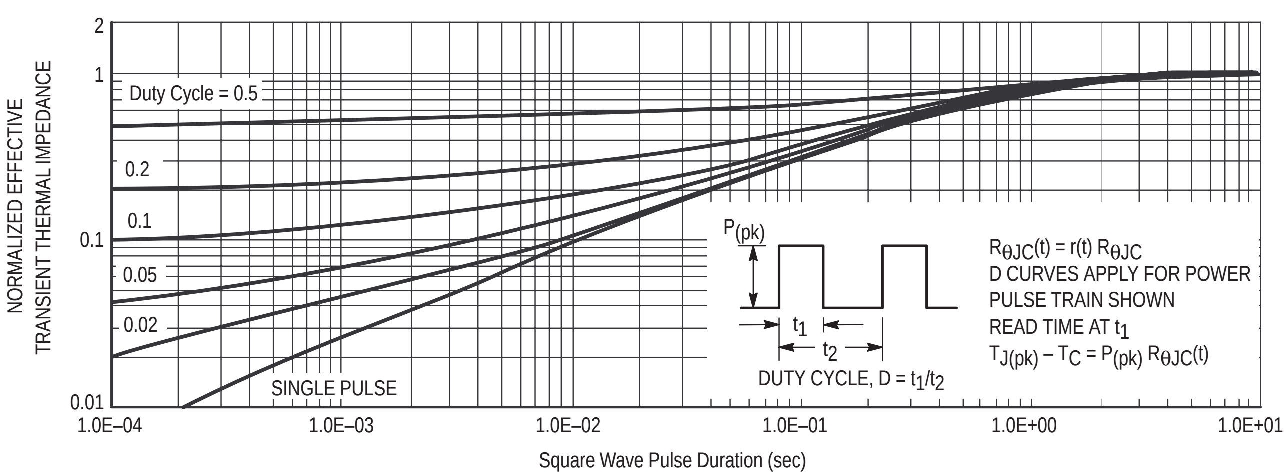

Figure 11. Normalized Thermal Transient Impedance, Junction–to–Ambient

GREEN LINE™

Preliminary Information

MGSF3454XT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 50 mΩ (TYP)

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

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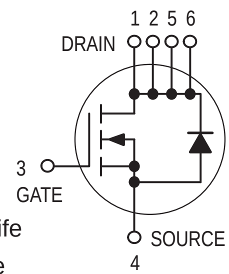

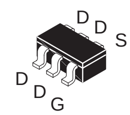

CASE 318G–02, Style 1
TSOP 6 PLASTIC

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \leq 10$ µs)	I_D I_{DM}	1.75 20	A
Total Power Dissipation @ T_A = 25°C	P_D	950	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	250	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

Device Marking = 3G

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3454XT1	7″	8 mm embossed tape	3000
MGSF3454XT3	13″	8 mm embossed tape	10,000

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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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)			—	—	25	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 1.75 A)		$r_{DS(on)}$	—	0.05	0.065	Ohms
(V_{GS} = 4.5 Vdc, I_D = 1.5 A)			—	0.07	0.095	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	345	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	215	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	140	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 10 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	10	—	ns
Rise Time		t_r	—	15	—	
Turn–Off Delay Time		$t_{d(off)}$	—	20	—	
Fall Time		t_f	—	10	—	
Gate Charge		Q_T	—	—	15	nC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage(2)		V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

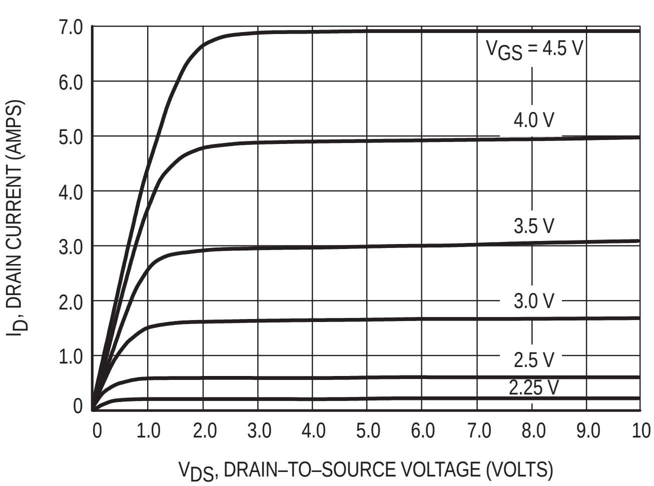

Figure 1. Output Characteristics

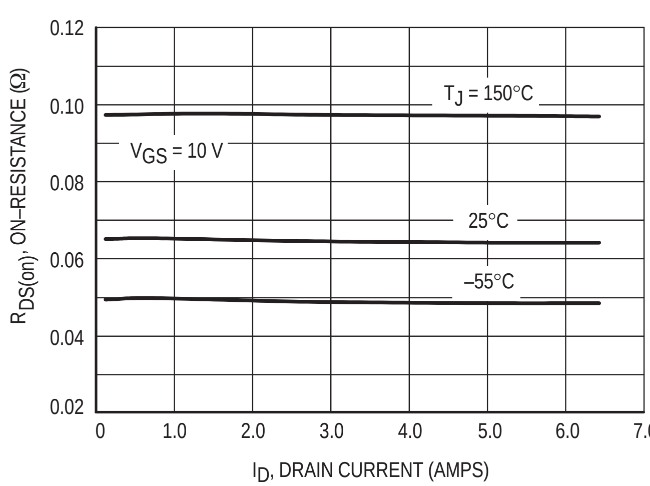

Figure 2. On–Resistance versus Drain Current

TYPICAL ELECTRICAL CHARACTERISTICS

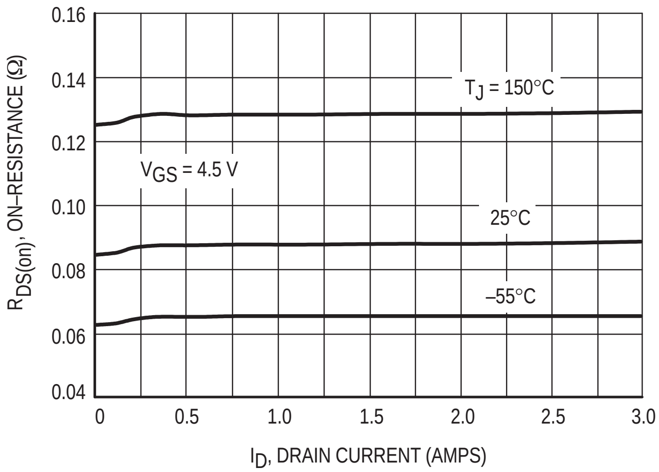

Figure 3. On–Resistance versus Drain Current

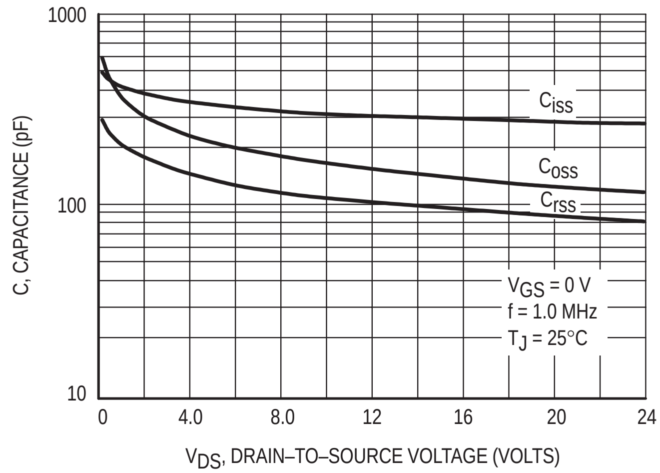

Figure 4. Capacitance

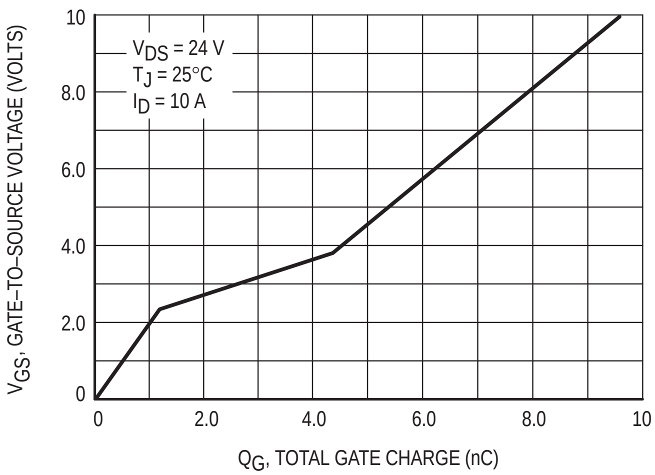

Figure 5. Gate Charge

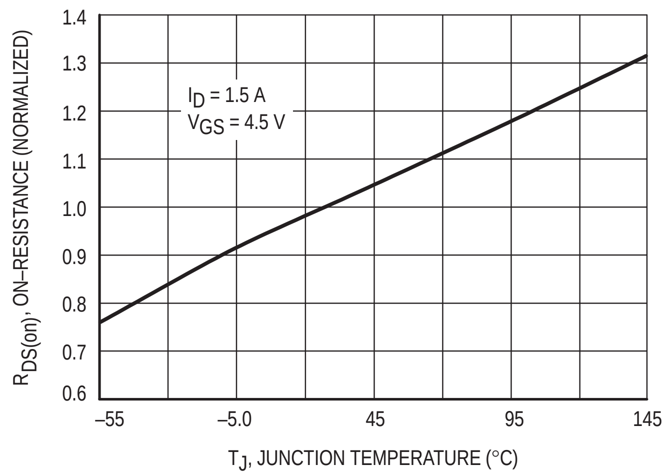

Figure 6. On–Resistance versus Junction Temperature

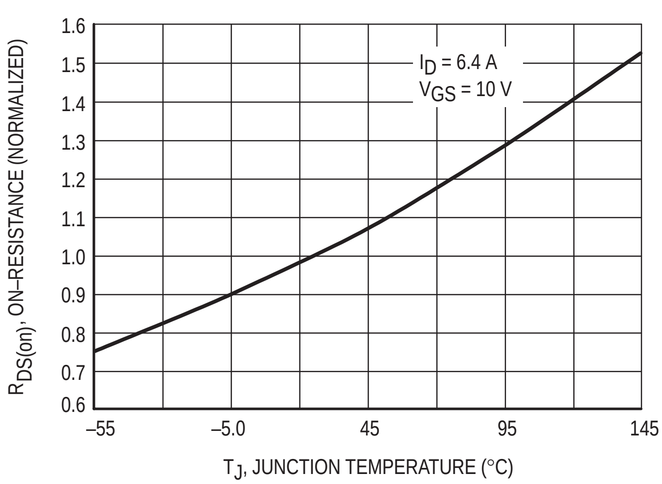

Figure 7. On–Resistance versus Junction Temperature

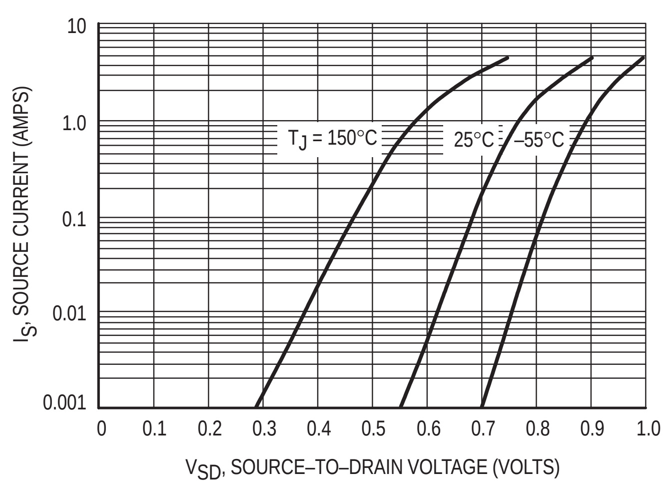

Figure 8. Source–Drain Diode Forward Voltage

TYPICAL ELECTRICAL CHARACTERISTICS

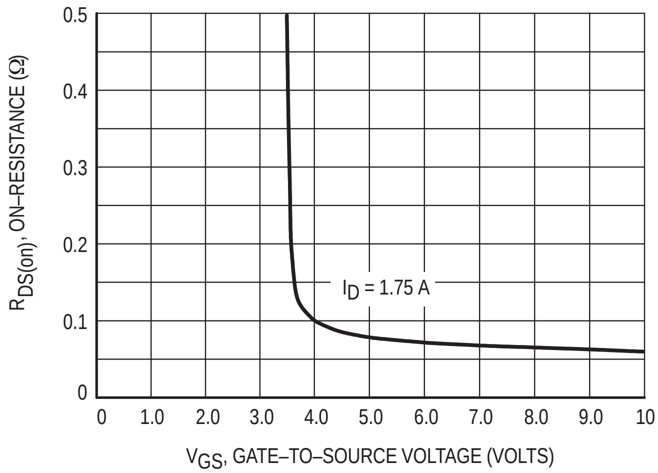

Figure 9. On–Resistance versus Gate–to–Source Voltage

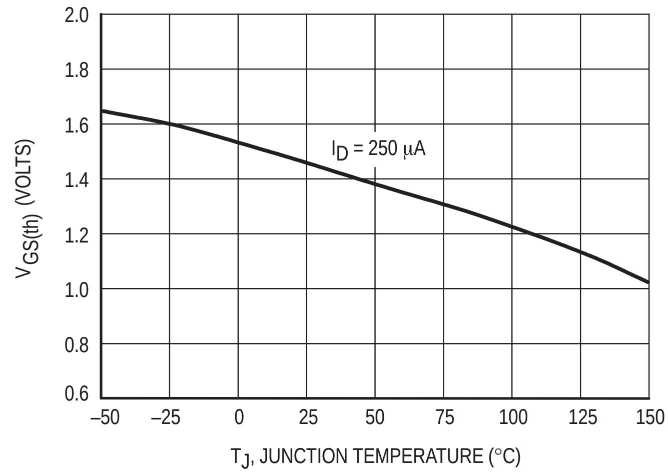

Figure 10. Threshold Voltage

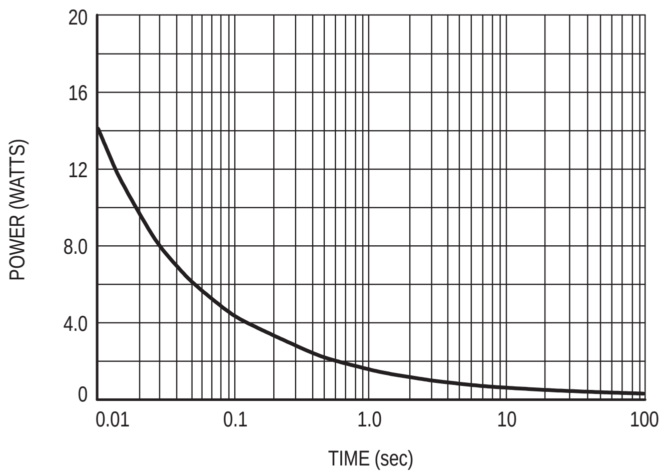

Figure 11. Single Pulse Power

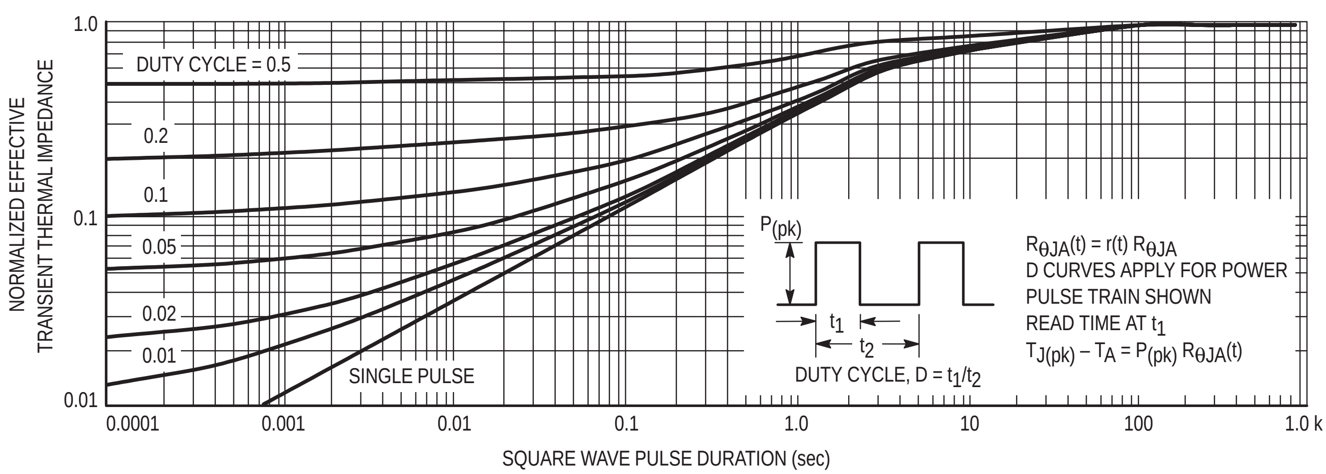

Figure 12. Normalized Thermal Transient Impedance, Junction–to–Ambient

GreenLine™

Preliminary Information

MGSF3455VT1

Motorola Preferred Device

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 80 mΩ (TYP)

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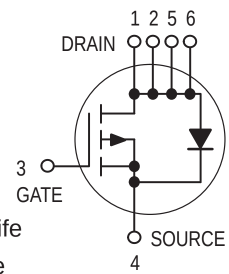

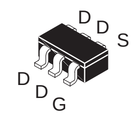

CASE 318G–02, Style 1
TSOP 6 PLASTIC

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10$ µs)	I_D I_{DM}	3.5 20	A
Total Power Dissipation @ T_A = 25°C Mounted on FR4 $t \le 5$ sec	P_D	2.0	W
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3455VT1	7″	8 mm embossed tape	3000
MGSF3455VT3	13″	8 mm embossed tape	10,000

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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 Vdc, I_D = 10 µA)		$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	µAdc
(V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)			—	—	5.0	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 µAdc)		$V_{GS(th)}$	1.0	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 3.5 A)		$r_{DS(on)}$	—	0.080	0.100	Ohms
(V_{GS} = 4.5 Vdc, I_D = 2.5 A)			—	0.134	0.190	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	10	20	ns
Rise Time		t_r	—	15	30	
Turn–Off Delay Time		$t_{d(off)}$	—	20	35	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	3000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage(2)		V_{SD}	—	—	1.2	V

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2%.
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TYPICAL ELECTRICAL CHARACTERISTICS

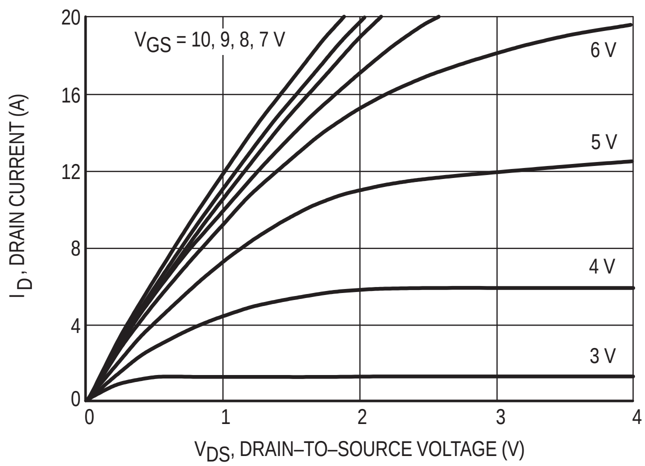


Figure 1. Output Characteristics

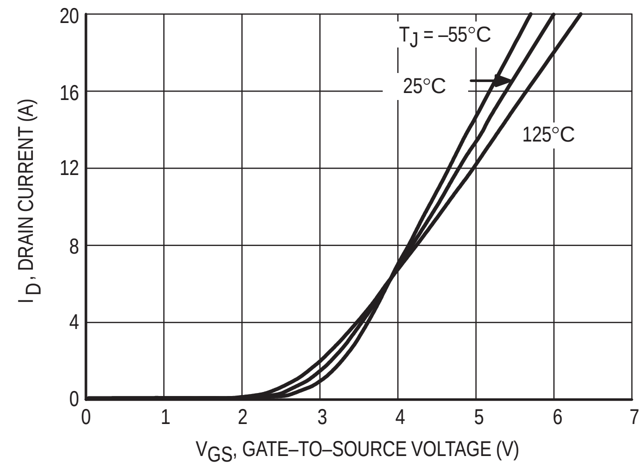


Figure 2. Transfer Characteristics

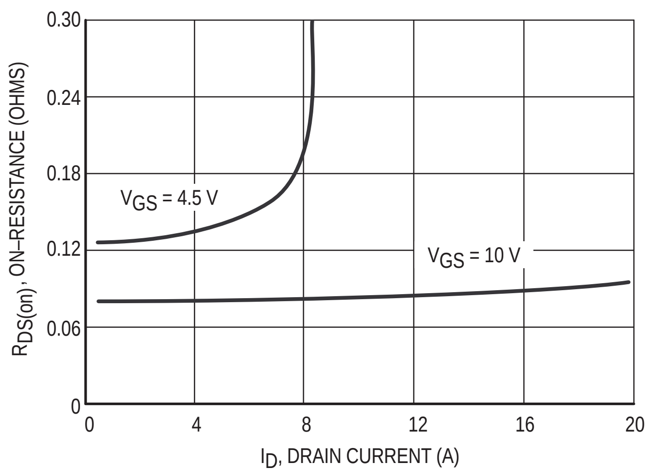


Figure 3. On–Resistance vs. Drain Current

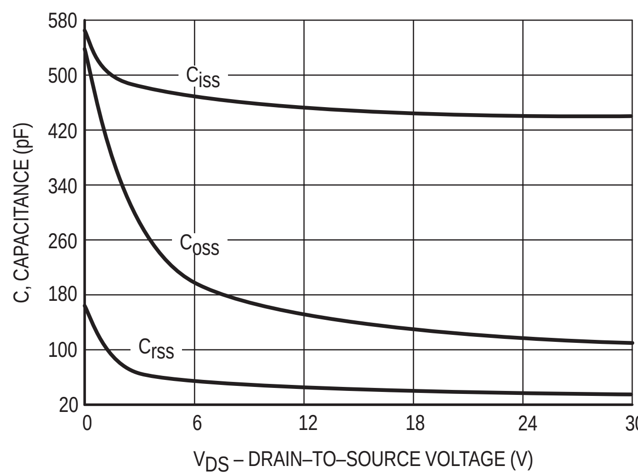


Figure 4. Capacitance

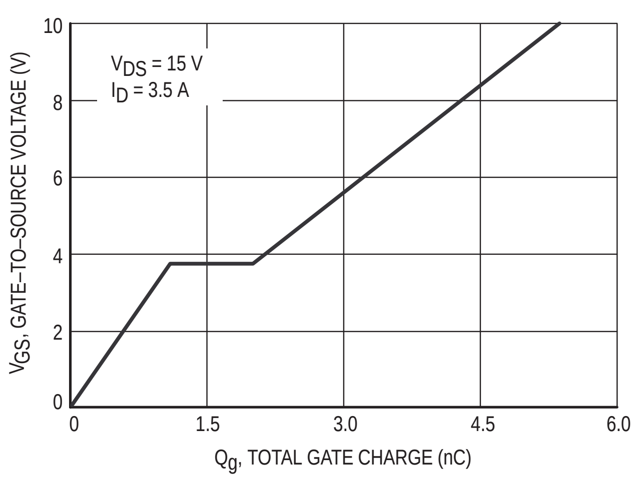


Figure 5. Gate Charge

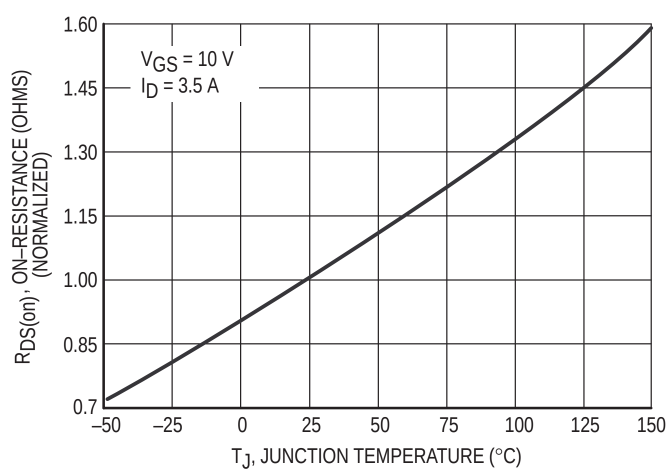


Figure 6. On–Resistance vs. Junction Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

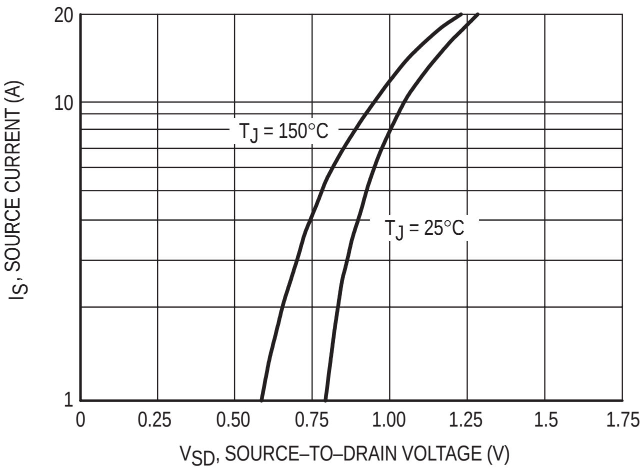


Figure 7. Source–Drain Diode Forward Voltage

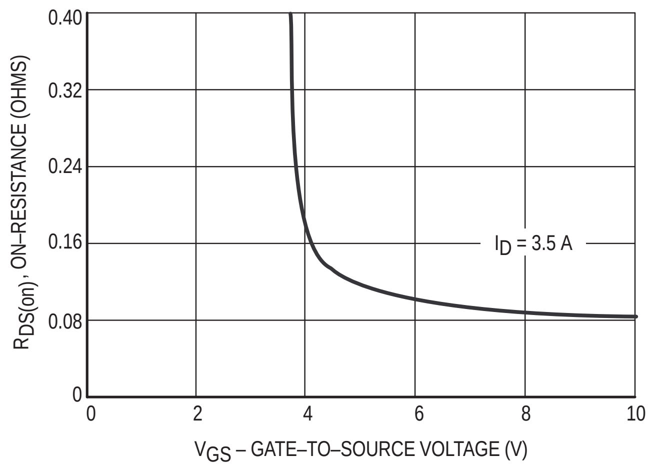


Figure 8. On–Resistance vs. Gate–to–Source Voltage

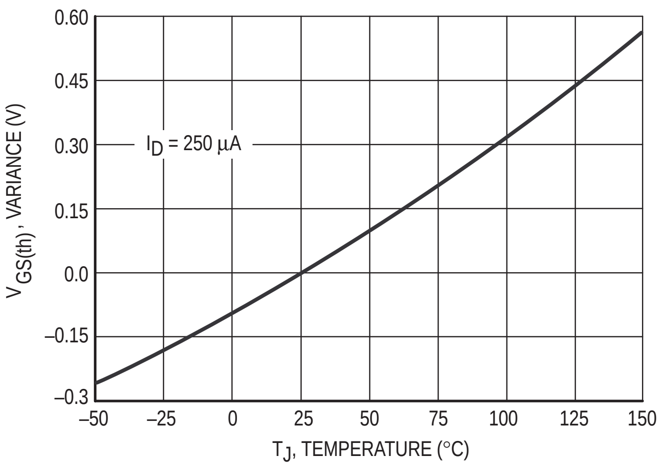


Figure 9. Threshold Voltage

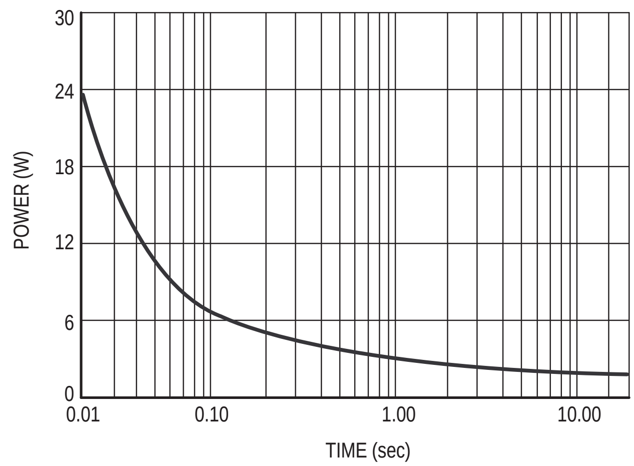


Figure 10. Single Pulse Power

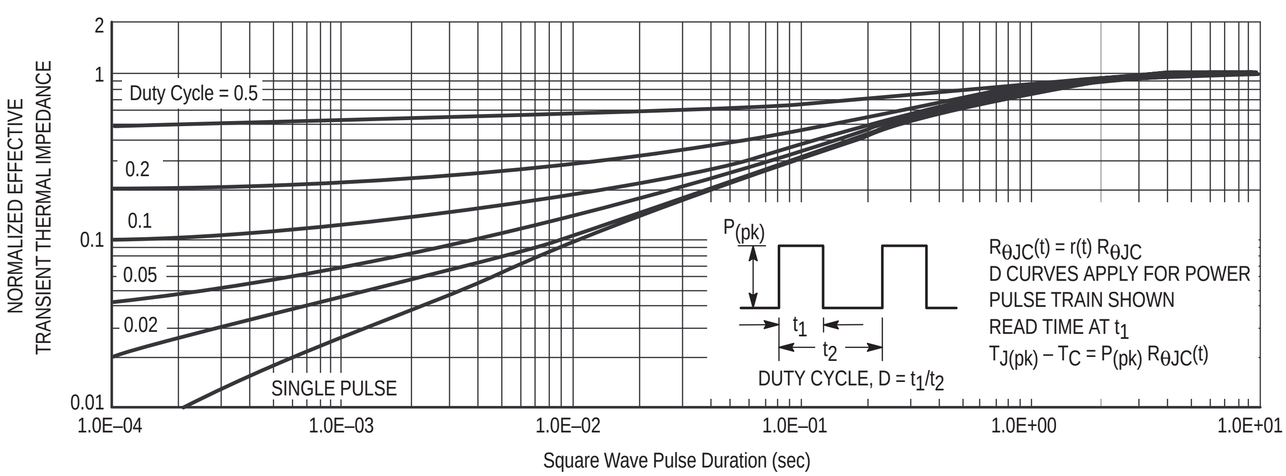


Figure 11. Normalized Thermal Transient Impedance, Junction–to–Ambient

GREEN LINE™

Preliminary Information

MGSF3455XT1

Motorola Preferred Device

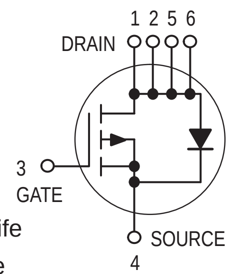
Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

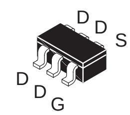
P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 80 mΩ (TYP)

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature TSOP 6 Surface Mount Package Saves Board Space
- Visit our Web Site at http://www.mot–sps.com/ospd





CASE 318G–02, Style 1
TSOP 6 PLASTIC

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	30	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_{DM}	1.45 10	A
Total Power Dissipation @ T_A = 25°C	P_D	400	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	300	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MGSF3455XT1	7″	8 mm embossed tape	3000
MGSF3455XT3	13″	8 mm embossed tape	10,000

This document contains information on a product under development. Motorola reserves the right to change or discontinue this product without notice.

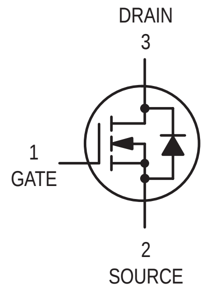
Preferred devices are Motorola recommended choices for future use and best overall value.

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

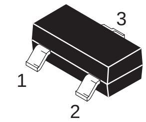
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain–to–Source Breakdown Voltage (V_{GS} = 0 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	30	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc, T_J = 70°C)		I_{DSS}	— —	— —	1.0 5.0	μAdc
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	—	—	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 1.45 A) (V_{GS} = 4.5 Vdc, I_D = 1.2 A)		$r_{DS(on)}$	— —	0.080 0.134	0.100 0.190	Ohms
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	90	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	50	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	10	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 1.0 A, V_{GEN} = 10 V, R_L = 10 Ω)	$t_{d(on)}$	—	10	20	ns
Rise Time		t_r	—	15	30	
Turn–Off Delay Time		$t_{d(off)}$	—	20	35	
Fall Time		t_f	—	10	20	
Gate Charge		Q_T	—	3000	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	1.0	A
Pulsed Current		I_{SM}	—	—	5.0	A
Forward Voltage(2)		V_{SD}	—	0.85	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TMOS FET Transistor
N–Channel



MMBF170LT1



CASE 318–08, STYLE 21
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	60	Vdc
Drain–Gate Voltage	V_{DGS}	60	Vdc
Gate–Source Voltage — Continuous — Non–repetitive ($t_p \leq 50$ μs)	 V_{GS} V_{GSM}	 ±20 ±40	 Vdc Vpk
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(1) $T_A = 25°C$ 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

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 (2)					
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	Ω
On–State Drain Current ($V_{DS} = 25$ Vdc, $V_{GS} = 0$)		$I_{D(off)}$	—	0.5	μA
DYNAMIC CHARACTERISTICS					
Input Capacitance ($V_{DS} = 10$ Vdc, $V_{GS} = 0$ V, f = 1.0 MHz)		C_{iss}	—	60	pF
SWITCHING CHARACTERISTICS (2)					
Turn–On Delay Time	($V_{DD} = 25$ Vdc, $I_D = 500$ mA, $R_{gen} = 50$ Ω) Figure 1	$t_{d(on)}$	—	10	ns
Turn–Off Delay Time		$t_{d(off)}$	—	10	

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

REV 2

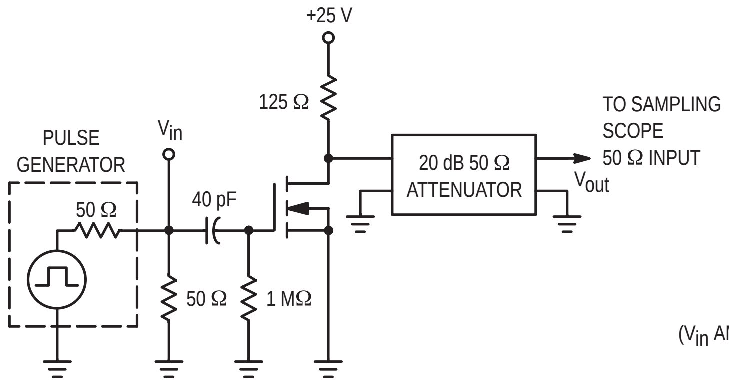


Figure 1. Switching Test Circuit

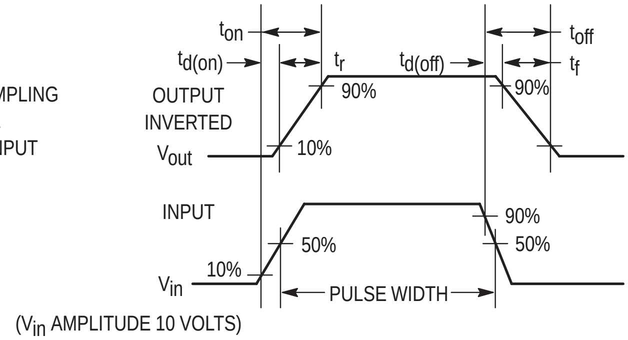


Figure 2. Switching Waveform

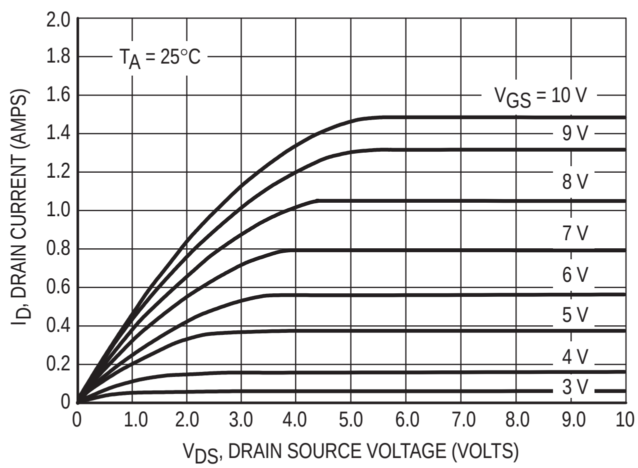


Figure 3. Ohmic Region

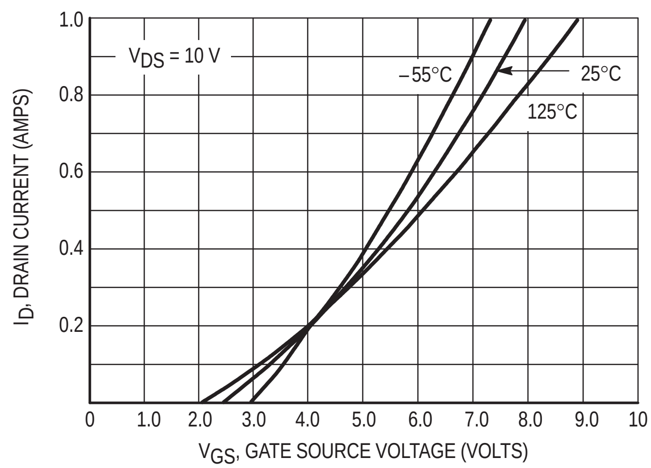


Figure 4. Transfer Characteristics

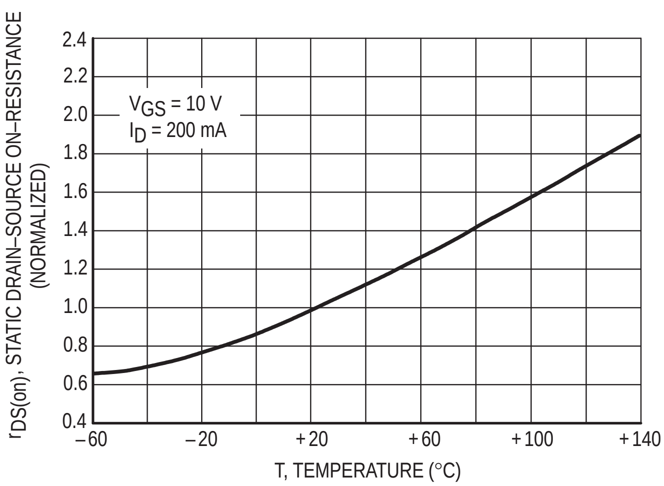


Figure 5. Temperature versus Static Drain–Source On–Resistance

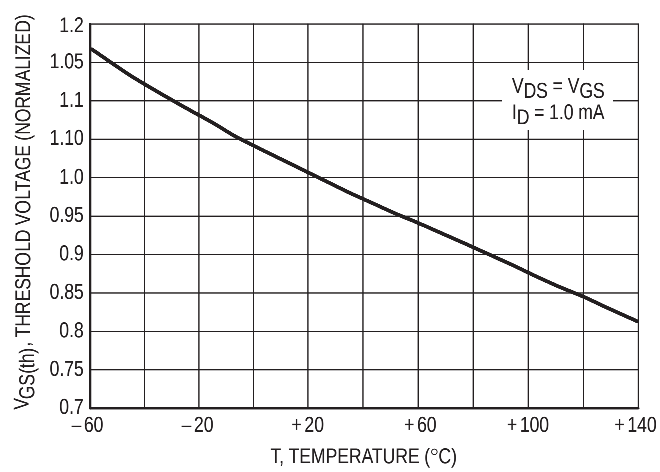


Figure 6. Temperature versus Gate Threshold Voltage

GREEN LINE™

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

MMBF0201NLT1

Motorola Preferred Device

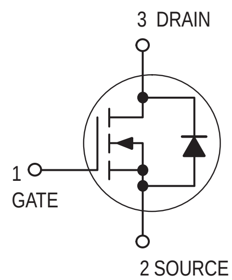
Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

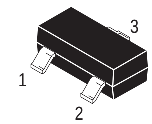
These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space

HD TMOS™

N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 1.0 OHM





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Continuous @ T_A = 70°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_D I_{DM}	300 240 750	mAdc
Total Power Dissipation @ T_A = 25°C(1)	P_D	225	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	556	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

DEVICE MARKING

N1

(1) Mounted on G10/FR4 glass epoxy board using minimum recommended footprint.

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMBF0201NLT1	7″	12 mm embossed tape	3000
MMBF0201NLT3	13″	12 mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 16 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 300 mAdc)		$r_{DS(on)}$	—	0.75	1.0	Ohms
(V_{GS} = 4.5 Vdc, I_D = 100 mAdc)			—	1.0	1.4	
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 200 mAdc)		g_{FS}	—	450	—	mMhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	45	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	25	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	5.0	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 300 mAdc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	2.5	—	
Turn–Off Delay Time		$t_{d(off)}$	—	15	—	
Fall Time		t_f	—	0.8	—	
Gate Charge (See Figure 5)		Q_T	—	1400	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.3	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	0.85	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

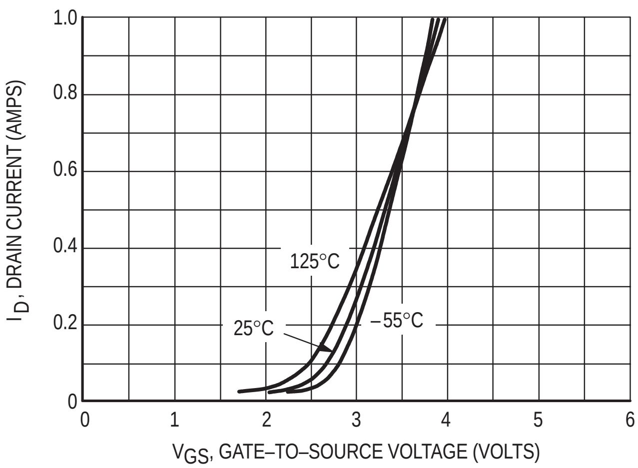


Figure 1. Transfer Characteristics

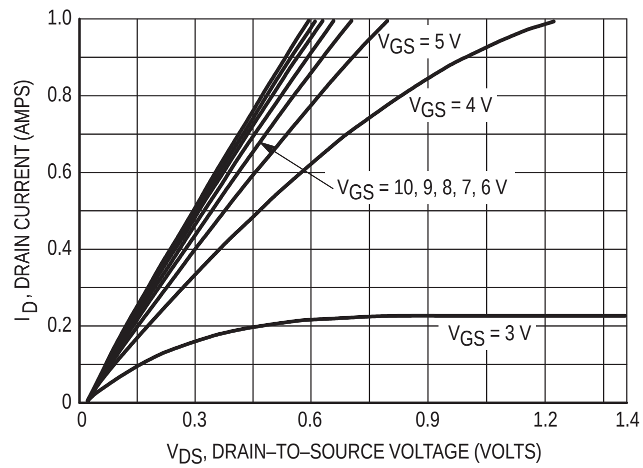


Figure 2. On–Region Characteristics

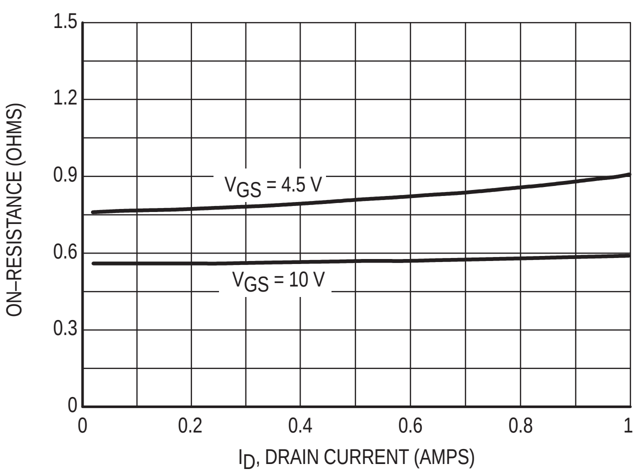


Figure 3. On–Resistance versus Drain Current

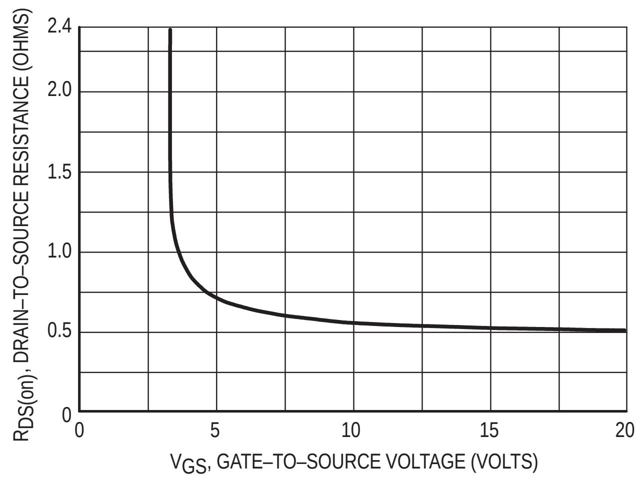


Figure 4. On–Resistance versus Gate–to–Source Voltage

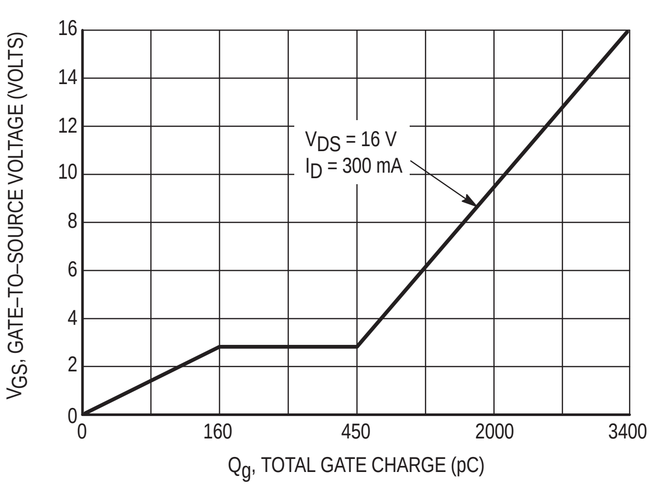


Figure 5. Gate Charge

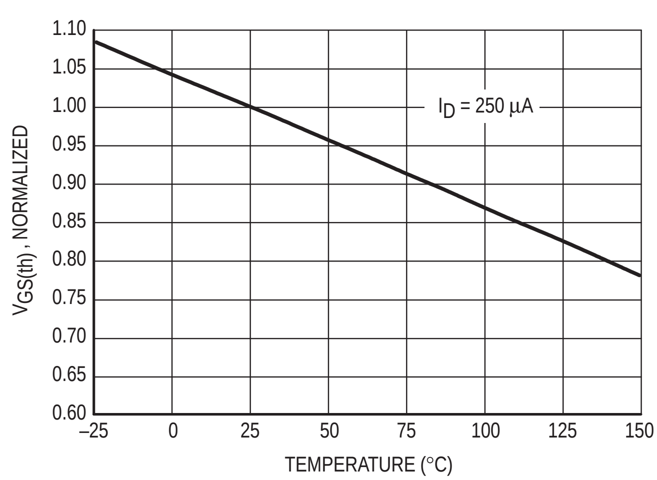


Figure 6. Threshold Voltage Variance Over Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

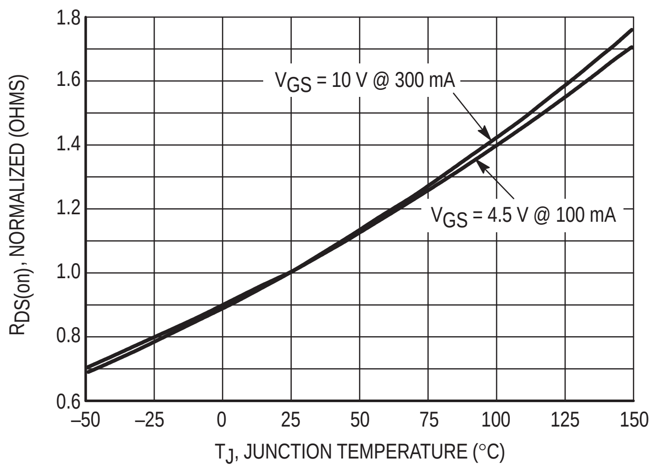


Figure 7. On–Resistance versus Junction Temperature

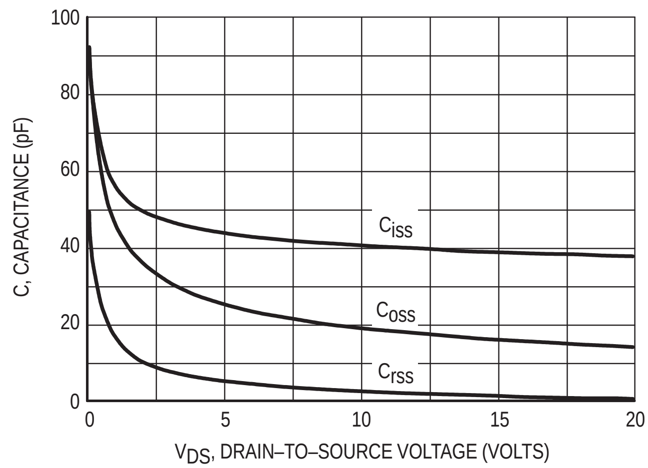


Figure 8. Capacitance

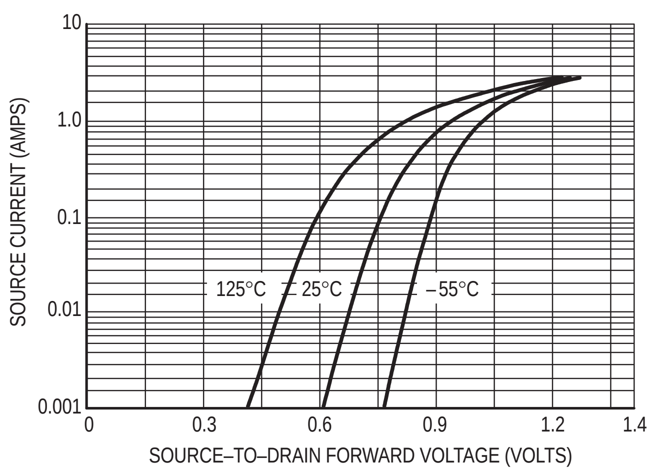


Figure 9. Source–to–Drain Forward Voltage versus Continuous Current (I_S)

GREEN LINE™

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

MMBF0202PLT1

Motorola Preferred Device

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

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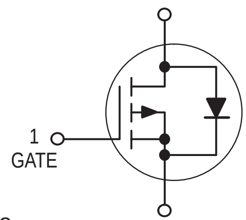
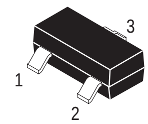
- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SOT–23 Surface Mount Package Saves Board Space

HD TMOS™

P–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 1.4 OHM





CASE 318–08, Style 21
SOT–23 (TO–236AB)

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Continuous @ T_A = 70°C — Pulsed Drain Current ($t_p \le 10\ \mu s$)	I_D I_D I_{DM}	300 240 750	mAdc
Total Power Dissipation @ T_A = 25°C(1)	P_D	225	mW
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	625	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

DEVICE MARKING

P3

(1) Mounted on G10/FR4 glass epoxy board using minimum recommended footprint.

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMBF0202PLT1	7″	12 mm embossed tape	3000
MMBF0202PLT3	13″	12 mm embossed tape	10,000

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

(Replaces MMBF0202P/D)

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 16 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 200 mAdc)		$r_{DS(on)}$	—	0.9	1.4	Ohms
(V_{GS} = 4.5 Vdc, I_D = 50 mAdc)			—	2.0	3.5	
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 200 mAdc)		g_{FS}	—	600	—	mMhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	50	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	45	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	20	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = –15 Vdc, R_L = 75 Ω, I_D = 200 mAdc, V_{GEN} = –10 V, R_G = 6.0 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 5)	(V_{DS} = 16 V, V_{GS} = 10 V, I_D = 200 mA)	Q_T	—	2700	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.3	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	1.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL ELECTRICAL CHARACTERISTICS

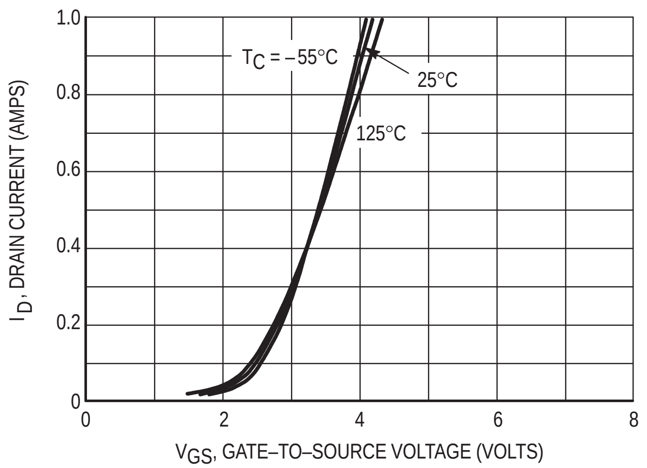


Figure 1. Transfer Characteristics

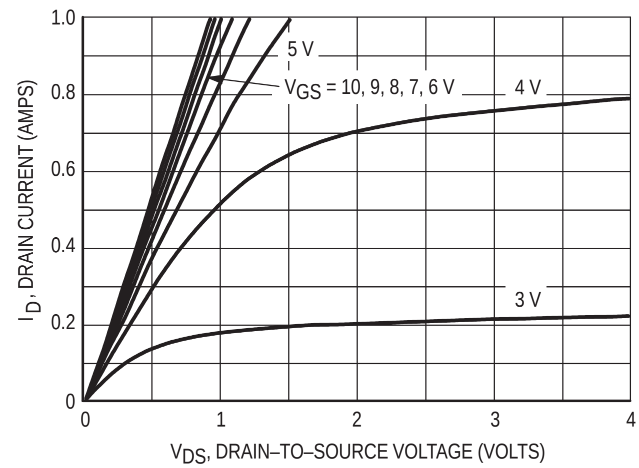


Figure 2. On–Region Characteristics

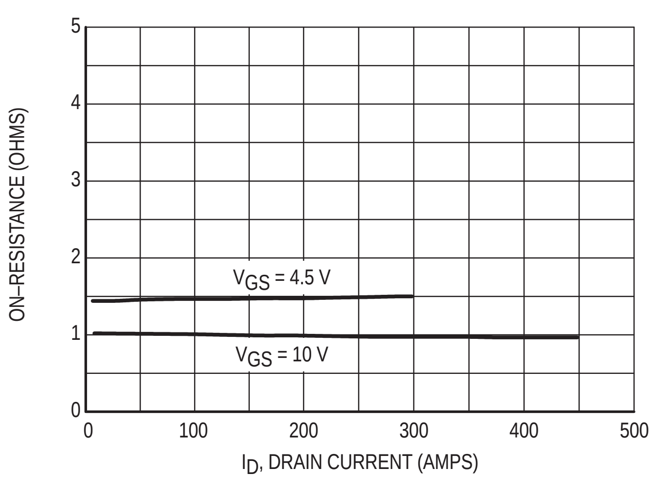


Figure 3. On–Resistance versus Drain Current

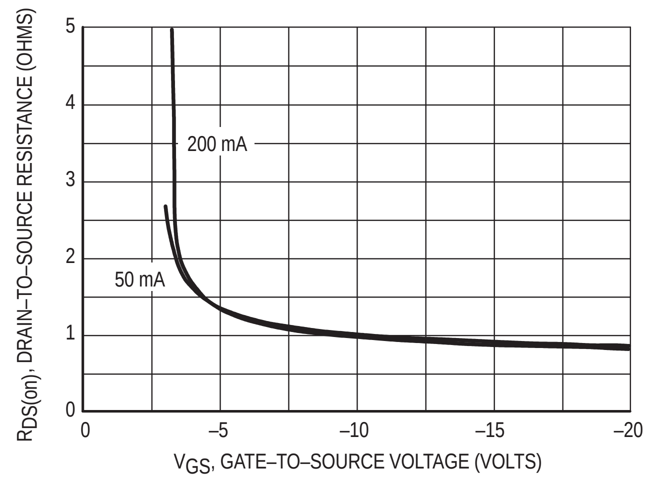


Figure 4. On–Resistance versus Gate–to–Source Voltage

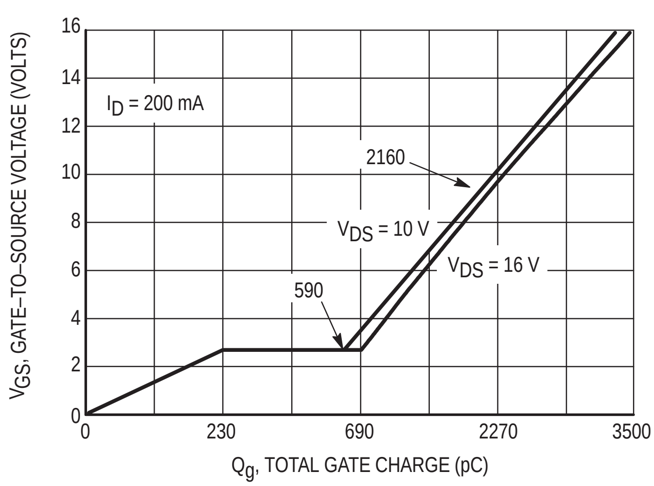


Figure 5. Gate Charge

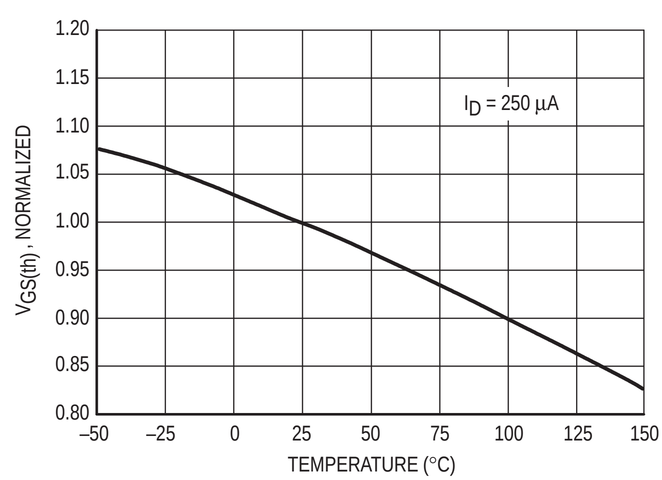


Figure 6. Threshold Voltage Variance Over Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

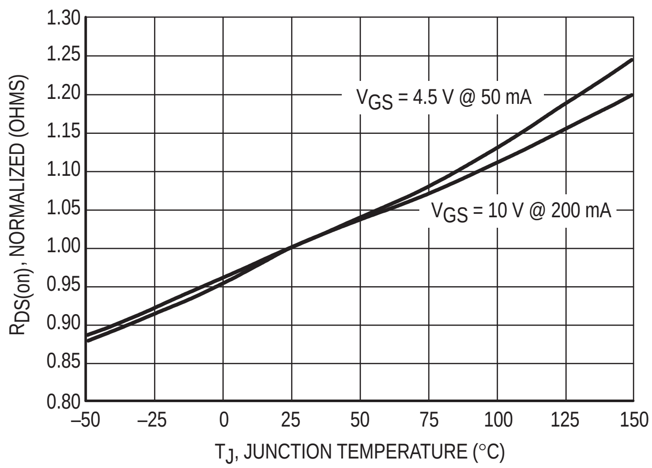


Figure 7. On–Resistance versus Junction Temperature

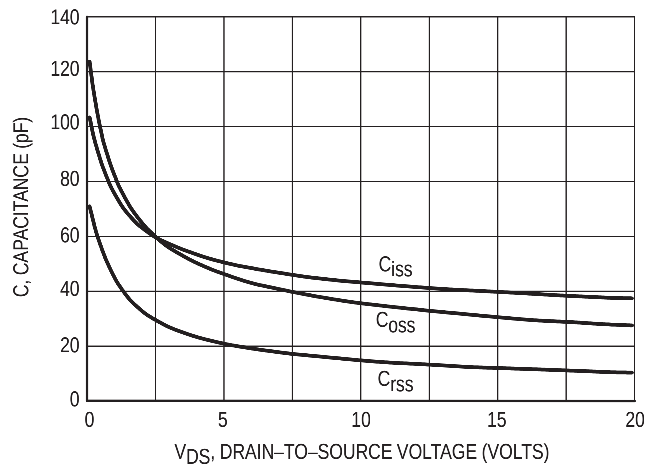


Figure 8. Capacitance

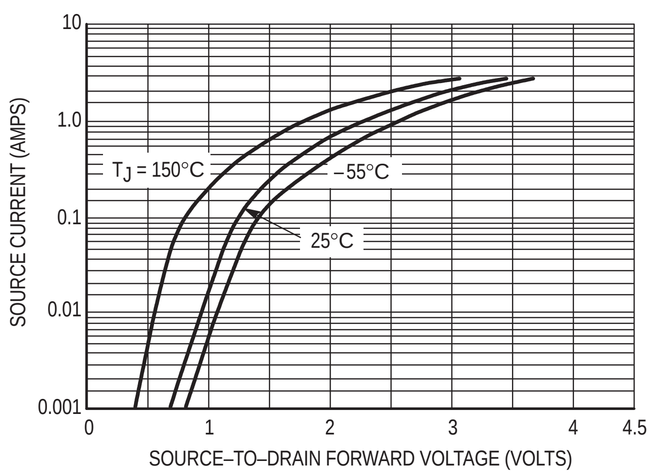


Figure 9. Source–to–Drain Forward Voltage versus Continuous Current (I_S)

GreenLine™

MMBF2201NT1

Motorola Preferred Device

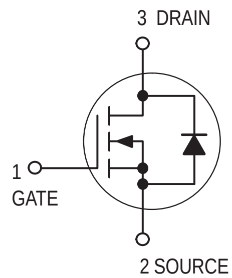
Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single N-Channel Field Effect Transistors

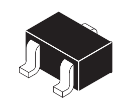
N–CHANNEL ENHANCEMENT–MODE TMOS MOSFET $r_{DS(on)}$ = 1.0 OHM

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SC–70/SOT–323 Surface Mount Package Saves Board Space





CASE 419–02, Style 7
SC–70/SOT–323

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Continuous @ T_A = 70°C — Pulsed Drain Current ($t_p \leq$ 10 μs)	I_D I_D I_{DM}	300 240 750	mAdc
Total Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	150 1.2	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	833	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

DEVICE MARKING

N1

(1) Mounted on G10/FR4 glass epoxy board using minimum recommended footprint.

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMBF2201NT1	7″	8 mm embossed tape	3000
MMBF2201NT3	13″	8 mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 10 µA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 16 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)		I_{DSS}	— —	— —	1.0 10	µAdc
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 µAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 300 mAdc) (V_{GS} = 4.5 Vdc, I_D = 100 mAdc)		$r_{DS(on)}$	— —	0.75 1.0	1.0 1.4	Ohms
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 200 mAdc)		g_{FS}	—	450	—	mMhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	45	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	25	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	5.0	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 300 mAdc, R_L = 50 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	2.5	—	
Turn–Off Delay Time		$t_{d(off)}$	—	15	—	
Fall Time		t_f	—	0.8	—	
Gate Charge (See Figure 5)		Q_T	—	1400	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.3	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	0.85	—	V

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL CHARACTERISTICS

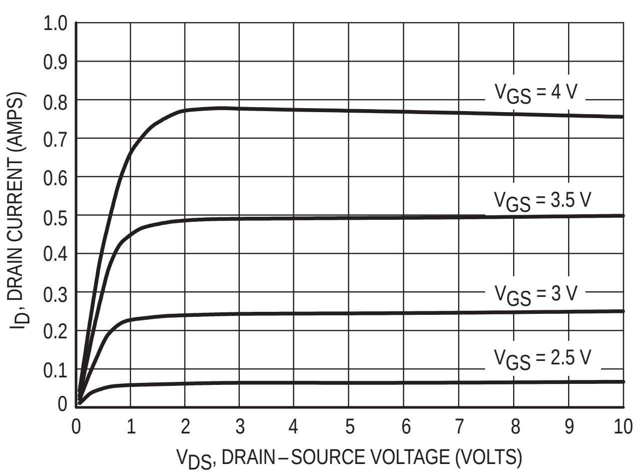


Figure 1. Typical Drain Characteristics

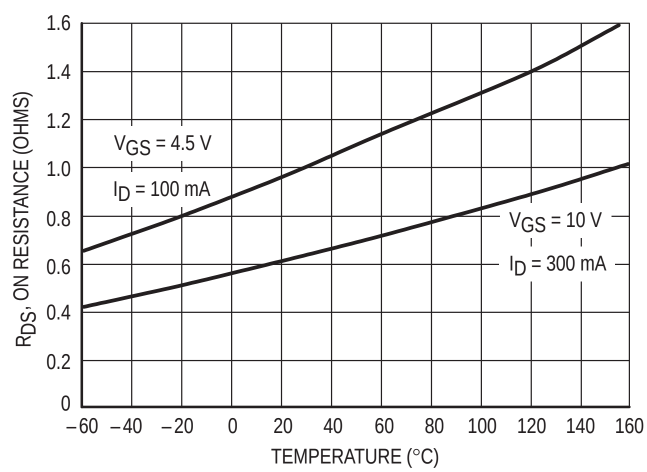


Figure 2. On Resistance versus Temperature

TYPICAL CHARACTERISTICS

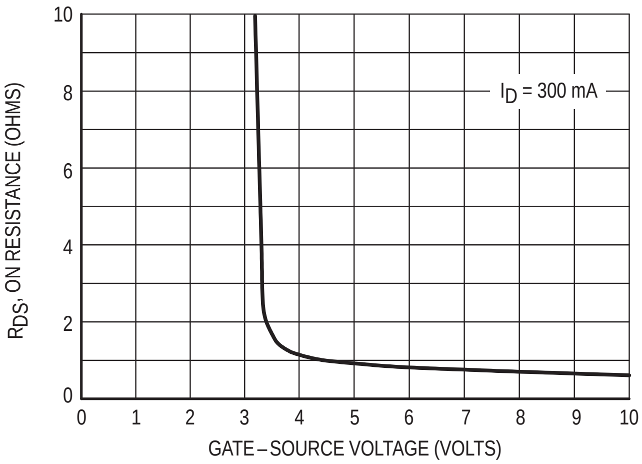


Figure 3. On Resistance versus Gate–Source Voltage

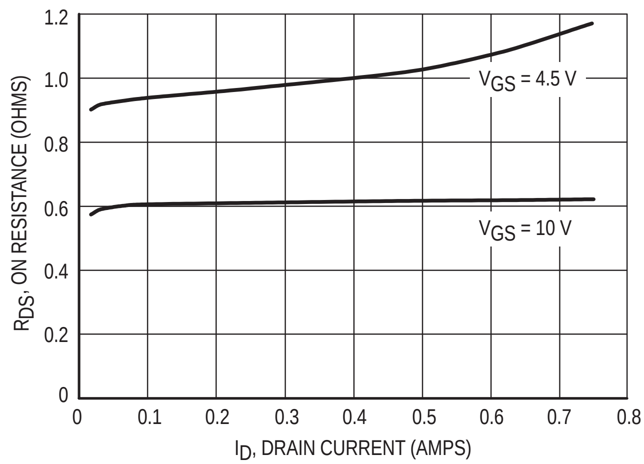


Figure 4. On Resistance versus Drain Current

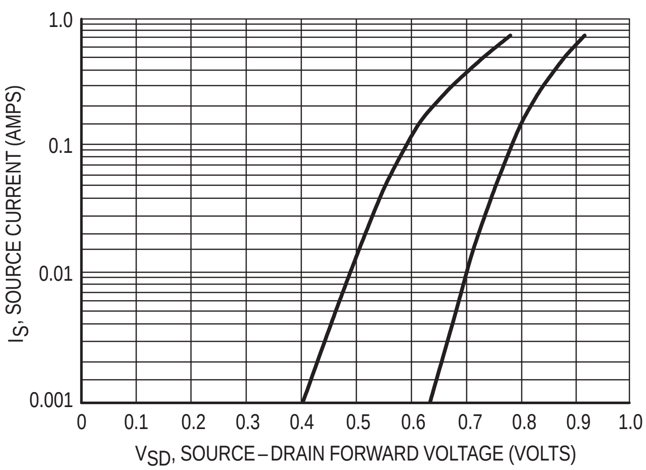


Figure 5. Source–Drain Forward Voltage

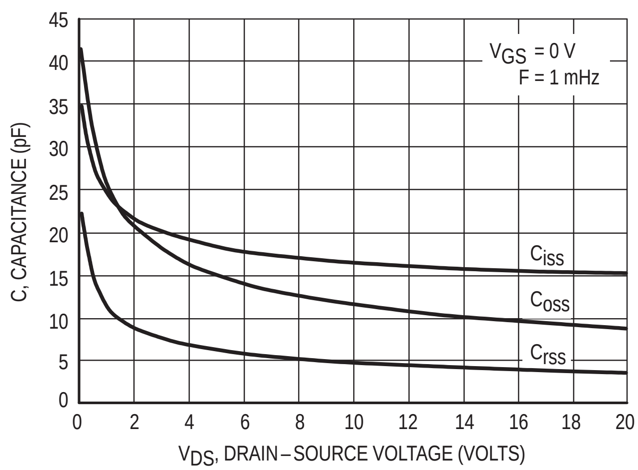


Figure 6. Capacitance Variation

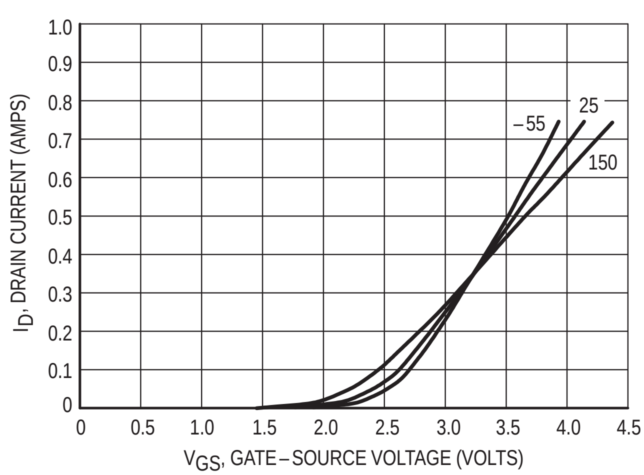


Figure 7. Transfer Characteristics

GREEN LINE™

Low $r_{DS(on)}$ Small-Signal MOSFETs TMOS Single P-Channel Field Effect Transistors

MMBF2202PT1

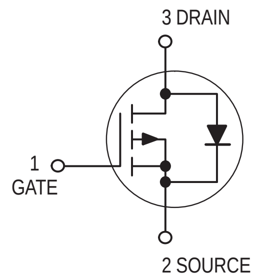
Motorola Preferred Device

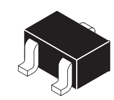
P–CHANNEL
ENHANCEMENT–MODE
TMOS MOSFET
$r_{DS(on)}$ = 2.2 OHM

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

These miniature surface mount MOSFETs utilize Motorola's High Cell Density, HDTMOS process. Low $r_{DS(on)}$ assures minimal power loss and conserves energy, making this device ideal for use in small power management circuitry. Typical applications are dc–dc converters, power management in portable and battery–powered products such as computers, printers, PCMCIA cards, cellular and cordless telephones.

- Low $r_{DS(on)}$ Provides Higher Efficiency and Extends Battery Life
- Miniature SC–70/SOT–323 Surface Mount Package Saves Board Space





CASE 419–02, STYLE 7
SC–70/SOT–323

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

Rating	Symbol	Value	Unit
Drain–to–Source Voltage	V_{DSS}	20	Vdc
Gate–to–Source Voltage — Continuous	V_{GS}	± 20	Vdc
Drain Current — Continuous @ T_A = 25°C — Continuous @ T_A = 70°C — Pulsed Drain Current ($t_p \leq 10\ \mu s$)	I_D I_D I_{DM}	300 240 750	mAdc
Total Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	150 1.2	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	– 55 to 150	°C
Thermal Resistance — Junction–to–Ambient	$R_{\theta JA}$	833	°C/W
Maximum Lead Temperature for Soldering Purposes, for 10 seconds	T_L	260	°C

DEVICE MARKING

P3

(1) Mounted on G10/FR4 glass epoxy board using minimum recommended footprint.

ORDERING INFORMATION

Device	Reel Size	Tape Width	Quantity
MMBF2202PT1	7″	8 mm embossed tape	3000
MMBF2202PT3	13″	8 mm embossed tape	10,000

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

REV 1

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 Vdc, I_D = 10 μA)		$V_{(BR)DSS}$	20	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 16 Vdc, V_{GS} = 0 Vdc)		I_{DSS}	—	—	1.0	μAdc
(V_{DS} = 16 Vdc, V_{GS} = 0 Vdc, T_J = 125°C)			—	—	10	
Gate–Body Leakage Current (V_{GS} = ± 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	±100	nAdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μAdc)		$V_{GS(th)}$	1.0	1.7	2.4	Vdc
Static Drain–to–Source On–Resistance (V_{GS} = 10 Vdc, I_D = 200 mAdc)		$r_{DS(on)}$	—	1.5	2.2	Ohms
(V_{GS} = 4.5 Vdc, I_D = 50 mAdc)			—	2.0	3.5	
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 200 mAdc)		g_{FS}	—	600	—	mMhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 5.0 V)	C_{iss}	—	50	—	pF
Output Capacitance	(V_{DS} = 5.0 V)	C_{oss}	—	45	—	
Transfer Capacitance	(V_{DG} = 5.0 V)	C_{rss}	—	20	—	
SWITCHING CHARACTERISTICS(2)						
Turn–On Delay Time	(V_{DD} = –15 Vdc, R_L = 75 Ω, I_D = 200 mAdc, V_{GEN} = –10 V, R_G = 6.0 Ω)	$t_{d(on)}$	—	2.5	—	ns
Rise Time		t_r	—	1.0	—	
Turn–Off Delay Time		$t_{d(off)}$	—	16	—	
Fall Time		t_f	—	8.0	—	
Gate Charge (See Figure 5)	(V_{DS} = 16 V, V_{GS} = 10 V, I_D = 200 mA)	Q_T	—	2700	—	pC
SOURCE–DRAIN DIODE CHARACTERISTICS						
Continuous Current		I_S	—	—	0.3	A
Pulsed Current		I_{SM}	—	—	0.75	
Forward Voltage(2)		V_{SD}	—	1.5	—	V

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
(2) Switching characteristics are independent of operating junction temperature.

TYPICAL CHARACTERISTICS

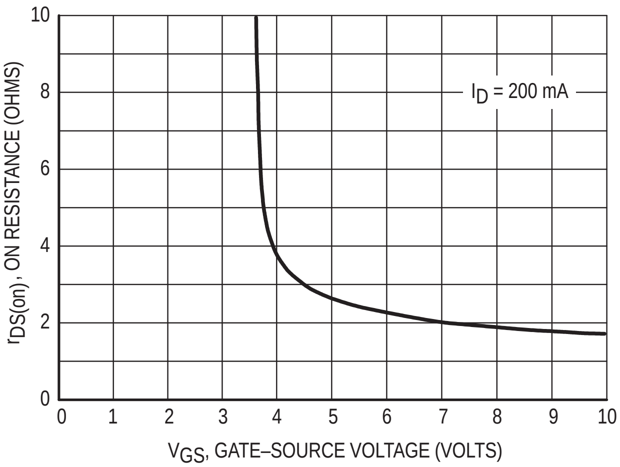


Figure 1. On Resistance versus Gate–Source Voltage

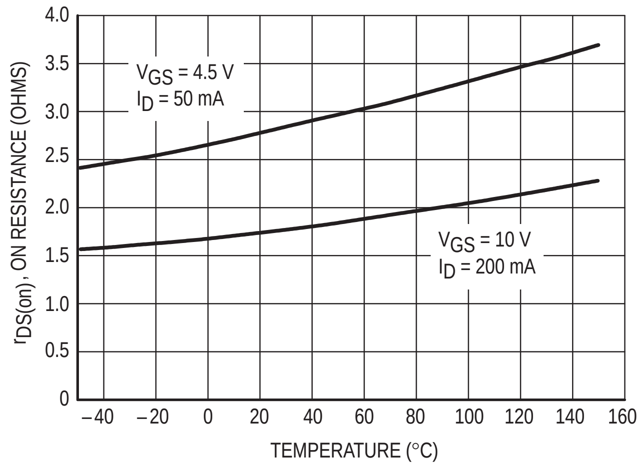


Figure 2. On Resistance versus Temperature

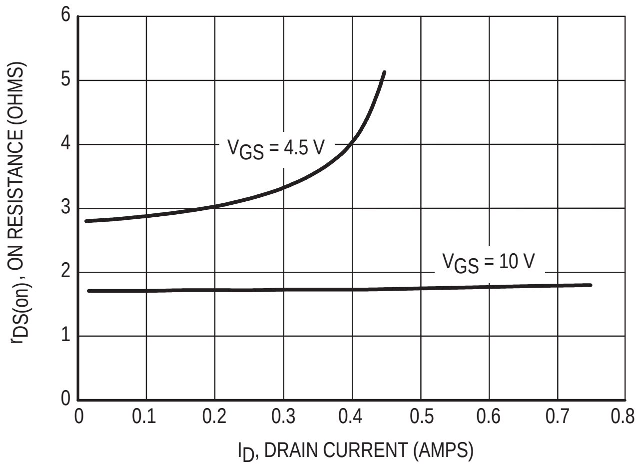


Figure 3. On Resistance versus Drain Current

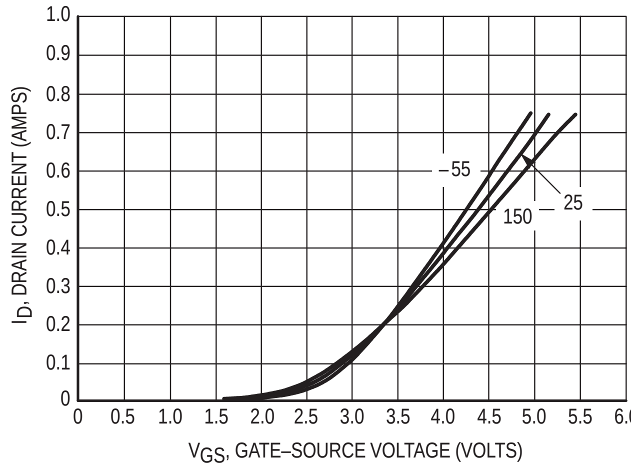


Figure 4. Transfer Characteristics

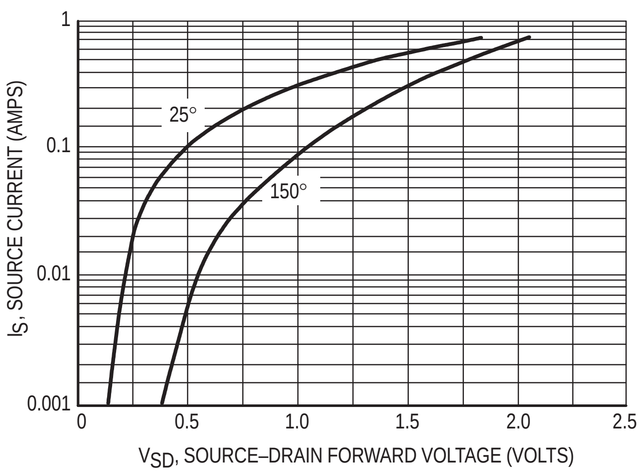


Figure 5. Source–Drain Forward Voltage

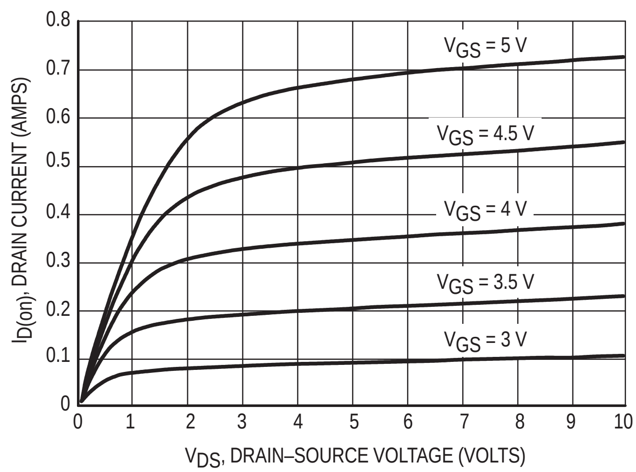


Figure 6. On Region Characteristics

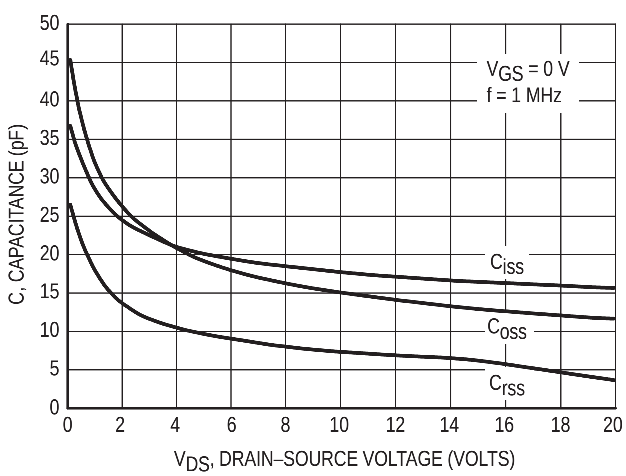


Figure 7. Capacitance Variation

Medium Power Field Effect Transistor

N–Channel Enhancement–Mode Silicon Gate TMOS SOT–223 for Surface Mount

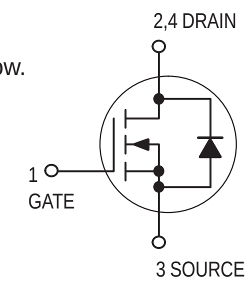
MMFT107T1

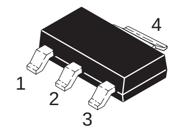
Motorola Preferred Device

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

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(1) 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 10	°C Sec

1. 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.

REV 3

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%.

TYPICAL ELECTRICAL CHARACTERISTICS

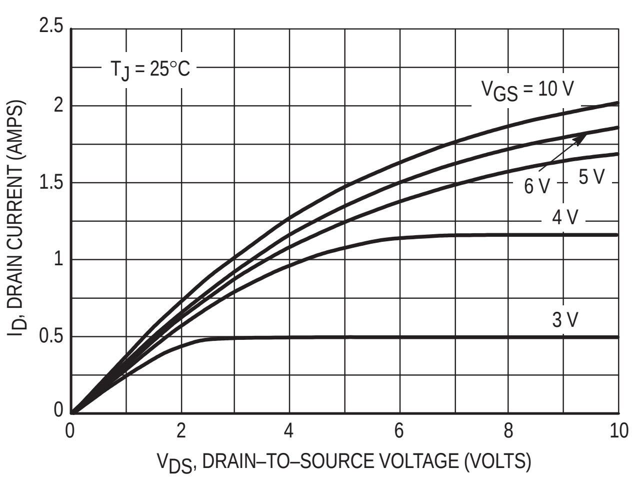


Figure 1. On–Region Characteristics

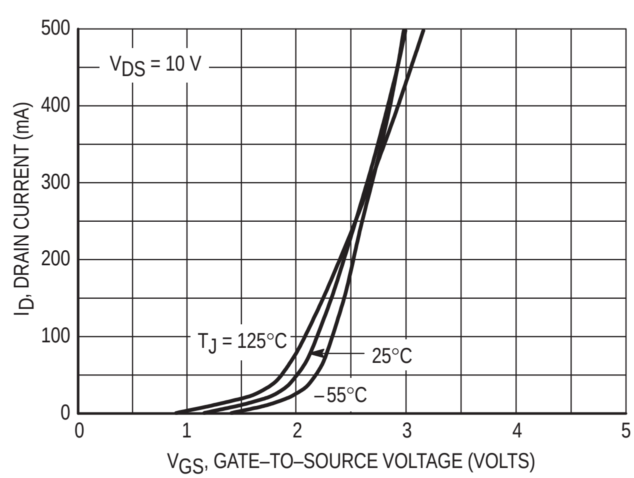


Figure 2. Transfer Characteristics

TYPICAL ELECTRICAL CHARACTERISTICS

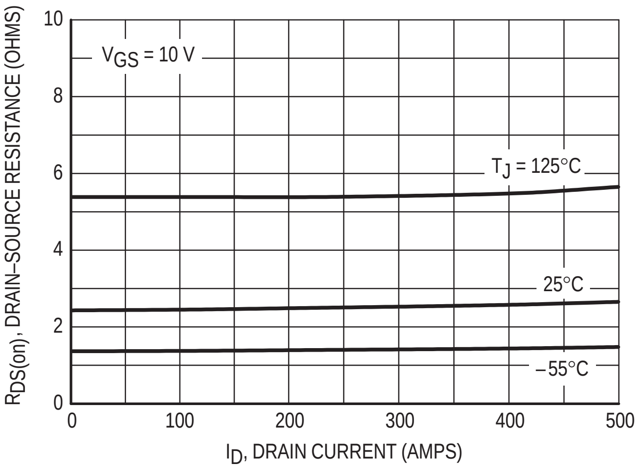


Figure 3. On–Resistance versus Drain Current

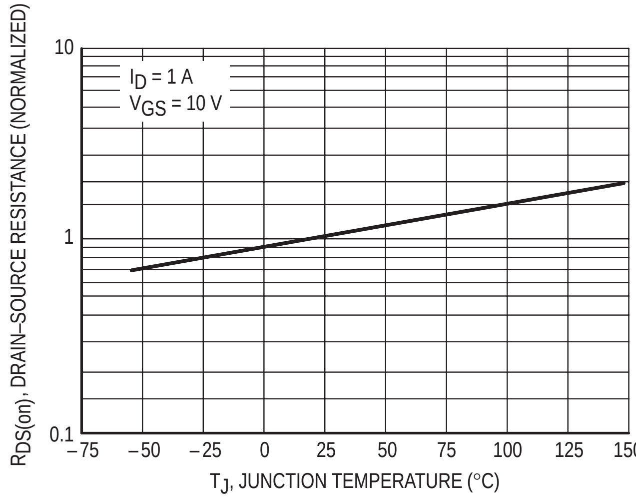


Figure 4. On–Resistance Variation with Temperature

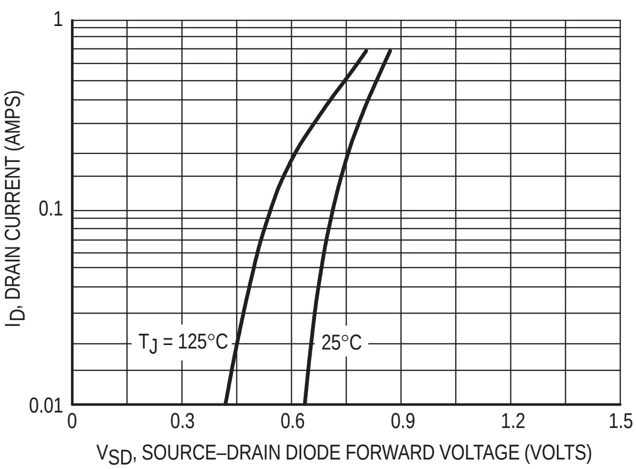


Figure 5. Source–Drain Diode Forward Voltage

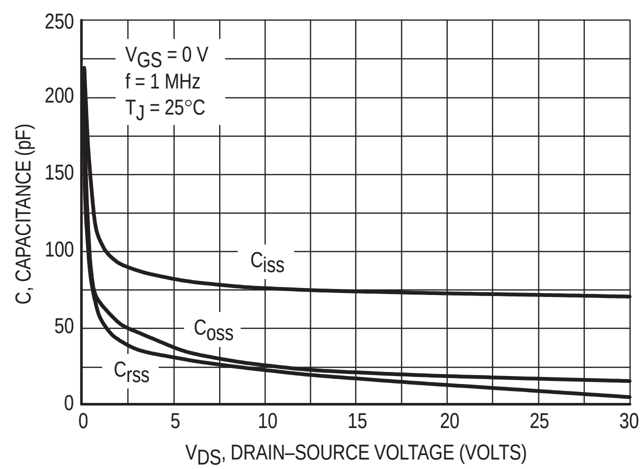


Figure 6. Capacitance Variation

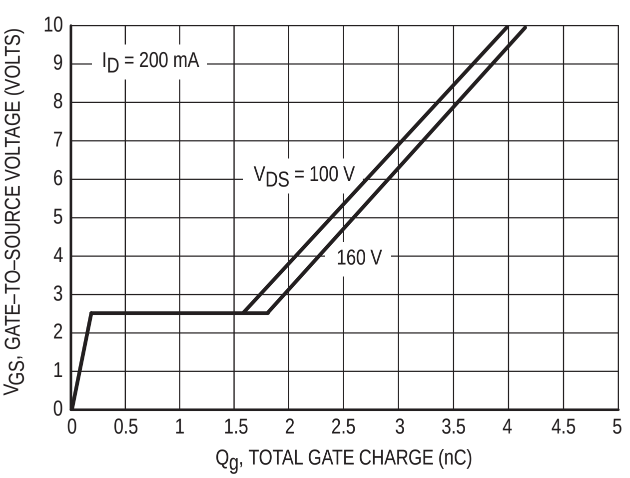


Figure 7. Gate Charge versus Gate–to–Source Voltage

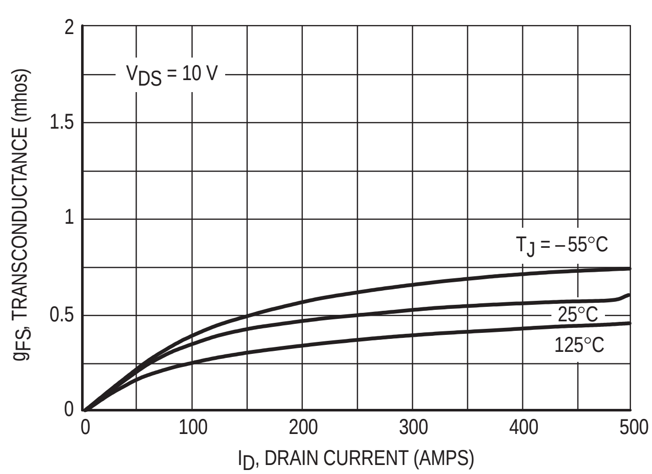


Figure 8. Transconductance

Medium Power Field Effect Transistor

N–Channel Enhancement–Mode Silicon Gate TMOS SOT–223 for Surface Mount

MMFT960T1

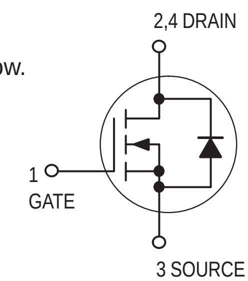
Motorola Preferred Device

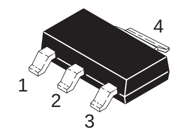
**MEDIUM POWER
TMOS FET
300 mA
60 VOLTS
$R_{DS(on)}$ = 1.7 OHM MAX**

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

TMOS®





**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(1) 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 10	°C Sec

1. Device mounted on a FR–4 glass epoxy printed circuit board using minimum recommended footprint.

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

REV 3

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

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
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%.

TYPICAL ELECTRICAL CHARACTERISTICS

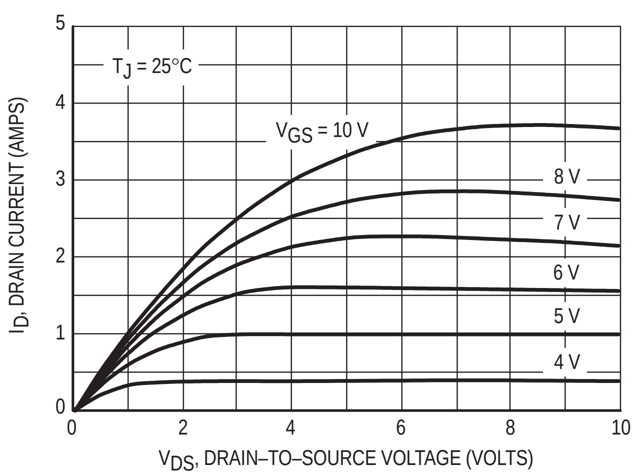


Figure 1. On–Region Characteristics

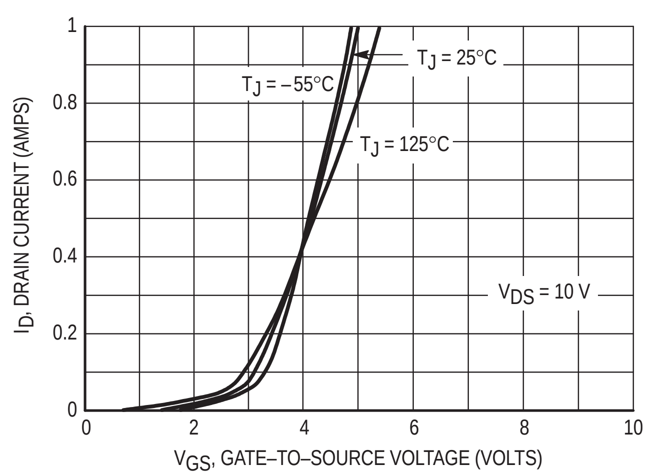


Figure 2. Transfer Characteristics

TYPICAL ELECTRICAL CHARACTERISTICS

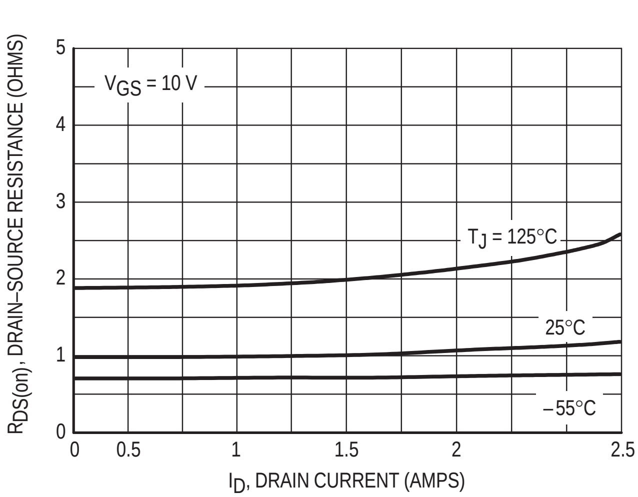


Figure 3. On–Resistance versus Drain Current

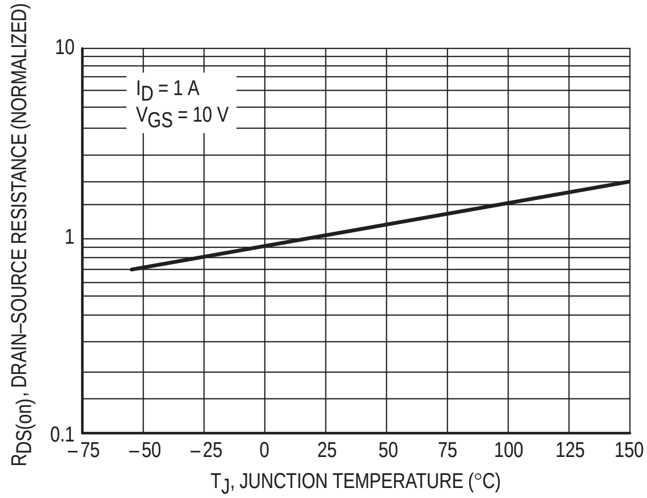


Figure 4. On–Resistance Variation with Temperature

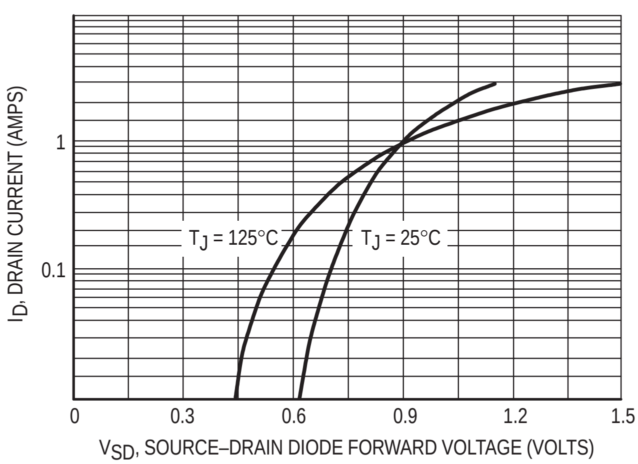


Figure 5. Source–Drain Diode Forward Voltage

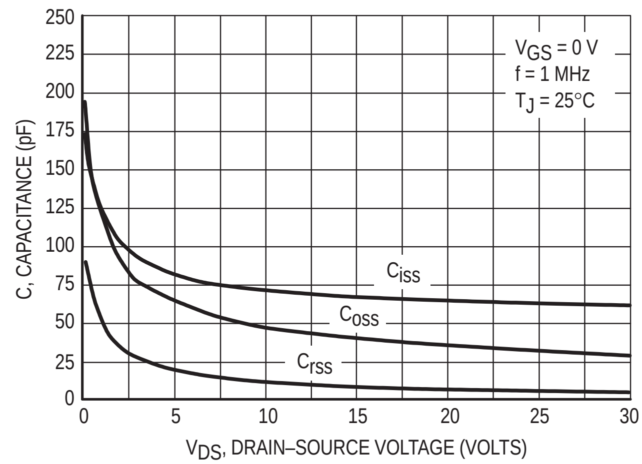


Figure 6. Capacitance Variation

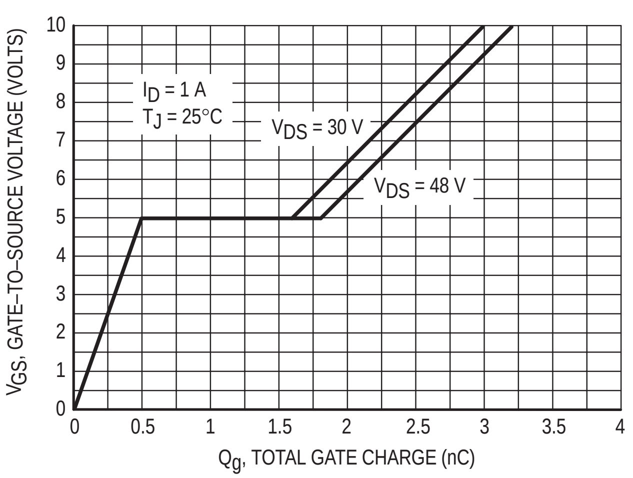


Figure 7. Gate Charge versus Gate–to–Source Voltage

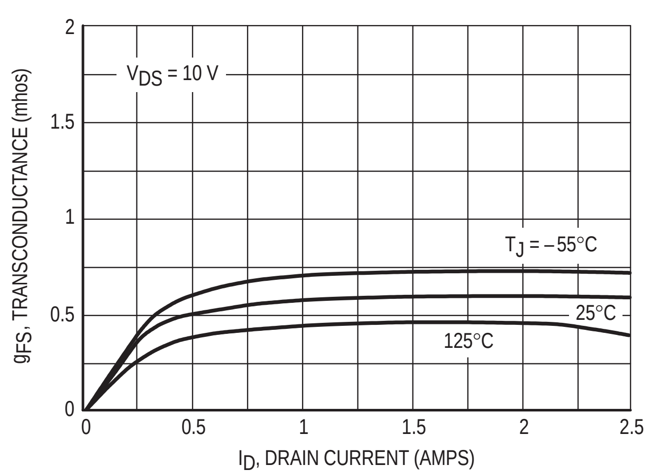


Figure 8. Transconductance

Medium Power Field Effect Transistor

N–Channel Enhancement Mode
Silicon Gate TMOS E–FET™
SOT–223 for Surface Mount

MMFT2406T1

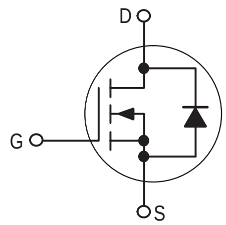
Motorola Preferred Device

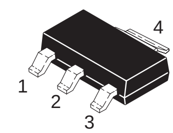
MEDIUM POWER
TMOS FET
700 mA
240 VOLTS
$R_{DS(on)}$ = 6.0 OHM

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.

TMOS®





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(1) 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)(1)	$R_{\theta JA}$	83.3	°C/W
Lead Temperature for Soldering Purposes, 1/16″ from case Time in Solder Bath	T_L	260 10	°C Sec

1. 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.

REV 1

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(2)				
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} = 2.5 Vdc, I_D = 0.1 Adc) (V_{GS} = 10 Vdc, I_D = 0.5 Adc)	$R_{DS(on)}$	 — —	 10 6.0	Ohms
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

Characteristics	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	
Transfer Capacitance		C_{rss}	—	20	

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

Medium Power Field Effect Transistor

N–Channel Enhancement–Mode Silicon Gate TMOS SOT–223 for Surface Mount

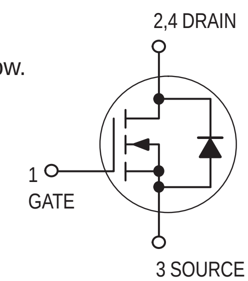
MMFT6661T1

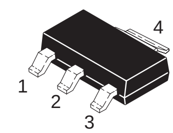
Motorola Preferred Device

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(1) 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 10	°C Sec

1. Device mounted on FR–4 glass epoxy printed circuit board using minimum recommended footprint.

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

REV 4

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(2)						
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	—	

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

TYPICAL ELECTRICAL CHARACTERISTICS

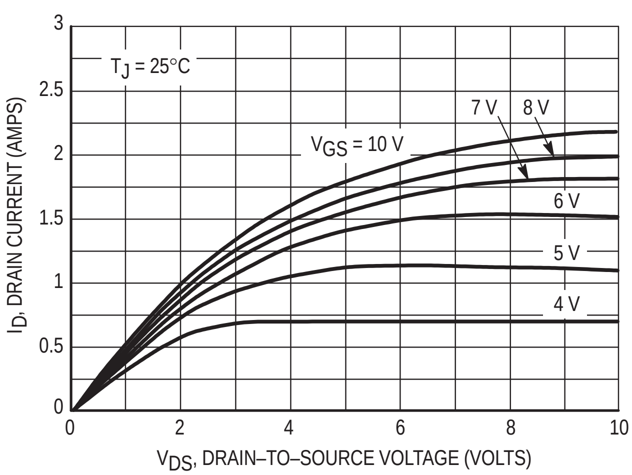


Figure 1. On–Region Characteristics

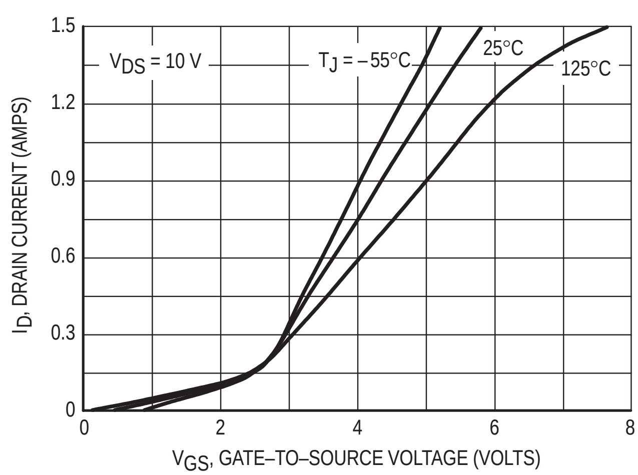


Figure 2. Transfer Characteristics

TYPICAL ELECTRICAL CHARACTERISTICS

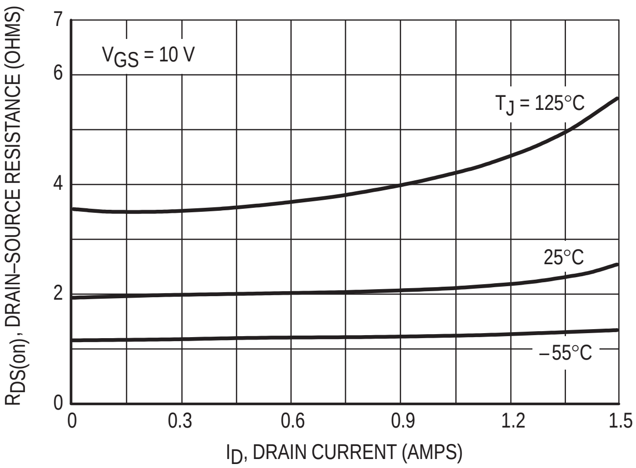


Figure 3. On–Resistance versus Drain Current

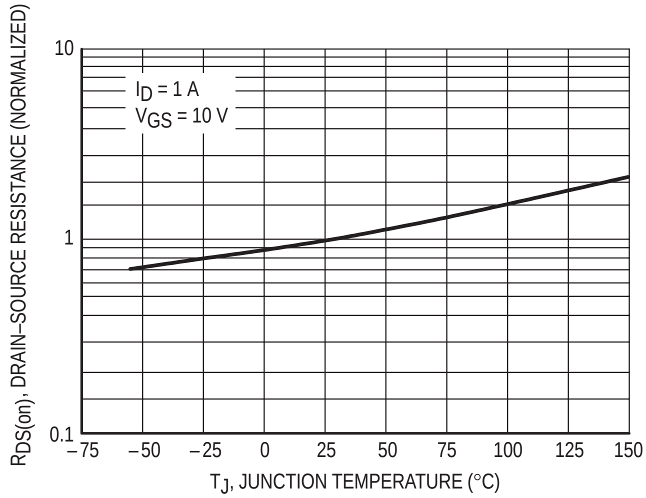


Figure 4. On–Resistance Variation with Temperature

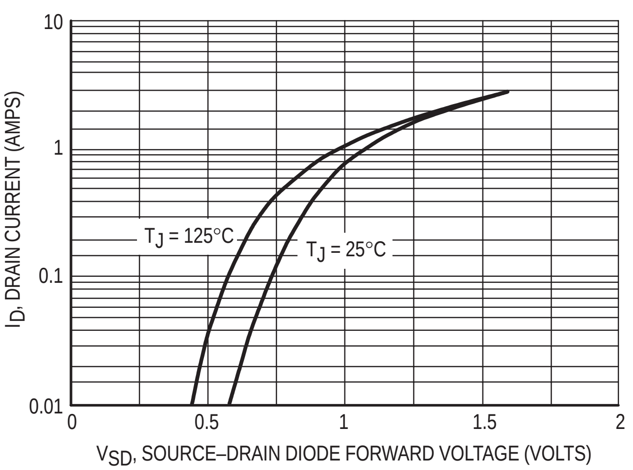


Figure 5. Source–Drain Diode Forward Voltage

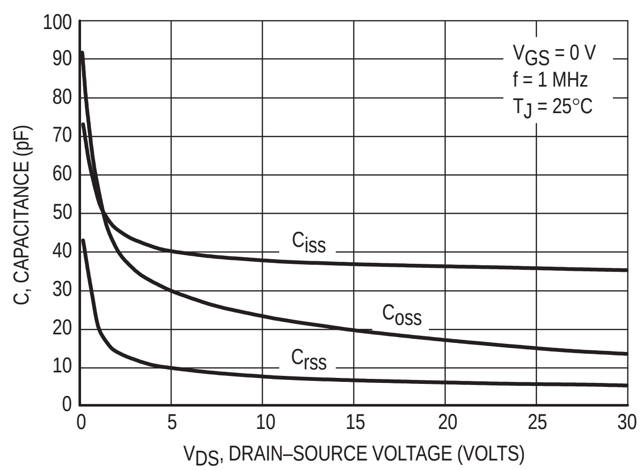


Figure 6. Capacitance versus Drain–Source Voltage

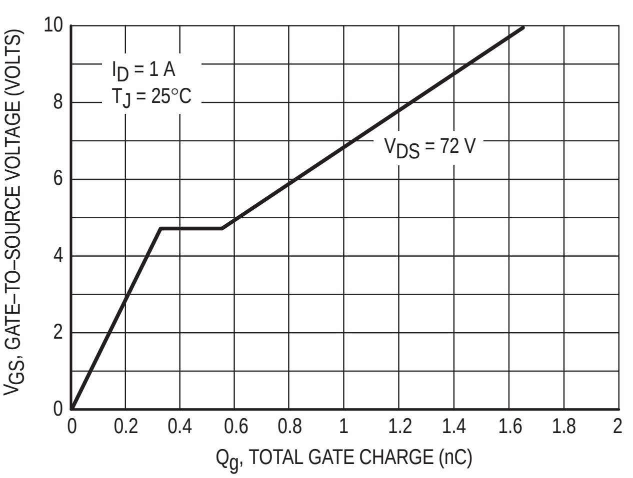


Figure 7. Gate Charge versus Gate–to–Source Voltage

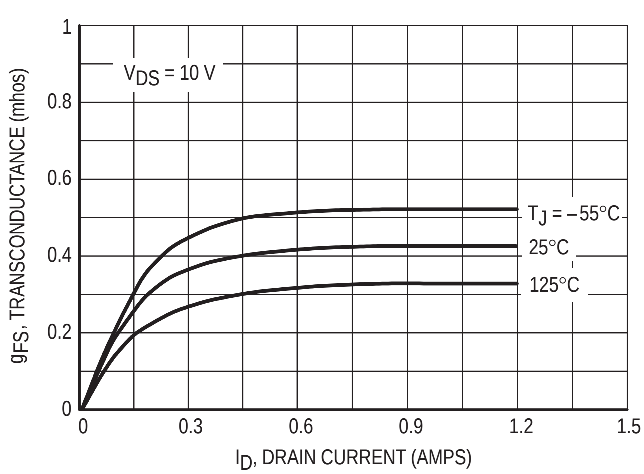
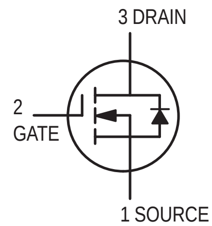


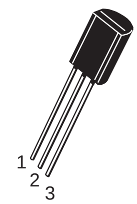
Figure 8. Transconductance

TMOS Switching

N–Channel — Enhancement

MPF910





CASE 29–05, STYLE 22
TO–92 (TO–226AE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DS}	60	Vdc
Gate–Source Voltage — Continuous — Non–repetitive ($t_p \le 50$ µs)	 V_{GS} V_{GSM}	 ±20 ±40	 Vdc Vpk
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

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

1. The Power Dissipation of the package may result in a lower continuous drain current.
2. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

REV 1

RESISTIVE SWITCHING

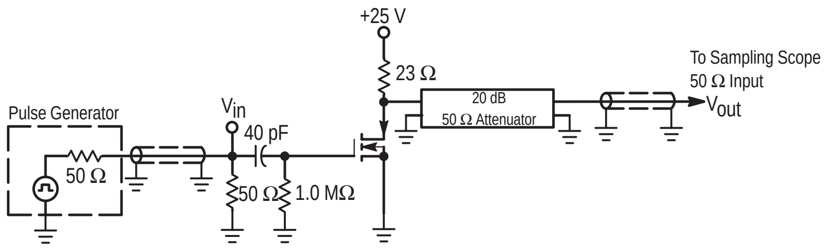


Figure 1. Switching Test Circuit

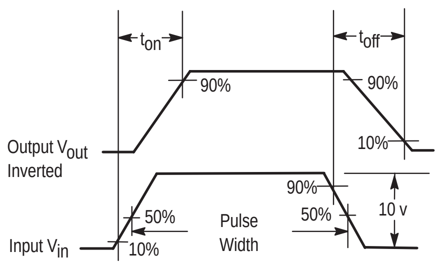


Figure 2. Switching Waveforms

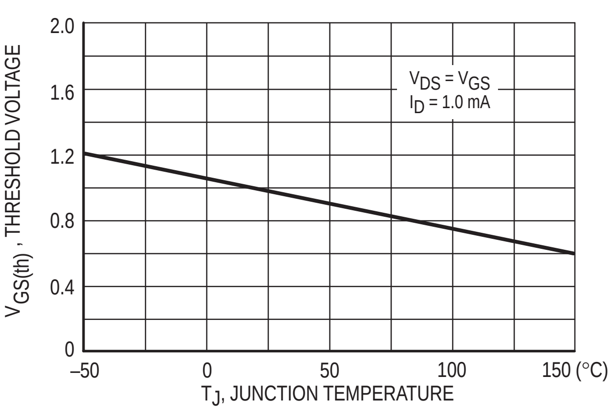


Figure 3. $V_{GS(th)}$ Normalized versus Temperature

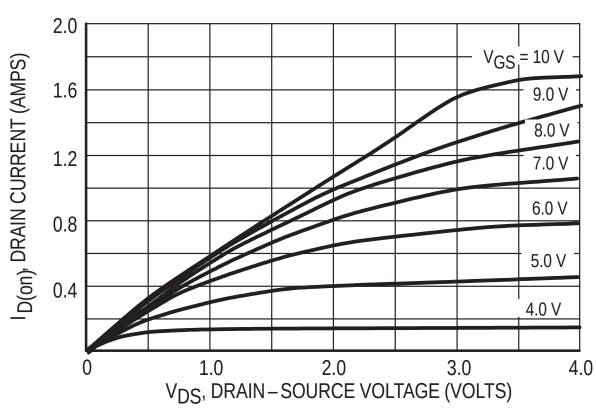


Figure 4. On–Region Characteristics

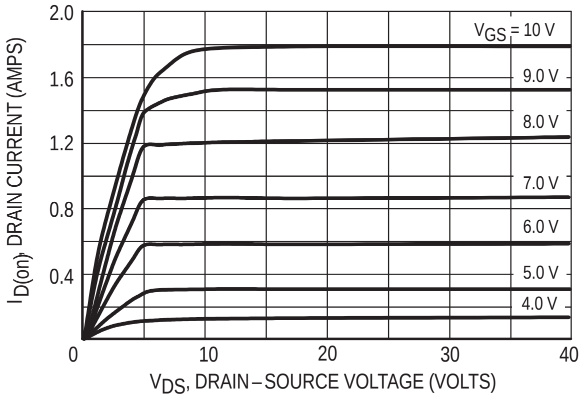


Figure 5. Output Characteristics

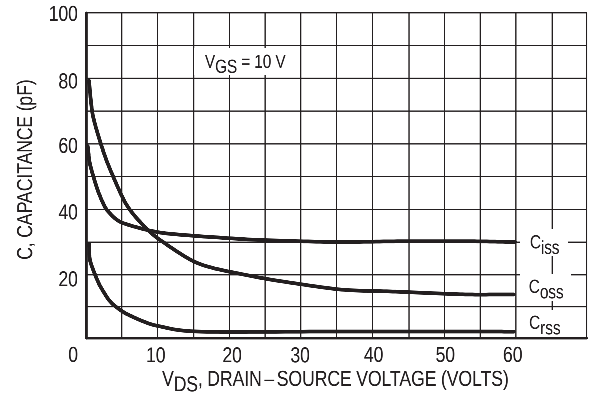


Figure 6. Capacitance versus Drain–to–Source Voltage

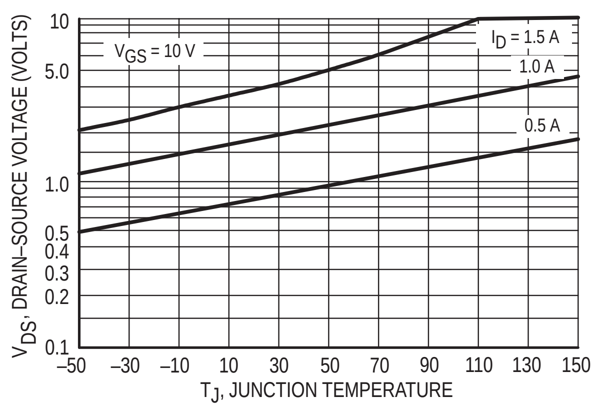
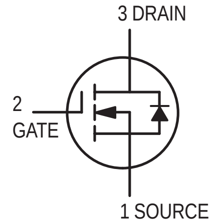


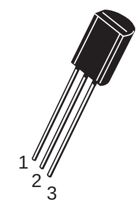
Figure 7. On Voltage versus Temperature

TMOS Switching

N–Channel — Enhancement

MPF930
MPF960
MPF990





CASE 29–05, STYLE 22
TO–92 (TO–226AE)

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 — Continuous — Non–repetitive ($t_p \le 50\ \mu s$)	 V_{GS} V_{GSM}		 ±20 ±40		 Vdc Vpk
Drain Current Continuous(1) Pulsed(2)	 I_D I_{DM}		 2.0 3.0		Adc
Total Device Dissipation @ T_A = 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 Resistance	θ_{JA}		125		°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 = 10 μAdc)	 MPF930 MPF960 MPF990	$V_{(BR)DSX}$	 35 60 90	 — — —	 — — —	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS(2)						
Zero–Gate–Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage (I_D = 1.0 mAdc, V_{DS} = V_{GS})		$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain–Source On–Voltage (V_{GS} = 10 Vdc) (I_D = 0.5 Adc)	 MPF930 MPF960 MPF990	$V_{DS(on)}$	 — — —	 0.4 0.6 0.6	 0.7 0.8 1.2	Vdc
(I_D = 1.0 Adc)	MPF930 MPF960 MPF990		— — —	0.9 1.2 1.2	1.4 1.7 2.4	
(I_D = 2.0 Adc)	MPF930 MPF960 MPF990		— — —	2.2 2.8 2.8	3.0 3.5 4.8	

1. The Power Dissipation of the package may result in a lower continuous drain current.
2. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

REV 2

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2) (Continued)						
Static Drain–Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	MPF930 MPF960 MPF990	$r_{DS(on)}$	— — —	0.9 1.2 1.2	1.4 1.7 2.0	Ω
On–State Drain Current (V_{DS} = 25 Vdc, V_{GS} = 10 Vdc)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL–SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	70	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	20	—	pF
Output Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	49	—	pF
Forward Transconductance (V_{DS} = 25 Vdc, I_D = 0.5 Adc)		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

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

RESISTIVE SWITCHING

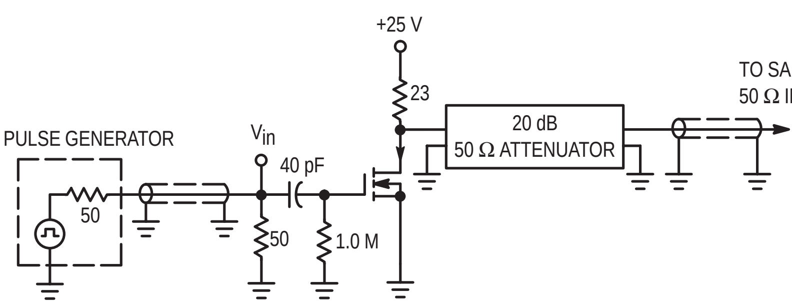


Figure 1. Switching Test Circuit

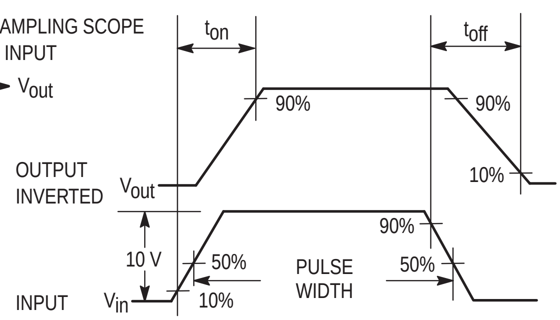


Figure 2. Switching Waveforms

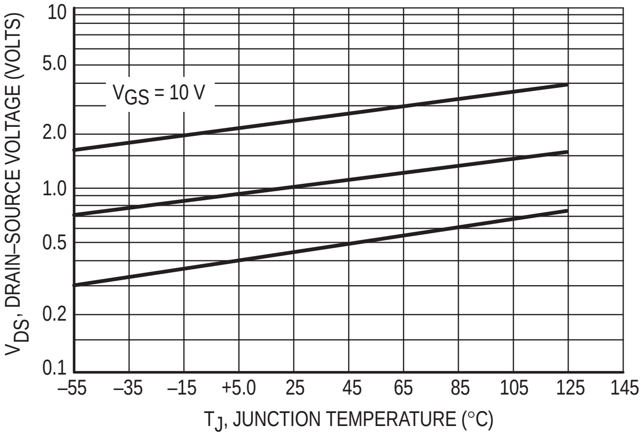


Figure 3. On Voltage versus Temperature

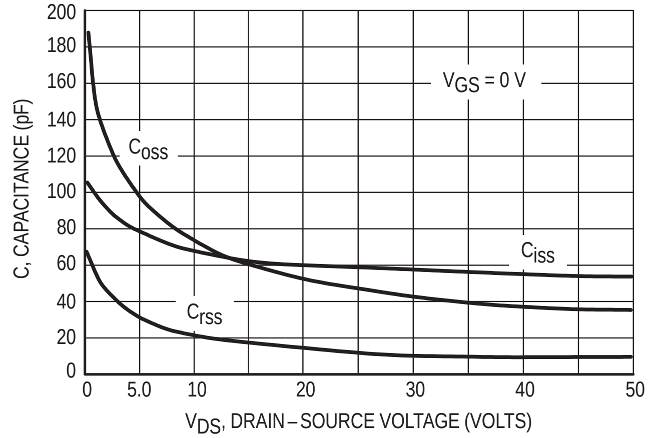


Figure 4. Capacitance Variation

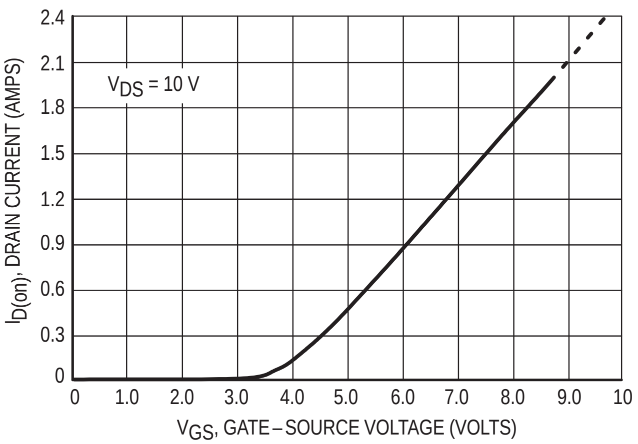


Figure 5. Transfer Characteristic

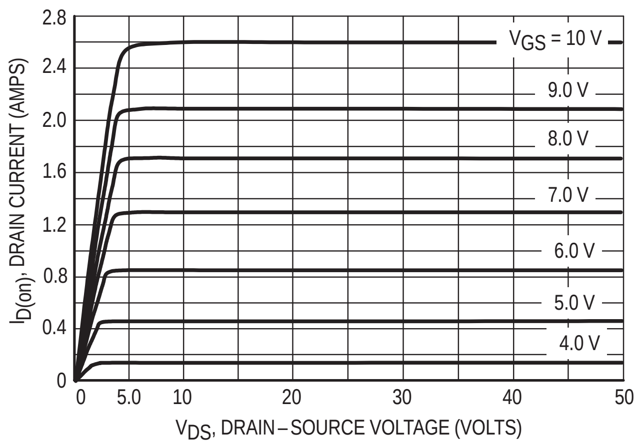


Figure 6. Output Characteristic

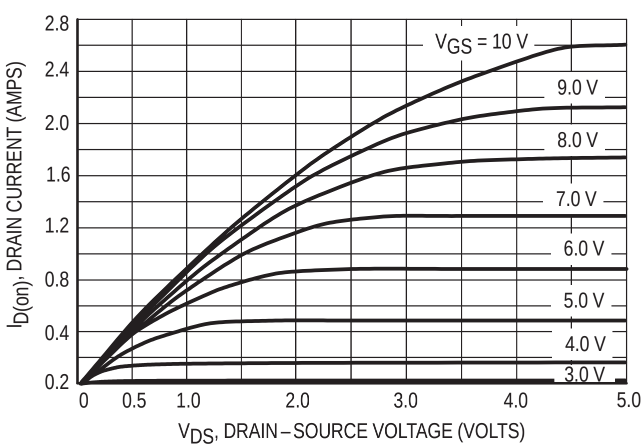
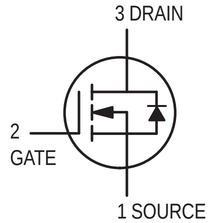


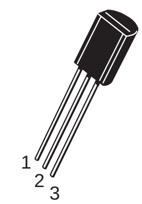
Figure 7. Saturation Characteristic

TMOS FET Transistors

N–Channel — Enhancement



MPF6659
MPF6660
MPF6661



CASE 29–05, STYLE 22
TO–92 (TO–226AE)

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 — Continuous — Non–repetitive ($t_p \le 50\ \mu s$)	 V_{GS} V_{GSM}	 ±20 ±40			 Vdc Vpk
Drain Current Continuous(1) Pulsed(2)	 I_D I_{DM}	 2.0 3.0			Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	 2.5 20			 Watts mW/°C
Total Device Dissipation @ $T_A = 25°C$ 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

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 ($V_{GS} = 15$ Vdc, $V_{DS} = 0$)		I_{GSS}	—	—	100	nAdc
Drain–Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 10\ \mu$Adc)	 MPF6659 MPF6660 MPF6661	$V_{(BR)DSX}$	 35 60 90	 — — —	 — — —	Vdc
ON CHARACTERISTICS(2)						
Gate Threshold Voltage ($V_{DS} = V_{GS}$, $I_D = 1.0$ mAdc)		$V_{GS(Th)}$	0.8	1.4	2.0	Vdc
Drain–Source On–Voltage ($V_{GS} = 10$ Vdc, $I_D = 1.0$ Adc)	 MPF6659 MPF6660 MPF6661	$V_{DS(on)}$	 — — —	 — — —	 1.8 3.0 4.0	Vdc
($V_{GS} = 5.0$ Vdc, $I_D = 0.3$ Adc)	MPF6659 MPF6660 MPF6661		— — —	0.8 0.9 0.9	1.5 1.5 1.6	

1. The Power Dissipation of the package may result in a lower continuous drain current.
2. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

REV 2

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

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2) (Continued)					
Static Drain–Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc) MPF6659	$r_{DS(on)}$	—	—	1.8	Ω
MPF6660		—	—	3.0	
MPF6661		—	—	4.0	
On–State Drain Current (V_{DS} = 25 Vdc, V_{GS} = 10 Vdc)	$I_{D(on)}$	1.0	2.0	—	Amps
SMALL–SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	30	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	3.6	—	pF
Output Capacitance (V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	20	—	pF
Forward Transconductance (V_{DS} = 25 Vdc, I_D = 0.5 Adc)	g_{fs}	170	—	—	mmhos
SWITCHING CHARACTERISTICS(2)					
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

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

RESISTIVE SWITCHING

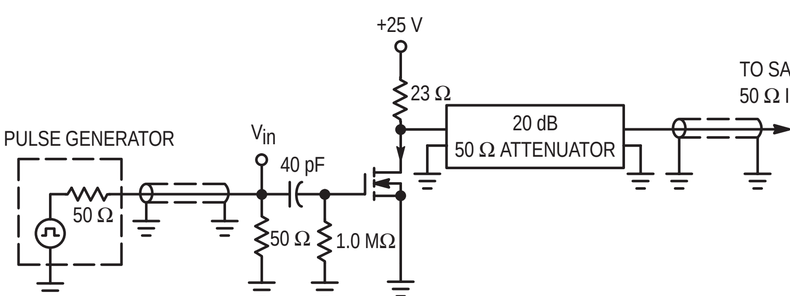


Figure 1. Switching Test Circuit

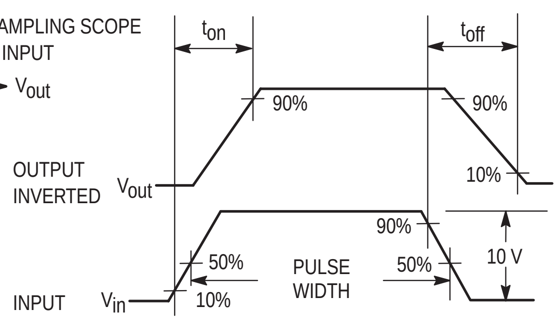


Figure 2. Switching Waveforms

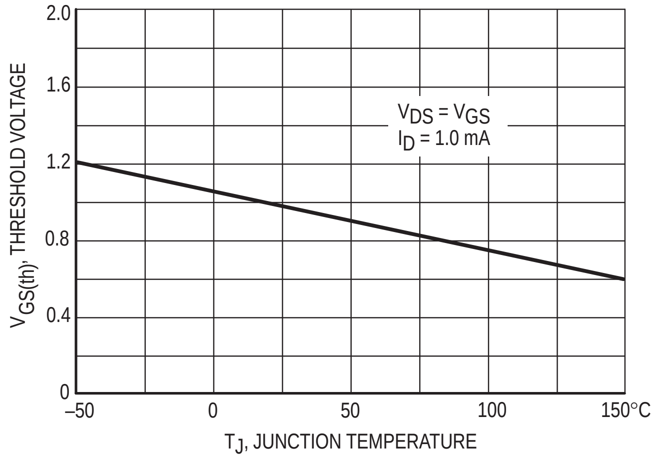


Figure 3. $V_{GS(th)}$ Normalized versus Temperature

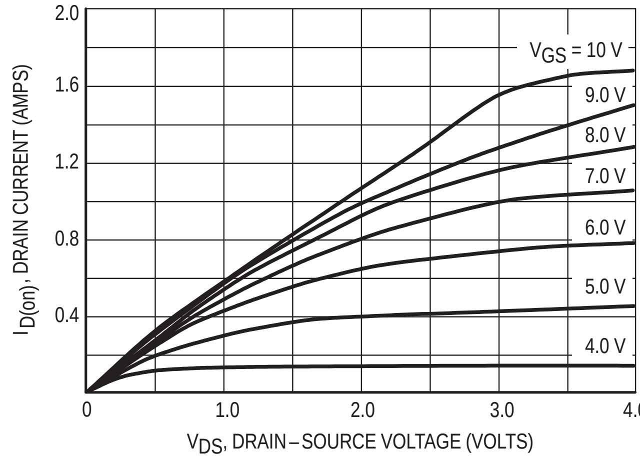


Figure 4. On–Region Characteristics

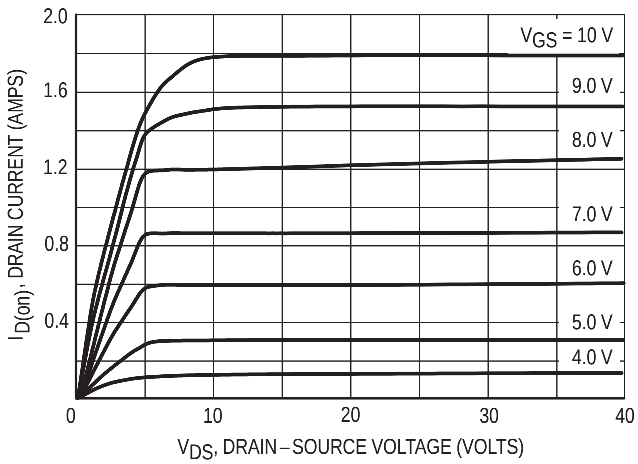


Figure 5. Output Characteristics

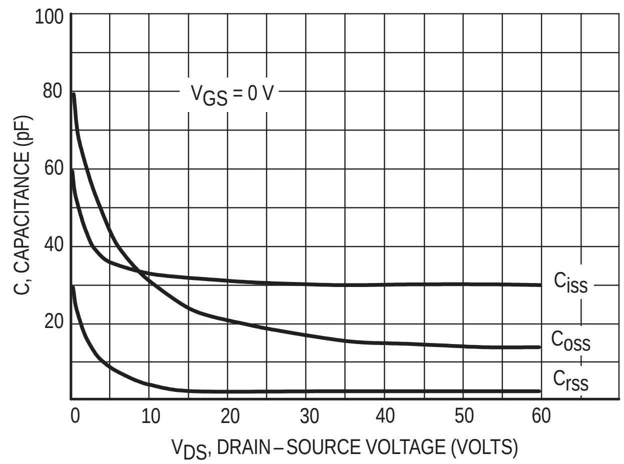


Figure 6. Capacitance versus Drain–To–Source Voltage

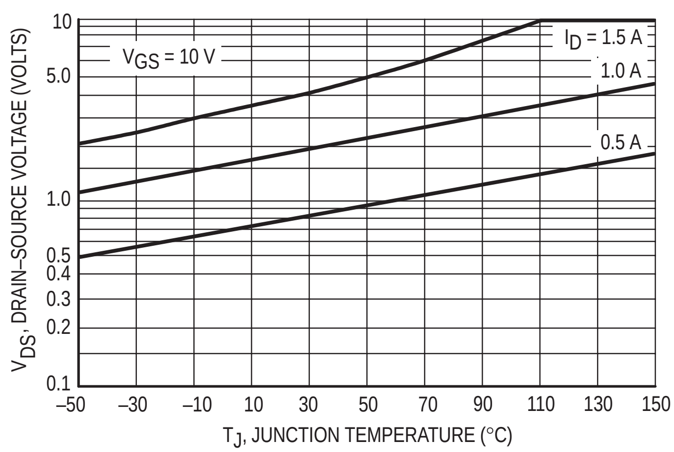
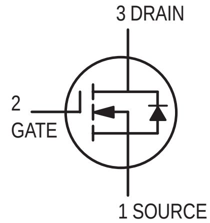


Figure 7. On–Voltage versus Temperature

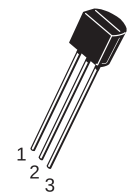
TMOS FET Transistor
N–Channel — Enhancement

TMOS®



VN0300L

Motorola Preferred Device



CASE 29–04, STYLE 22
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	60	V
Drain–Gate Voltage	V_{DGR}	60	V
Gate–Source Voltage – Continuous – Non–repetitive ($t_p \le 50\ \mu s$)	V_{GS} V_{GSM}	± 20 ± 40	Vdc Vpk
Continuous Drain Current	I_D	200	mA
Pulsed Drain Current	I_{DM}	500	mA
Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Temperature	T_J, T_{stg}	—	°C

THERMAL CHARACTERISTICS

Characteristics	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 ($V_{DS} = 0$, $I_D = 10\ \mu A$)	$V_{(BR)DSS}$	30	—	V
Zero Gate Voltage Drain Current ($V_{DS} = 48$ Vdc, $V_{GS} = 0$) ($V_{DS} = 48$ Vdc, $V_{GS} = 0$, $T_A = 125°C$)	I_{DSS}	 — —	 10 500	µA
Gate–Body Leakage ($V_{DS} = 0$, $V_{GS} = \pm 30$ 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(1) ($V_{DS} = V_{GS}$, $I_D = 1.0$ mA)	$I_{D(on)}$	1.0	—	A
Drain–Source On Resistance(1) ($V_{GS} = 5.0$ V, $I_D = 0.3$ A) ($V_{GS} = 10$ V, $I_D = 1.0$ A)	$r_{DS(on)}$	 — —	 3.3 1.2	Ω
Forward Transconductance(1) ($V_{DS} = 10$ V, $I_D = 0.5$ A)	g_{fs}	200	—	mS

1. Pulse Test; Pulse Width < 300 µs, Duty Cycle ≤ 2.0%.

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

REV 1

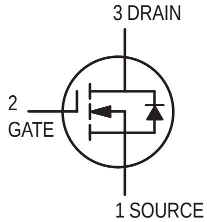
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

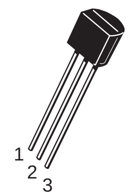
Characteristic		Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	100	pF
Output Capacitance		C_{oss}	—	95	pF
Reverse Transfer Capacitance		C_{rss}	—	25	pF
SWITCHING CHARACTERISTICS					
Turn–On Time	(V_{DD} = 25 Vdc, I_D = 1.0 A, R_L = 24 Ω, RG = 25 Ω)	t_{on}	—	30	ns
Turn–Off Time		t_{off}	—	30	ns

TMOS FET Transistor

N–Channel — Enhancement

VN0610LL





CASE 29–04, STYLE 22
TO–92 (TO–226AA)

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 – Continuous – Non–repetitive ($t_p \leq 50$ μs)	 V_{GS} V_{GSM}	 ± 20 ± 40	 Vdc Vpk
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

Characteristics	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_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 Vdc, V_{GS} = 0) (V_{DS} = 48 Vdc, V_{GS} = 0, T_J = 125°C)	I_{DSS}	 — —	 10 500	μAdc
Gate–Body Leakage Current, Forward (V_{GSF} = 30 V, V_{DS} = 0)	I_{GSSF}	—	–100	nAdc
ON CHARACTERISTICS(1)				
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 V, I_D = 500 mA) (V_{GS} = 10 V, I_D = 500 mA, T_C = 125°C)	$r_{DS(on)}$	 — —	 5.0 9.0	Ω
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	—	mAdc
Forward Transconductance ($V_{DS} \geq 2.0\ V_{DS(on)}$, I_D = 500 mA)	g_{fs}	100	—	μmhos

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

REV 1

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

Characteristic		Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 25 Vdc, 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(1)					
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 600 mA, R_{gen} = 25 Ω, R_L = 23 Ω)	t_{on}	—	10	ns
Turn–Off Delay Time		t_{off}	—	10	

1. Pulse Test: Pulse Width ≤ 300 ms, Duty Cycle ≤ 10%.

RESISTIVE SWITCHING

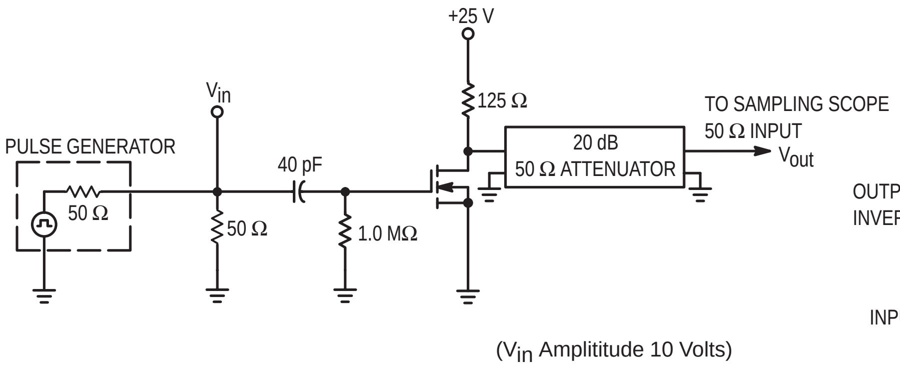


Figure 1. Switching Test Circuit

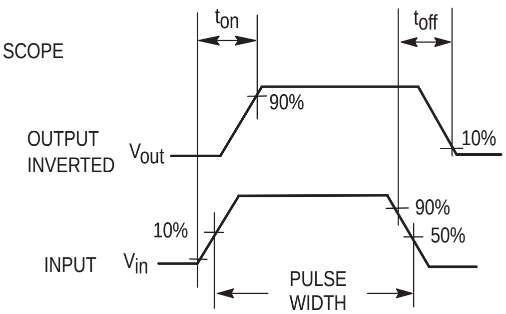


Figure 2. Switching Waveforms

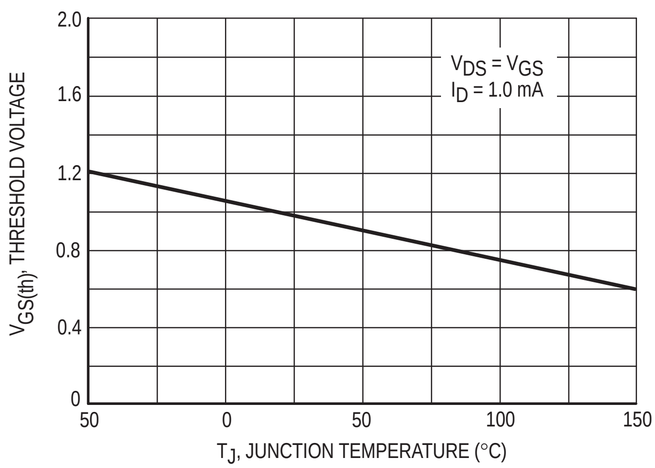


Figure 3. $V_{GS(th)}$ Normalized versus Temperature

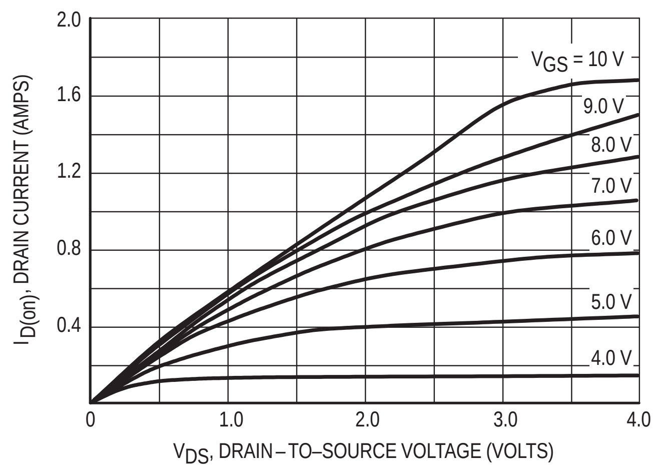


Figure 4. On–Region Characteristics

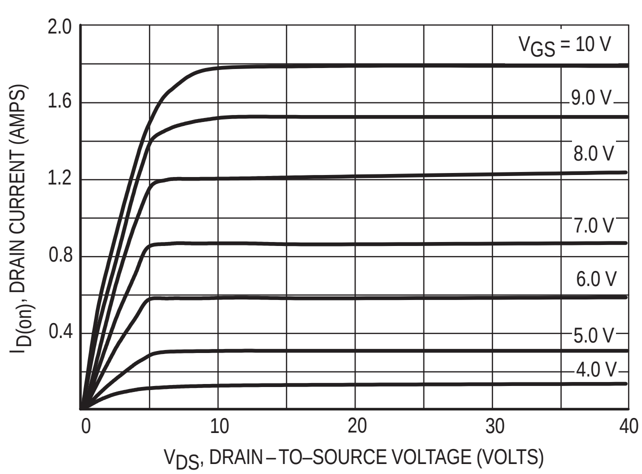


Figure 5. Output Characteristics

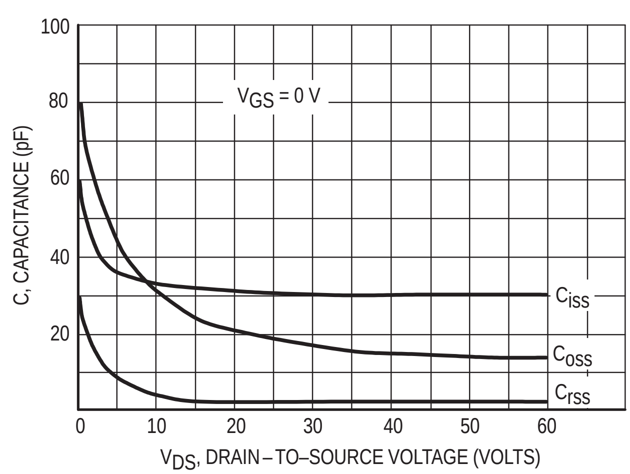
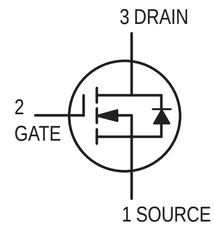
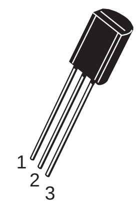


Figure 6. Capacitance versus Drain–To–Source Voltage

TMOS FET Transistor
N–Channel — Enhancement

VN10LM





CASE 29–05, STYLE 22
TO–92 (TO–226AE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	60	Vdc
Gate–Source Voltage — Continuous — Non–repetitive ($t_p \leq 50\ \mu s$)	 V_{GS} V_{GSM}	 ±20 ±40	 Vdc Vpk
Drain Current – Continuous(1) – Pulsed(2)	I_D I_{DM}	0.3 1.0	Adc
Total Device 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

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_{GSS1}	—	—	100	nAdc
Gate–Body Leakage Current (V_{GS} = 15 V, V_{DS} = 0)	I_{GSS2}	—	—	–100	nAdc

1. The Power Dissipation of the package may result in a lower continuous drain current.
2. Pulse Width ≤ 300 μs, Duty Cycle.

REV 1

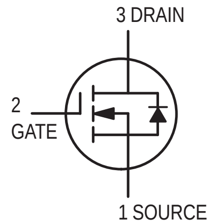
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

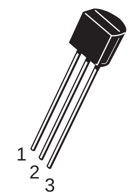
Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
Gate Threshold Voltage ($V_{DS} = V_{GS}$, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	—	2.5	Vdc
On–State Drain Current (V_{DS} = 15 V, V_{GS} = 10 V)	$I_{D(on)}$	750	—	—	mA
Forward Transconductance (V_{DS} = 15 V, I_D = 500 mA)	g_{fs}	200	—	—	mmhos
Drain–Source 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, 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

TMOS FET Transistor
N–Channel — Enhancement

VN2222LL

Motorola Preferred Device





CASE 29–04, STYLE 22
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	60	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	60	Vdc
Gate–Source Voltage — Continuous — Non–repetitive ($t_p \leq 50$ µs)	V_{GS} V_{GSM}	±20 ±40	Vdc Vpk
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

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_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 µAdc)	$V_{(BR)DSS}$	60	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 48 Vdc, V_{GS} = 0) (V_{DS} = 48 Vdc, 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(1)				
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)	$V_{GS(th)}$	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 Vdc, T_C = 125°C)	$r_{DS(on)}$	— —	7.5 13.5	Ω

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

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

REV 1

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS[1] (Continued)					
Drain–Source On–Voltage (V_{GS} = 5.0 Vdc, I_D = 200 mAdc) (V_{GS} = 10 Vdc, I_D = 500 mAdc)		$V_{DS(on)}$	 — —	 1.5 3.75	Vdc
On–State Drain Current (V_{GS} = 10 Vdc, $V_{DS} \geq 2.0\ V_{DS(on)}$)		$I_{D(on)}$	750	—	mA
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 500 mAdc)		g_{fs}	100	—	µmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 25 Vdc, 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[1]					
Turn–On Delay Time	(V_{DD} = 15 Vdc, I_D = 600 mA, R_{gen} = 25 Ω, R_L = 23 Ω)	t_{on}	—	10	ns
Turn–Off Delay Time		t_{off}	—	10	

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

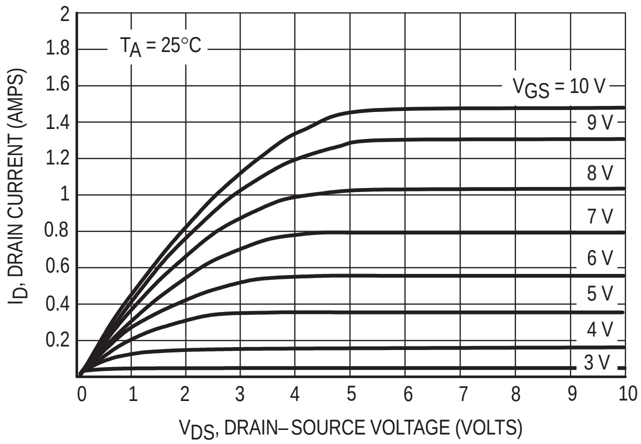


Figure 1. Ohmic Region

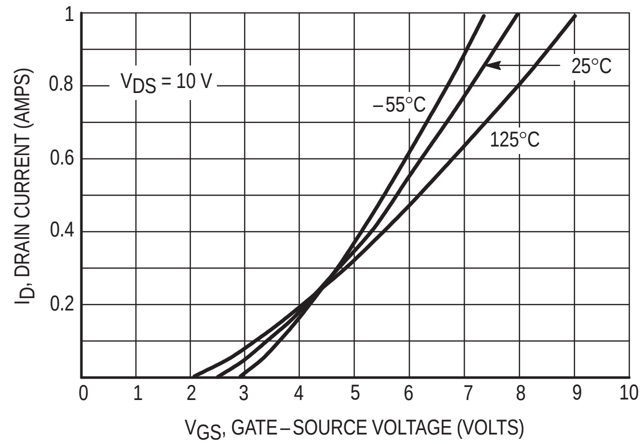


Figure 2. Transfer Characteristics

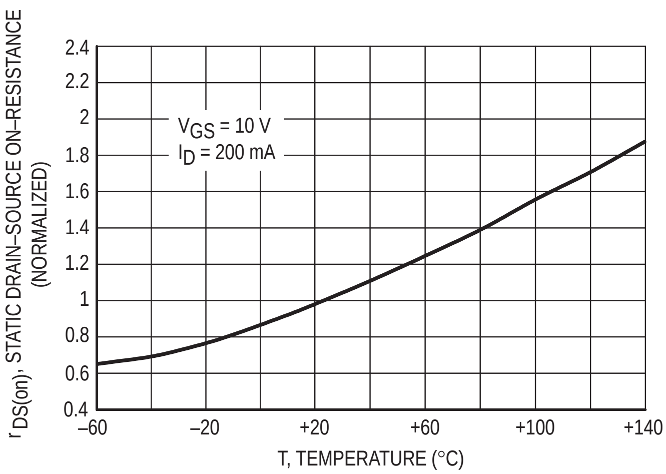


Figure 3. Temperature versus Static Drain–Source On–Resistance

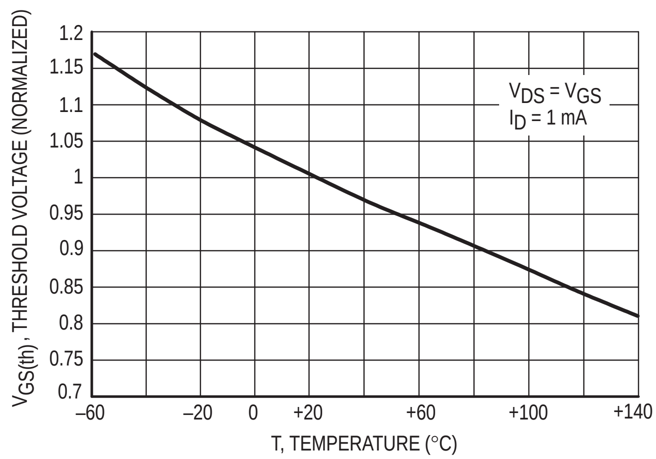
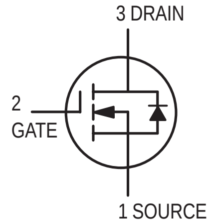


Figure 4. Temperature versus Gate Threshold Voltage

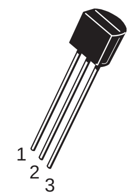
TMOS FET Transistor

N–Channel — Enhancement



VN2406L

Motorola Preferred Device



CASE 29–04, STYLE 22
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	240	Vdc
Drain–Gate Voltage	V_{DGR}	60	Vdc
Gate–Source Voltage – Continuous – Non–repetitive ($t_p \le 50$ µs)	 V_{GS} V_{GSM}	 ± 20 ± 40	 Vdc Vpk
Continuous Drain Current	I_D	200	mAdc
Pulsed Drain Current	I_{DM}	500	mAdc
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	350 2.8	mW 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	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 120 Vdc, V_{GS} = 0) (V_{DS} = 120 Vdc, V_{GS} = 0, T_A = 125°C)	I_{DSS}	 — —	 10 500	µAdc
Gate– Body Leakage (V_{DS} = 0, V_{GS} = ±15 V)	I_{GSS}	—	±100	nAdc
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	2.0	Vdc
On–State Drain Current(1) (V_{GS} = 10 V, $V_{DS} \ge$ 2.0 $V_{DS(on)}$)	$I_{D(on)}$	1.0	—	Adc
Drain–Source On Resistance(1) (V_{GS} = 2.5 V, I_D = 0.1 A) (V_{GS} = 10 V, I_D = 0.5 A)	$r_{DS(on)}$	 — —	 10 6.0	Ω
Forward Transconductance(1) (V_{DS} = 10 V, I_D = 0.5 A)	g_{fs}	300	—	mS

1. Pulse Test; Pulse Width < 300 µs, Duty Cycle ≤ 2.0%.

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

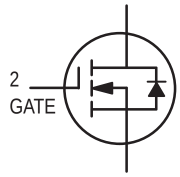
REV 1

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

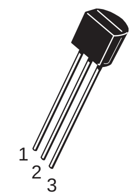
Characteristic		Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	125	pF
Output Capacitance		C_{oss}	—	50	pF
Reverse Transfer Capacitance		C_{rss}	—	20	pF
SWITCHING CHARACTERISTICS					
Turn–On Time	(V_{DD} = 60 Vdc, I_D = 0.4 A, R_L = 150 Ω, R_G = 25 Ω)	$t_{(on)}$	—	8.0	ns
		$t_{(r)}$	—	8.0	ns
Turn–Off Time		$t_{(off)}$	—	23	ns
		$t_{(f)}$	—	34	ns

TMOS FET Transistor
N–Channel — Enhancement

TMOS



VN2410L



CASE 29–04, STYLE 22
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	240	Vdc
Drain–Gate Voltage	V_{DGR}	60	Vdc
Gate–Source Voltage – Continuous – Non–repetitive ($t_p \leq 50$ µs)	 V_{GS} V_{GSM}	 ± 20 ± 40	 Vdc Vpk
Continuous Drain Current	I_D	200	mAdc
Pulsed Drain Current	I_{DM}	500	mAdc
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	350 2.8	mW 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	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 120 Vdc, V_{GS} = 0) (V_{DS} = 120 Vdc, V_{GS} = 0, T_A = 125°C)	I_{DSS}	 — —	 10 500	µAdc
Gate– Body Leakage (V_{DS} = 0, V_{GS} = ±15 V)	I_{GSS}	—	±100	nAdc
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	2.0	Vdc
On–State Drain Current(1) (V_{GS} = 10 V, $V_{DS} \geq 2.0\ V_{DS(on)}$)	$I_{D(on)}$	1.0	—	Adc
Drain–Source On Resistance(1) (V_{GS} = 2.5 V, I_D = 0.1 A) (V_{GS} = 10 V, I_D = 0.5 A)	$r_{DS(on)}$	 — —	 10 10	Ω
Forward Transconductance(1) (V_{DS} = 10 V, I_D = 0.5 A)	g_{fs}	300	—	mS

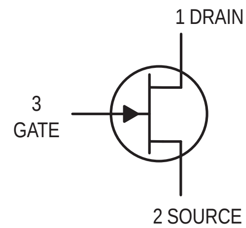
1. Pulse Test; Pulse Width < 300 µs, Duty Cycle ≤ 2.0%.

REV 1

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

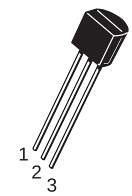
Characteristic		Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 25 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	125	pF
Output Capacitance		C_{oss}	—	50	pF
Reverse Transfer Capacitance		C_{rss}	—	20	pF
SWITCHING CHARACTERISTICS					
Turn–On Time	(V_{DD} = 60 Vdc, I_D = 0.4 A, R_L = 150 Ω, R_G = 25 Ω)	$t_{(on)}$	—	8.0	ns
		$t_{(r)}$	—	8.0	ns
Turn–Off Time		$t_{(off)}$	—	23	ns
		$t_{(f)}$	—	34	ns

JFETs — General Purpose
N–Channel — Depletion



2N5457

***Motorola Preferred Device**



CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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 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}	 — —	 — —	 –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 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	3.0	5.0	mAdc
SMALL–SIGNAL CHARACTERISTICS					
Forward Transfer Admittance Common Source (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	1000	—	5000	μmhos
Output Admittance Common Source (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{os} \rvert$	—	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 $\leq$ 630 ms, Duty Cycle $\leq$ 10%.

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

TYPICAL CHARACTERISTICS

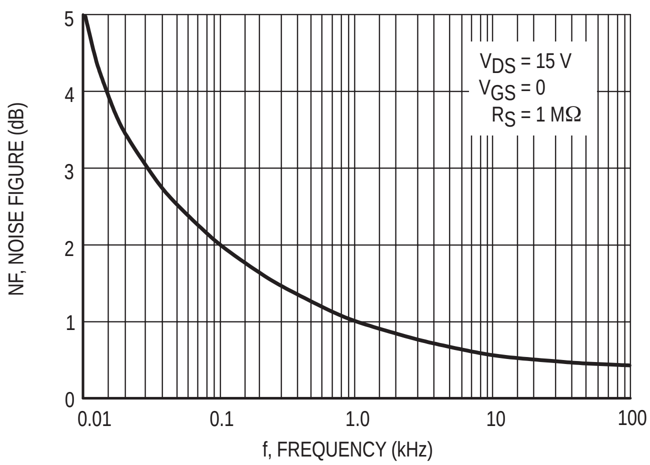


Figure 1. Noise Figure versus Frequency

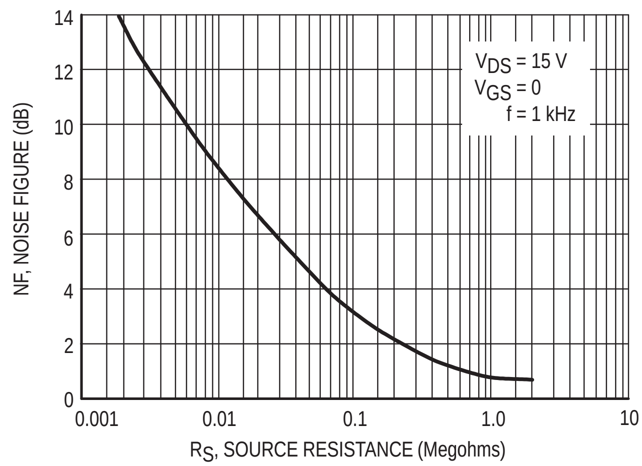


Figure 2. Noise Figure versus Source Resistance

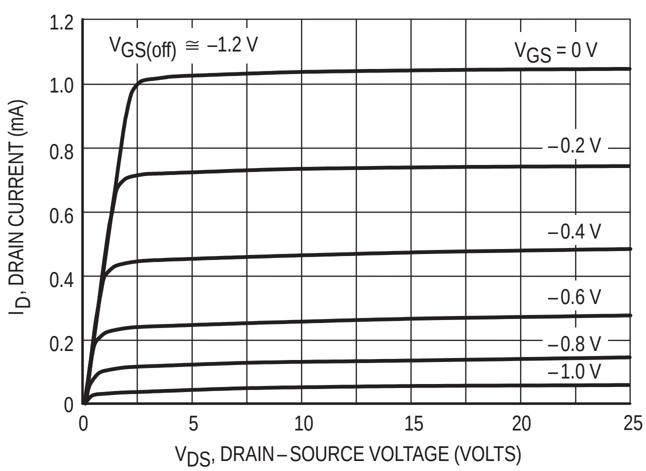


Figure 3. Typical Drain Characteristics

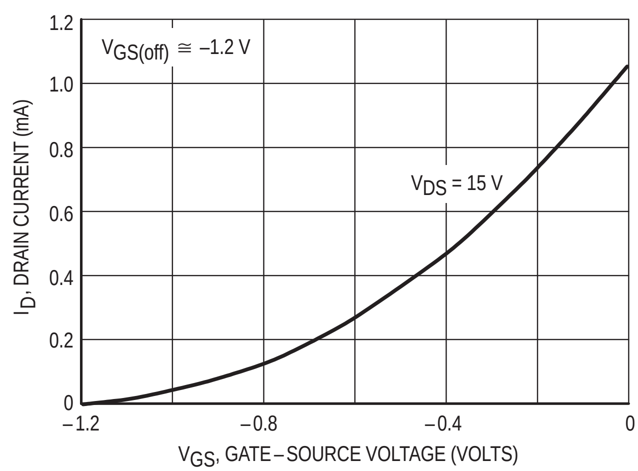


Figure 4. Common Source Transfer Characteristics

TYPICAL CHARACTERISTICS

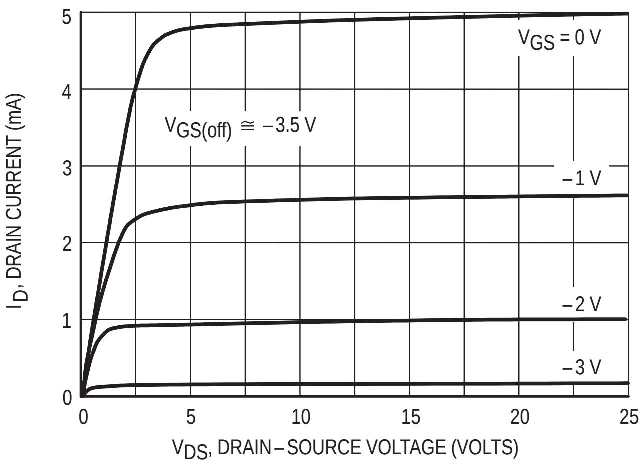


Figure 5. Typical Drain Characteristics

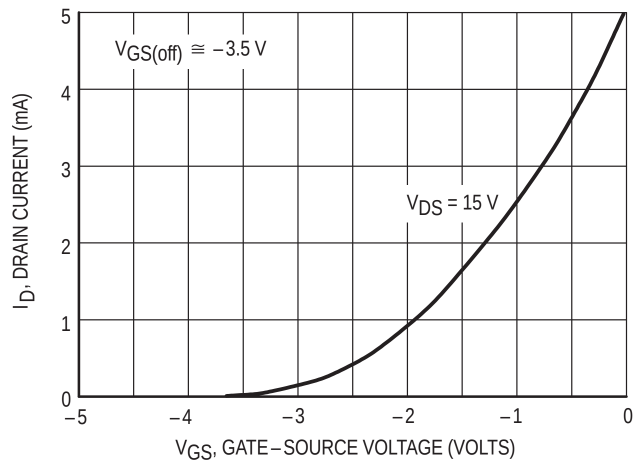


Figure 6. Common Source Transfer Characteristics

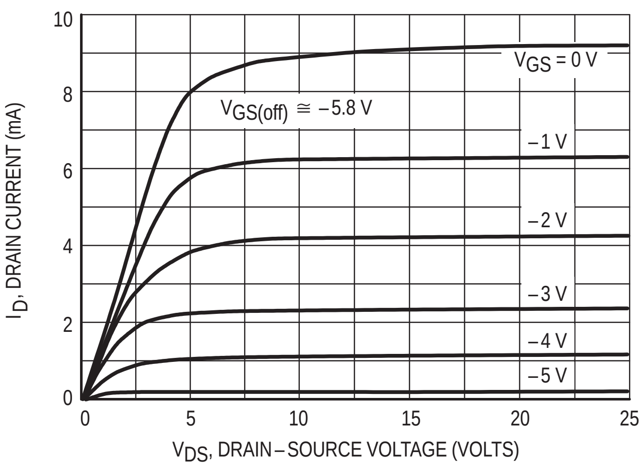


Figure 7. Typical Drain Characteristics

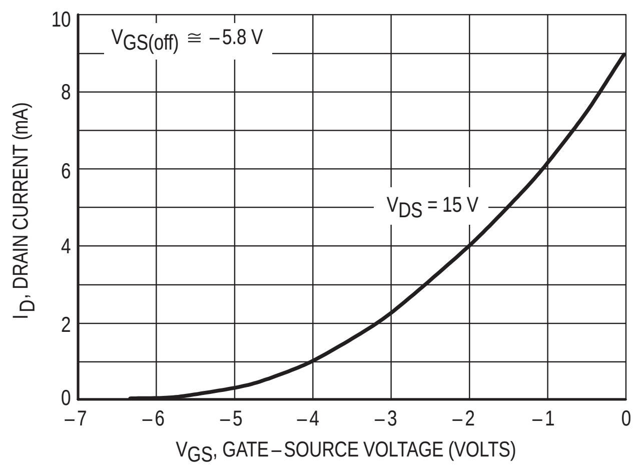


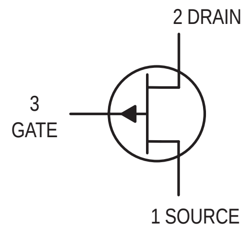
Figure 8. Common Source Transfer Characteristics

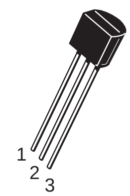
Note: Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS}.

JFET Amplifiers

P–Channel — Depletion

2N5460
2N5461
2N5462





CASE 29–04, STYLE 7
TO–92 (TO–226AA)

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)	2N5460, 2N5461, 2N5462	I_{GSS}	—	—	5.0	nAdc
(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		—	—	1.0	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	$\|y_{fs}\|$	1000 1500 2000	— — —	4000 5000 6000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	—	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

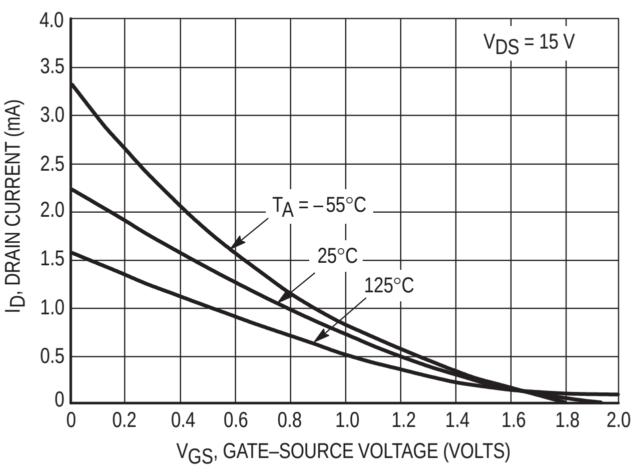


Figure 1. $V_{GS(off)}$ = 2.0 Volts

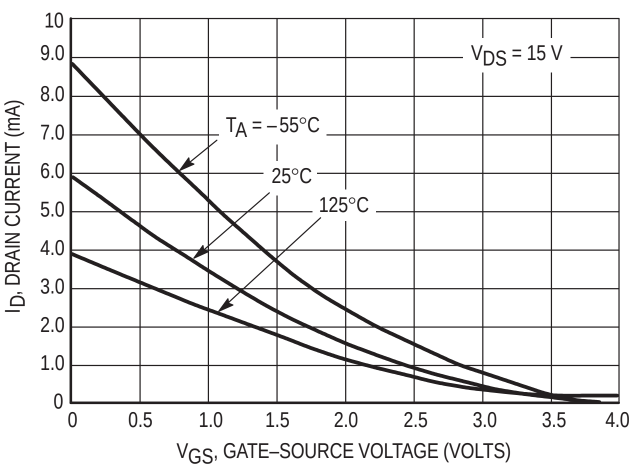


Figure 2. $V_{GS(off)}$ = 4.0 Volts

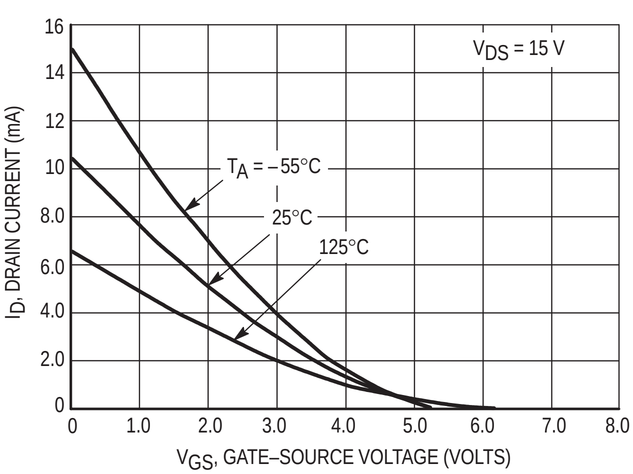


Figure 3. $V_{GS(off)}$ = 5.0 Volts

FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

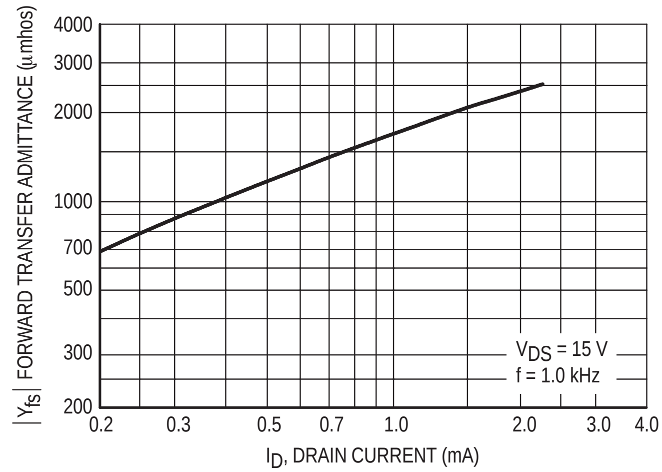


Figure 4. $V_{GS(off)}$ = 2.0 Volts

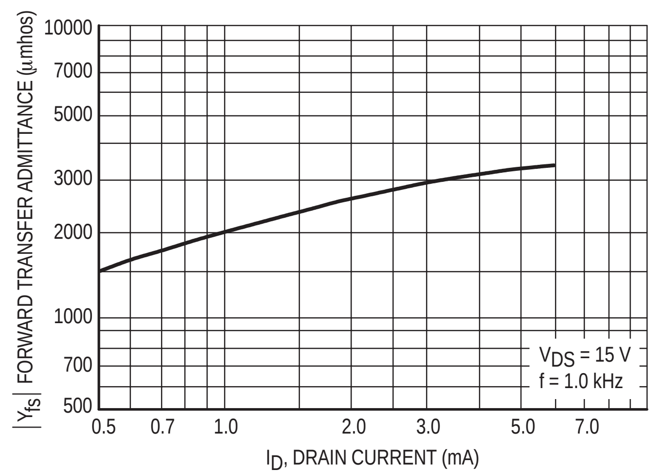


Figure 5. $V_{GS(off)}$ = 4.0 Volts

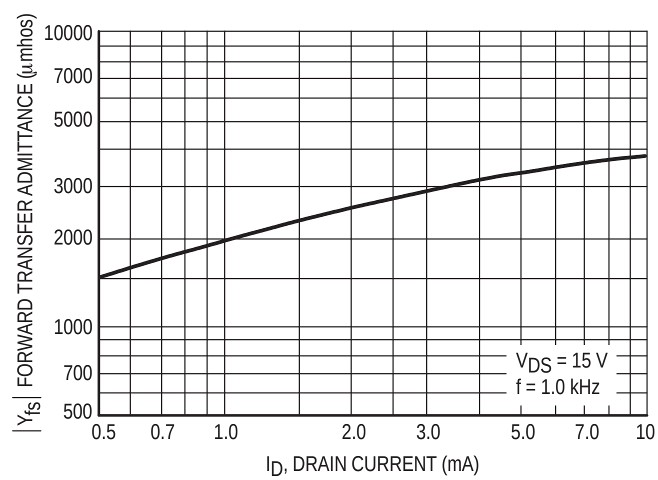


Figure 6. $V_{GS(off)}$ = 5.0 Volts

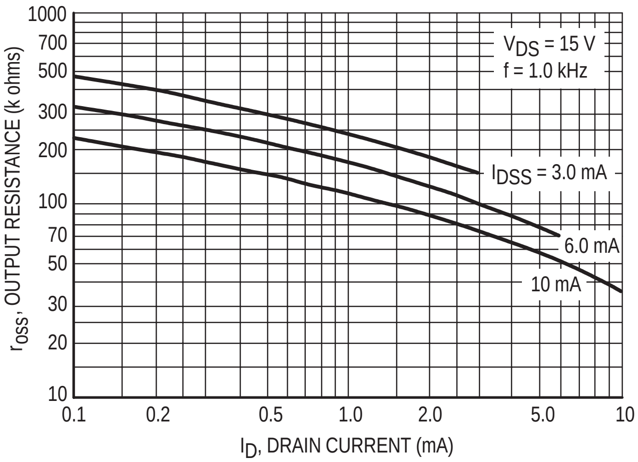


Figure 7. Output Resistance versus Drain Current

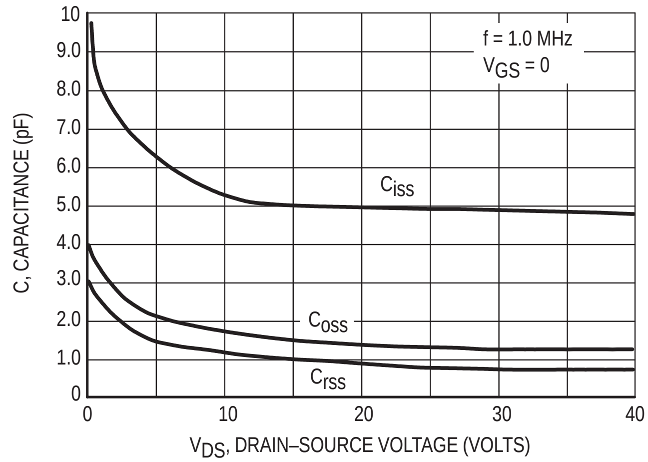


Figure 8. Capacitance versus Drain–Source Voltage

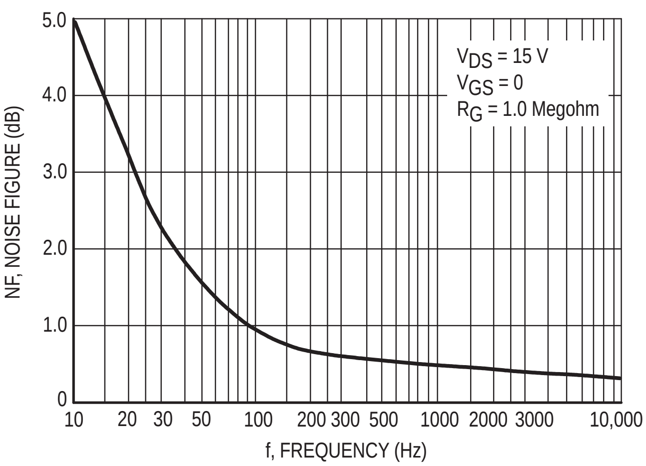


Figure 9. Noise Figure versus Frequency

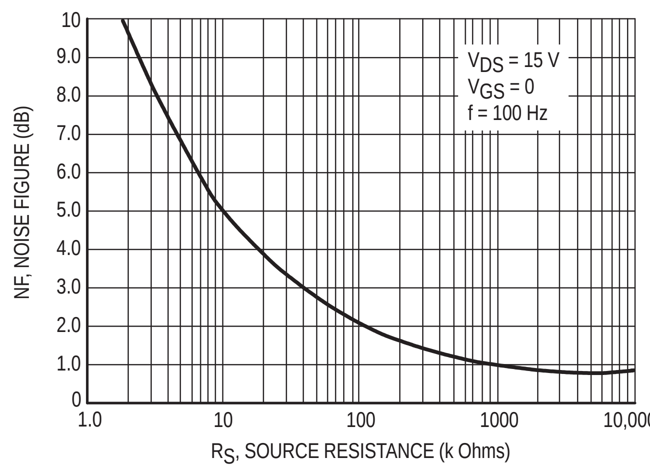
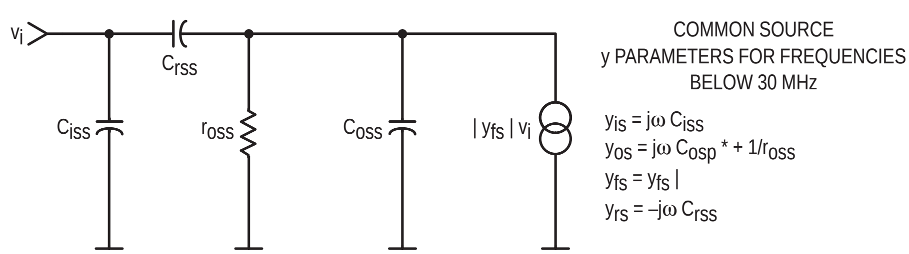


Figure 10. Noise Figure versus Source Resistance



* C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

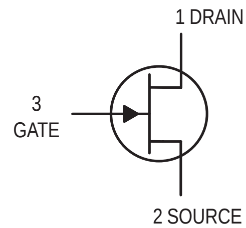
NOTE:
1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%).

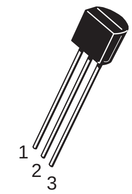
Figure 11. Equivalent Low Frequency Circuit

JFET VHF/UHF Amplifiers

N–Channel — Depletion

2N5484
2N5486





CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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 (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL–SIGNAL CHARACTERISTICS (continued)						
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, $R_G \approx$ 1.0 kΩ, f = 100 MHz)	2N5484		—	—	3.0	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, $R_G \approx$ 1.0 kΩ, f = 200 MHz)	2N5484		—	4.0	—	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 kΩ, f = 100 MHz)	2N5486		—	—	2.0	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 kΩ, 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	

POWER GAIN

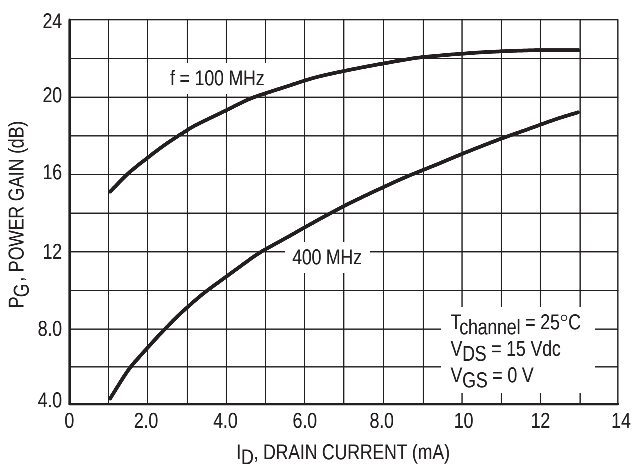
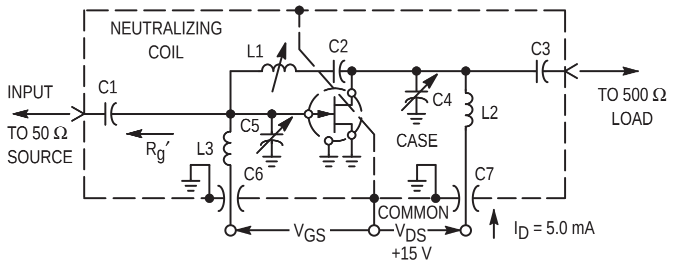


Figure 1. Effects of Drain Current



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).

Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1–12 pF	0.8–8.0 pF
C5	1–12 pF	0.8–8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH*	0.2 μH**
L2	0.15 μH*	0.03 μH**
L3	0.14 μH*	0.022 μH**

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32″ ceramic coil form. Tuning provided by a powdered iron slug.
L2 4–1/2 turns, AWG #18 enameled copper wire, 5/16″ long, 3/8″ I.D. (AIR CORE).
L3 3–1/2 turns, AWG #18 enameled copper wire, 1/4″ long, 3/8″ I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32″ ceramic coil form. Tuning provided by an aluminum slug.
L2 1 turn, AWG #16 enameled copper wire, 3/8″ I.D. (AIR CORE).
L3 1/2 turn, AWG #16 enameled copper wire, 1/4″ I.D. (AIR CORE).

Figure 2. 100 MHz and 400 MHz Neutralized Test Circuit

NOISE FIGURE
($T_{channel}$ = 25°C)

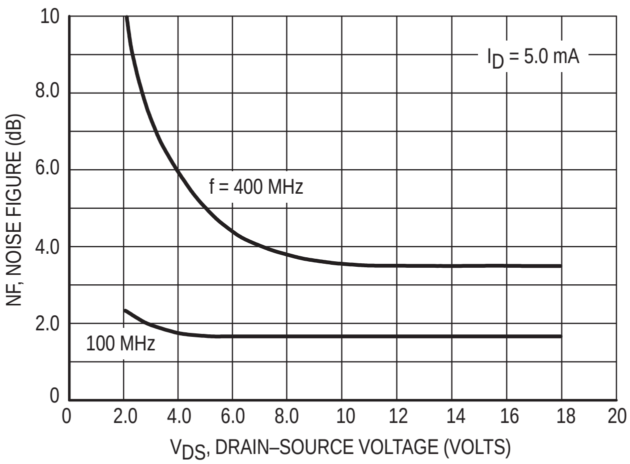


Figure 3. Effects of Drain–Source Voltage

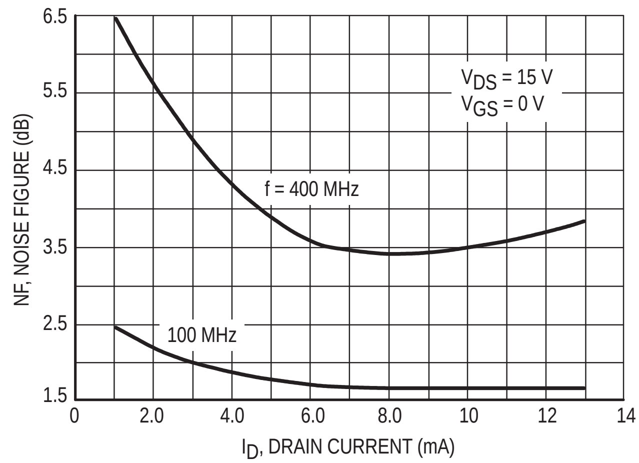


Figure 4. Effects of Drain Current

INTERMODULATION CHARACTERISTICS

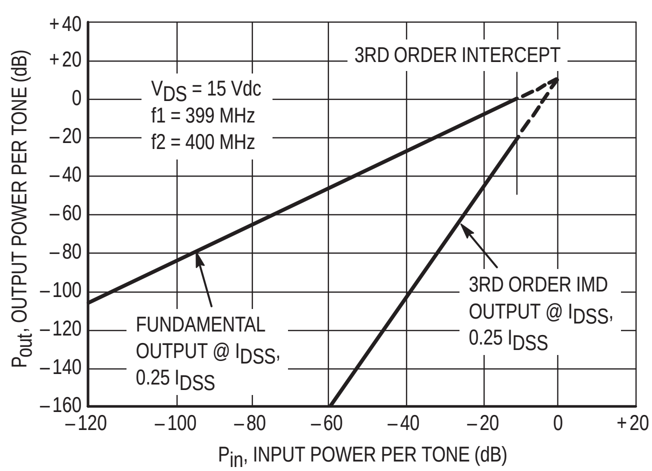


Figure 5. Third Order Intermodulation Distortion

COMMON SOURCE CHARACTERISTICS
ADMITTANCE PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

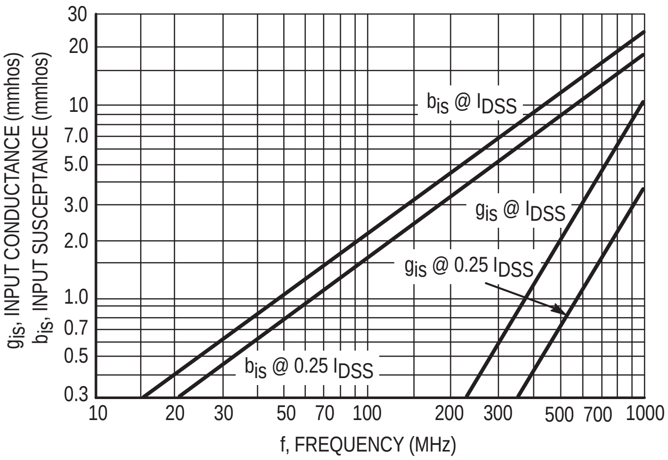


Figure 6. Input Admittance (y_{is})

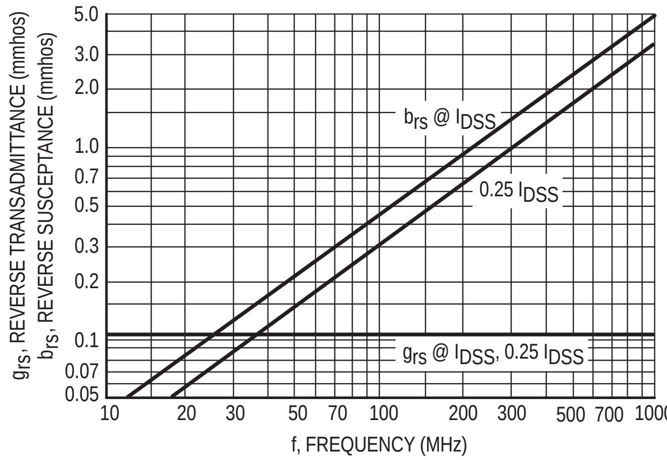


Figure 7. Reverse Transfer Admittance (y_{rs})

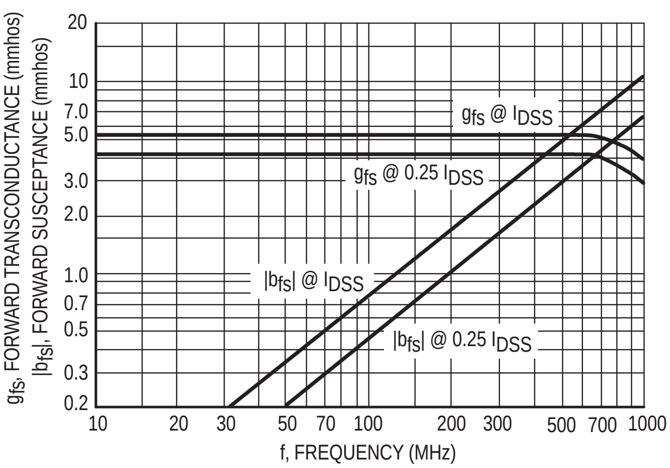


Figure 8. Forward Transadmittance (y_{fs})

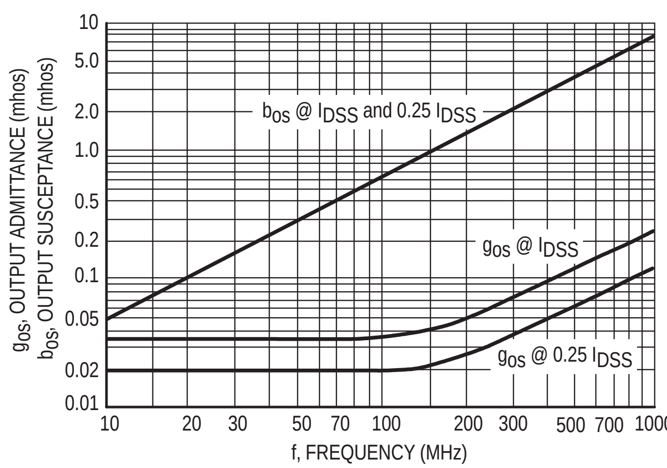


Figure 9. Output Admittance (y_{os})

COMMON SOURCE CHARACTERISTICS

S–PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

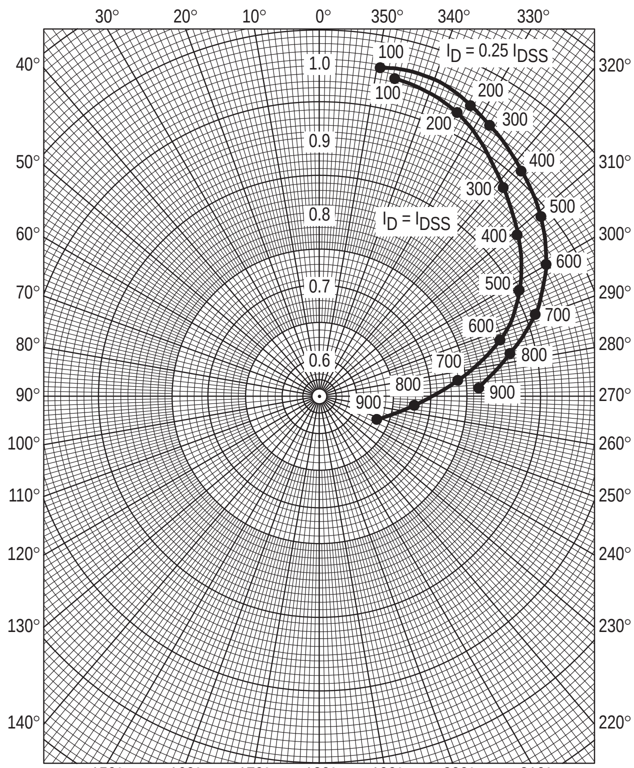


Figure 10. S_{11s}

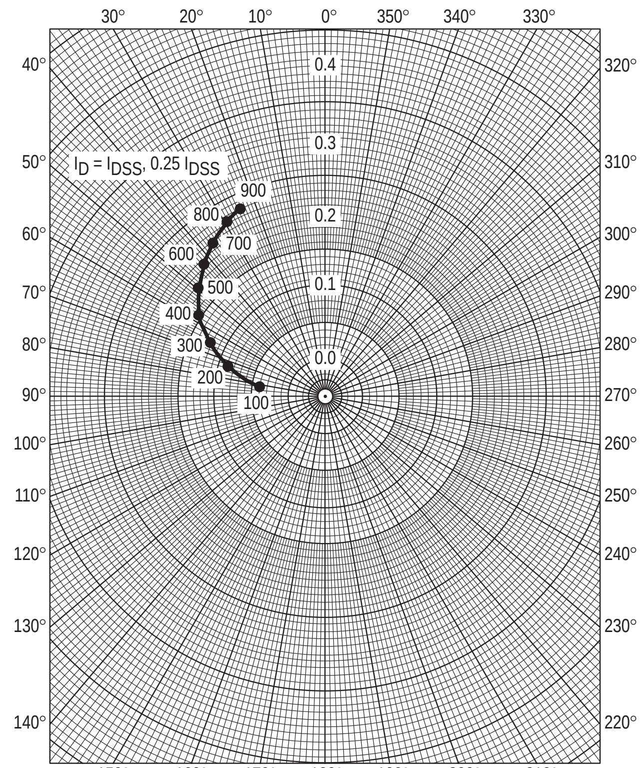


Figure 11. S_{12s}

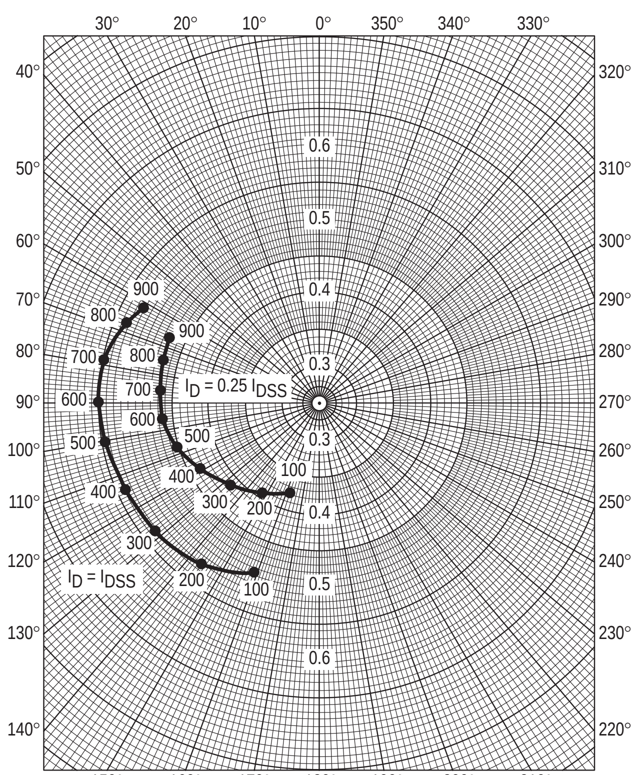


Figure 12. S_{21s}

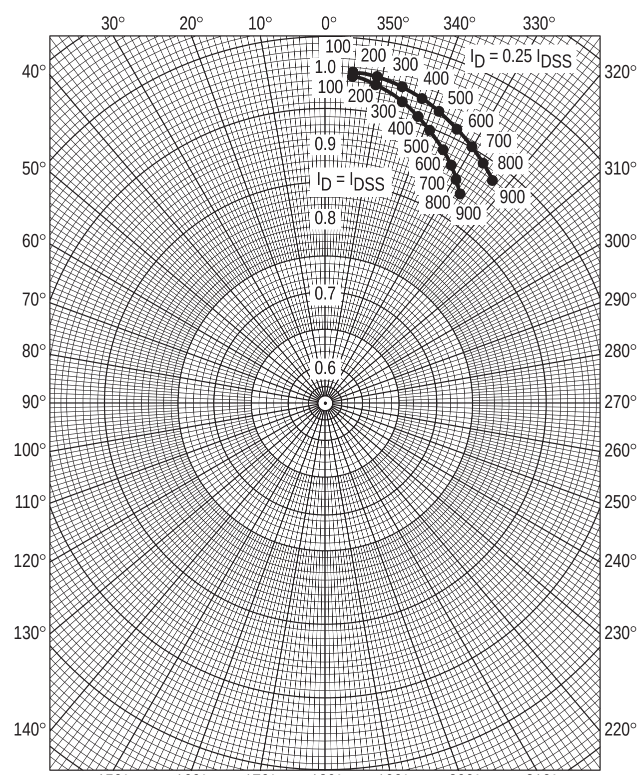


Figure 13. S_{22s}

COMMON GATE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

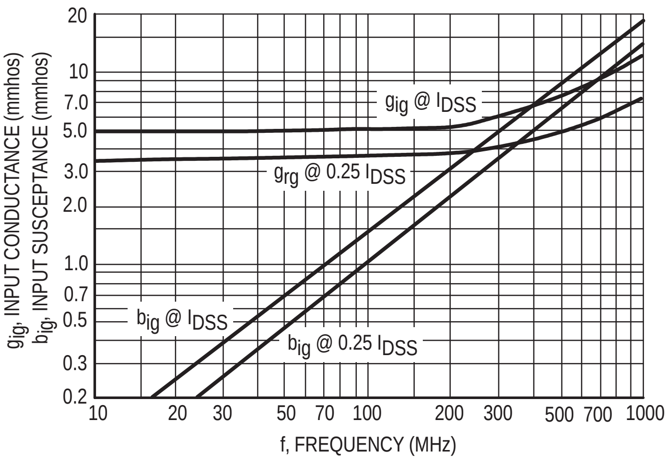


Figure 14. Input Admittance (y_{ig})

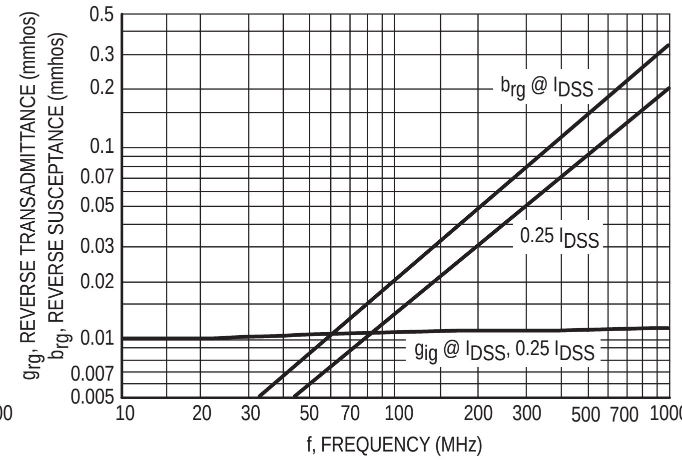


Figure 15. Reverse Transfer Admittance (y_{rg})

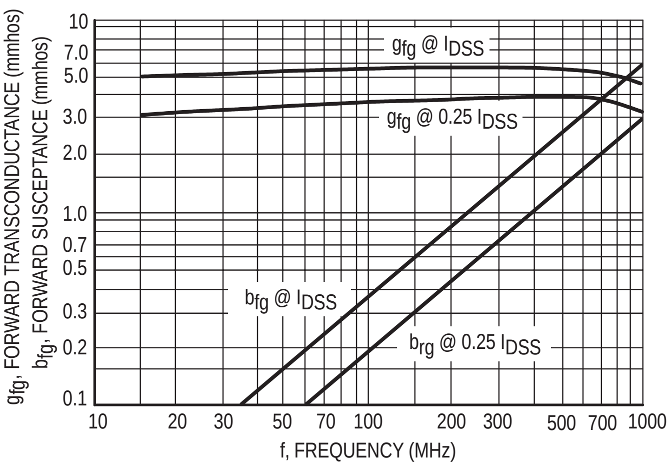


Figure 16. Forward Transfer Admittance (y_{fg})

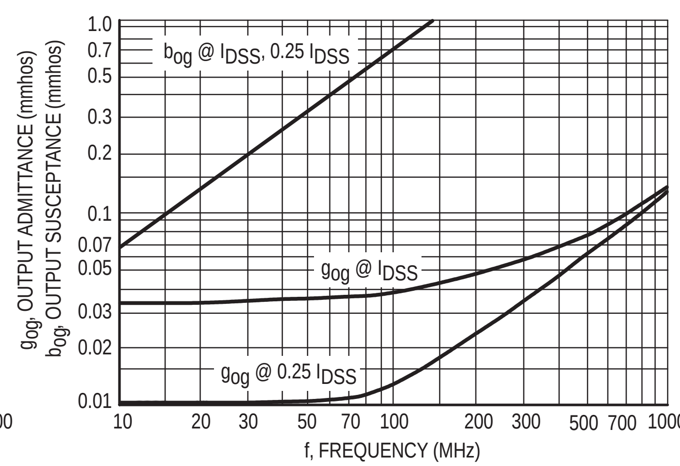


Figure 17. Output Admittance (y_{og})

COMMON GATE CHARACTERISTICS
S–PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

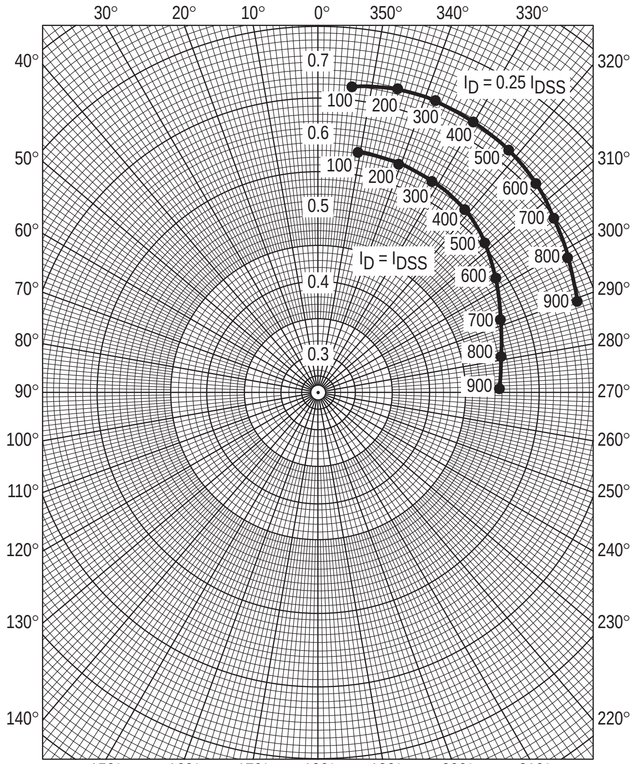


Figure 18. S_{11g}

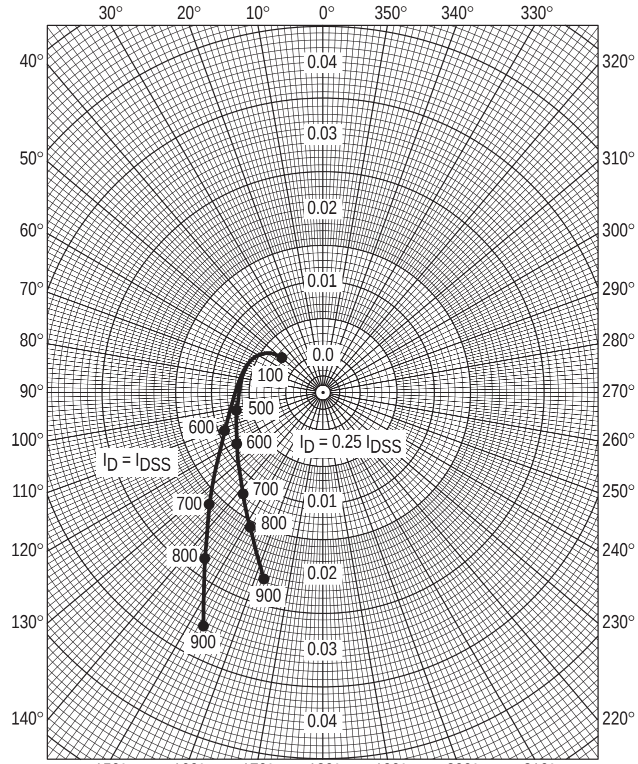


Figure 19. S_{12g}

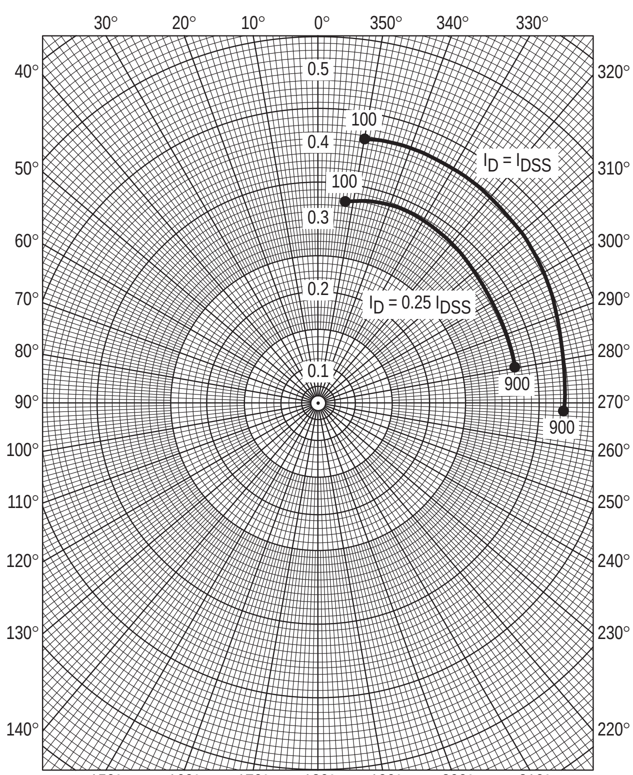


Figure 20. S_{21g}

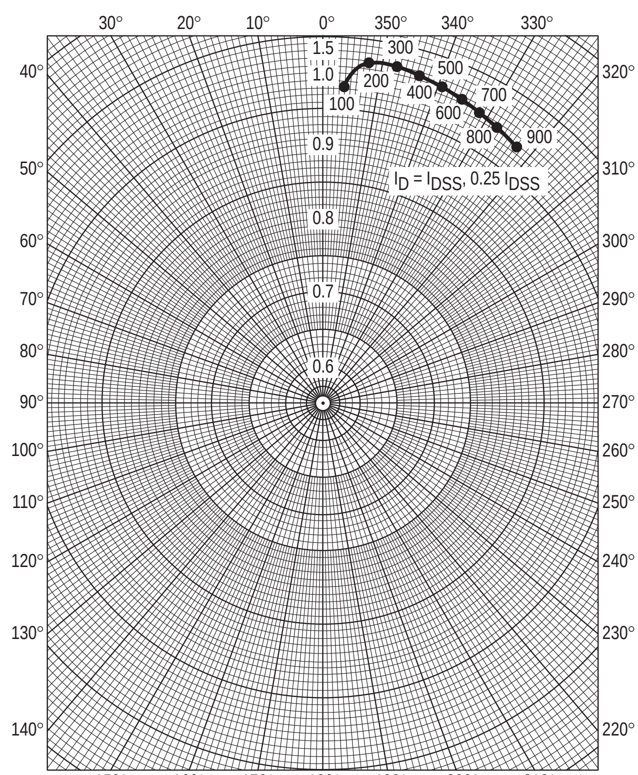
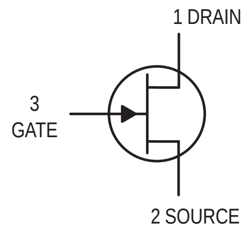
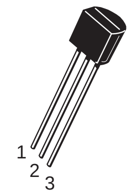


Figure 21. S_{22g}

JFET Switching
N–Channel — Depletion

2N5555





CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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 μAdc, 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(1) (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, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = –10 Vdc) (See Figure 1)	$t_{d(on)}$	—	5.0	ns
Rise Time		t_r	—	5.0	ns
Turn–Off Delay Time	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 7.0 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = –10 Vdc) (See Figure 1)	$t_{d(off)}$	—	15	ns
Fall Time		t_f	—	10	ns

1. Pulse Test: Pulse Width < 300 μs, Duty Cycle < 3.0%.

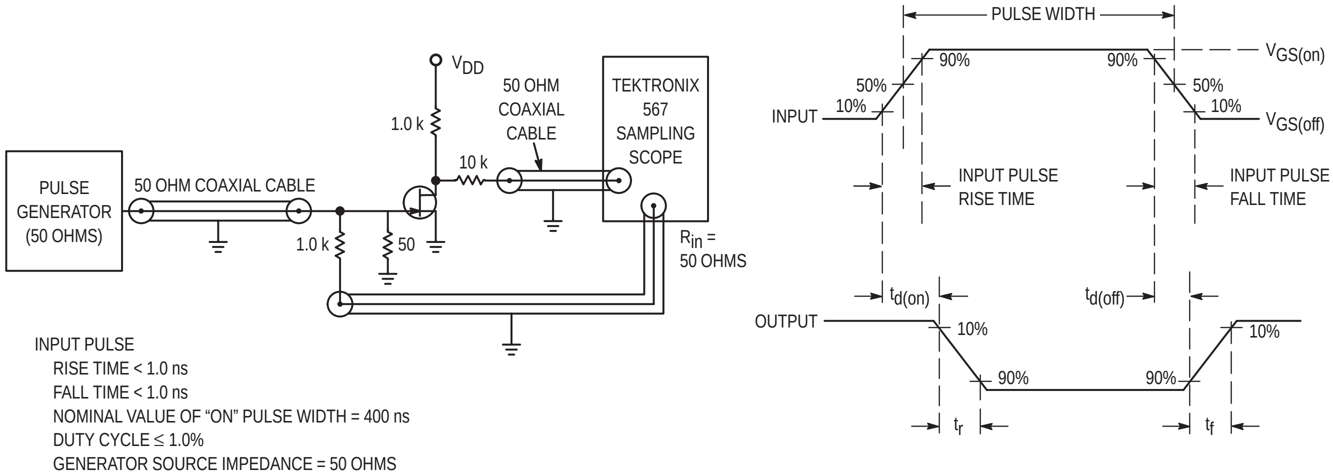


Figure 1. Switching Times Test Circuit

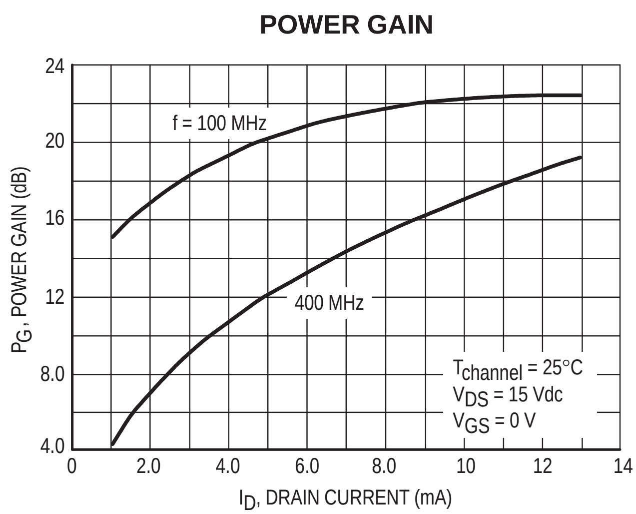
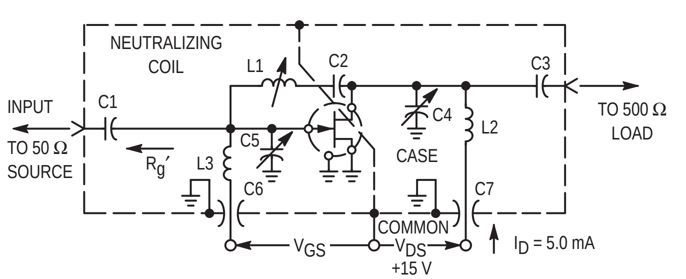


Figure 2. Effects of Drain Current



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).

Reference Designation	VALUE 100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1–12 pF	0.8–8.0 pF
C5	1–12 pF	0.8–8.0 pF
C6	0.0015 µF	0.001 µF
C7	0.0015 µF	0.001 µF
L1	3.0 µH*	0.2 µH**
L2	0.15 µH*	0.03 µH**
L3	0.14 µH*	0.022 µH**

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32″ ceramic coil form. Tuning provided by a powdered iron slug.
L2 4–1/2 turns, AWG #18 enameled copper wire, 5/16″ long, 3/8″ I.D. (AIR CORE).
L3 3–1/2 turns, AWG #18 enameled copper wire, 1/4″ long, 3/8″ I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32″ ceramic coil form. Tuning provided by an aluminum slug.
L2 1 turn, AWG #16 enameled copper wire, 3/8″ I.D. (AIR CORE).
L3 1/2 turn, AWG #16 enameled copper wire, 1/4″ I.D. (AIR CORE).

Figure 3. 100 MHz and 400 MHz Neutralized Test Circuit

NOISE FIGURE

($T_{channel}$ = 25°C)

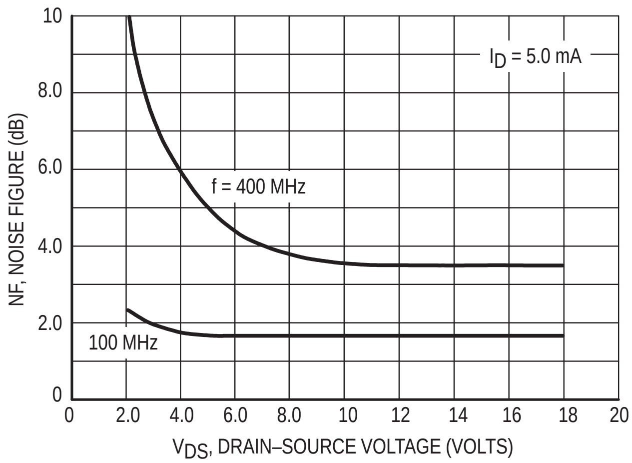


Figure 4. Effects of Drain–Source Voltage

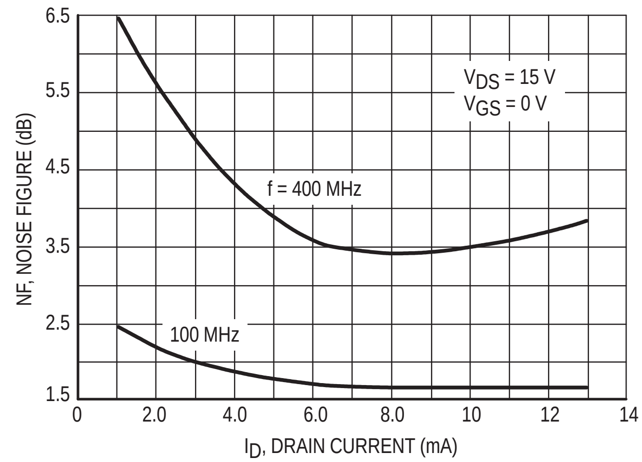


Figure 5. Effects of Drain Current

INTERMODULATION CHARACTERISTICS

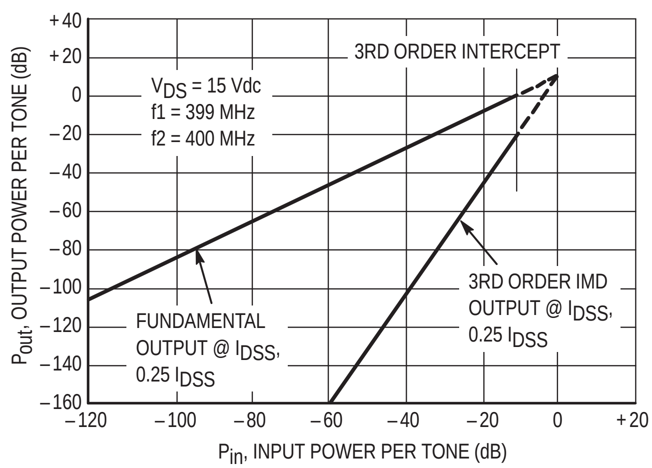


Figure 6. Third Order Intermodulation Distortion

COMMON SOURCE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

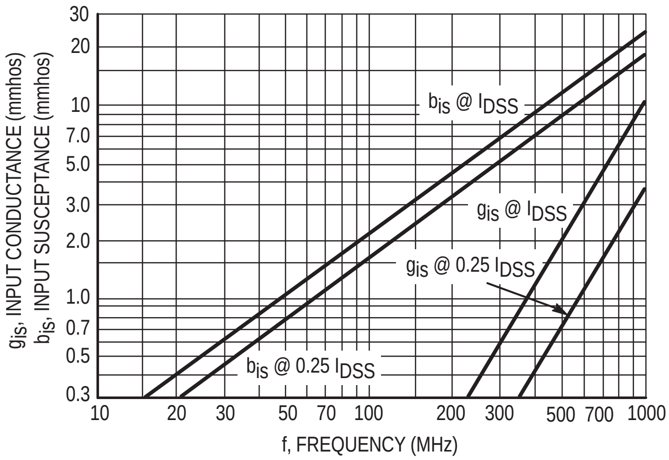


Figure 7. Input Admittance (y_{is})

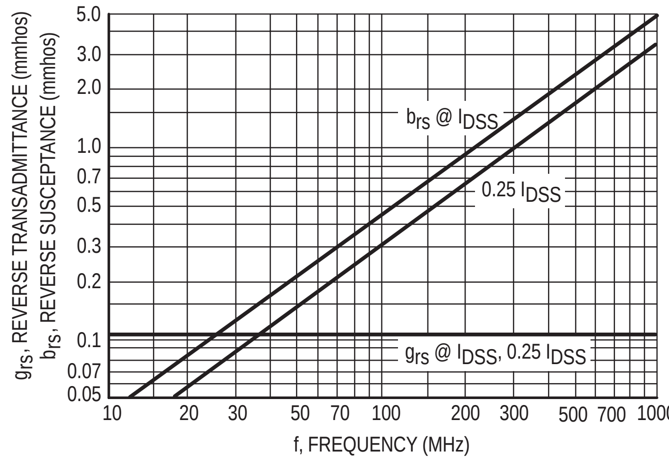


Figure 8. Reverse Transfer Admittance (y_{rs})

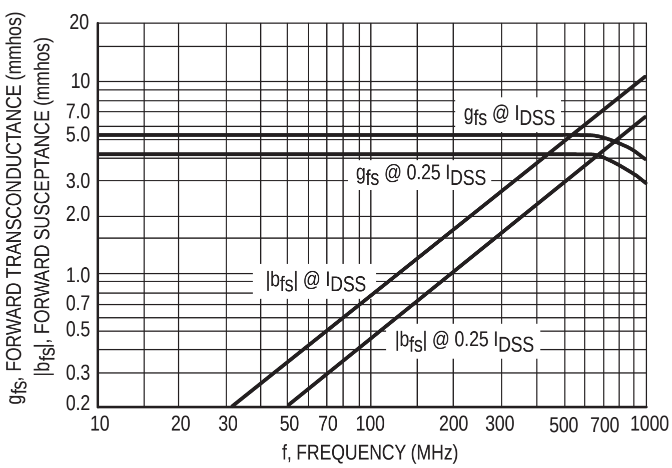


Figure 9. Forward Transadmittance (y_{fs})

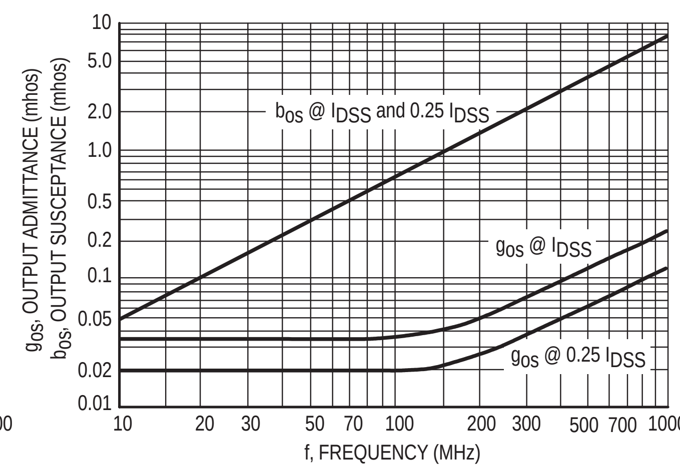


Figure 10. Output Admittance (y_{os})

COMMON SOURCE CHARACTERISTICS
S–PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

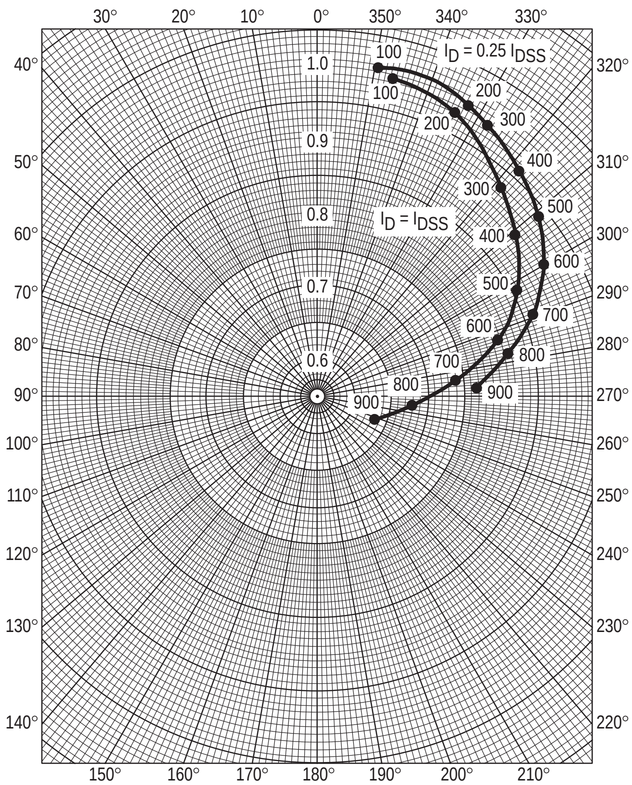


Figure 11. S_{11s}

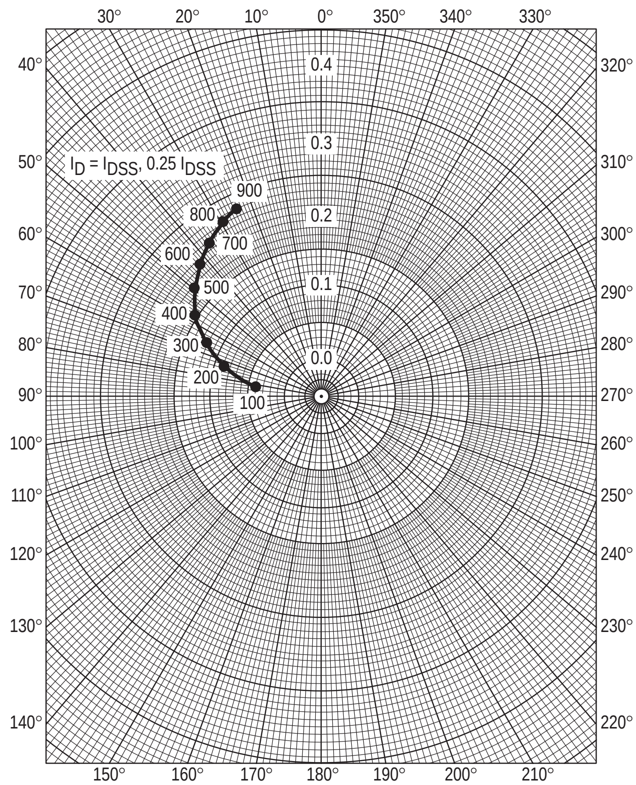


Figure 12. S_{12s}

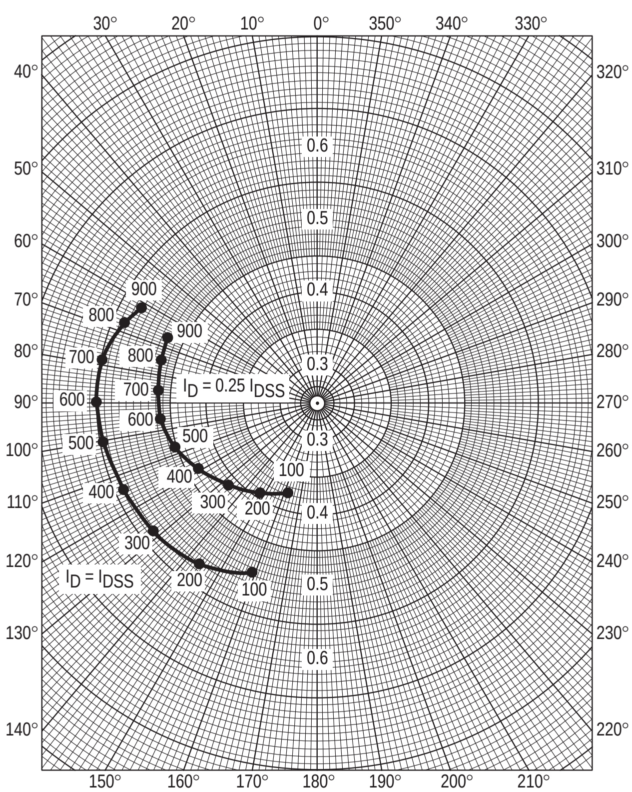


Figure 13. S_{21s}

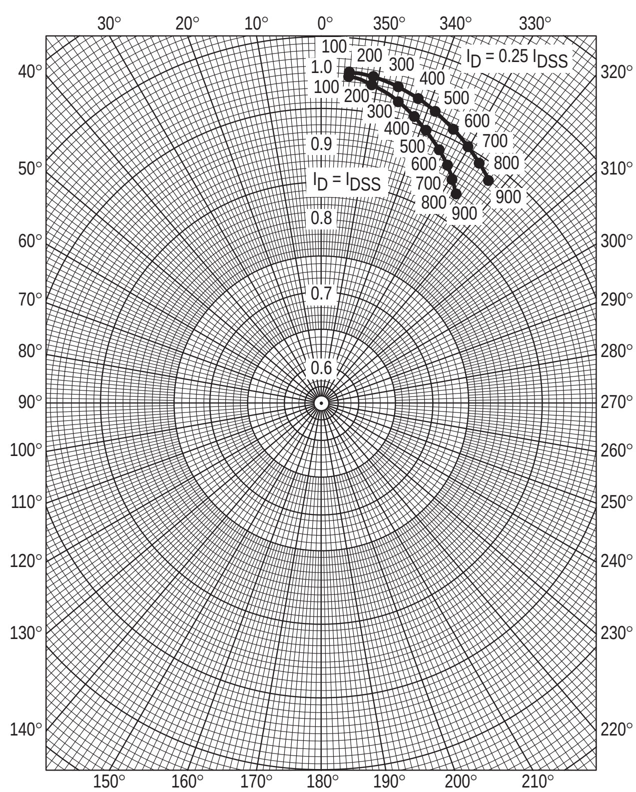


Figure 14. S_{22s}

COMMON GATE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

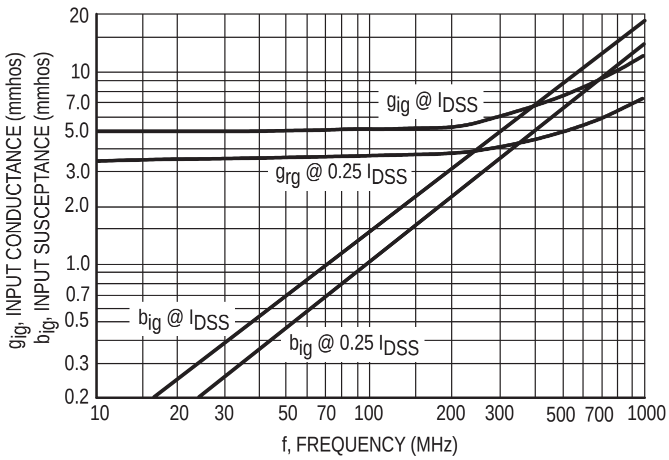


Figure 15. Input Admittance (y_{ig})

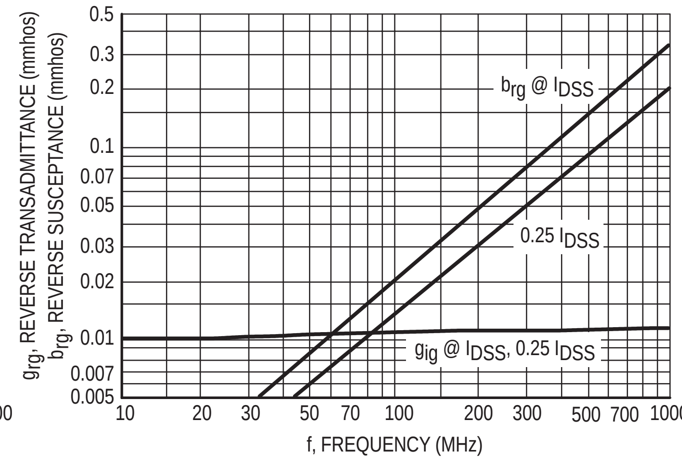


Figure 16. Reverse Transfer Admittance (y_{rg})

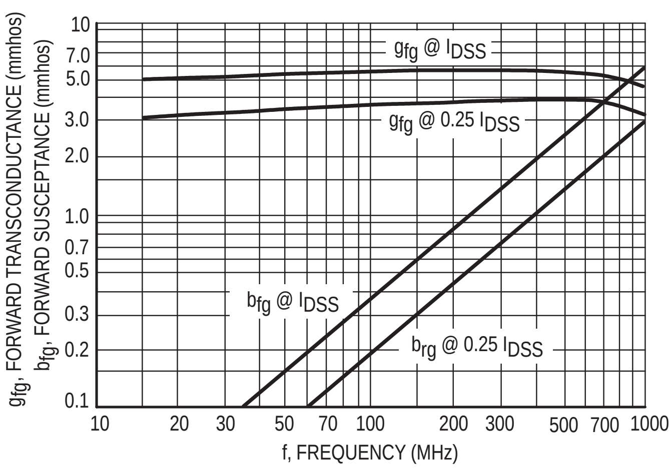


Figure 17. Forward Transfer Admittance (y_{fg})

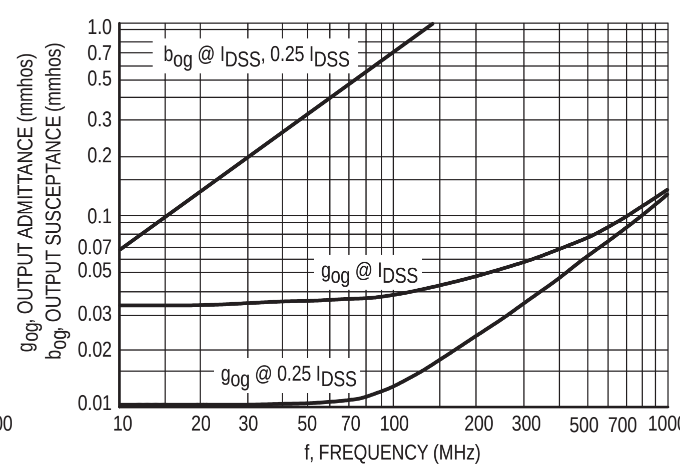


Figure 18. Output Admittance (y_{og})

COMMON GATE CHARACTERISTICS
S–PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

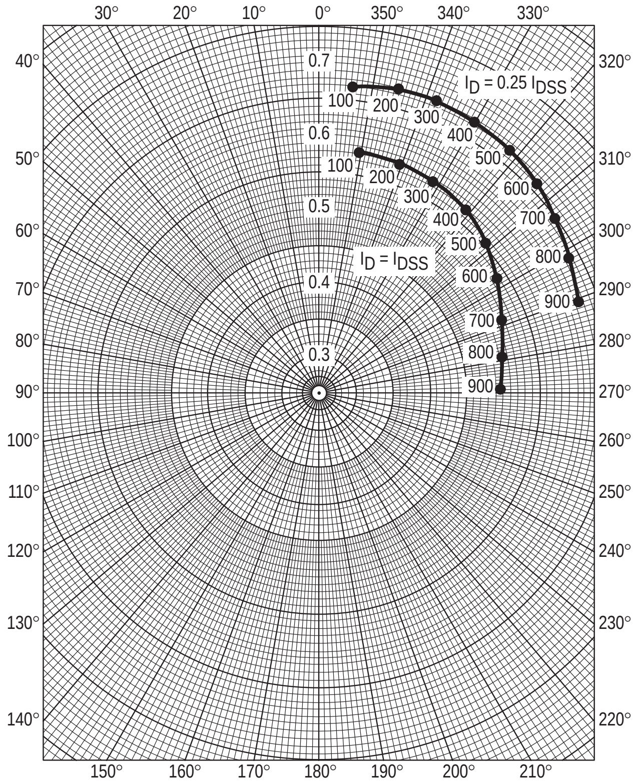


Figure 19. S_{11g}

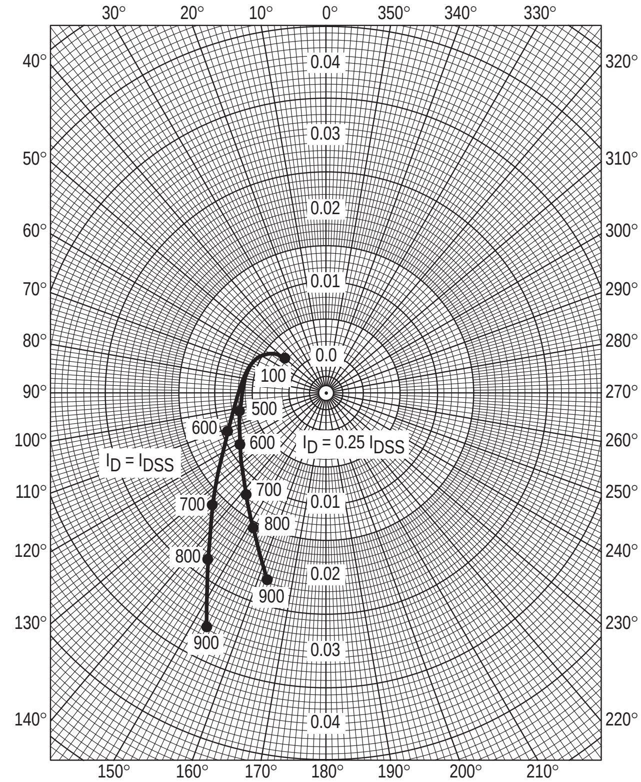


Figure 20. S_{12g}

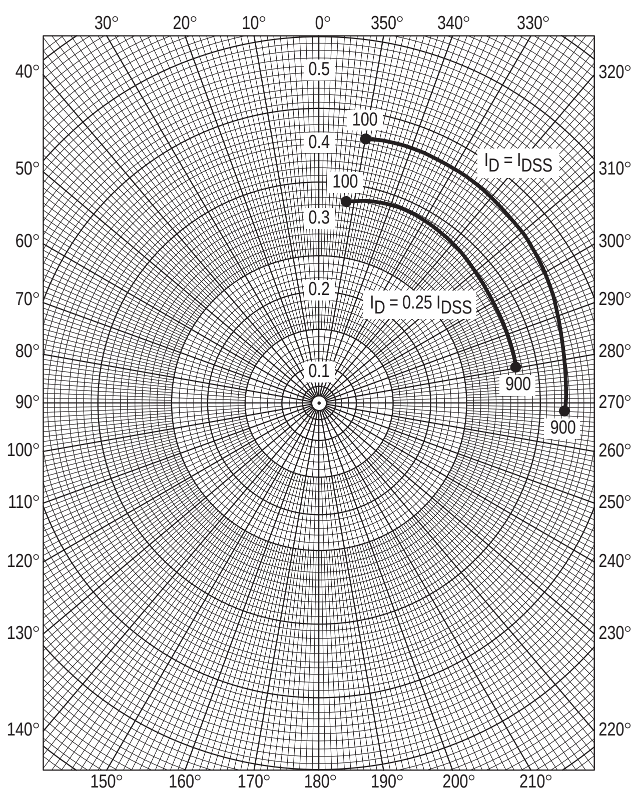


Figure 21. S_{21g}

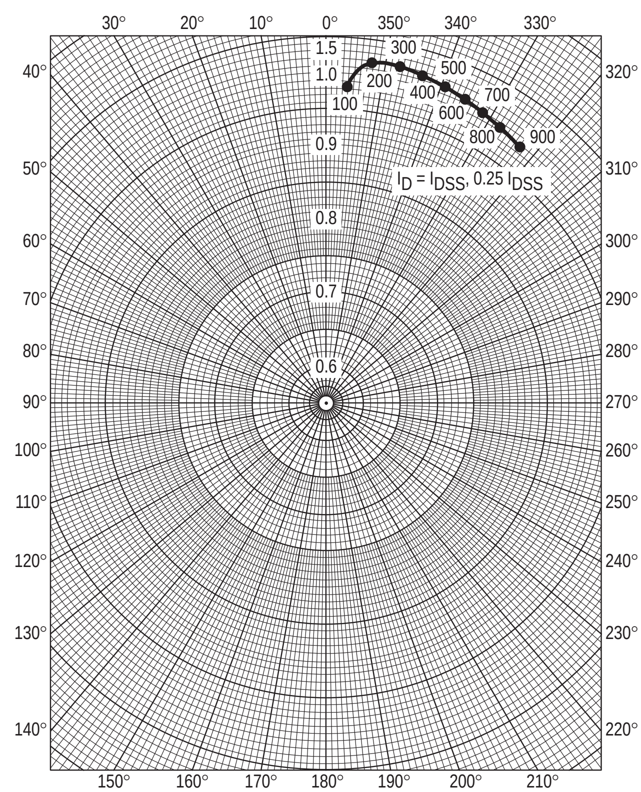
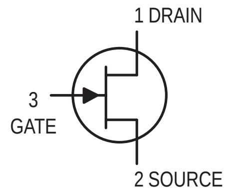


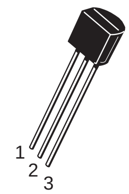
Figure 22. S_{22g}

JFETs Switching

N–Channel — Depletion

2N5640





CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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

1. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 3.0%.

REV 1

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

Characteristic			Symbol	Min	Max	Unit
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						
Turn–On Delay Time	V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = –10 Vdc, R_G' = 50 Ω	$I_{D(on)}$ = 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

TYPICAL SWITCHING CHARACTERISTICS

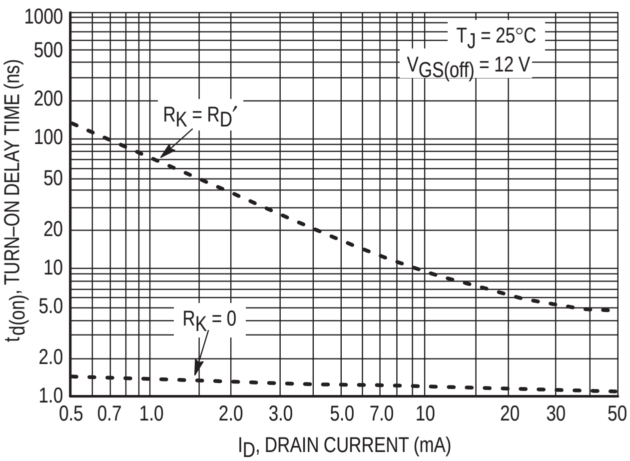


Figure 1. Turn–On Delay Time

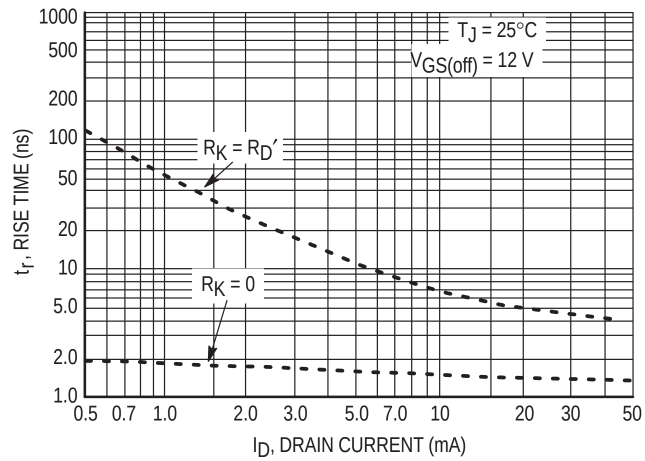


Figure 2. Rise Time

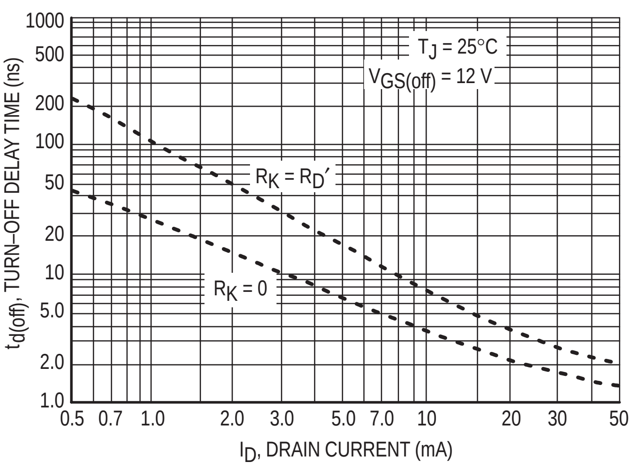


Figure 3. Turn–Off Delay Time

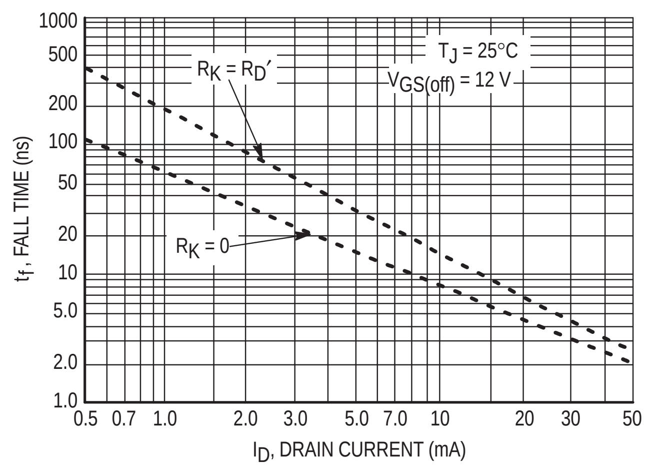


Figure 4. Fall Time

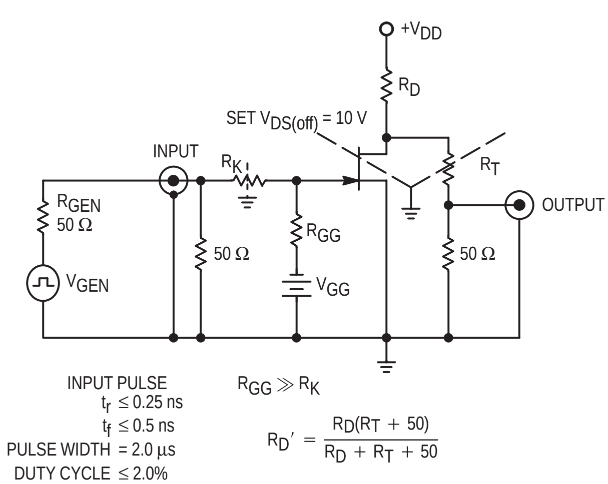


Figure 5. Switching Time Test Circuit

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.

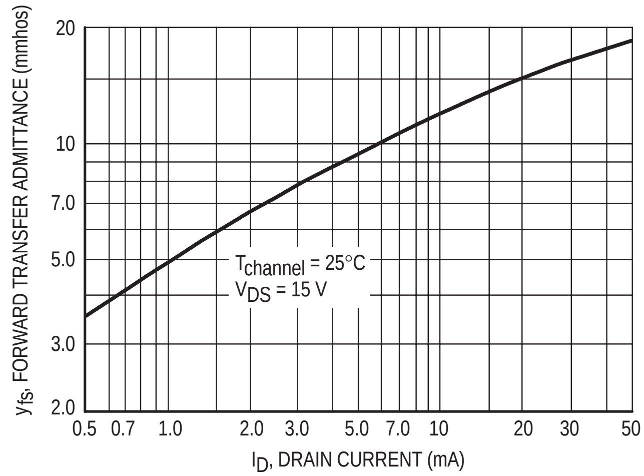


Figure 6. Typical Forward Transfer Admittance

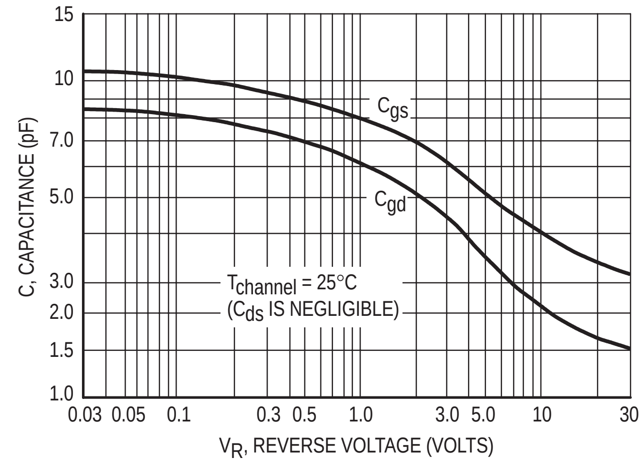


Figure 7. Typical Capacitance

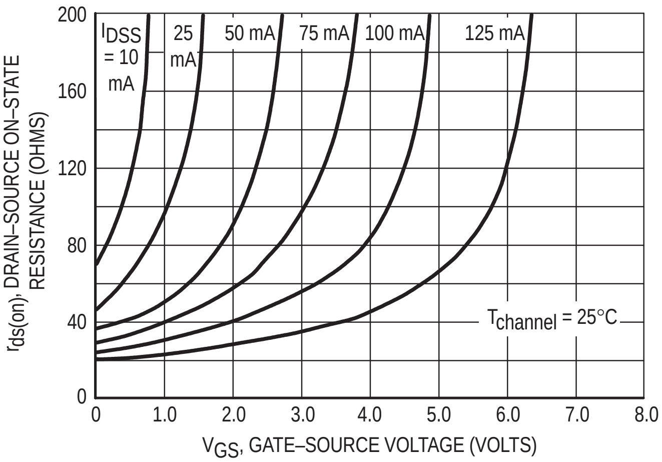


Figure 8. Effect of Gate–Source Voltage On Drain–Source Resistance

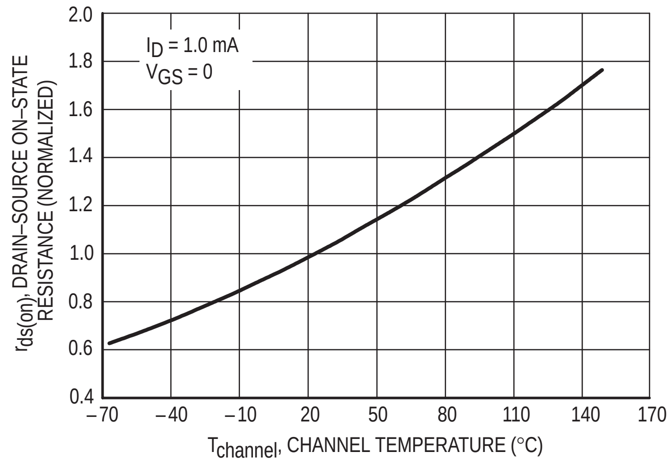


Figure 9. Effect of Temperature On Drain–Source On–State Resistance

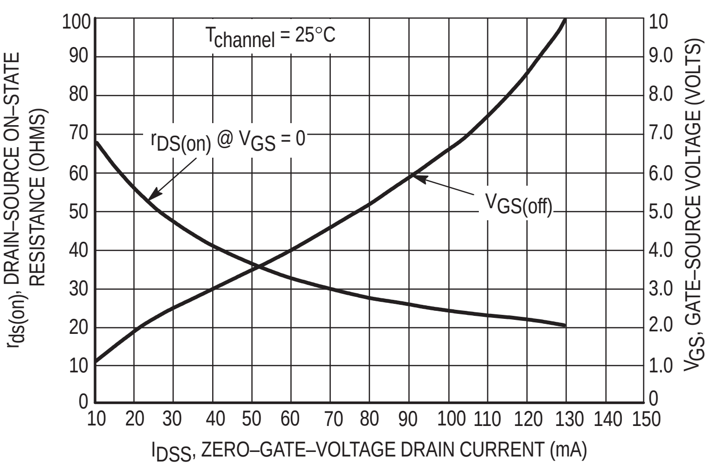


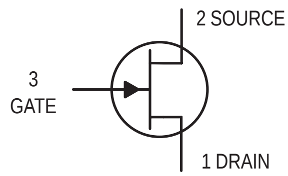
Figure 10. Effect of I_{DSS} On Drain–Source Resistance and Gate–Source Voltage

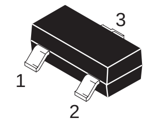
NOTE 2

The Zero–Gate–Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 10 shows the relationship of Gate–Source Off Voltage ($V_{GS(off)}$ and Drain–Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±10% of the values shown in Figure 10. This data will be useful in predicting the characteristic variations for a given part number.

JFET Amplifiers
N–Channel

BFR30LT1
BFR31LT1





CASE 318–08, STYLE 10
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

BFR30LT1 = M1; BFR31LT1 = M2

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) (I_D = 50 μAdc, V_{DS} = 10 Vdc)	BFR30 BFR31 BFR30 BFR31	V_{GS}	–0.7 — — —	–3.0 –1.3 –4.0 –2.0	Vdc

1. Device mounted on FR4 glass epoxy printed circuit board using the recommended footprint.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

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

Characteristic			Symbol	Min	Max	Unit
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) (I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 kHz)		 BFR30 BFR31 BFR30 BFR31	$\lvert y_{fs} \rvert$	 1.0 1.5 0.5 0.75	 4.0 4.5 — —	mAdc
Output Admittance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 kHz) (I_D = 200 μAdc, V_{DS} = 10 Vdc)		 BFR30 BFR31	$\lvert y_{os} \rvert$	 40 20	 25 15	μAdc
Input Capacitance	(I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 MHz) (I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)		C_{iss}	— —	5.0 4.0	pF
Reverse Transfer Capacitance	(I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 MHz) (I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)		C_{rss}	— —	1.5 1.5	pF

TYPICAL CHARACTERISTICS

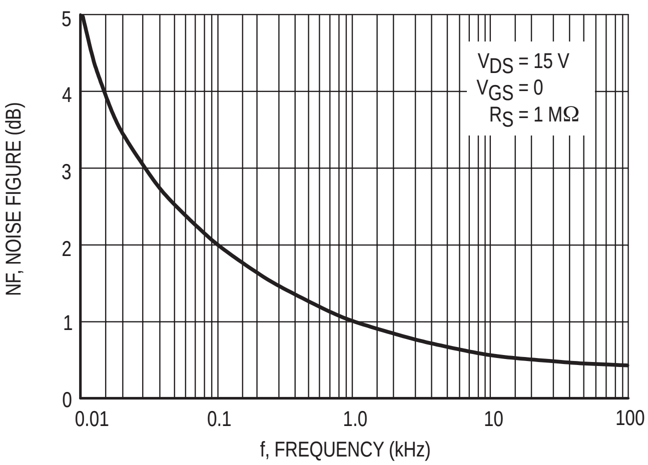


Figure 1. Noise Figure versus Frequency

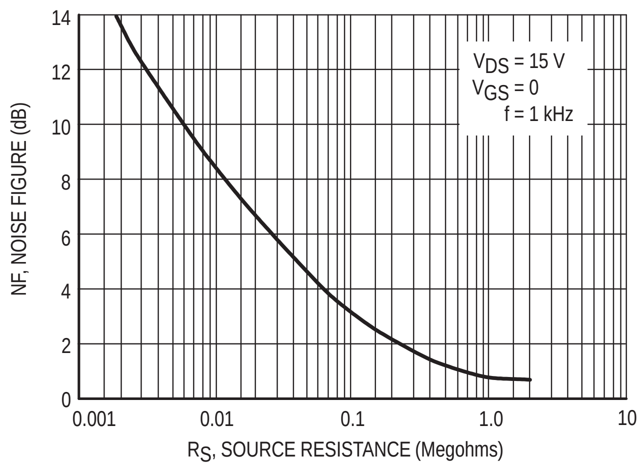


Figure 2. Noise Figure versus Source Resistance

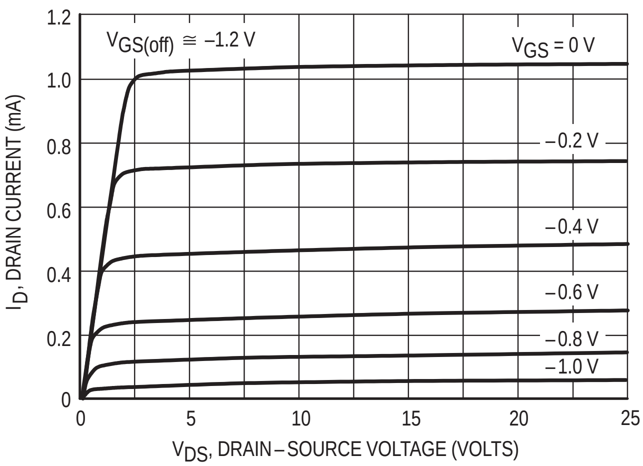


Figure 3. Typical Drain Characteristics

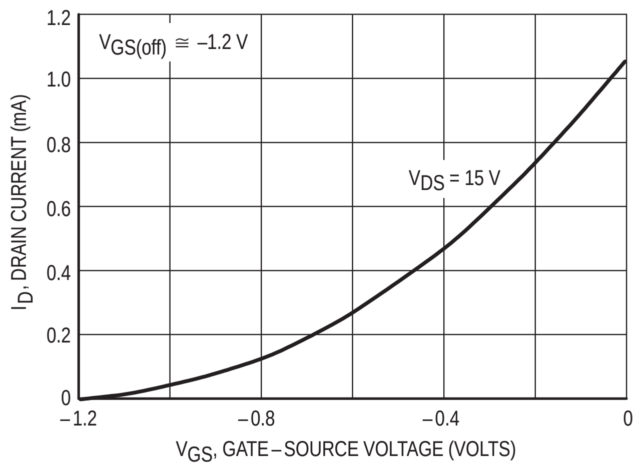


Figure 4. Common Source Transfer Characteristics

TYPICAL CHARACTERISTICS

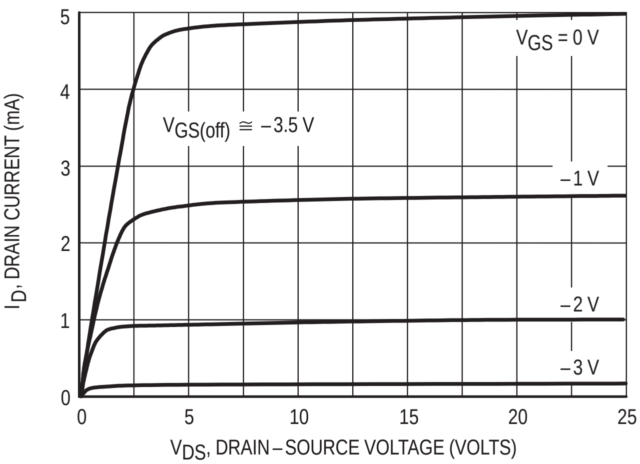


Figure 5. Typical Drain Characteristics

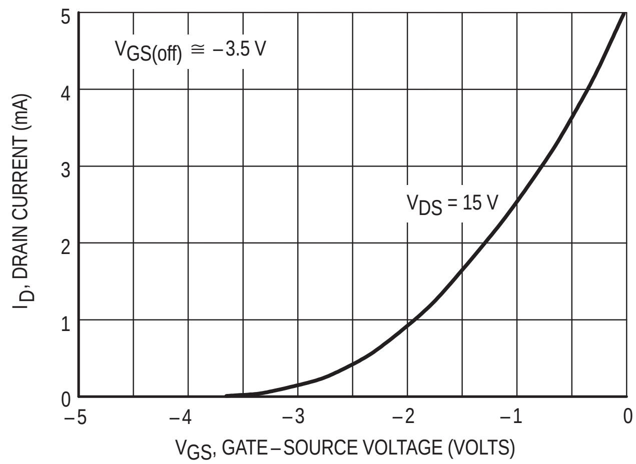


Figure 6. Common Source Transfer Characteristics

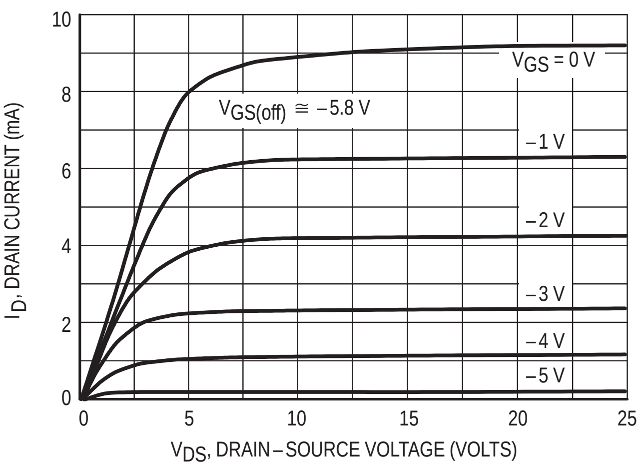


Figure 7. Typical Drain Characteristics

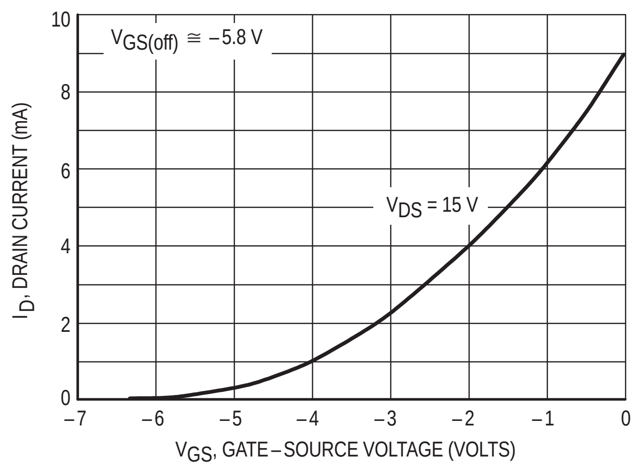
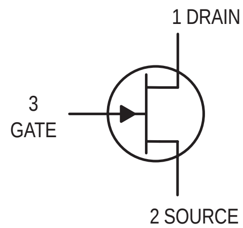


Figure 8. Common Source Transfer Characteristics

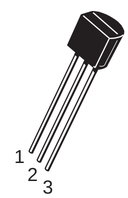
Note: Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS}.

JFET Chopper Transistor

N–Channel — Depletion



J112



CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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	mAdc
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 μAdc)	$V_{(BR)GSS}$	35	—	Vdc
Gate Reverse Current (V_{GS} = –15 Vdc)	I_{GSS}	—	–1.0	nAdc
Gate Source Cutoff Voltage (V_{DS} = 5.0 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	–1.0	–5.0	Vdc
Drain–Cutoff Current (V_{DS} = 5.0 Vdc, V_{GS} = –10 Vdc)	$I_{D(off)}$	—	1.0	nAdc
ON CHARACTERISTICS				
Zero–Gate–Voltage Drain Current(1) (V_{DS} = 15 Vdc)	I_{DSS}	5.0	—	mAdc
Static Drain–Source On Resistance (V_{DS} = 0.1 Vdc)	$r_{DS(on)}$	—	50	Ω
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 Vdc, f = 1.0 MHz)	$C_{dg(off)}$	—	5.0	pF
Source Gate Off–Capacitance (V_{GS} = –10 Vdc, f = 1.0 MHz)	$C_{sg(off)}$	—	5.0	pF

1. Pulse Width = 300 μs, Duty Cycle = 3.0%.

(Replaces J111/D)

TYPICAL SWITCHING CHARACTERISTICS

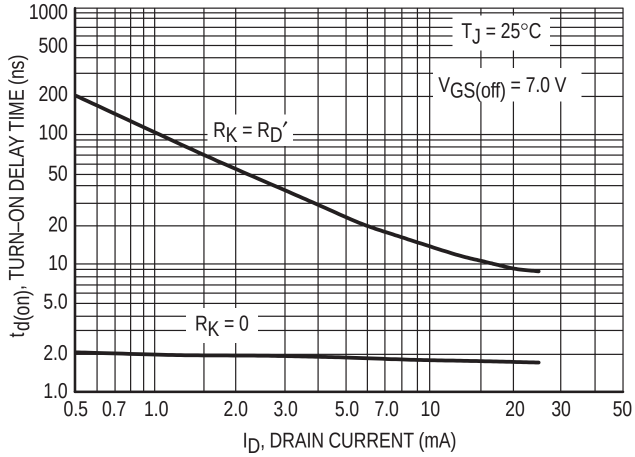


Figure 1. Turn–On Delay Time

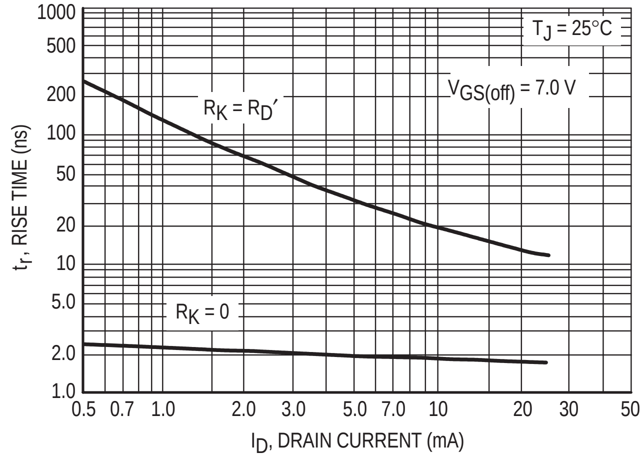


Figure 2. Rise Time

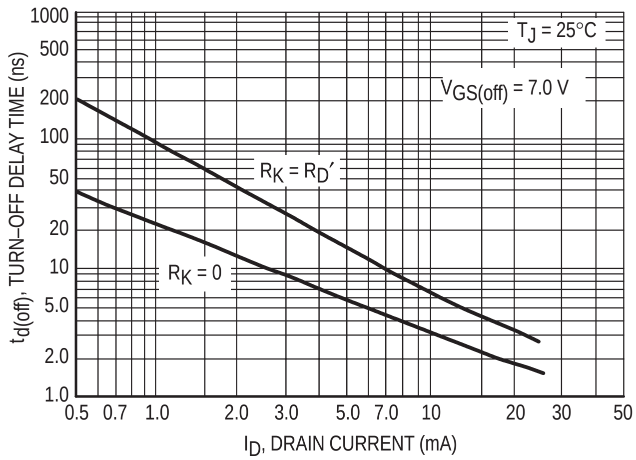


Figure 3. Turn–Off Delay Time

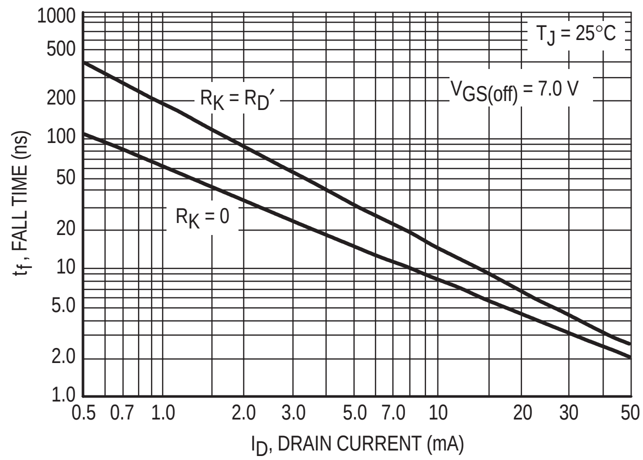


Figure 4. Fall Time

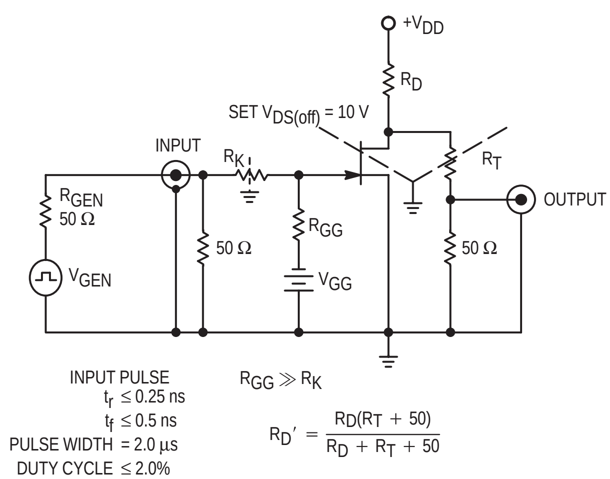


Figure 5. Switching Time Test Circuit

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.

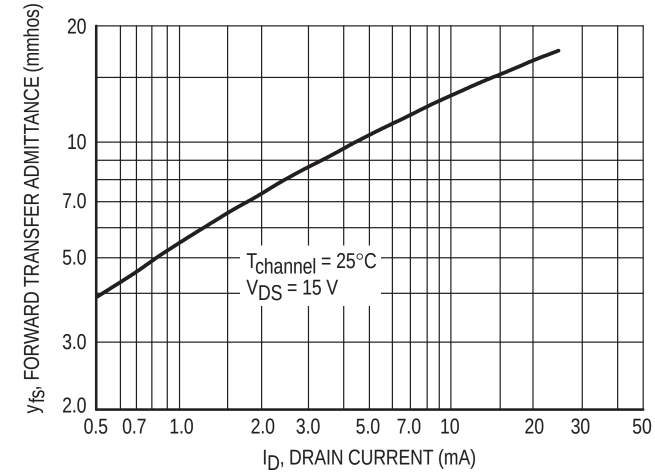


Figure 6. Typical Forward Transfer Admittance

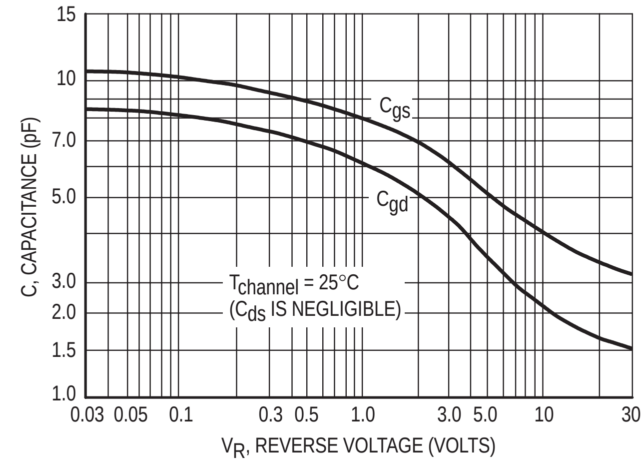


Figure 7. Typical Capacitance

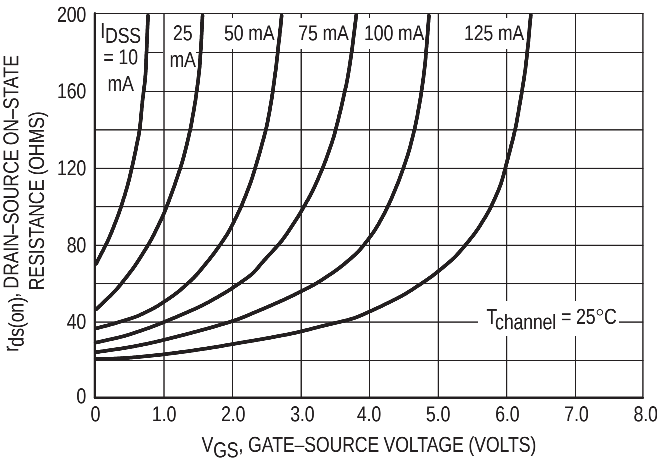


Figure 8. Effect of Gate–Source Voltage On Drain–Source Resistance

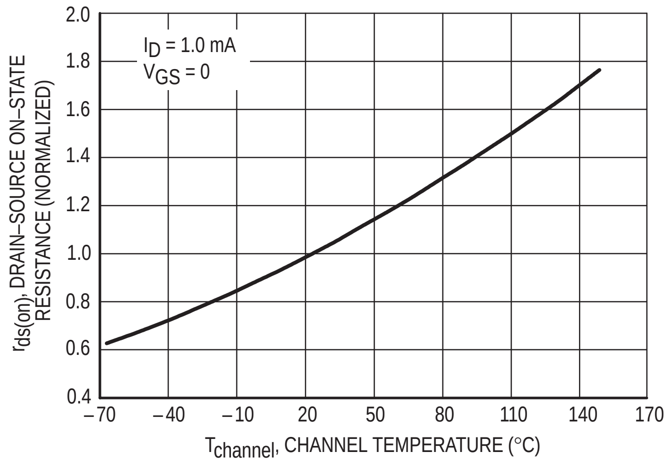


Figure 9. Effect of Temperature On Drain–Source On–State Resistance

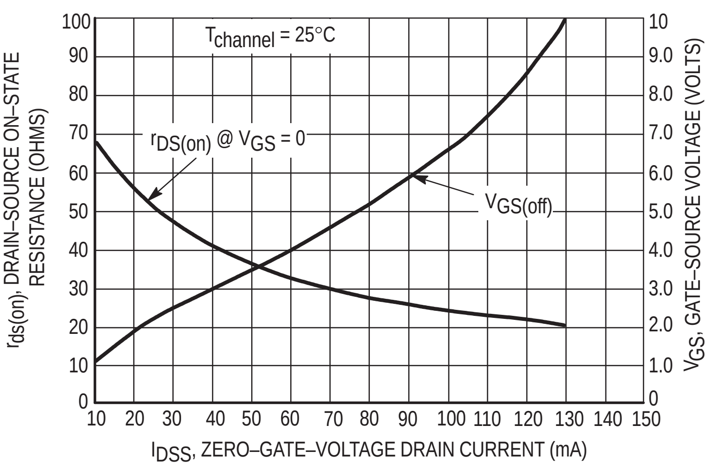


Figure 10. Effect of I_{DSS} On Drain–Source Resistance and Gate–Source Voltage

NOTE 2

The Zero–Gate–Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 10 shows the relationship of Gate–Source Off Voltage ($V_{GS(off)}$) and Drain–Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±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

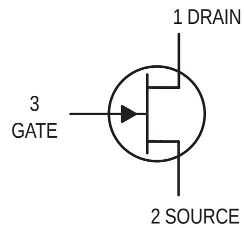
$r_{ds(on)}$ and V_{GS} range for an J112

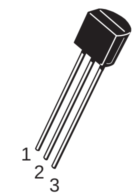
The electrical characteristics table indicates that an J112 has an I_{DSS} range of 25 to 75 mA. Figure 10, shows $r_{ds(on)}$ = 52 Ohms for I_{DSS} = 25 mA and 30 Ohms for I_{DSS} = 75 mA. The corresponding V_{GS} values are 2.2 volts and 4.8 volts.

JFETs Low Frequency/ Low Noise

N–Channel — Depletion

J202





CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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	mAdc
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 μAdc)	$V_{(BR)GSS}$	–40	—	Vdc
Gate Reverse Current (V_{GS} = –20 Vdc)	I_{GSS}	—	–100	pA
Gate Source Cutoff Voltage (V_{DS} = 20 Vdc, I_D = 10 nAdc)	$V_{GS(off)}$	–0.8	–4.0	Vdc
ON CHARACTERISTICS				
Zero–Gate–Voltage Drain Current(1) (V_{DS} = 20 Vdc)	I_{DSS}	0.9	4.5	mAdc
SMALL–SIGNAL CHARACTERISTICS				
Forward Transfer Admittance(1) (V_{DS} = 20 Vdc, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	1000	—	μmhos

1. Pulse Width ≤ 2.0 ms.

REV 1

TYPICAL CHARACTERISTICS

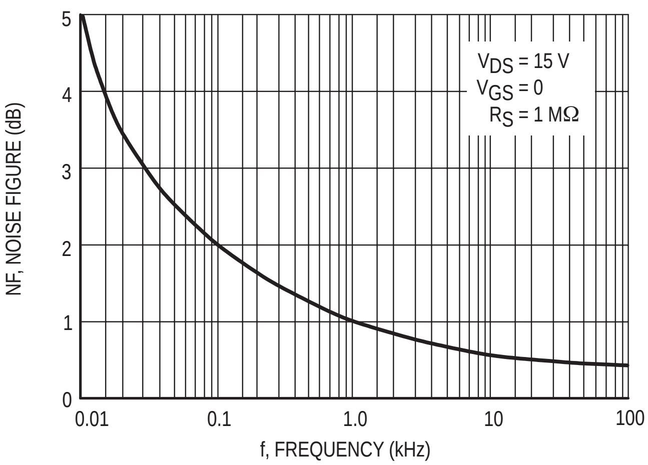


Figure 1. Noise Figure versus Frequency

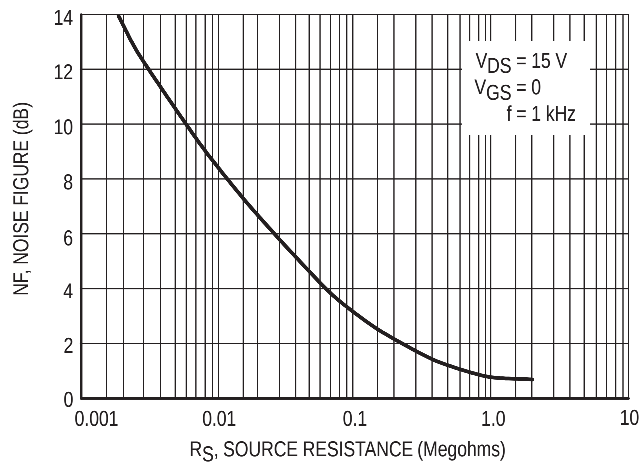


Figure 2. Noise Figure versus Source Resistance

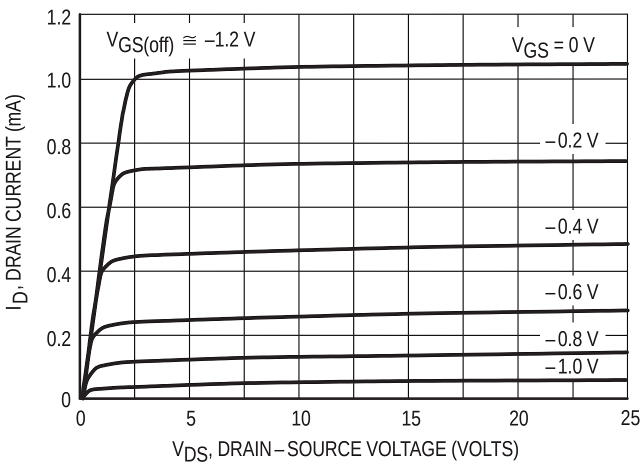


Figure 3. Typical Drain Characteristics

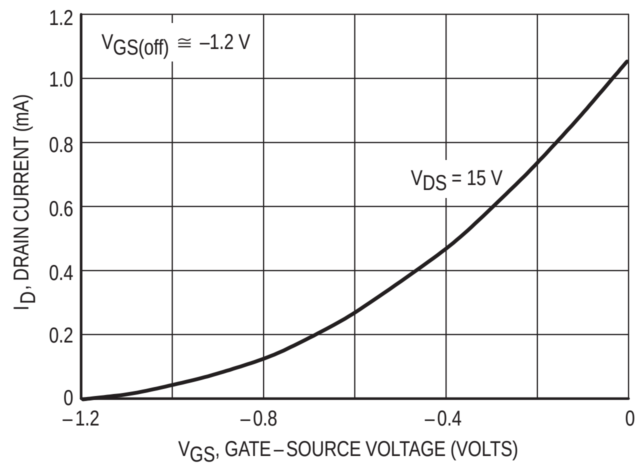


Figure 4. Common Source Transfer Characteristics

TYPICAL CHARACTERISTICS

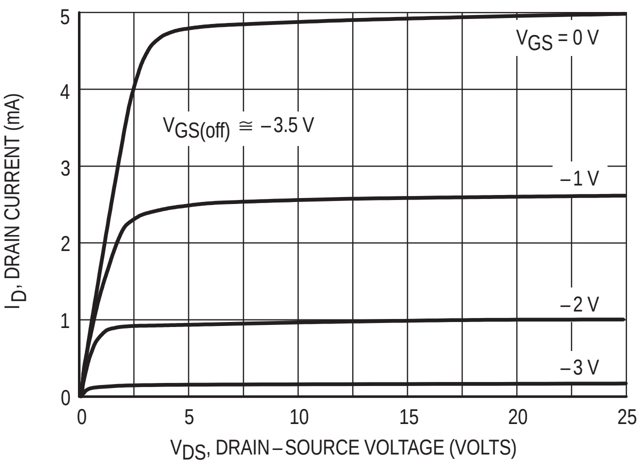


Figure 5. Typical Drain Characteristics

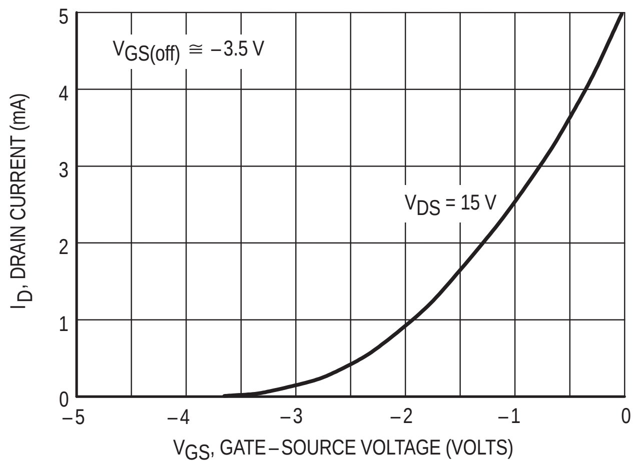


Figure 6. Common Source Transfer Characteristics

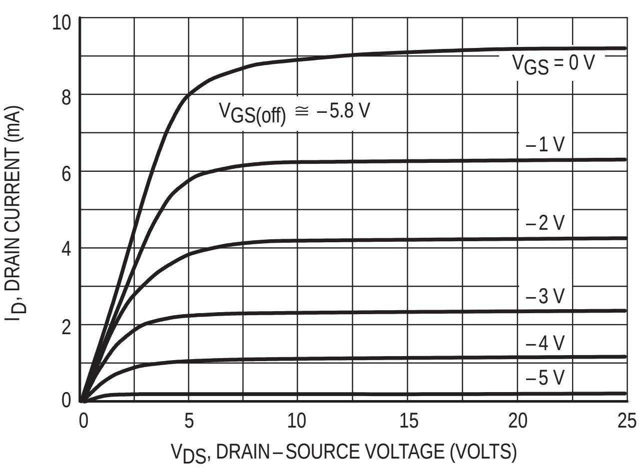


Figure 7. Typical Drain Characteristics

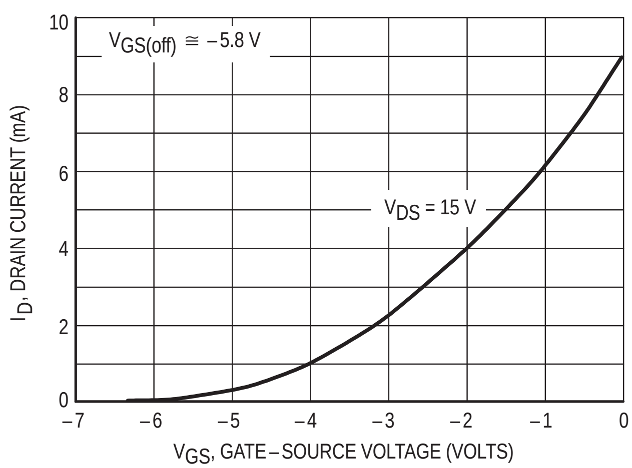


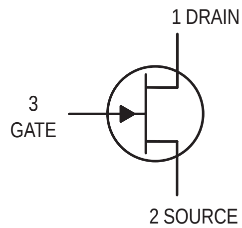
Figure 8. Common Source Transfer Characteristics

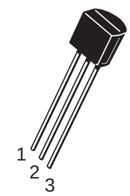
Note: Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS}.

JFET High Frequency Amplifier

N–Channel — Depletion

J304





CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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 µAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = –20 Vdc, V_{DS} = 0)	I_{GSS}	—	100	pA
Gate–Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 nAdc)	$V_{GS(off)}$	–2.0	–6.0	Vdc
ON CHARACTERISTICS				
Zero–Gate–Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	15	mA
SMALL–SIGNAL CHARACTERISTICS				
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	50	µmhos
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$Re(y_{fs})$	4500	7500	µmhos

REV 1

POWER GAIN

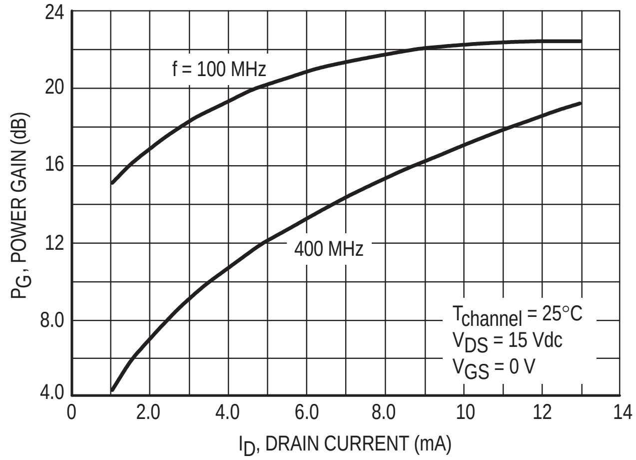
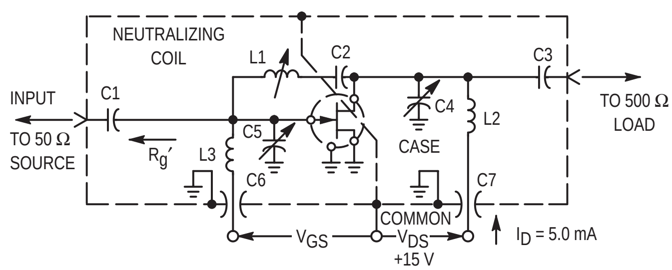


Figure 1. Effects of Drain Current



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).

Figure 2. 100 MHz and 400 MHz Neutralized Test Circuit

NOISE FIGURE
($T_{channel}$ = 25°C)

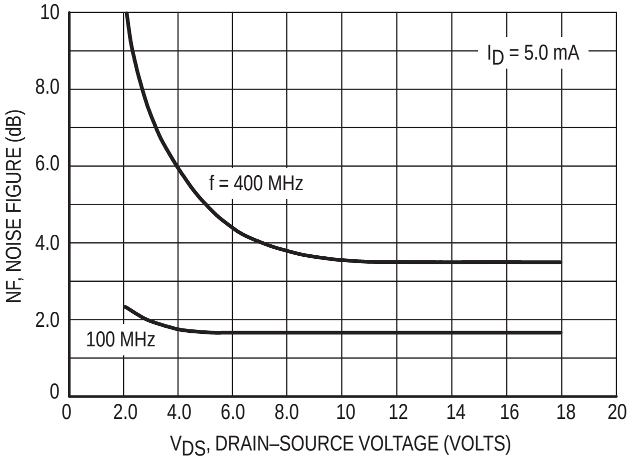


Figure 3. Effects of Drain–Source Voltage

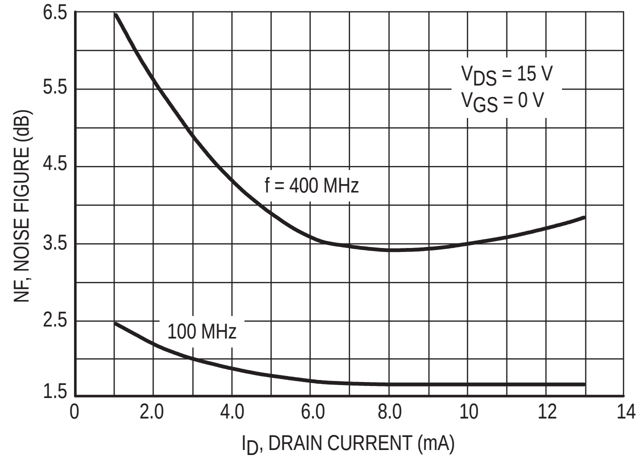


Figure 4. Effects of Drain Current

INTERMODULATION CHARACTERISTICS

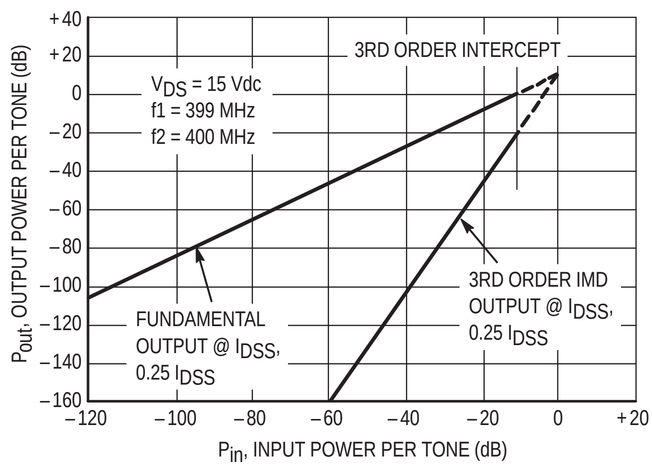


Figure 5. Third Order Intermodulation Distortion

COMMON SOURCE CHARACTERISTICS
ADMITTANCE PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

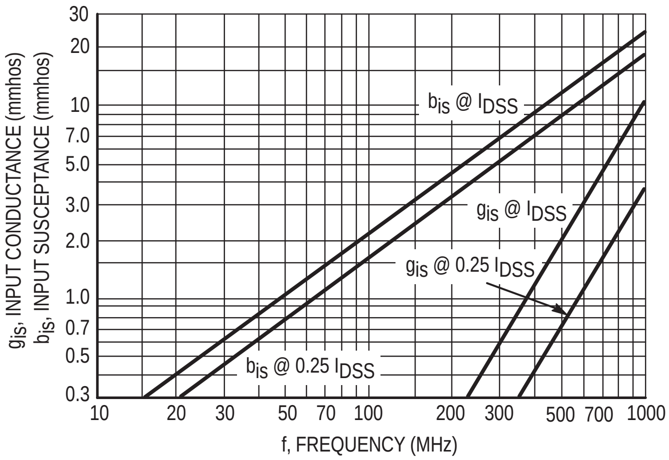


Figure 6. Input Admittance (y_{is})

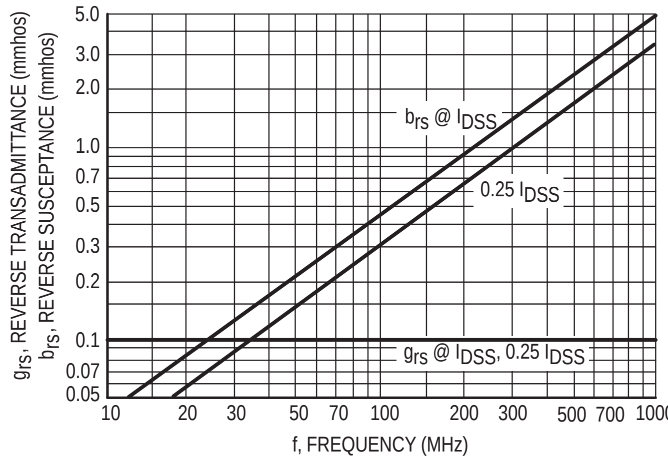


Figure 7. Reverse Transfer Admittance (y_{rs})

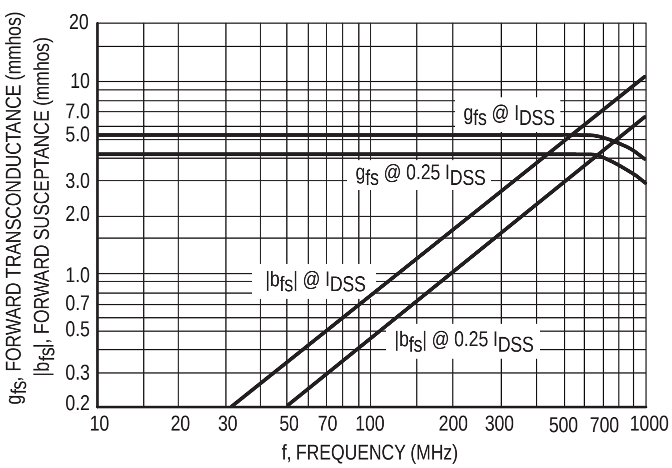


Figure 8. Forward Transadmittance (y_{fs})

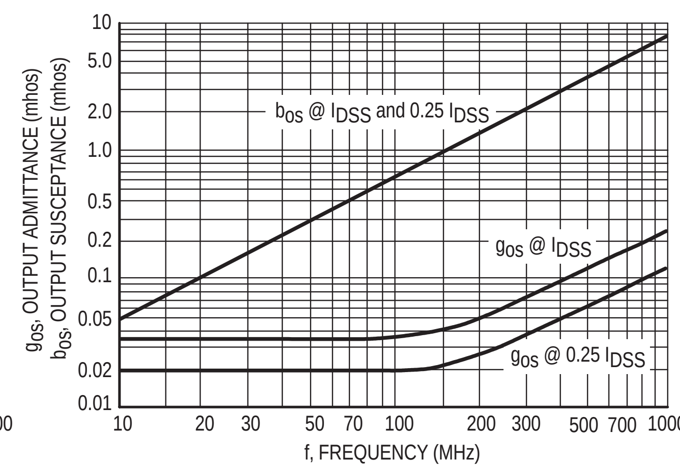


Figure 9. Output Admittance (y_{os})

COMMON SOURCE CHARACTERISTICS
S–PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

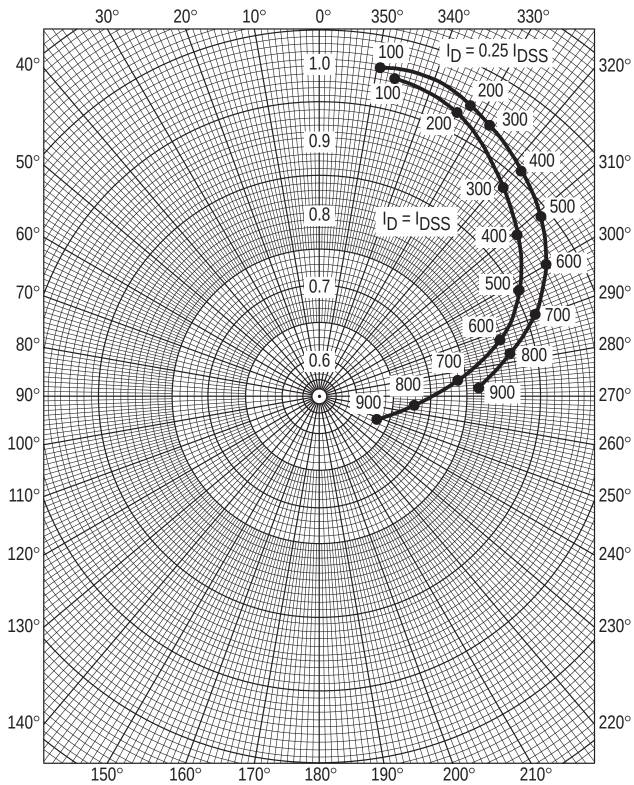


Figure 10. S_{11s}

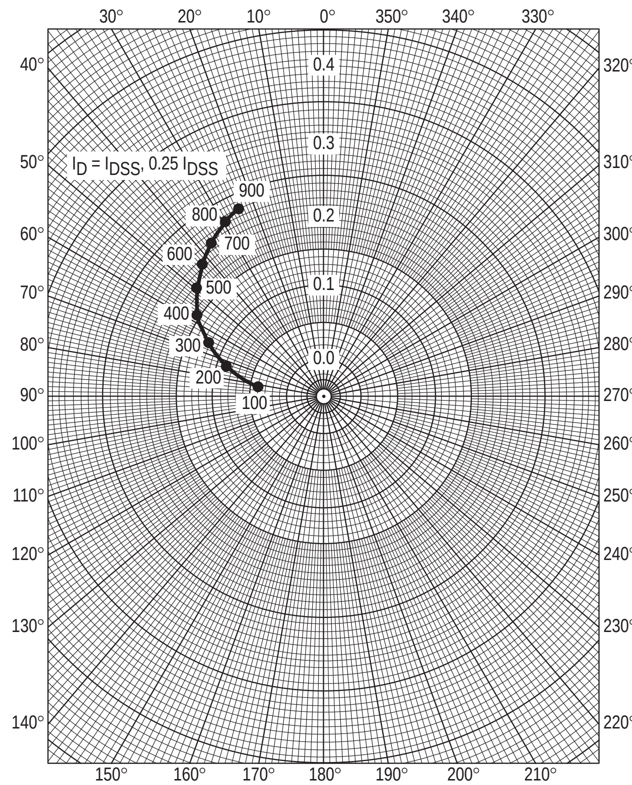


Figure 11. S_{12s}

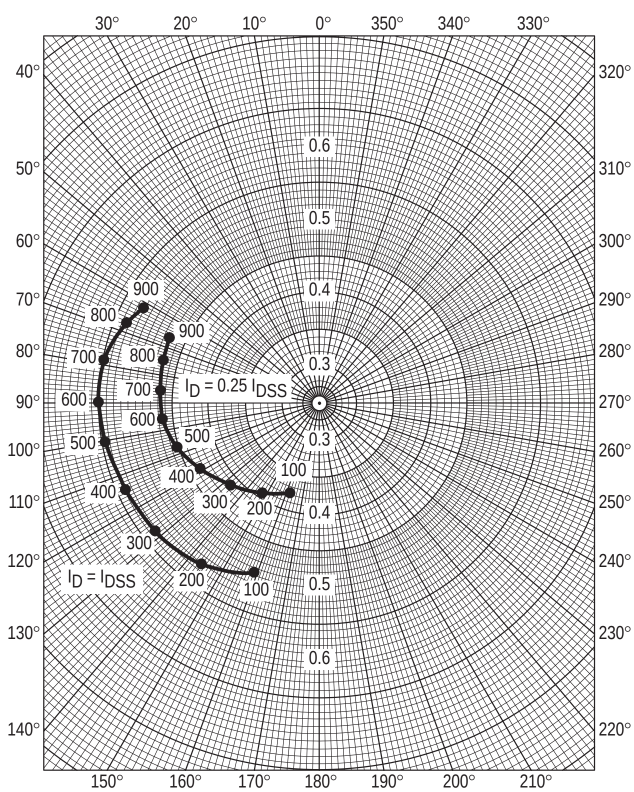


Figure 12. S_{21s}

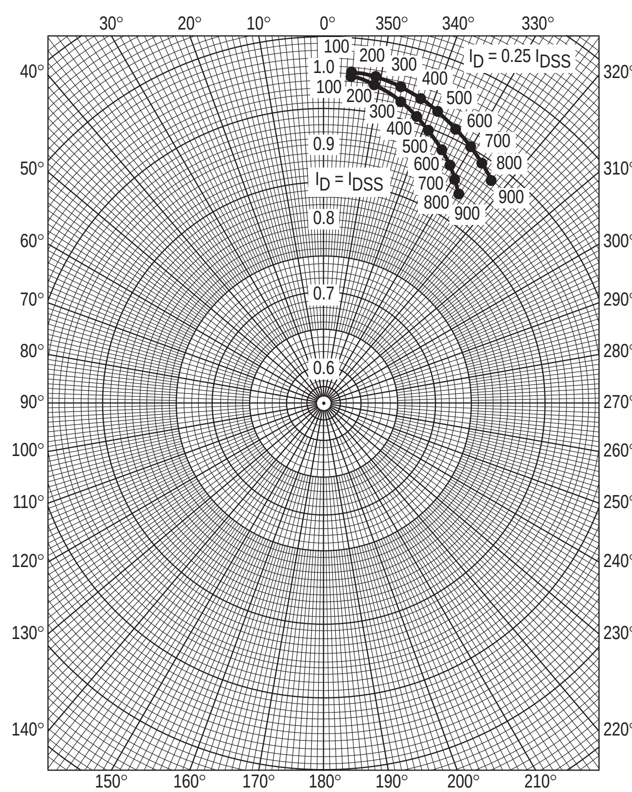


Figure 13. S_{22s}

COMMON GATE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

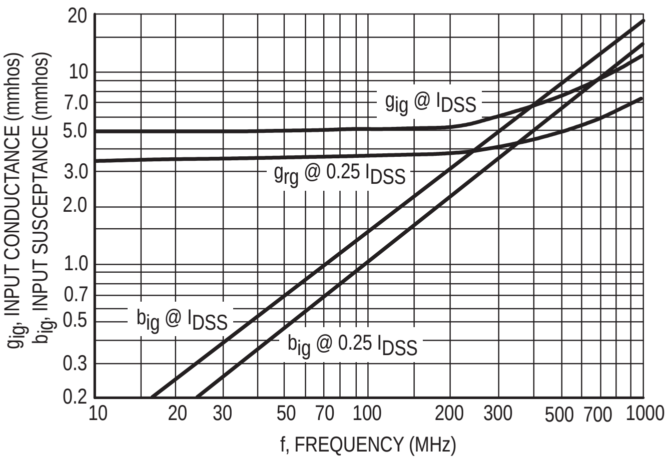


Figure 14. Input Admittance (y_{ig})

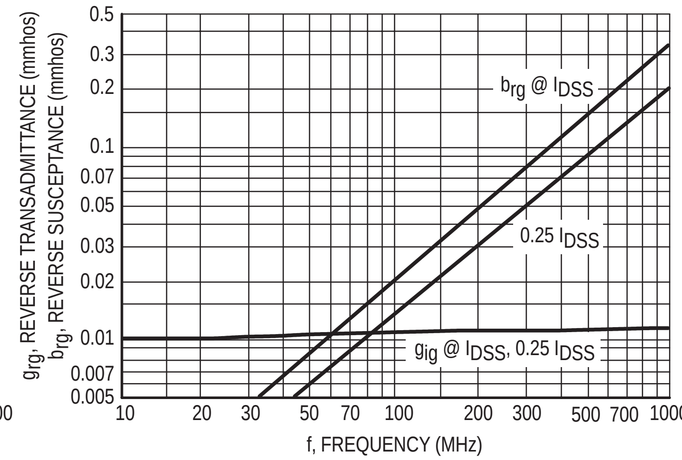


Figure 15. Reverse Transfer Admittance (y_{rg})

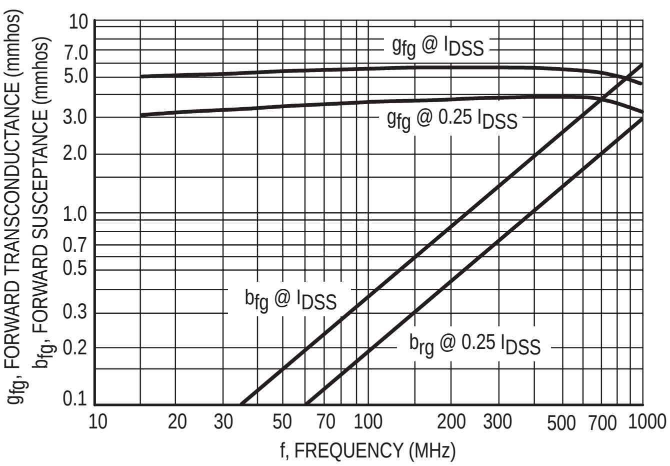


Figure 16. Forward Transfer Admittance (y_{fg})

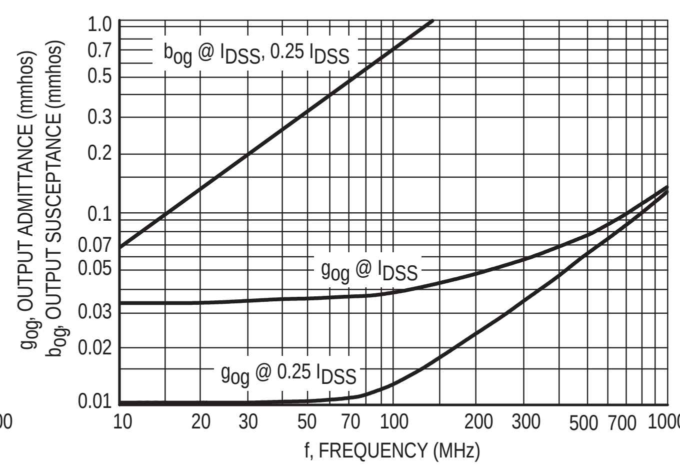


Figure 17. Output Admittance (y_{og})

COMMON GATE CHARACTERISTICS
S–PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

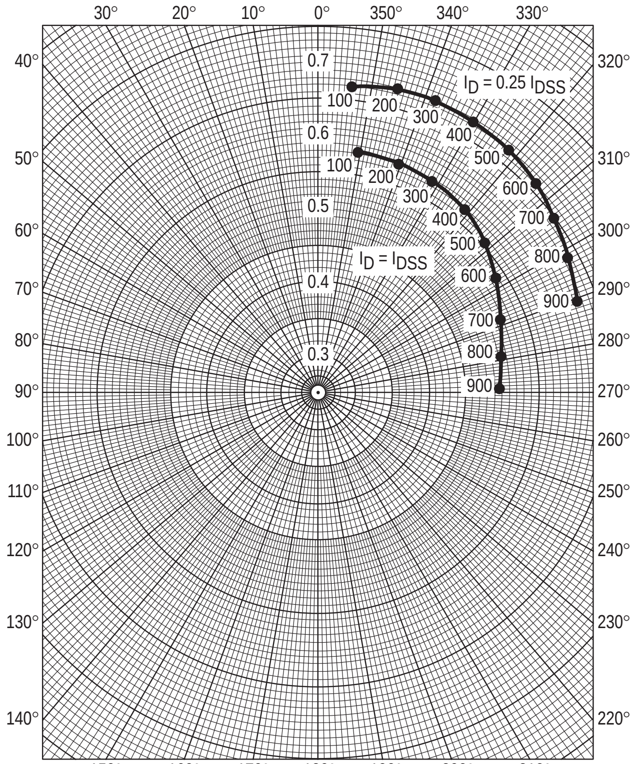


Figure 18. S_{11g}

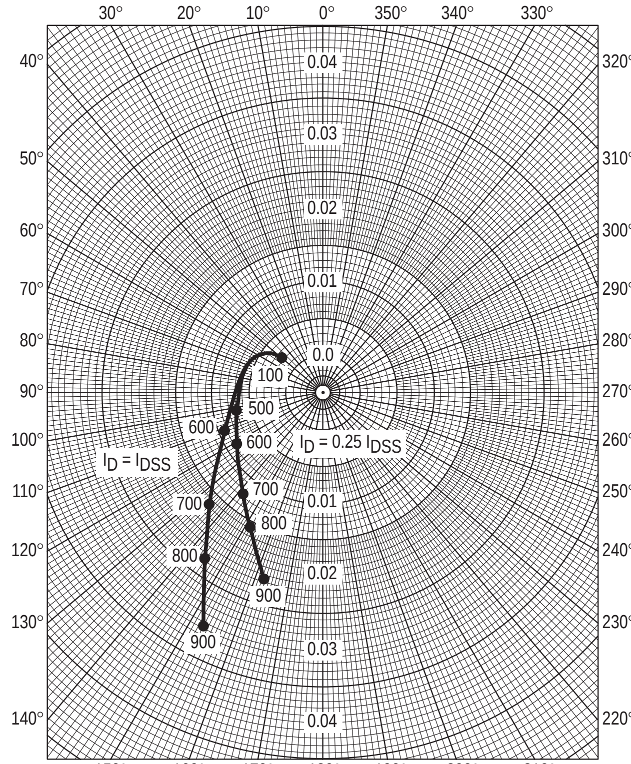


Figure 19. S_{12g}

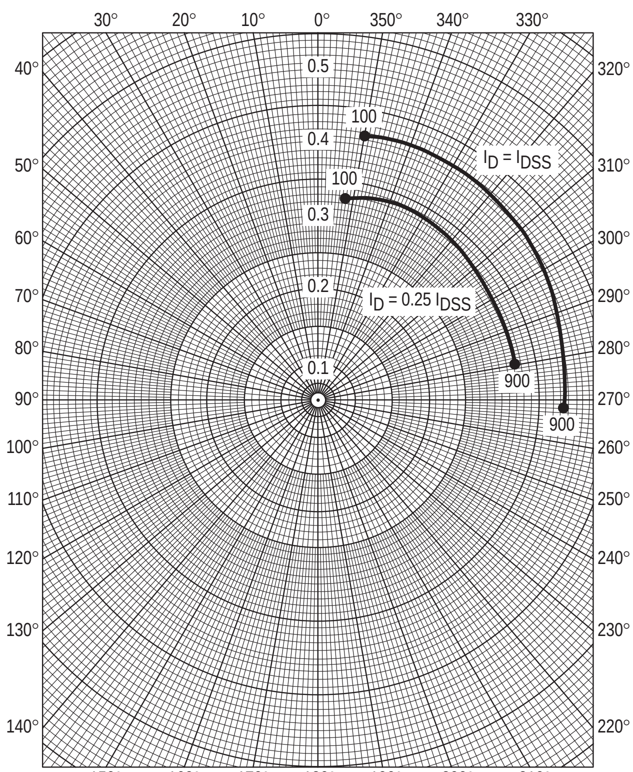


Figure 20. S_{21g}

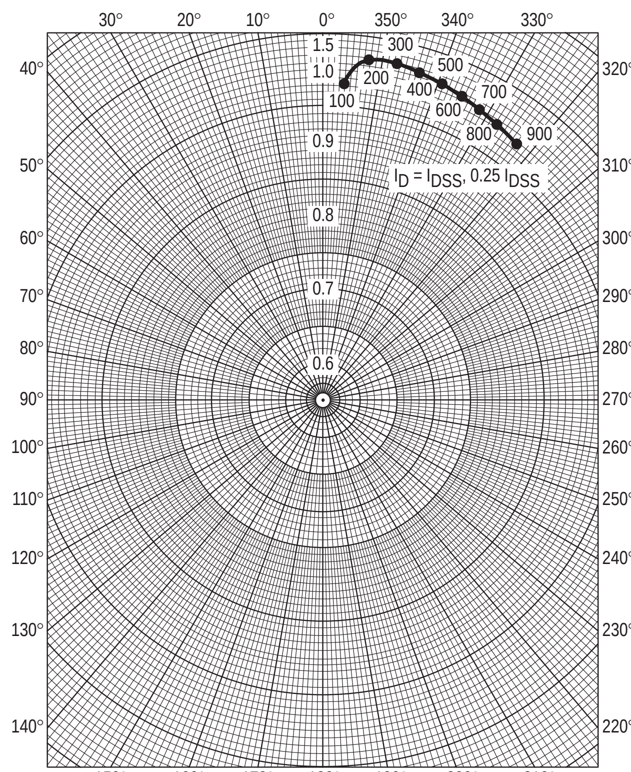


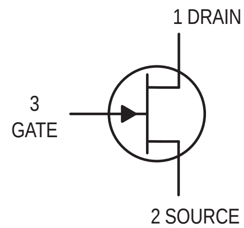
Figure 21. S_{22g}

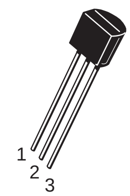
JFET VHF/UHF Amplifiers

N–Channel — Depletion

J308
J309
J310

Motorola Preferred Devices





CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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

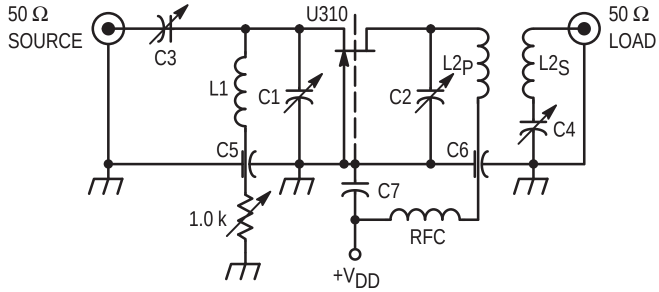
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate–Source Breakdown Voltage (I_G = –1.0 µAdc, V_{DS} = 0)		$V_{(BR)GSS}$	–25	—	—	Vdc
Gate Reverse Current (V_{GS} = –15 Vdc, V_{DS} = 0, T_A = 25°C) (V_{GS} = –15 Vdc, V_{DS} = 0, 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)	 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 Vdc, V_{GS} = 0)	 J308 J309 J310	I_{DSS}	 12 12 24	 — — —	 60 30 60	mAdc
Gate–Source Forward Voltage (V_{DS} = 0, I_G = 1.0 mAdc)		$V_{GS(f)}$	—	—	1.0	Vdc
SMALL–SIGNAL CHARACTERISTICS						
Common–Source Input Conductance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 MHz)	 J308 J309 J310	$Re(y_{is})$	 — — —	 0.7 0.7 0.5	 — — —	mmhos
Common–Source Output Conductance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 MHz)		$Re(y_{os})$	—	0.25	—	mmhos
Common–Gate Power Gain (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 MHz)		G_{pg}	—	16	—	dB

1. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 3.0%.

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

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL–SIGNAL CHARACTERISTICS (continued)						
Common–Source Forward Transconductance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 MHz)		$Re(y_{fs})$	—	12	—	mmhos
Common–Gate Input Conductance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 MHz)		$Re(y_{ig})$	—	12	—	mmhos
Common–Source Forward Transconductance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	J308	g_{fs}	8000	—	20000	μmhos
	J309		10000	—	20000	
	J310		8000	—	18000	
Common–Source Output Conductance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)		g_{os}	—	—	250	μmhos
Common–Gate Forward Transconductance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	J308	g_{fg}	—	13000	—	μmhos
	J309		—	13000	—	
	J310		—	12000	—	
Common–Gate Output Conductance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	J308	g_{og}	—	150	—	μmhos
	J309		—	100	—	
	J310		—	150	—	
Gate–Drain Capacitance (V_{DS} = 0, V_{GS} = –10 Vdc, f = 1.0 MHz)		C_{gd}	—	1.8	2.5	pF
Gate–Source Capacitance (V_{DS} = 0, V_{GS} = –10 Vdc, f = 1.0 MHz)		C_{gs}	—	4.3	5.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 450 MHz)		NF	—	1.5	—	dB
Equivalent Short–Circuit Input Noise Voltage (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 Hz)		$\overline{e_n}$	—	10	—	$nV/\sqrt{Hz}$



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).

Figure 1. 450 MHz Common–Gate Amplifier Test Circuit

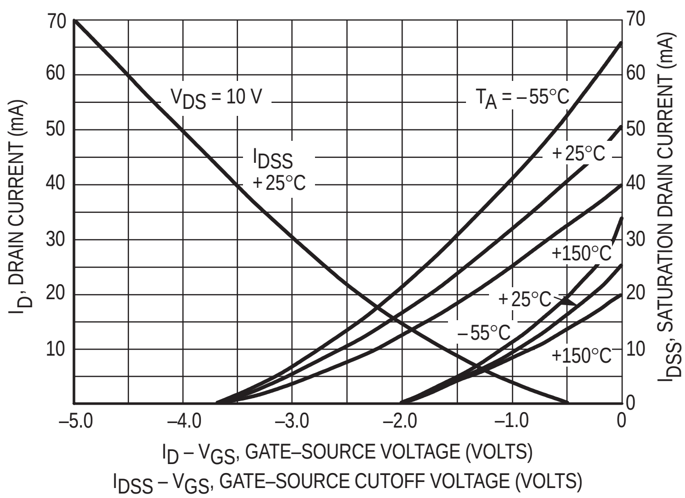


Figure 2. Drain Current and Transfer Characteristics versus Gate–Source Voltage

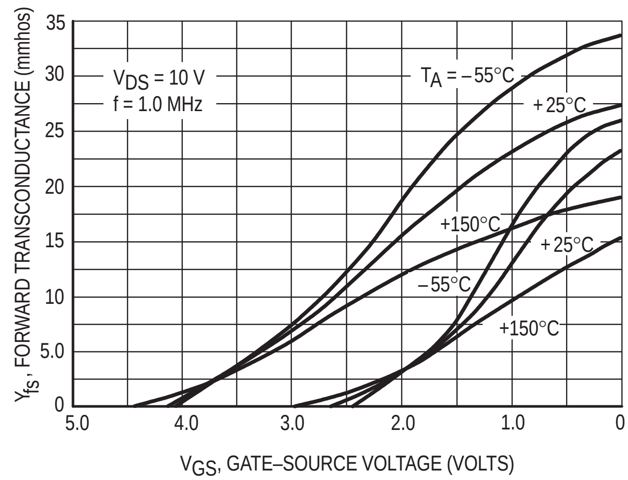


Figure 3. Forward Transconductance versus Gate–Source Voltage

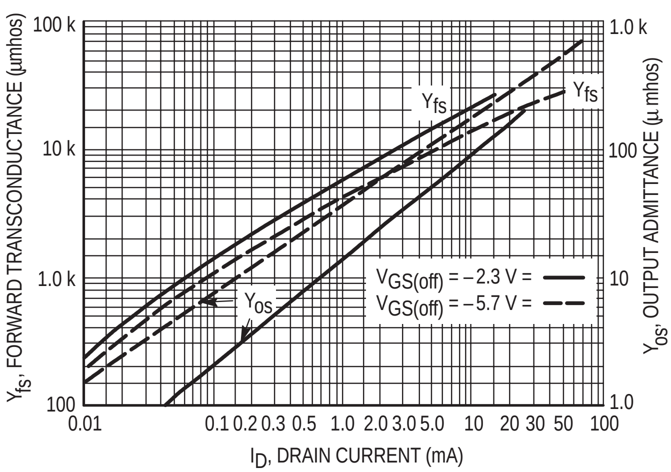


Figure 4. Common–Source Output Admittance and Forward Transconductance versus Drain Current

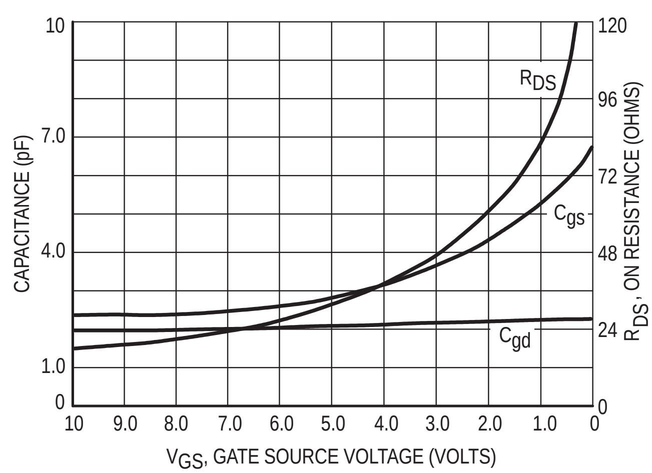


Figure 5. On Resistance and Junction Capacitance versus Gate–Source Voltage

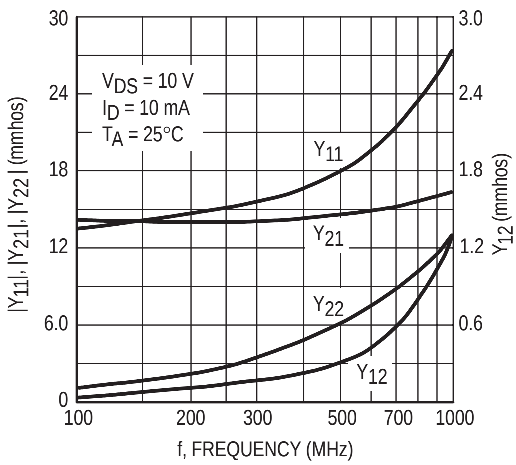


Figure 6. Common–Gate Y Parameter Magnitude versus Frequency

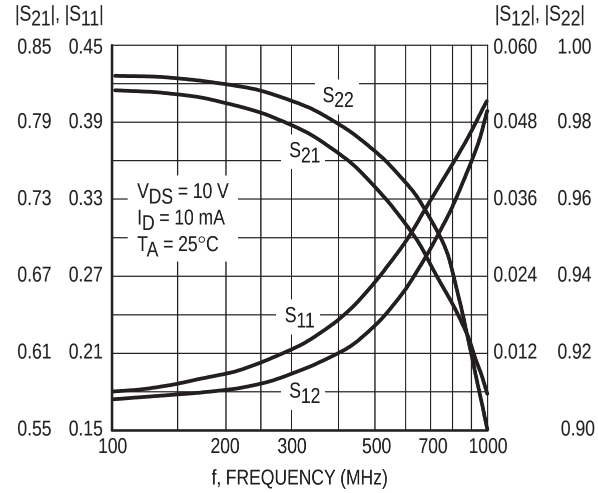


Figure 7. Common–Gate S Parameter Magnitude versus Frequency

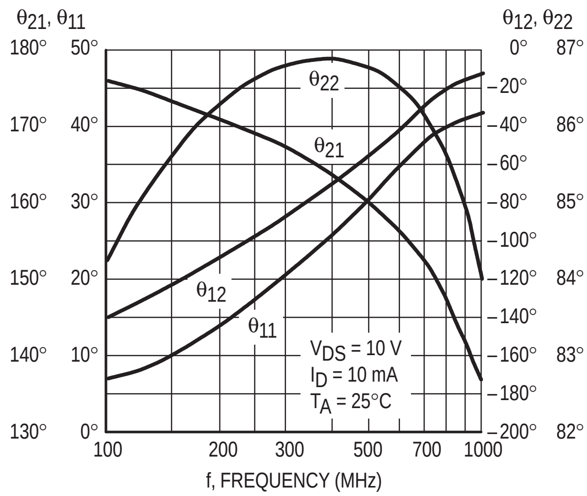


Figure 8. Common–Gate Y Parameter Phase–Angle versus Frequency

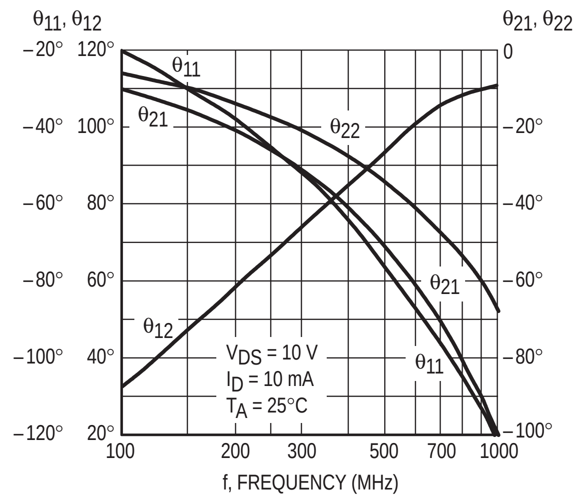


Figure 9. S Parameter Phase–Angle versus Frequency

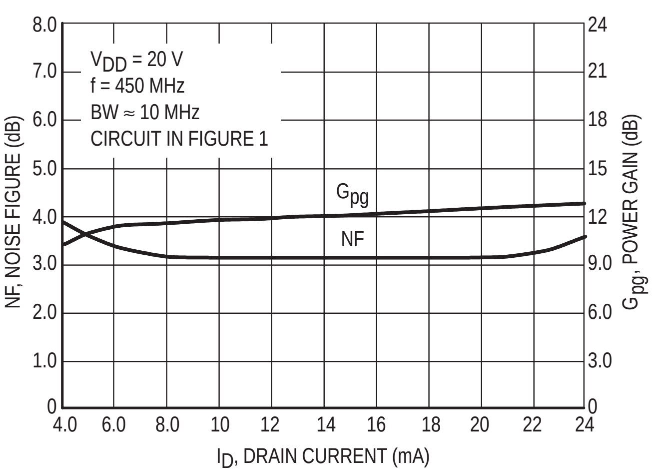


Figure 10. Noise Figure and Power Gain versus Drain Current

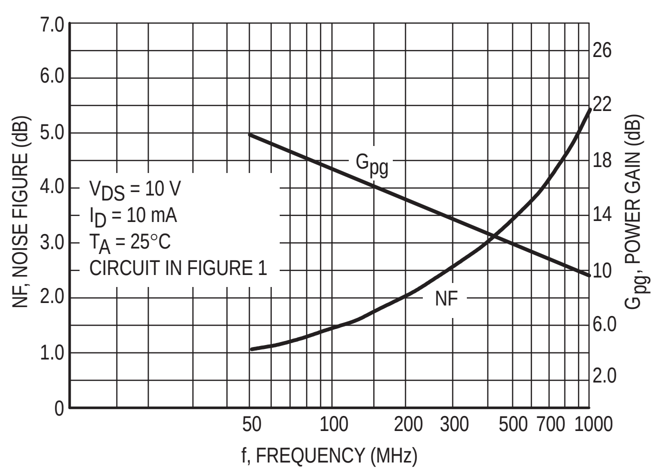
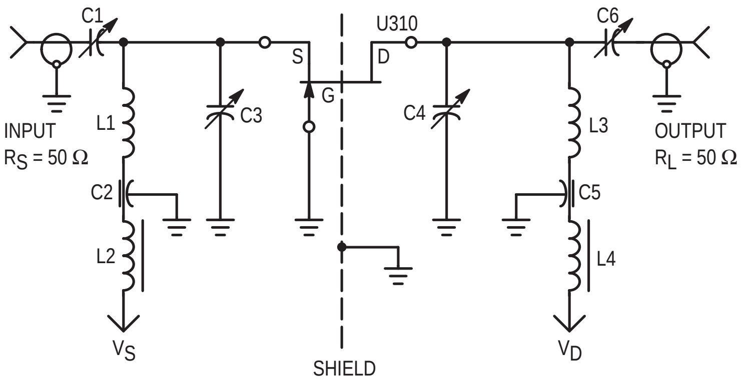


Figure 11. Noise Figure and Power Gain versus Frequency



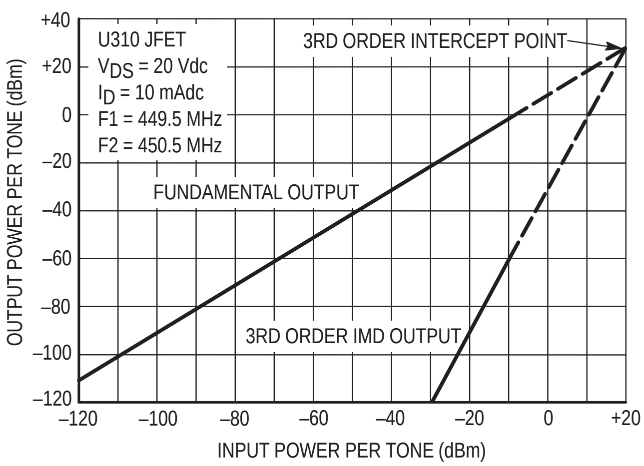
B_W (3 dB) – 36.5 MHz
I_D – 10 mAdc
V_{DS} – 20 Vdc
Device case grounded
IM test tones – f1 = 449.5 MHz, f2 = 450.5 MHz

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.

Figure 12. 450 MHz IMD Evaluation Amplifier

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.



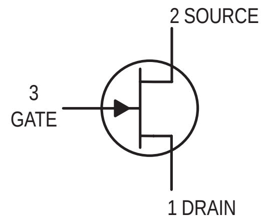
Example of intercept point plot use:
Assume two in–band signals of –20 dBm at the amplifier input. They will result in a 3rd order IMD signal at the output of –90 dBm. Also, each signal level at the output will be –11 dBm, showing an amplifier gain of 9.0 dB and an intermodulation ratio (IMR) capability of 79 dB. The gain and IMR values apply only for signal levels below comparison.

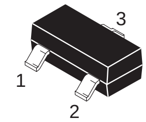
Figure 13. Two Tone 3rd Order Intercept Point

JFET Switching Transistors

N–Channel

MMBF4391LT1
MMBF4392LT1
MMBF4393LT1





CASE 318–08, STYLE 10
SOT–23 (TO–236AB)

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(1) 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

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 (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 25°C) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	 — —	 1.0 0.20	 nAdc µAdc
Gate–Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc) MMBF4391LT1 MMBF4392LT1 MMBF4393LT1	$V_{GS(off)}$	 –4.0 –2.0 –0.5	 –10 –5.0 –3.0	Vdc
Off–State Drain 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 1.0	 nAdc µAdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.

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

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
Zero–Gate–Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	MMBF4391LT1 MMBF4392LT1 MMBF4393LT1	I_{DSS}	50 25 5.0	150 75 30	mAdc
Drain–Source On–Voltage (I_D = 12 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 3.0 mAdc, V_{GS} = 0)	MMBF4391LT1 MMBF4392LT1 MMBF4393LT1	$V_{DS(on)}$	— — —	0.4 0.4 0.4	Vdc
Static Drain–Source On–Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	MMBF4391LT1 MMBF4392LT1 MMBF4393LT1	$r_{DS(on)}$	— — —	30 60 100	Ω
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

TYPICAL CHARACTERISTICS

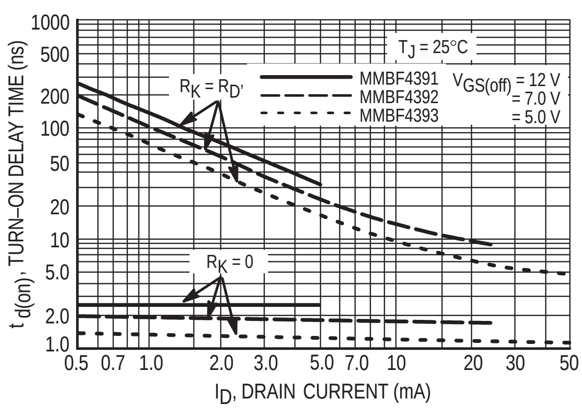


Figure 1. Turn–On Delay Time

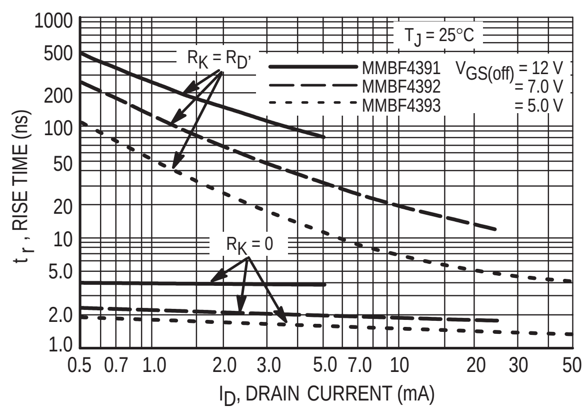


Figure 2. Rise Time

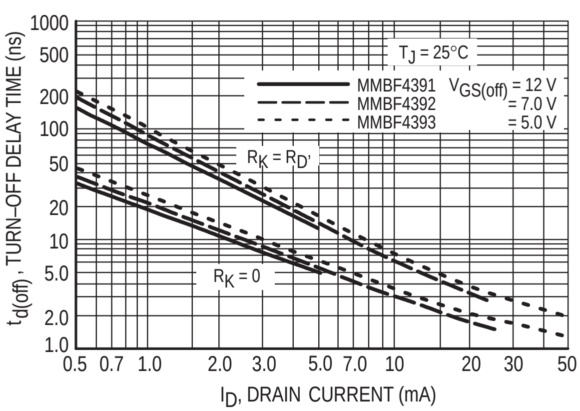


Figure 3. Turn–Off Delay Time

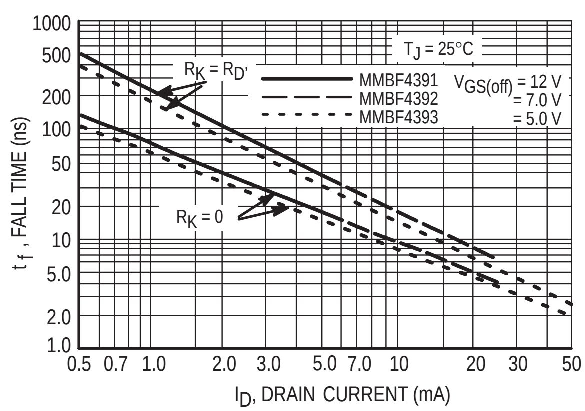


Figure 4. Fall Time

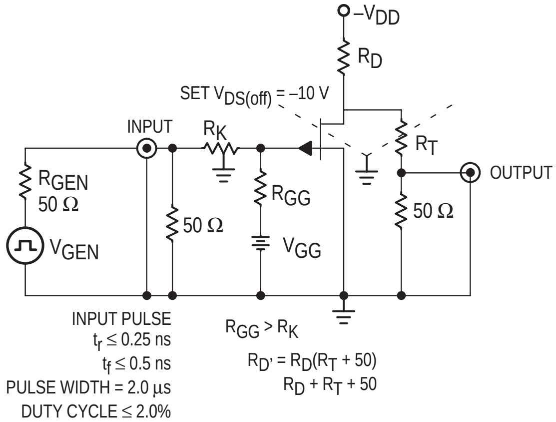


Figure 5. Switching Time Test Circuit

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}) of 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.

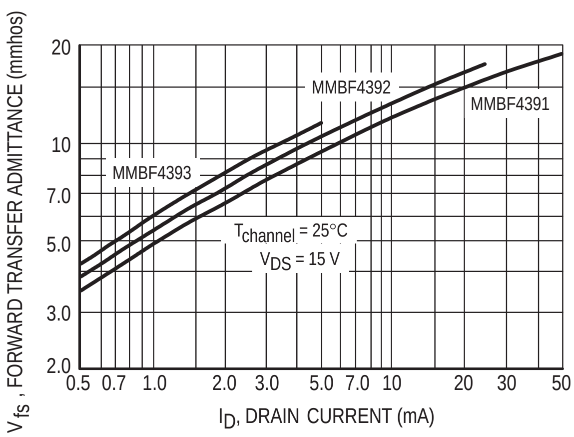


Figure 6. Typical Forward Transfer Admittance

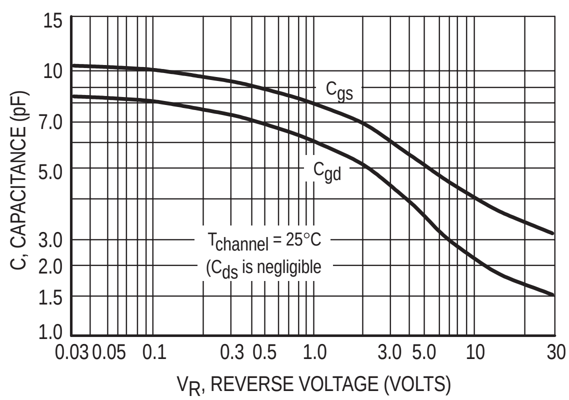


Figure 7. Typical Capacitance

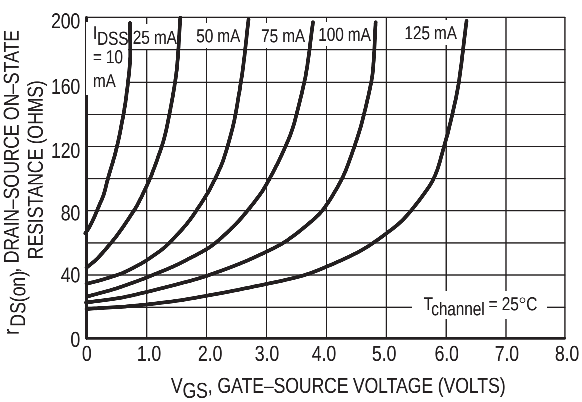


Figure 8. Effect of Gate–Source Voltage on Drain–Source Resistance

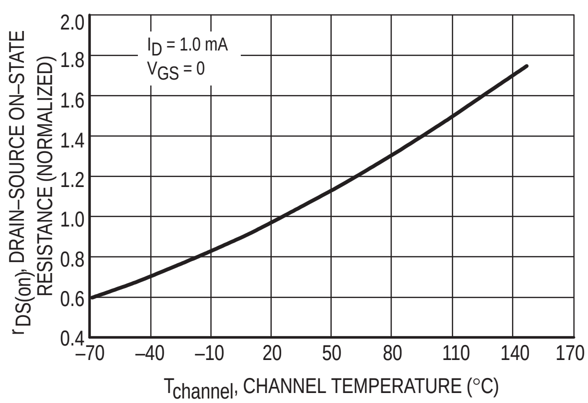


Figure 9. Effect of Temperature on Drain–Source On–State Resistance

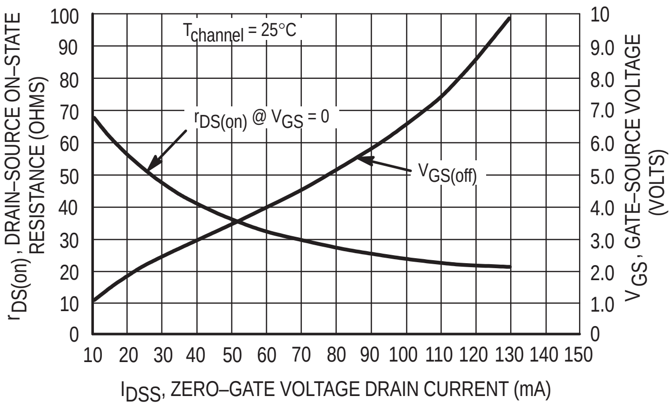


Figure 10. Effect of I_{DSS} on Drain–Source Resistance and Gate–Source Voltage

NOTE 2

The Zero–Gate–Voltage Drain Current (I_{DSS}) is the principle determinant of other J–FET characteristics. Figure 10 shows the relationship of Gate–Source Off Voltage ($V_{GS(off)}$) and Drain–Source On Resistance ($r_{DS(on)}$) to I_{DSS}. Most of the devices will be within ±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

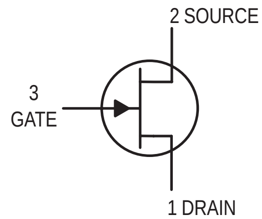
$r_{DS(on)}$ and V_{GS} range for an MMBF4392

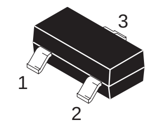
The electrical characteristics table indicates that an MMBF4392 has an I_{DSS} range of 25 to 75 mA. Figure 10 shows $r_{DS(on)}$ = 52 Ohms for I_{DSS} = 25 mA and 30 Ohms for I_{DSS} = 75 mA. The corresponding V_{GS} values are 2.2 volts and 4.8 volts.

JFET
VHF/UHF Amplifier Transistor
N–Channel

MMBF4416LT1

Motorola Preferred Device





CASE 318–08, STYLE 10
SOT–23 (TO–236AB)

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(1) 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

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
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	mAdc
Gate–Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	—	1.0	Vdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.

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

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

Characteristic	Symbol	Min	Max	Unit
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 = 10 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	NF			dB
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ≈ 1000 Ω, f = 100 MHz)		—	2.0	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ≈ 1000 Ω, f = 400 MHz)		—	4.0	
Common Source Power Gain	G_{ps}			dB
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 100 MHz)		18	—	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 400 MHz)		10	—	

POWER GAIN

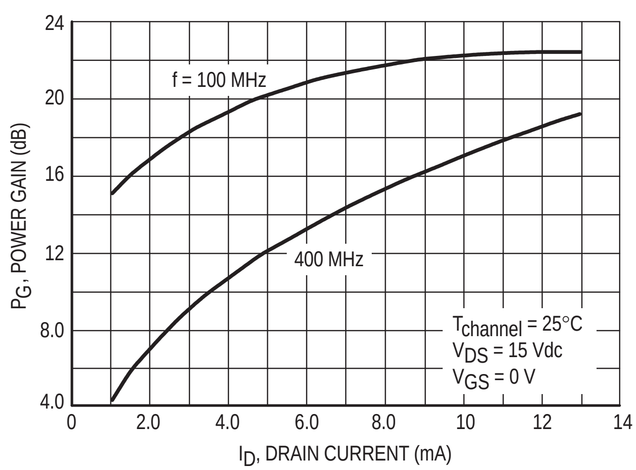
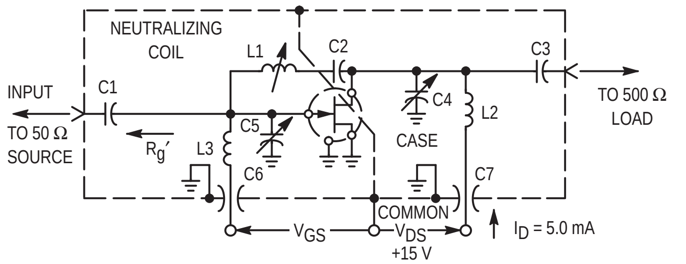


Figure 1. Effects of Drain Current



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).

Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1–12 pF	0.8–8.0 pF
C5	1–12 pF	0.8–8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH*	0.2 μH**
L2	0.15 μH*	0.03 μH**
L3	0.14 μH*	0.022 μH**

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32″ ceramic coil form. Tuning provided by a powdered iron slug.
L2 4–1/2 turns, AWG #18 enameled copper wire, 5/16″ long, 3/8″ I.D. (AIR CORE).
L3 3–1/2 turns, AWG #18 enameled copper wire, 1/4″ long, 3/8″ I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32″ ceramic coil form. Tuning provided by an aluminum slug.
L2 1 turn, AWG #16 enameled copper wire, 3/8″ I.D. (AIR CORE).
L3 1/2 turn, AWG #16 enameled copper wire, 1/4″ I.D. (AIR CORE).

Figure 2. 100 MHz and 400 MHz Neutralized Test Circuit

NOISE FIGURE
($T_{channel}$ = 25°C)

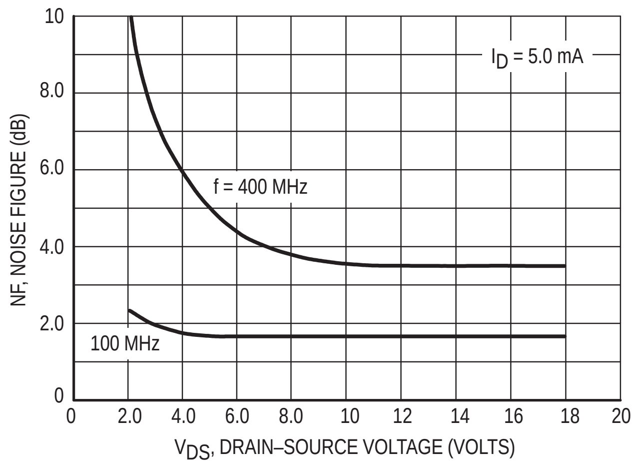


Figure 3. Effects of Drain–Source Voltage

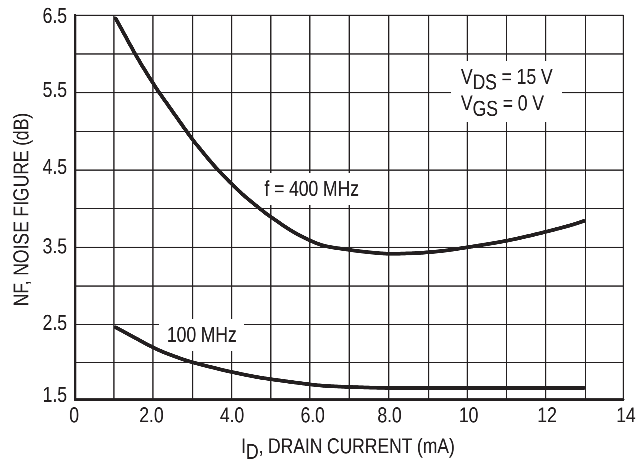


Figure 4. Effects of Drain Current

INTERMODULATION CHARACTERISTICS

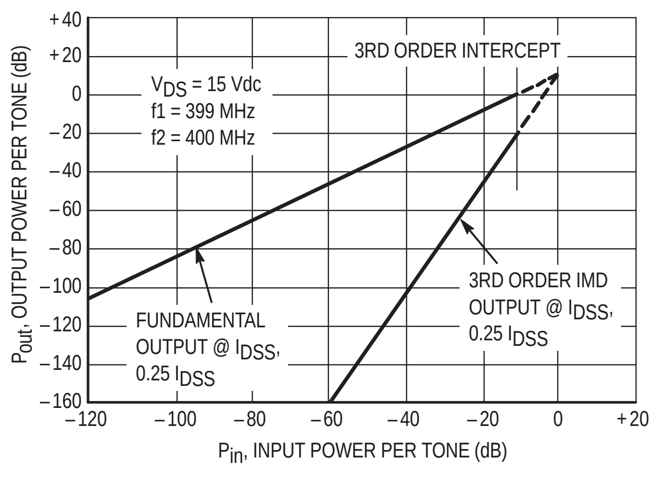


Figure 5. Third Order Intermodulation Distortion

COMMON SOURCE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

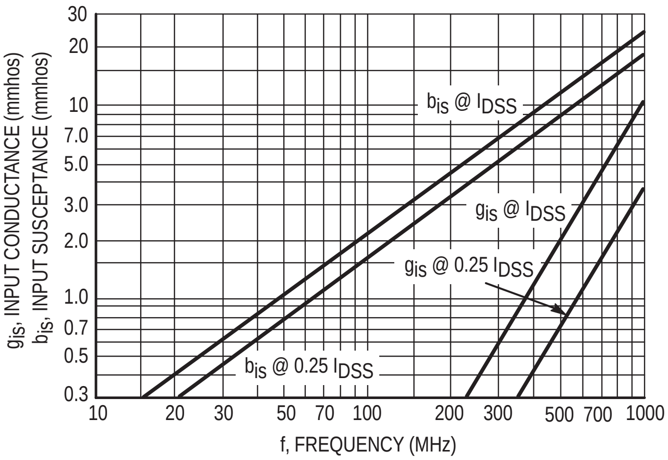


Figure 6. Input Admittance (y_{is})

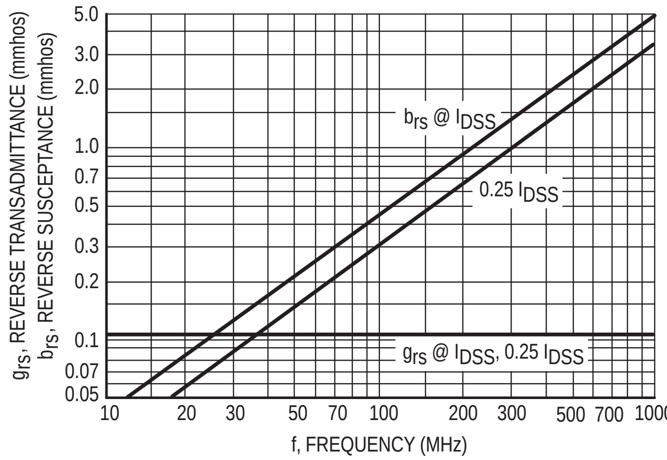


Figure 7. Reverse Transfer Admittance (y_{rs})

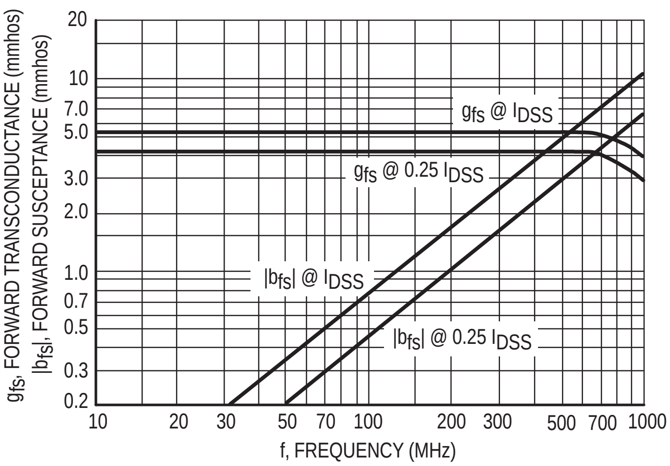


Figure 8. Forward Transadmittance (y_{fs})

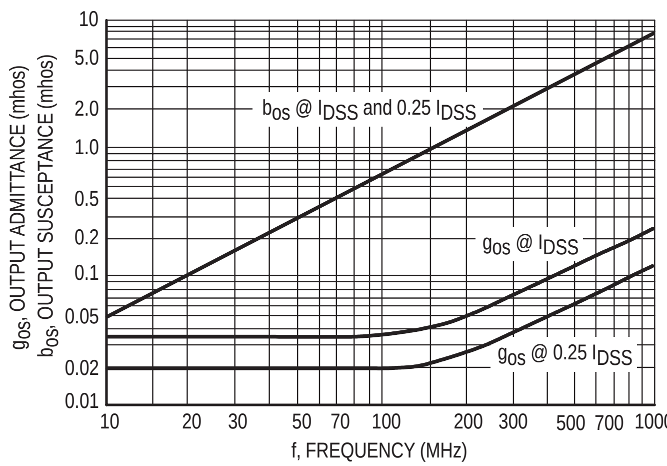


Figure 9. Output Admittance (y_{os})

COMMON SOURCE CHARACTERISTICS

S–PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

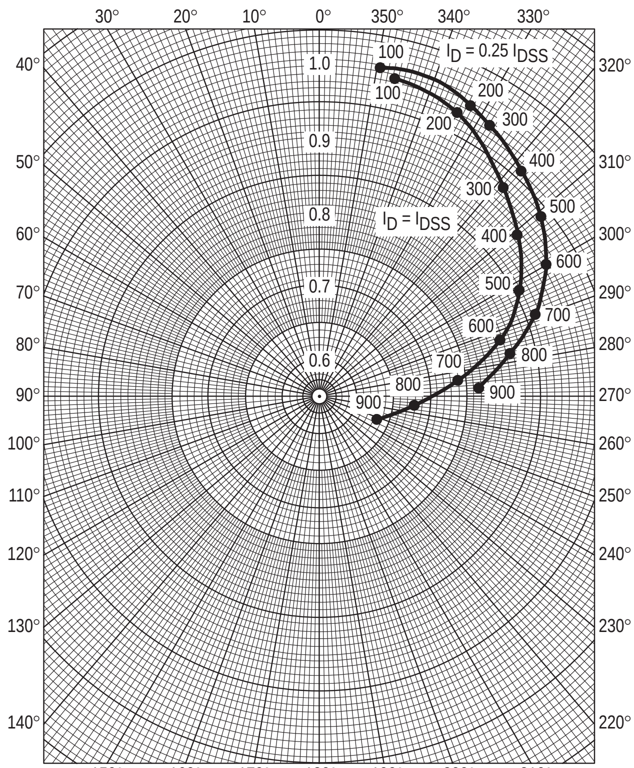


Figure 10. S_{11s}

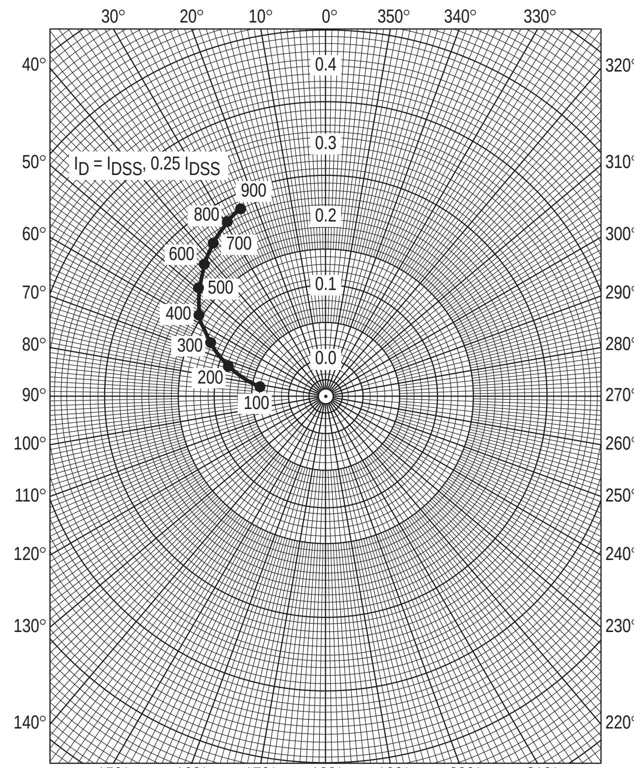


Figure 11. S_{12s}

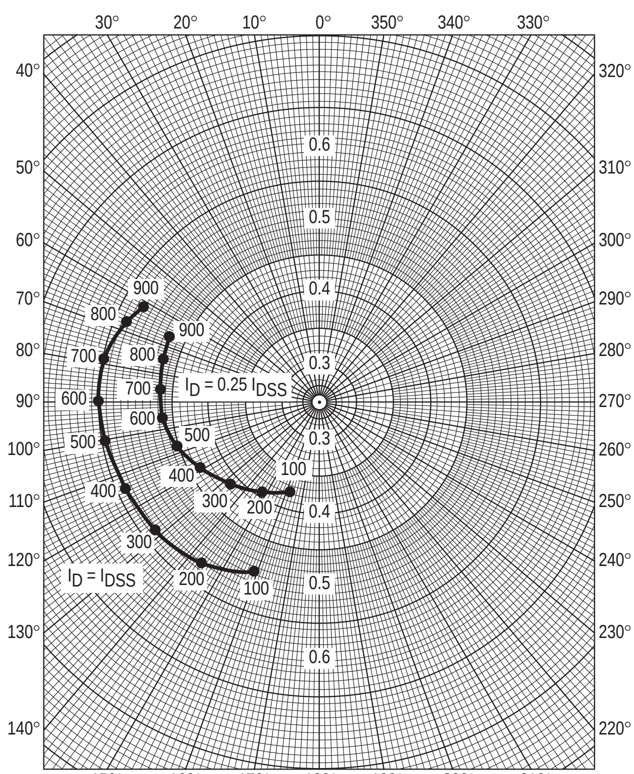


Figure 12. S_{21s}

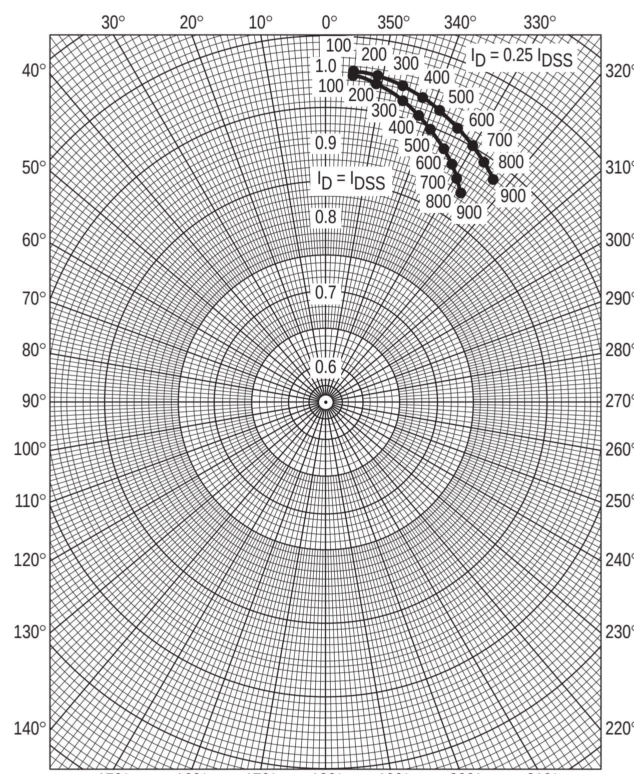


Figure 13. S_{22s}

COMMON GATE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

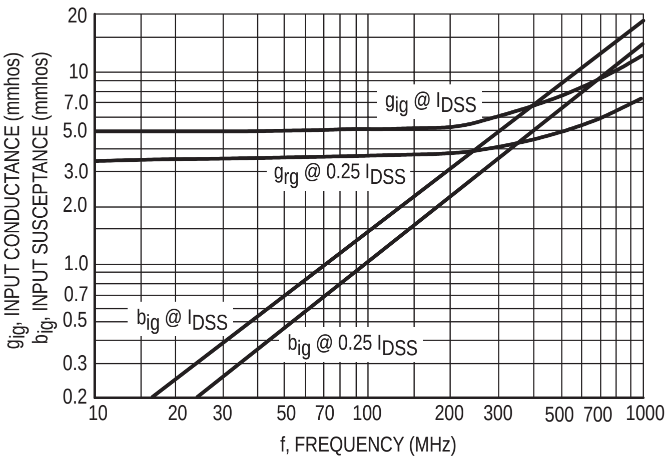


Figure 14. Input Admittance (y_{ig})

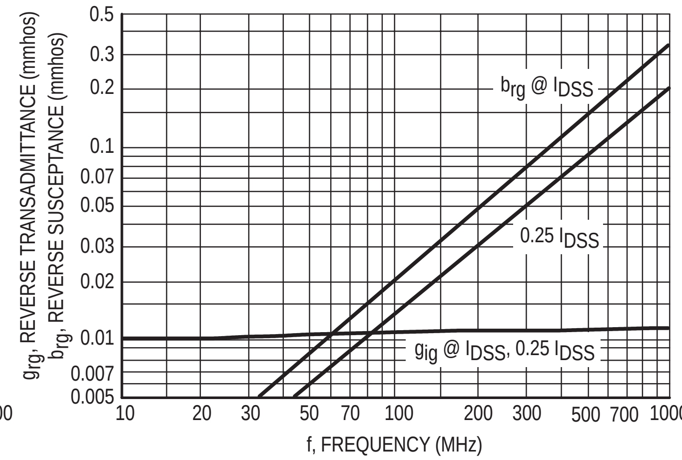


Figure 15. Reverse Transfer Admittance (y_{rg})

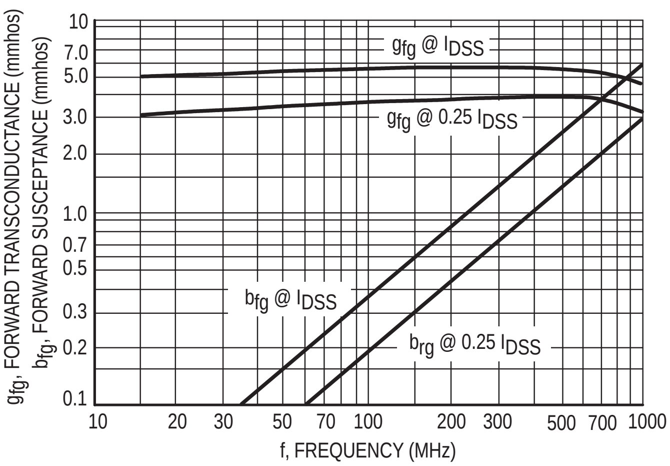


Figure 16. Forward Transfer Admittance (y_{fg})

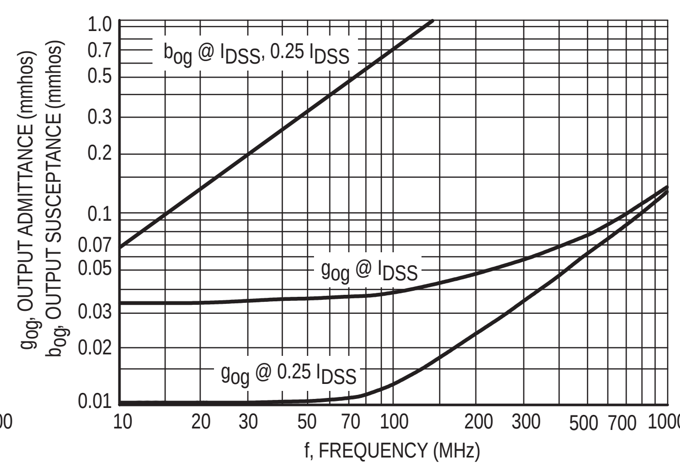


Figure 17. Output Admittance (y_{og})

COMMON GATE CHARACTERISTICS
S–PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

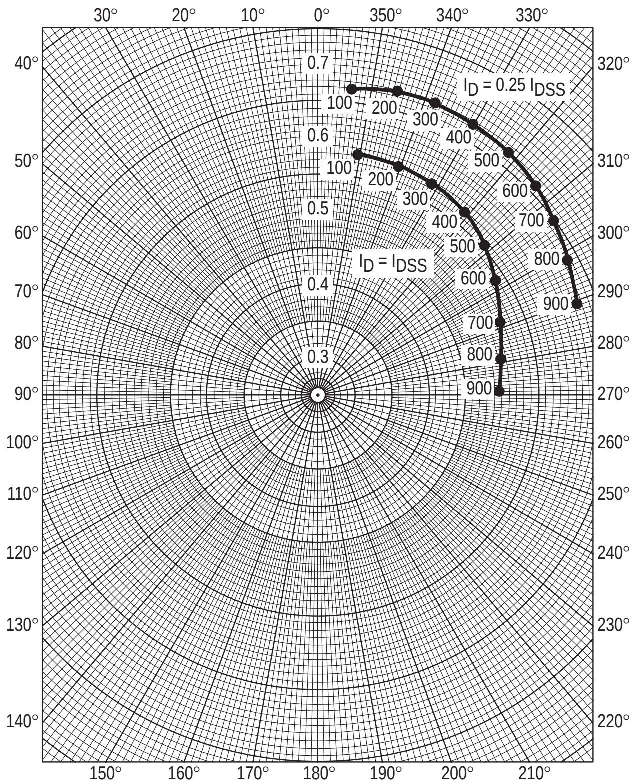


Figure 18. S_{11g}

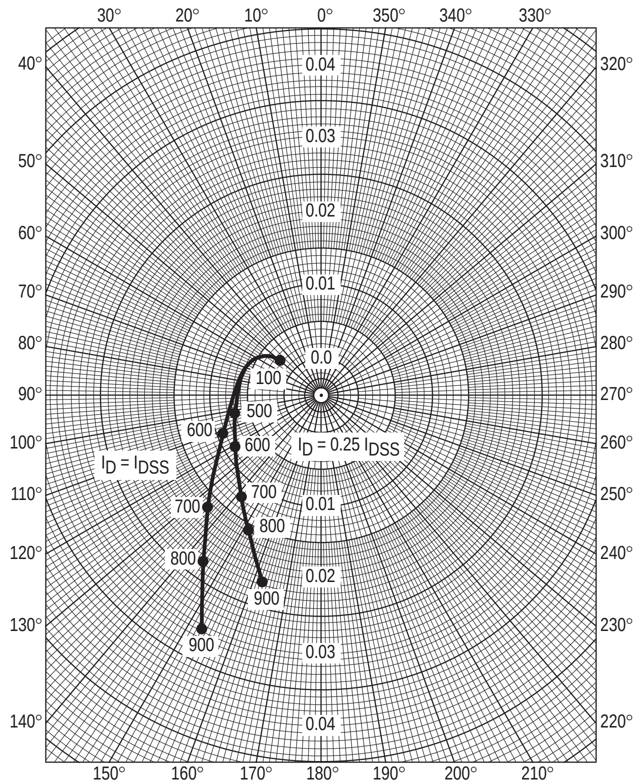


Figure 19. S_{12g}

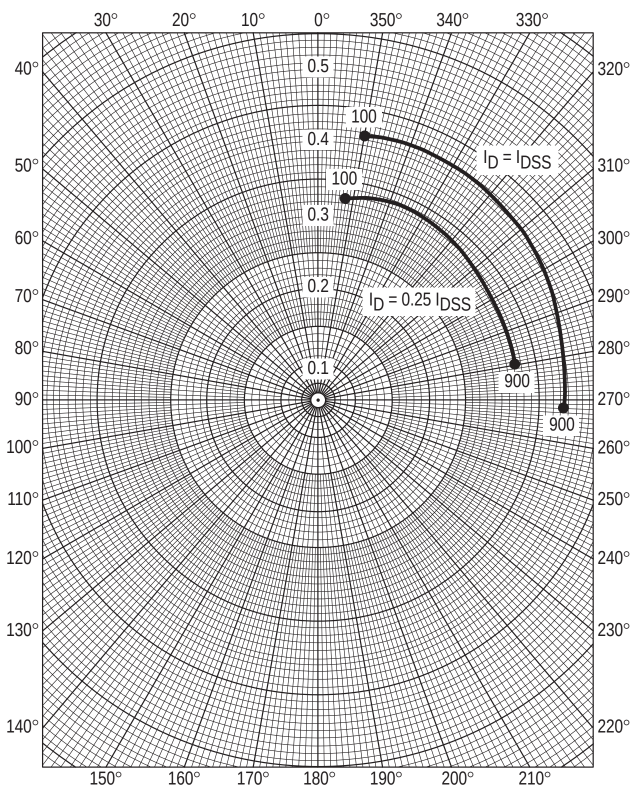


Figure 20. S_{21g}

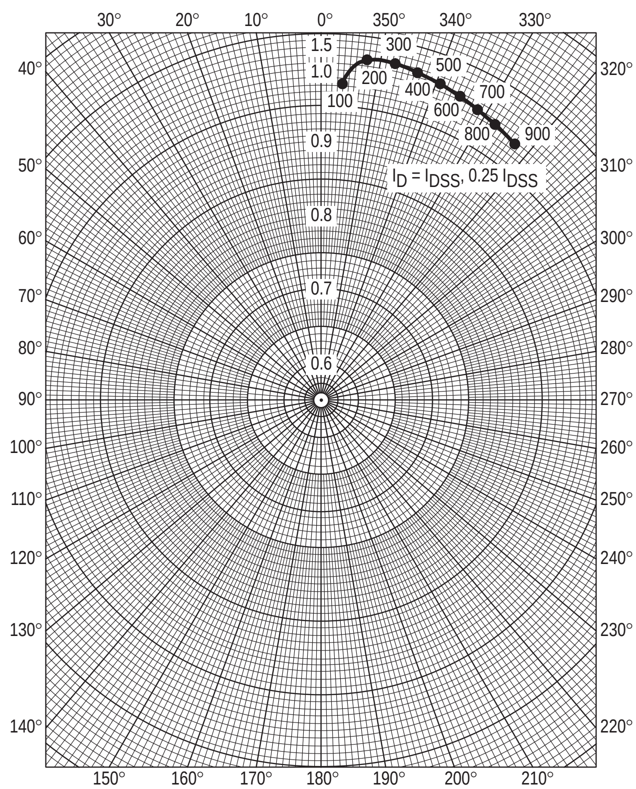


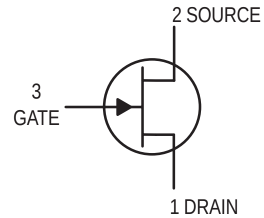
Figure 21. S_{22g}

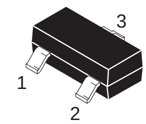
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

JFET — General Purpose Transistor

N–Channel

MMBF5457LT1





CASE 318–08, STYLE 10
SOT–23 (TO–236AB)

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(1) 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

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 (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 µAdc)	V_{GS}	—	–2.5	—	Vdc
ON CHARACTERISTICS					
Zero–Gate–Voltage Drain Current(2) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	1.0	—	5.0	mAdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

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

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL–SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(2) (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

2. Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

TYPICAL CHARACTERISTICS

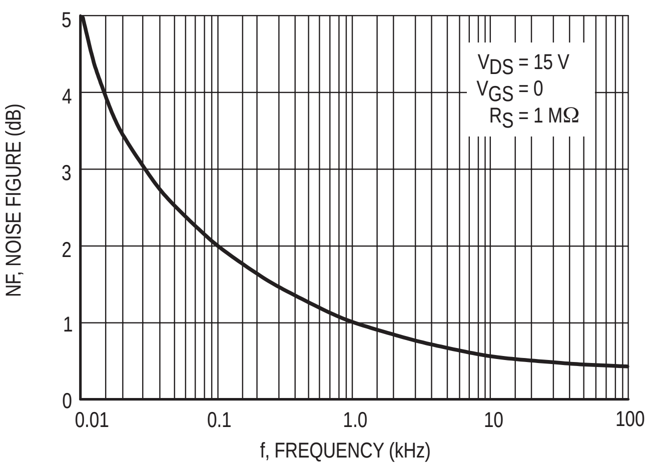


Figure 1. Noise Figure versus Frequency

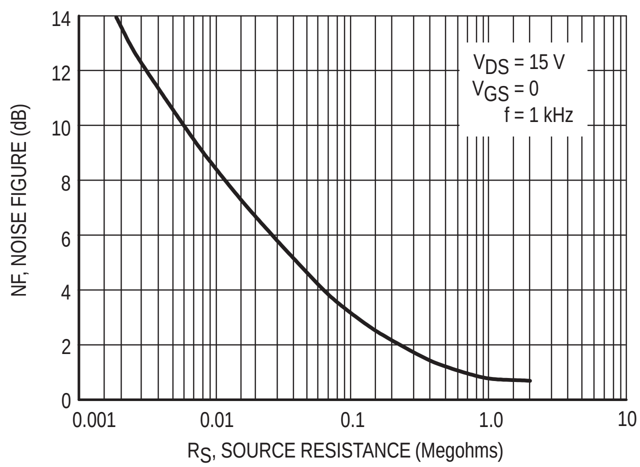


Figure 2. Noise Figure versus Source Resistance

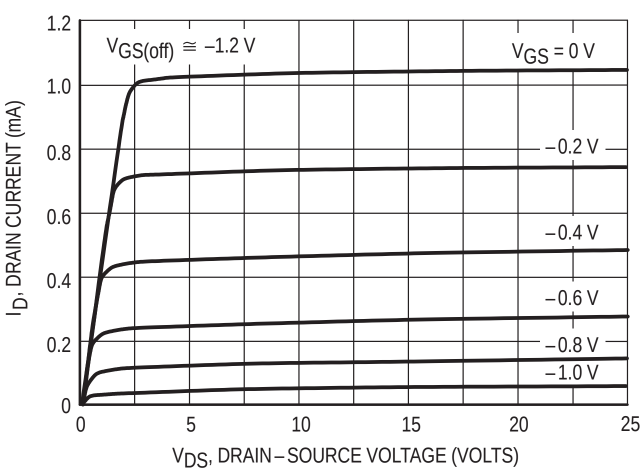


Figure 3. Typical Drain Characteristics

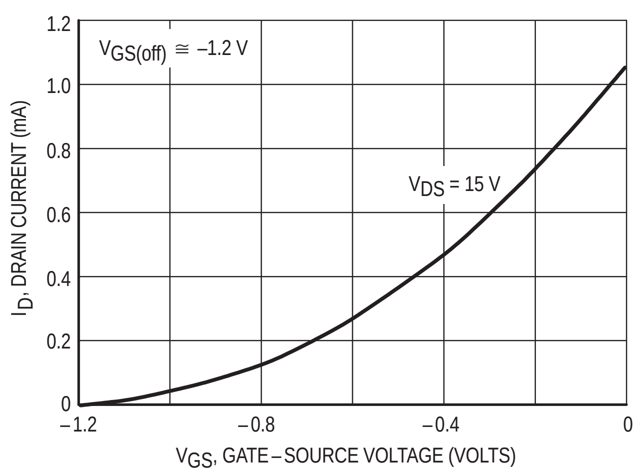


Figure 4. Common Source Transfer Characteristics

TYPICAL CHARACTERISTICS

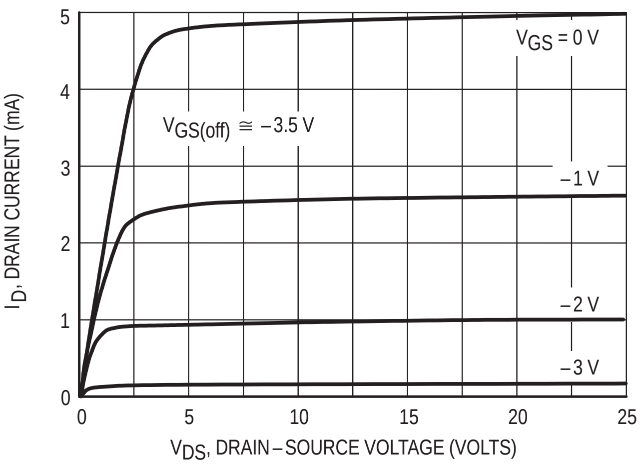


Figure 5. Typical Drain Characteristics

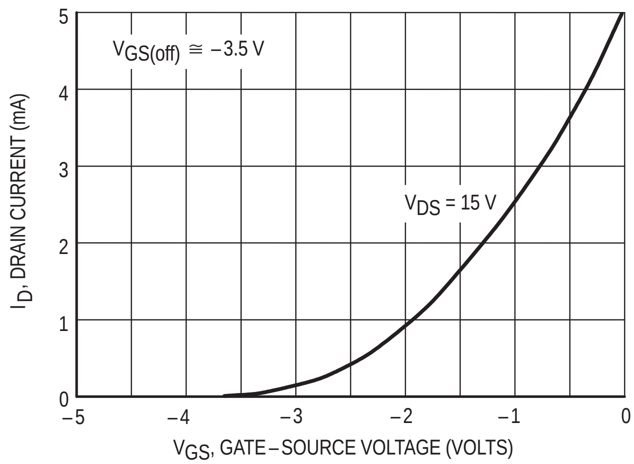


Figure 6. Common Source Transfer Characteristics

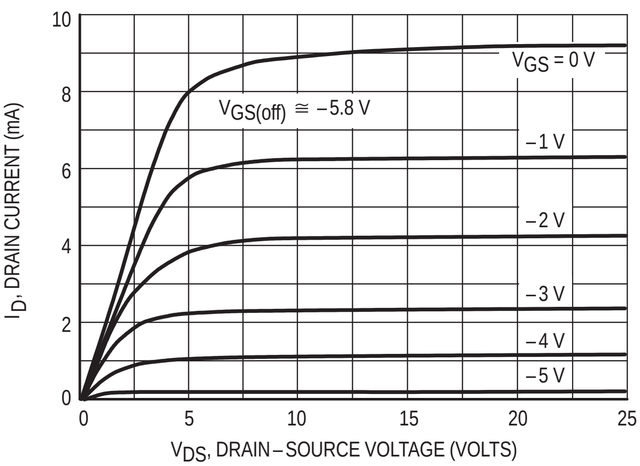


Figure 7. Typical Drain Characteristics

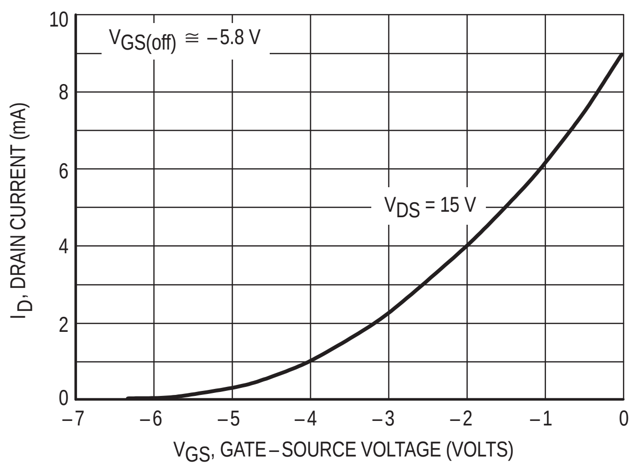


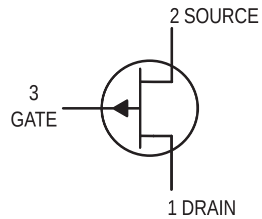
Figure 8. Common Source Transfer Characteristics

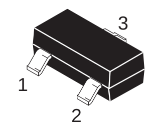
Note: Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS}.

JFET General Purpose Transistor

P–Channel

MMBF5460LT1





CASE 318–08, STYLE 10
SOT–23 (TO–236AB)

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(1) 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

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 (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	 — —	 — —	 5.0 1.0	 nAdc 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)	$\|Y_{fs}\|$	1000	—	4000	µmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	—	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	—	$nV/\sqrt{Hz}$

1. FR–5 = 1.0 × 0.75 × 0.062 in.

DRAIN CURRENT versus GATE SOURCE VOLTAGE

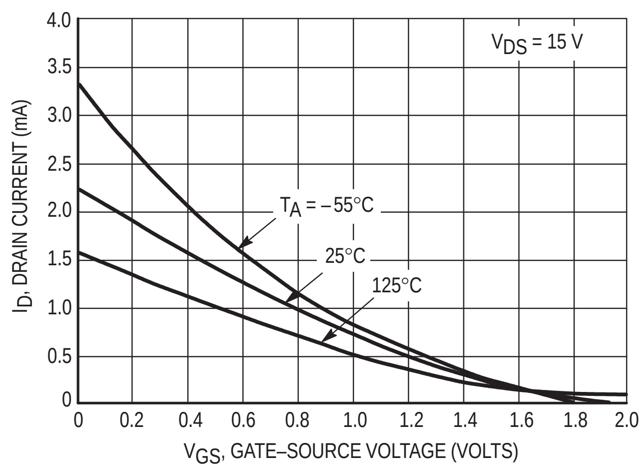


Figure 1. $V_{GS(off)}$ = 2.0 Volts

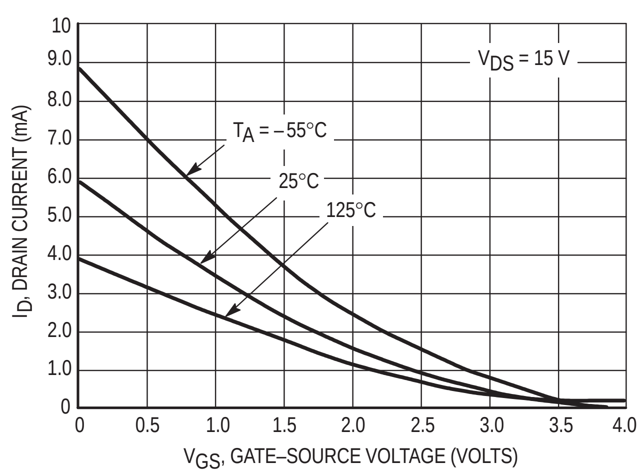


Figure 2. $V_{GS(off)}$ = 4.0 Volts

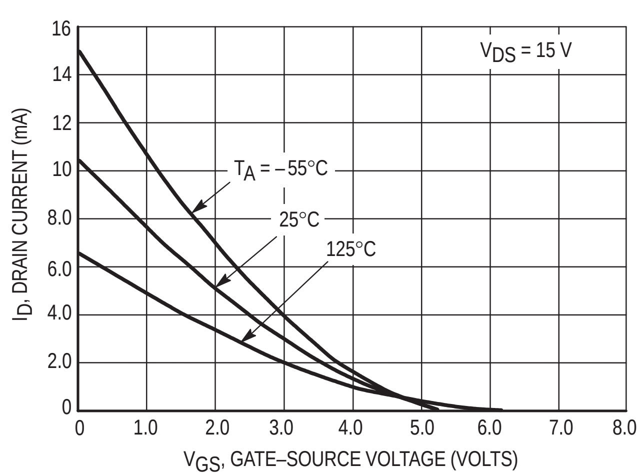


Figure 3. $V_{GS(off)}$ = 5.0 Volts

FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

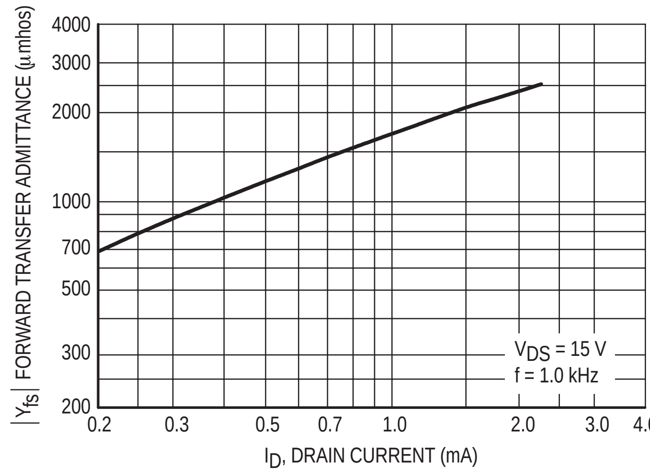


Figure 4. $V_{GS(off)}$ = 2.0 Volts

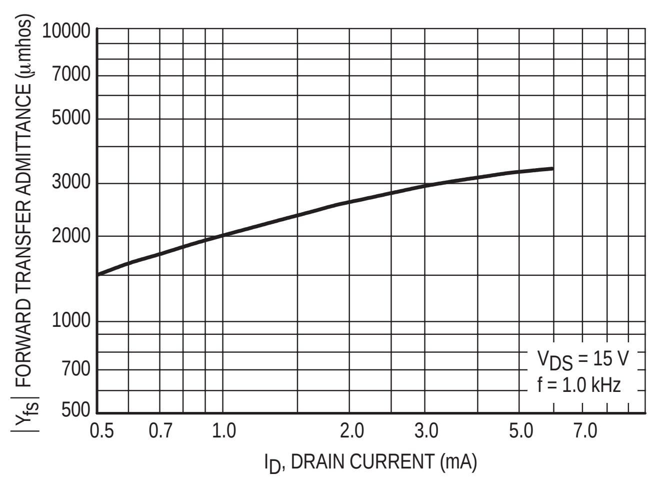


Figure 5. $V_{GS(off)}$ = 4.0 Volts

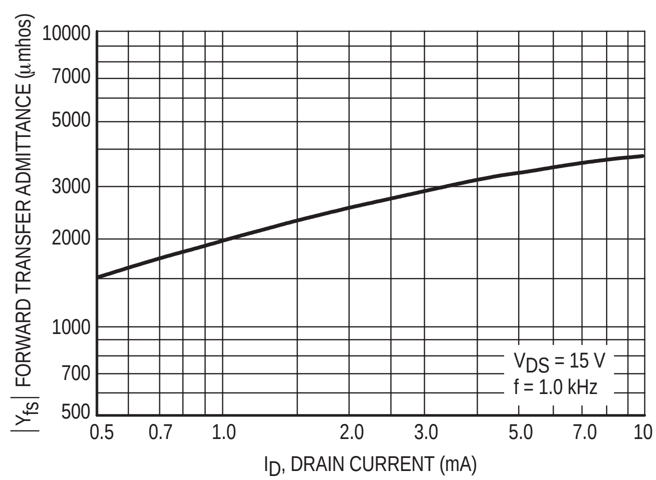


Figure 6. $V_{GS(off)}$ = 5.0 Volts

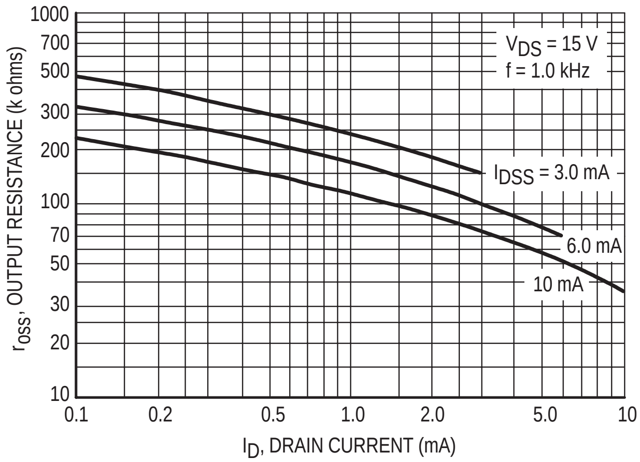


Figure 7. Output Resistance versus Drain Current

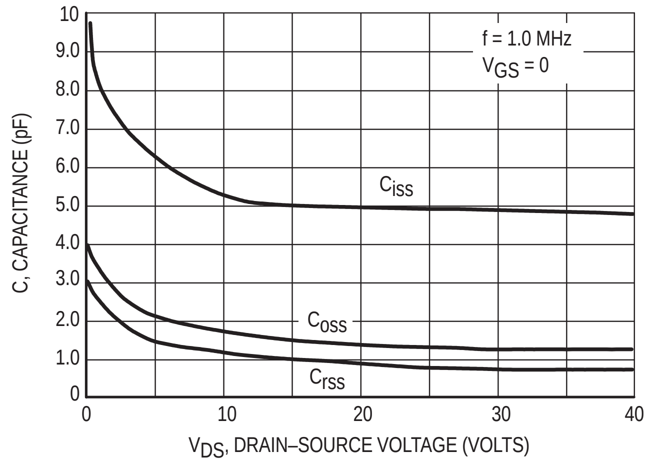


Figure 8. Capacitance versus Drain–Source Voltage

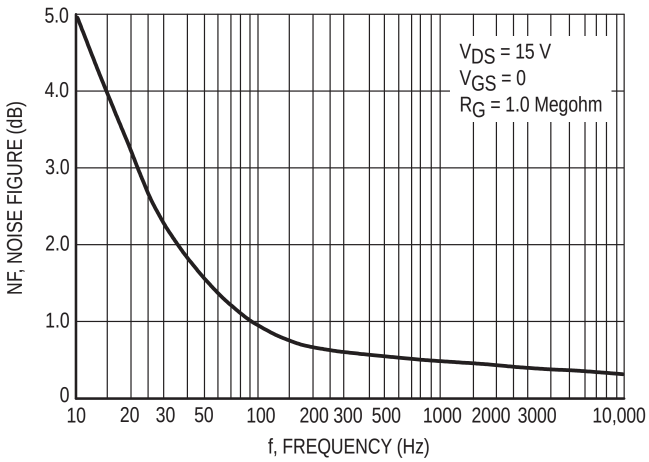


Figure 9. Noise Figure versus Frequency

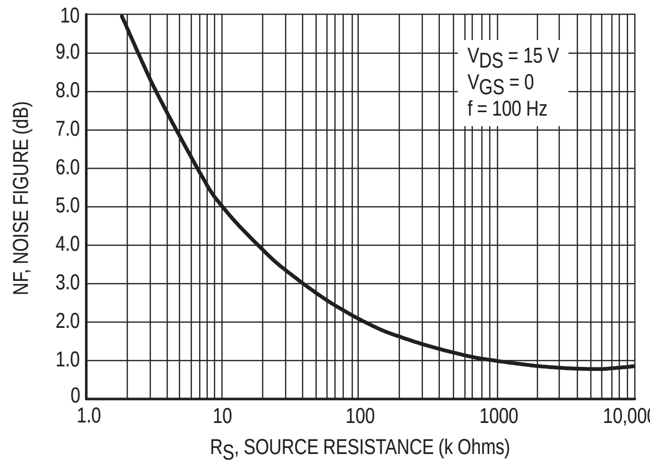
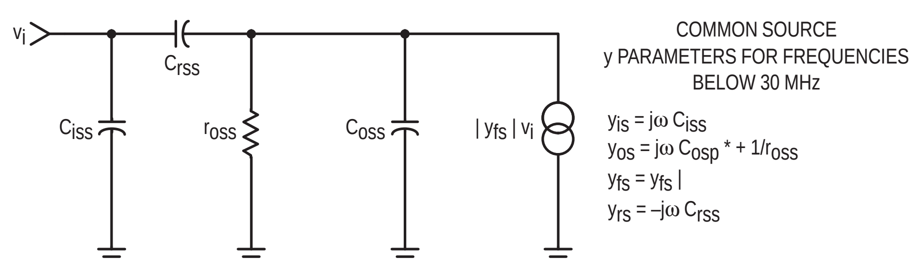


Figure 10. Noise Figure versus Source Resistance



* 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%).

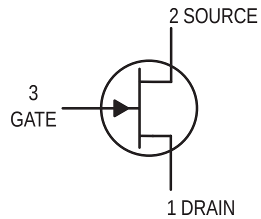
Figure 11. Equivalent Low Frequency Circuit

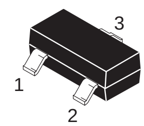
MMBF5484LT1

Motorola Preferred Device

JFET Transistor

N–Channel





CASE 318 – 08, STYLE 10
SOT– 23 (TO – 236AB)

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(1) 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

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 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)	$V_{GS(off)}$	– 0.3	– 3.0	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)	$\|Y_{fs}\|$	3000	6000	µmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	50	µmhos

1. FR– 5 = 1.0 × 0.75 × 0.062 in.

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

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

Characteristic	Symbol	Min	Max	Unit
SMALL–SIGNAL CHARACTERISTICS (Continued)				
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 = 10 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, I_D = 1.0 mAdc, YG′ = 1.0 mmhos) (R_G = 1.0 kΩ, f = 100 MHz)		—	3.0	
(V_{DS} = 15 Vdc, V_{GS} = 0, YG′ = 1.0 μmhos) (R_G = 1.0 MΩ, f = 1.0 kHz)		—	2.5	
Common Source Power Gain (V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	G_{ps}	16	25	dB

POWER GAIN

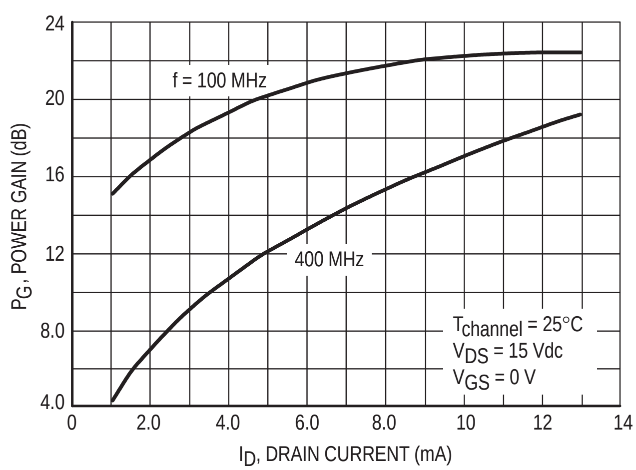
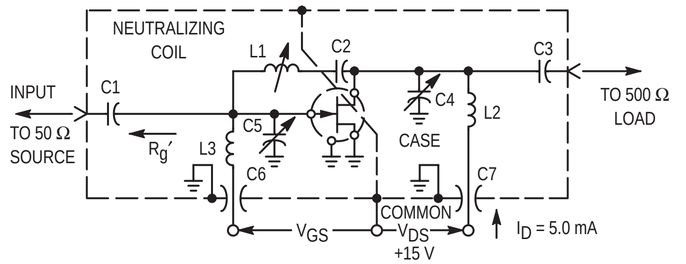


Figure 1. Effects of Drain Current



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).

Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1–12 pF	0.8–8.0 pF
C5	1–12 pF	0.8–8.0 pF
C6	0.0015 µF	0.001 µF
C7	0.0015 µF	0.001 µF
L1	3.0 µH*	0.2 µH**
L2	0.15 µH*	0.03 µH**
L3	0.14 µH*	0.022 µH**

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32″ ceramic coil form. Tuning provided by a powdered iron slug.
L2 4–1/2 turns, AWG #18 enameled copper wire, 5/16″ long, 3/8″ I.D. (AIR CORE).
L3 3–1/2 turns, AWG #18 enameled copper wire, 1/4″ long, 3/8″ I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32″ ceramic coil form. Tuning provided by an aluminum slug.
L2 1 turn, AWG #16 enameled copper wire, 3/8″ I.D. (AIR CORE).
L3 1/2 turn, AWG #16 enameled copper wire, 1/4″ I.D. (AIR CORE).

Figure 2. 100 MHz and 400 MHz Neutralized Test Circuit

NOISE FIGURE

($T_{channel}$ = 25°C)

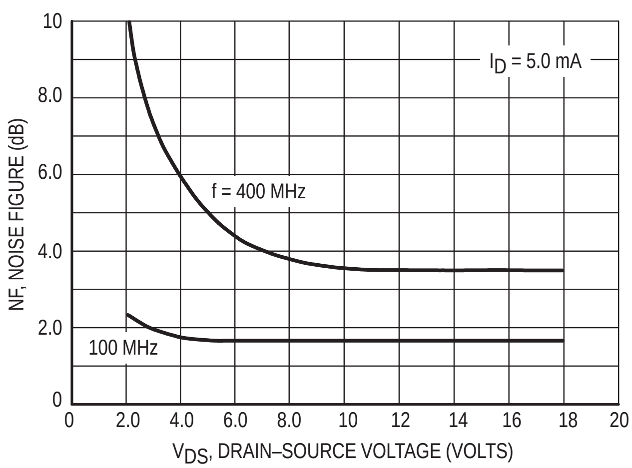


Figure 3. Effects of Drain–Source Voltage

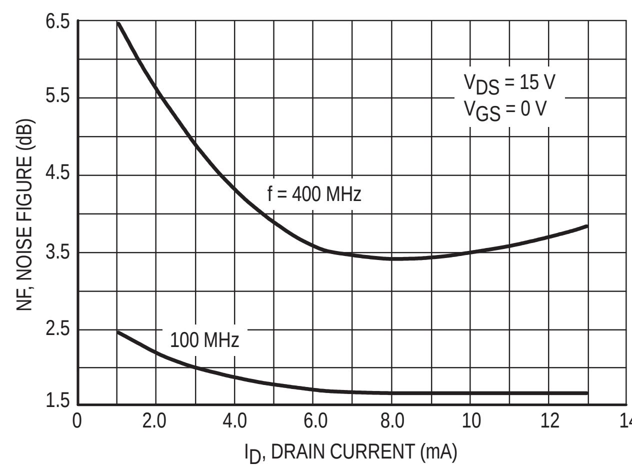


Figure 4. Effects of Drain Current

INTERMODULATION CHARACTERISTICS

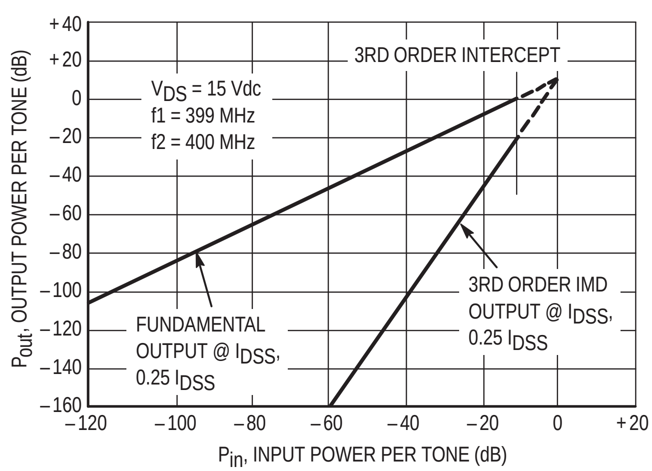


Figure 5. Third Order Intermodulation Distortion

COMMON SOURCE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

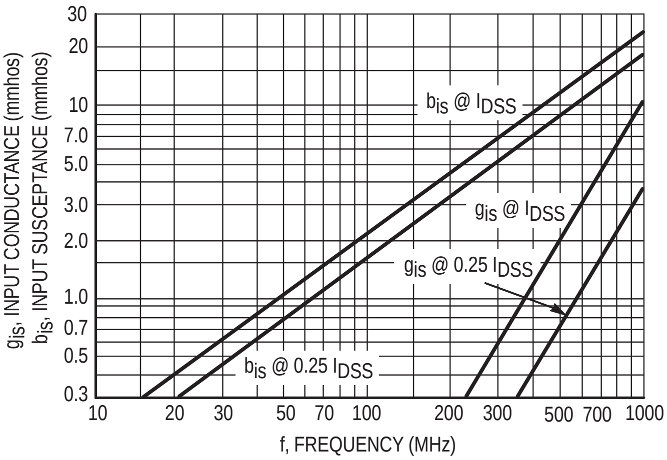


Figure 6. Input Admittance (y_{is})

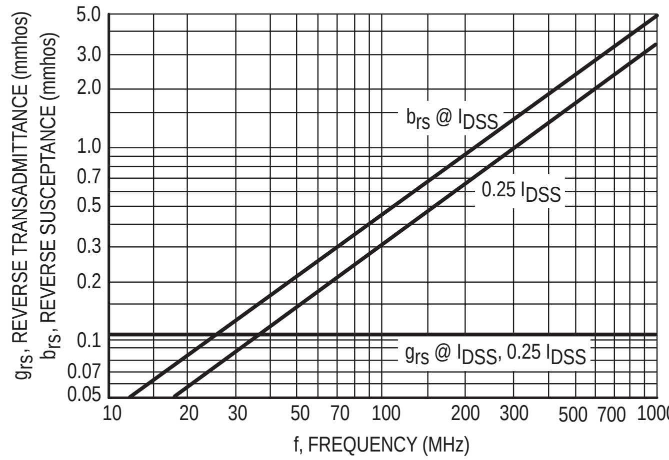


Figure 7. Reverse Transfer Admittance (y_{rs})

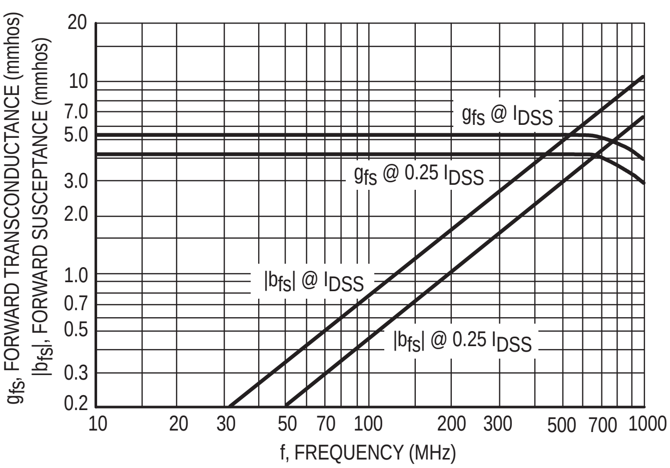


Figure 8. Forward Transadmittance (y_{fs})

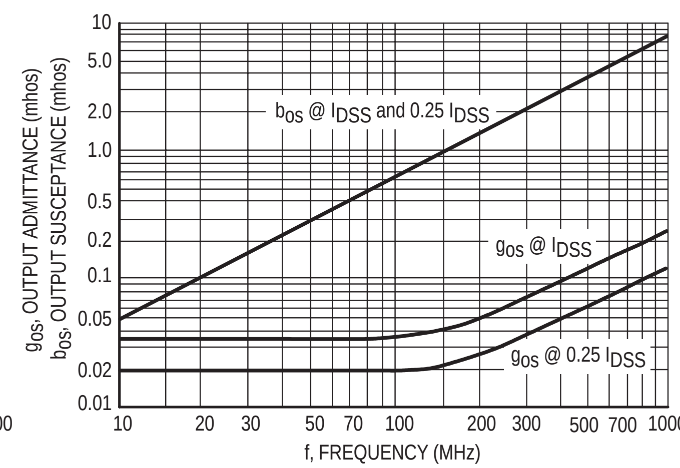


Figure 9. Output Admittance (y_{os})

COMMON SOURCE CHARACTERISTICS

S–PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

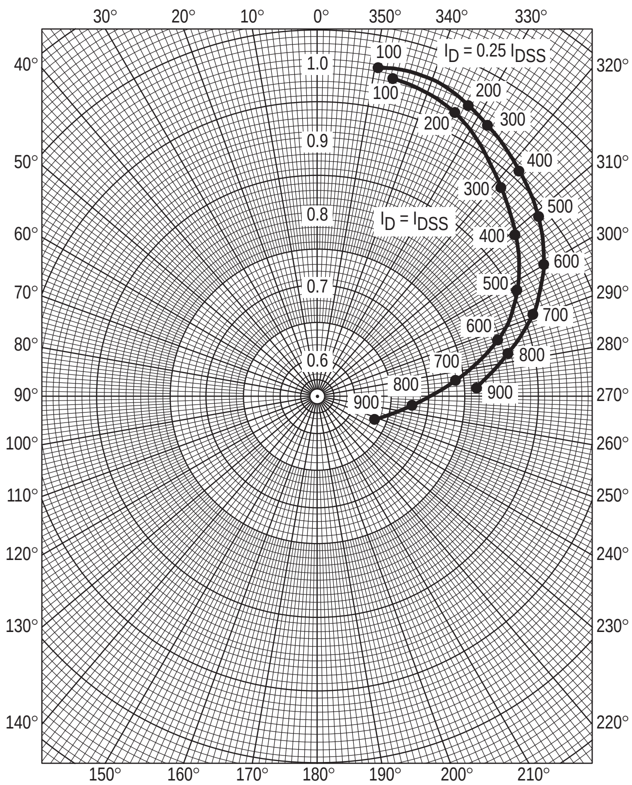


Figure 10. S_{11s}

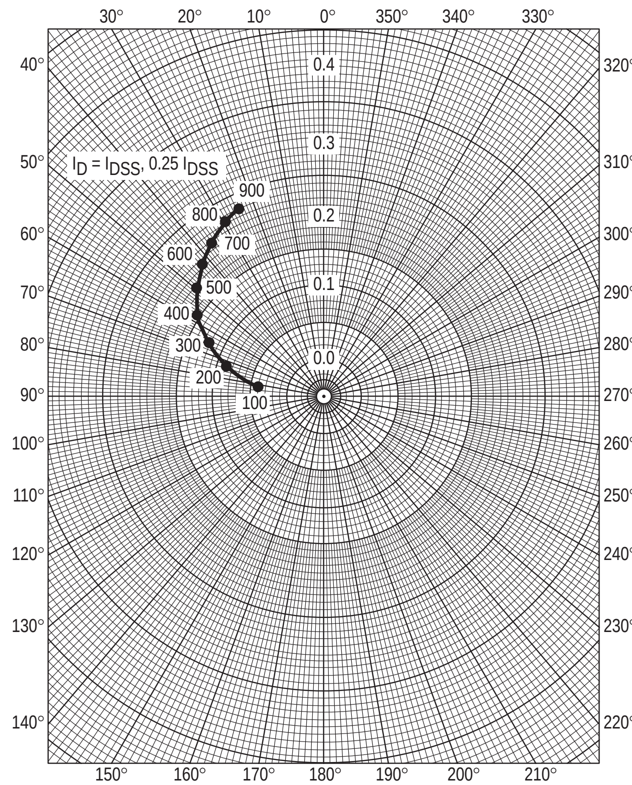


Figure 11. S_{12s}

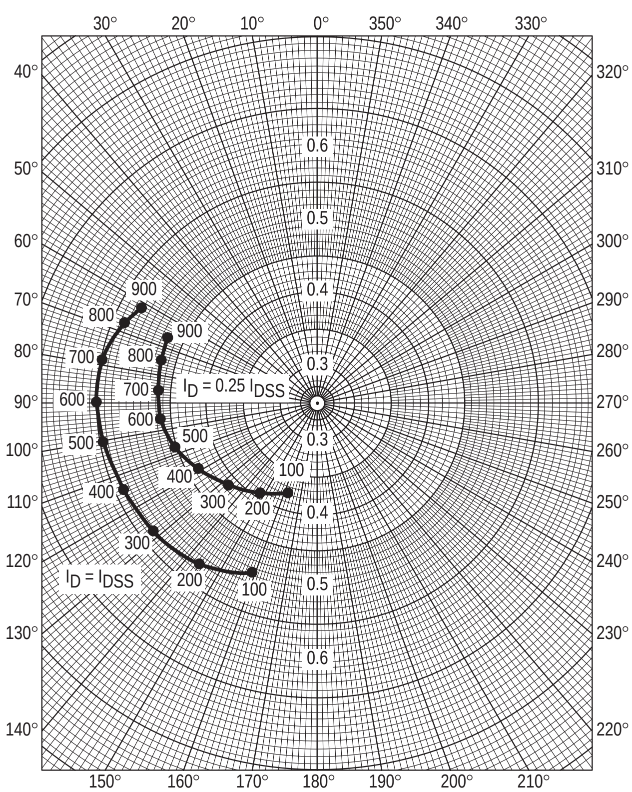


Figure 12. S_{21s}

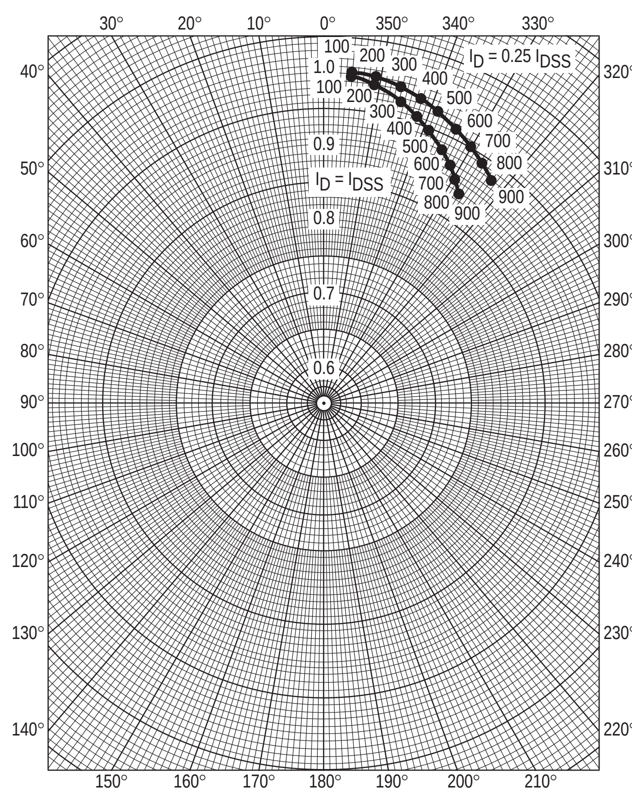


Figure 13. S_{22s}

COMMON GATE CHARACTERISTICS
ADMITTANCE PARAMETERS
(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

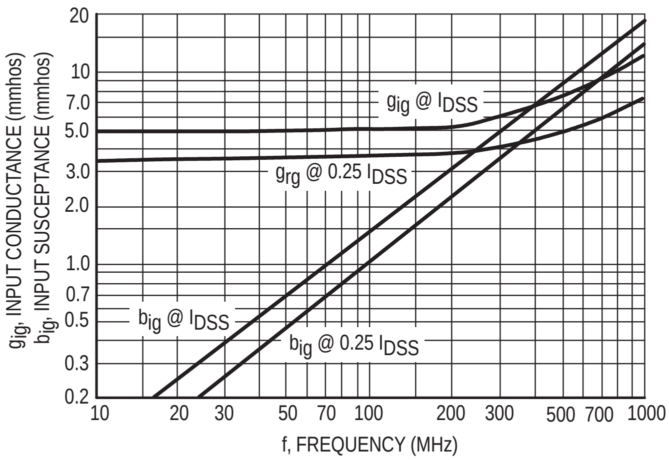


Figure 14. Input Admittance (y_{ig})

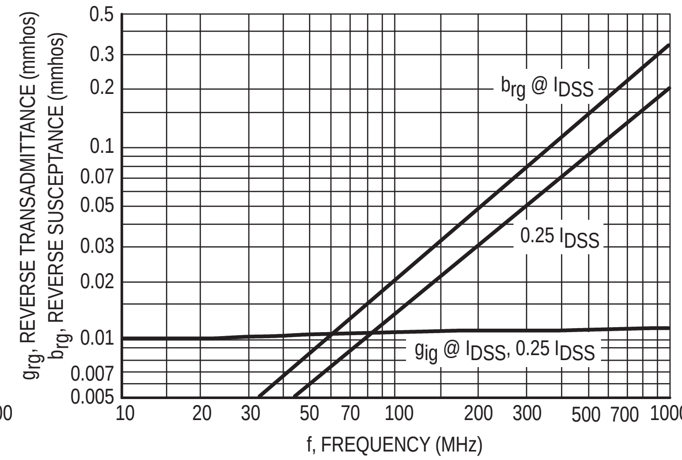


Figure 15. Reverse Transfer Admittance (y_{rg})

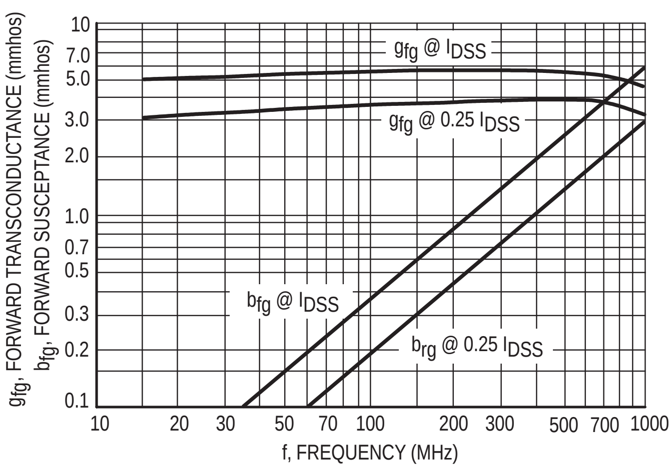


Figure 16. Forward Transfer Admittance (y_{fg})

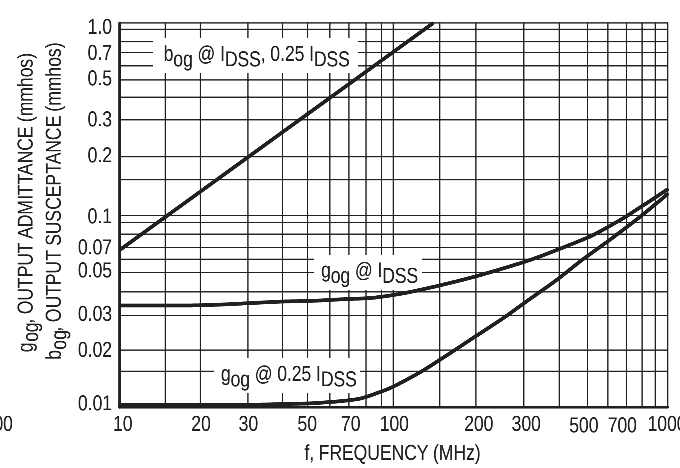


Figure 17. Output Admittance (y_{og})

COMMON GATE CHARACTERISTICS

S–PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

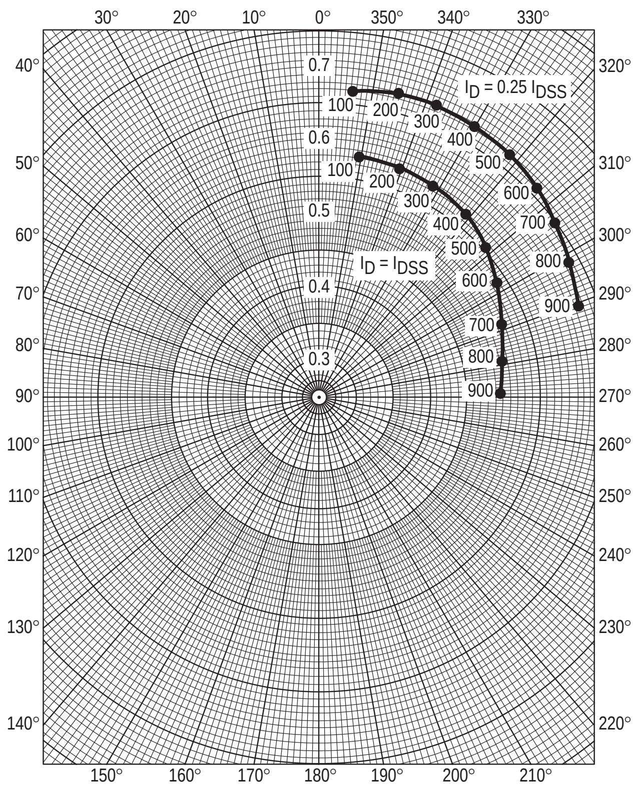


Figure 18. S_{11g}

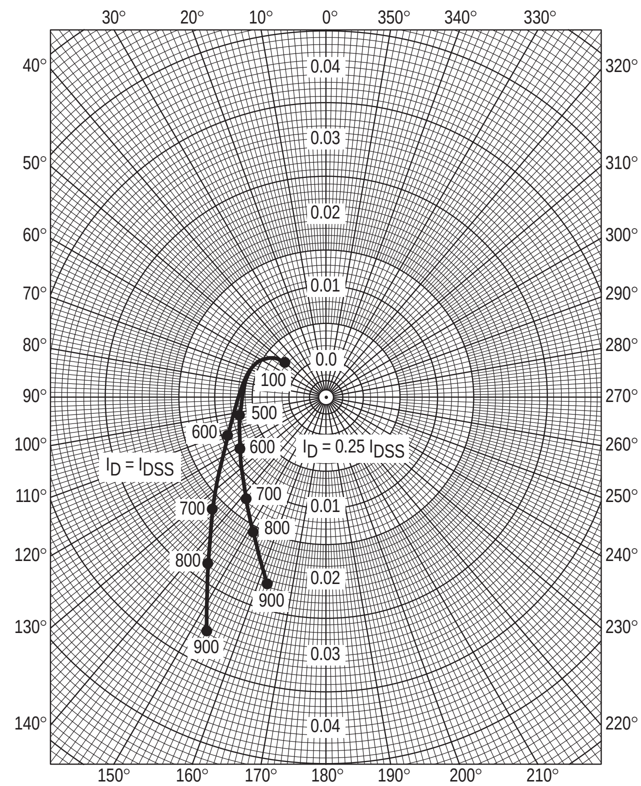


Figure 19. S_{12g}

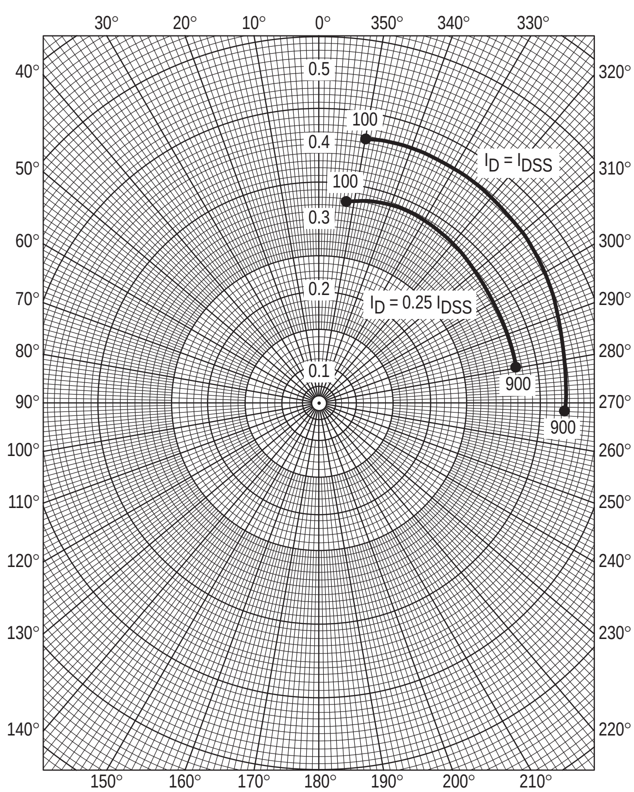


Figure 20. S_{21g}

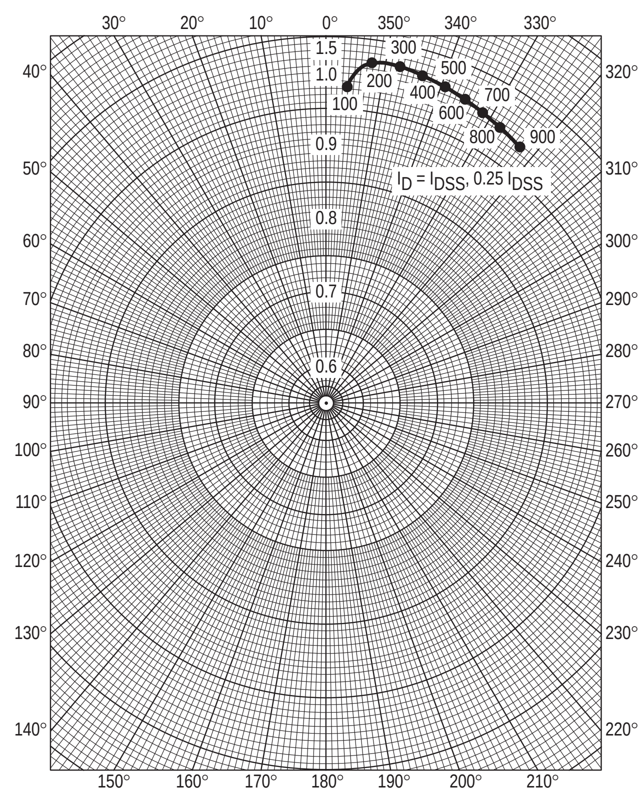
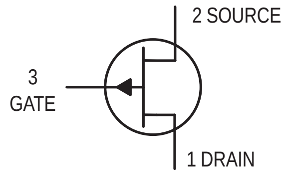


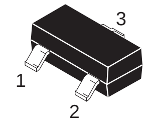
Figure 21. S_{22g}

JFET Chopper
P–Channel — Depletion

MMBFJ175LT1

Motorola Preferred Device





CASE 318–08, STYLE 10
SOT–23 (TO–236AB)

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(1) 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

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 (2) (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 (V_{DS} = 0, V_{GS} = 10 V, f = 1.0 MHz)	C_{rss}	—	5.5	pF

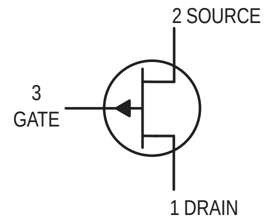
1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

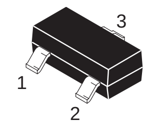
Preferred devices are Motorola recommended choices for future use and best overall value.

JFET Chopper

P–Channel — Depletion

MMBFJ177LT1





CASE 318–08, STYLE 10
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Gate Voltage	V_{DG}	25	Vdc
Reverse Gate–Source Voltage	$V_{GS(r)}$	–25	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) $T_A = 25°C$	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

DEVICE MARKING

MMBFJ177LT1 = 6Y

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

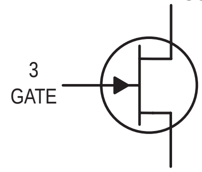
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate–Source Breakdown Voltage (V_{DS} = 0, I_D = 1.0 μAdc)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{DS} = 0 Vdc, V_{GS} = 20 Vdc)	I_{GSS}	—	1.0	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	$V_{GS(off)}$	0.8	2.5	Vdc
ON CHARACTERISTICS				
Zero–Gate–Voltage Drain Current(2) (V_{GS} = 0, V_{DS} = 15 Vdc)	I_{DSS}	1.5	20	mAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 10 Vdc)	$I_{D(off)}$	—	1.0	nAdc
Drain Source On Resistance (I_D = 500 μAdc)	$r_{DS(on)}$	—	300	Ω
Input Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{iss}	—	11	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{rss}	—	5.5	pF

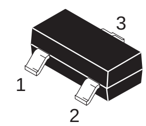
1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Pulse Test: Pulse Width < 300 μs, Duty Cycle ≤ 2%.

JFET VHF/UHF Amplifier Transistor

N–Channel

MMBFJ309LT1
MMBFJ310LT1





CASE 318–08, STYLE 10
SOT–23 (TO–236AB)

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(1) 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

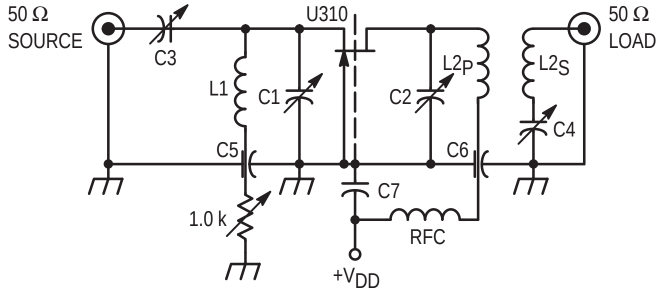
DEVICE MARKING

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 Vdc) (V_{GS} = –15 Vdc, 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	—	$nV/\sqrt{Hz}$

1. FR–5 = 1.0 × 0.75 × 0.062 in.



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).

Figure 1. 450 MHz Common–Gate Amplifier Test Circuit

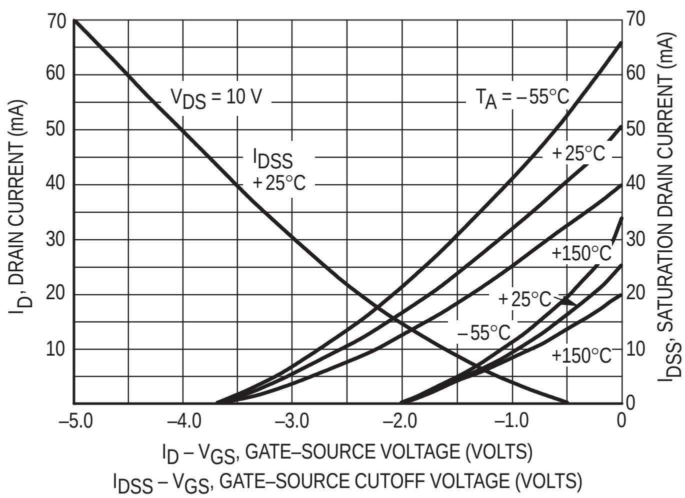


Figure 2. Drain Current and Transfer Characteristics versus Gate–Source Voltage

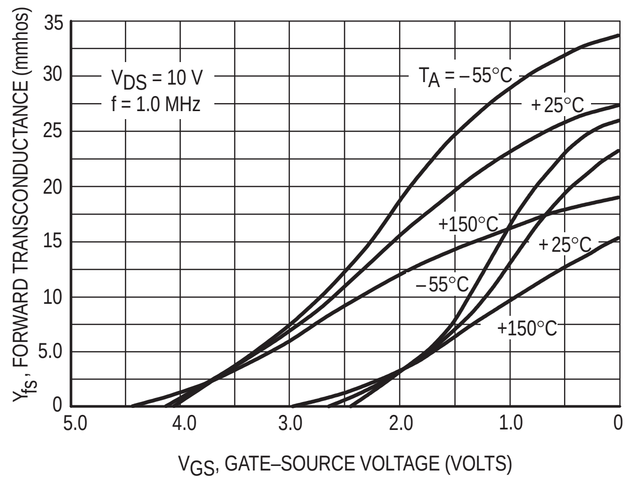


Figure 3. Forward Transconductance versus Gate–Source Voltage

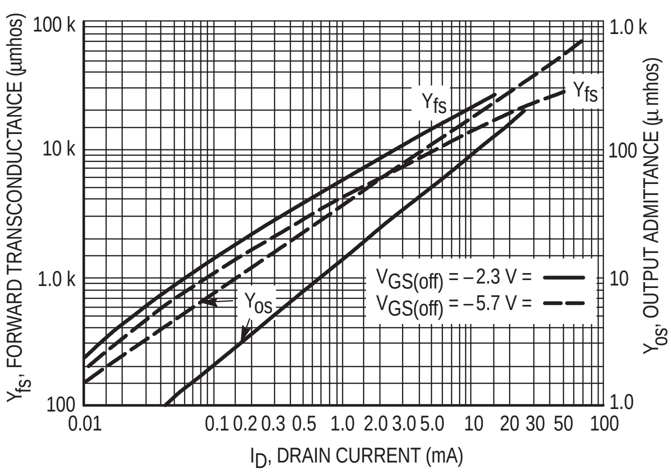


Figure 4. Common–Source Output Admittance and Forward Transconductance versus Drain Current

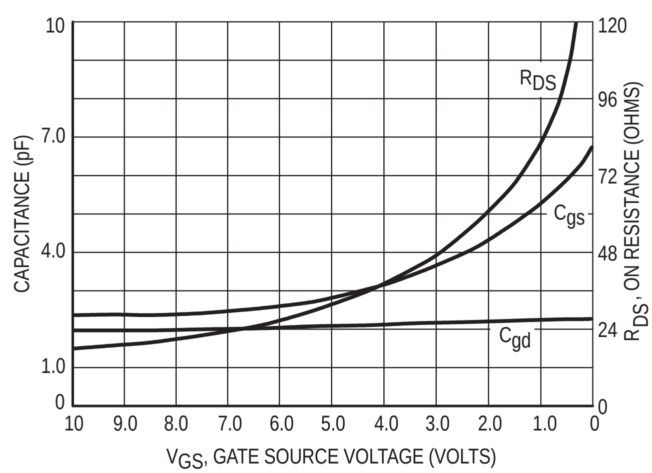


Figure 5. On Resistance and Junction Capacitance versus Gate–Source Voltage

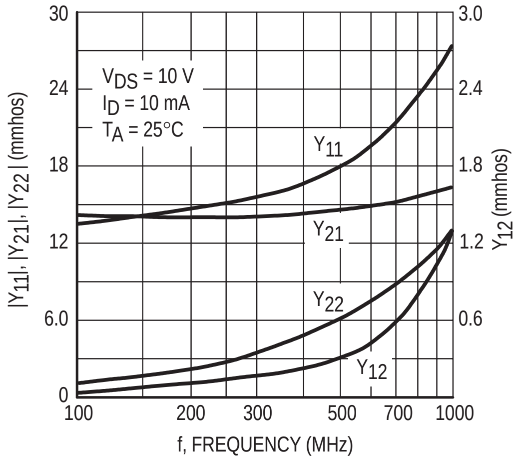


Figure 6. Common–Gate Y Parameter Magnitude versus Frequency

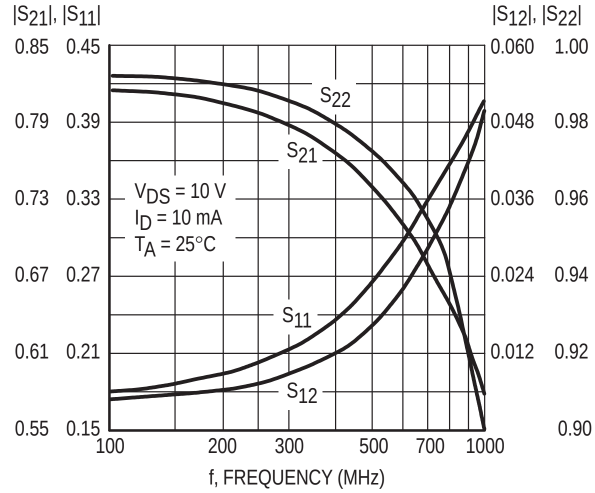


Figure 7. Common–Gate S Parameter Magnitude versus Frequency

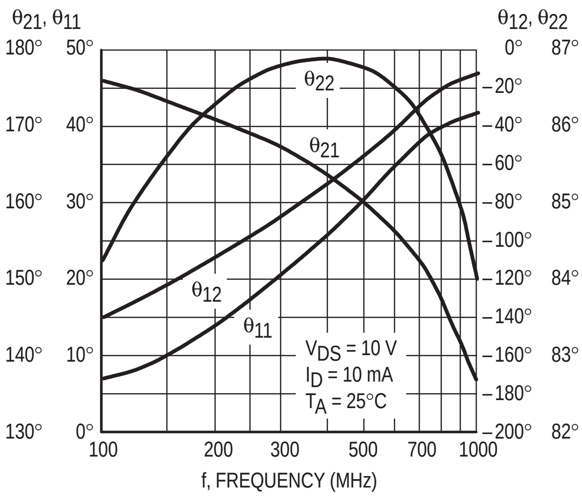


Figure 8. Common–Gate Y Parameter Phase–Angle versus Frequency

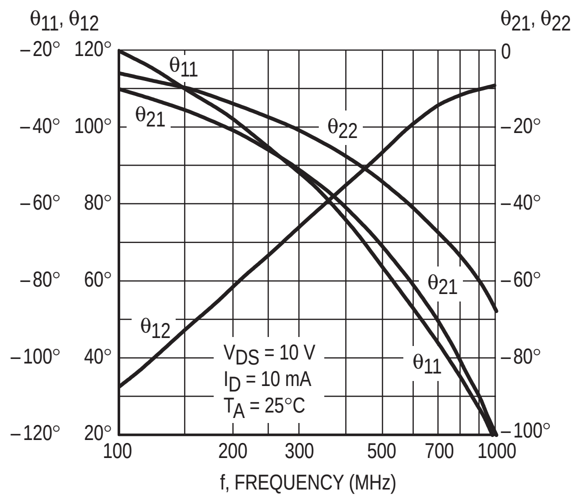


Figure 9. S Parameter Phase–Angle versus Frequency

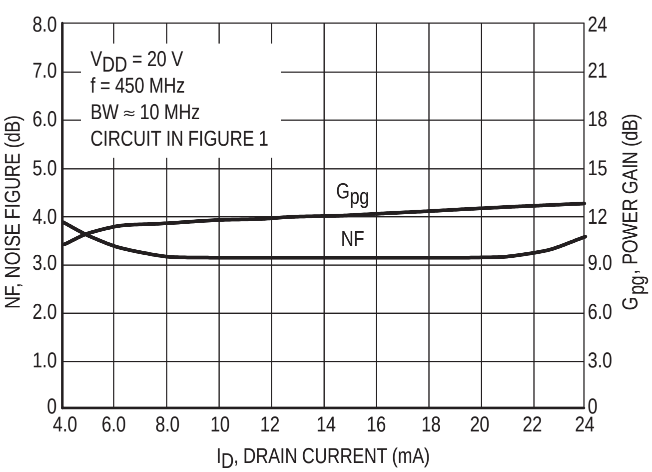


Figure 10. Noise Figure and Power Gain versus Drain Current

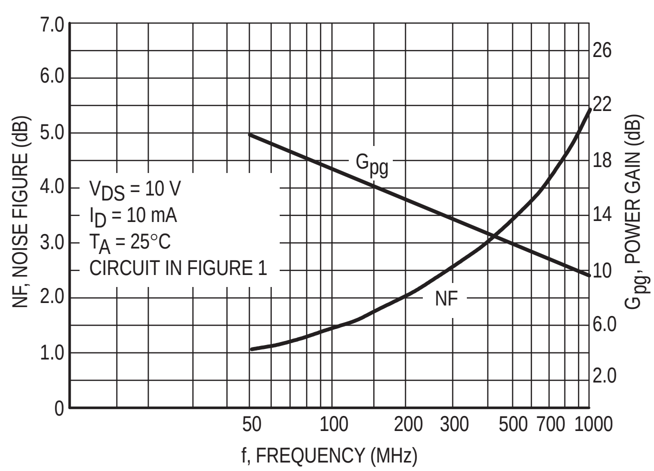
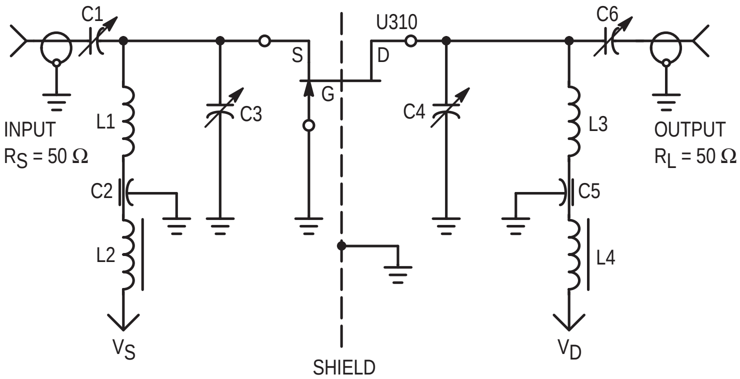


Figure 11. Noise Figure and Power Gain versus Frequency



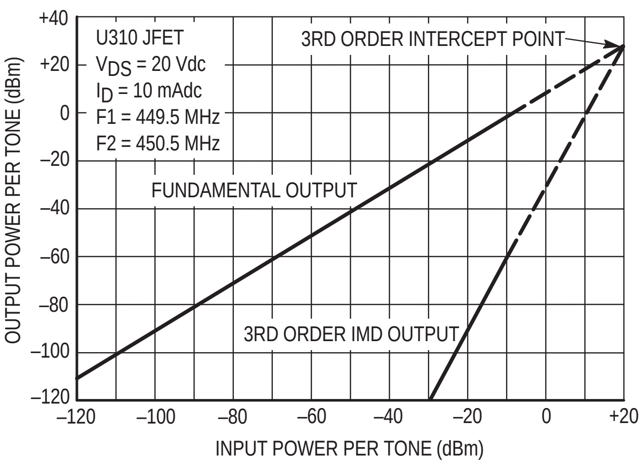
B_W (3 dB) – 36.5 MHz
I_D – 10 mAdc
V_{DS} – 20 Vdc
Device case grounded
IM test tones – f1 = 449.5 MHz, f2 = 450.5 MHz

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.

Figure 12. 450 MHz IMD Evaluation Amplifier

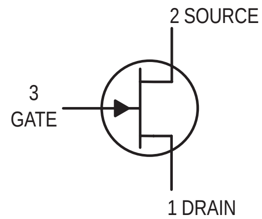
Amplifier power gain and IMD products are a function of the load impedance. For the amplifier design shown above with C4 and C6 adjusted to reflect a load to the drain resulting in a nominal power gain of 9 dB, the 3rd order intercept point (IP) value is 29 dBm. Adjusting C4, C6 to provide larger load 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.



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 comparison.

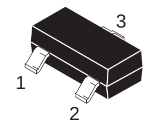
Figure 13. Two Tone 3rd Order Intercept Point

JFET Transistor
N–Channel



MMBFU310LT1

Motorola Preferred Device



CASE 318–08, STYLE 10
SOT–23 (TO–236AB)

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(1) 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

DEVICE MARKING

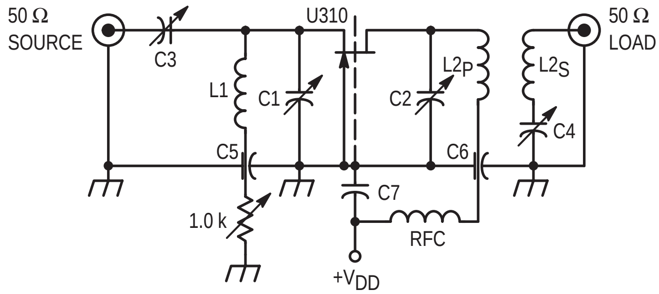
MMBFU310LT1 = 6C

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate–Source Breakdown Voltage (I_G = –1.0 µAdc, V_{DS} = 0)	$V_{(BR)GSS}$	–25	—	Vdc
Gate 1 Leakage Current (V_{GS} = –15 Vdc, V_{DS} = 0)	I_{G1SS}	—	–150	pA
Gate 2 Leakage Current (V_{GS} = –15 Vdc, V_{DS} = 0, T_A = 125°C)	I_{G2SS}	—	–150	nAdc
Gate Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 nAdc)	$V_{GS(off)}$	–2.5	–6.0	Vdc
ON CHARACTERISTICS				
Zero–Gate–Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	24	60	mAdc
Gate–Source Forward Voltage (I_G = 10 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)	$\|Y_{fs}\|$	10	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

1. FR–5 = 1.0 × 0.75 × 0.062 in.

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



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).

Figure 1. 450 MHz Common–Gate Amplifier Test Circuit

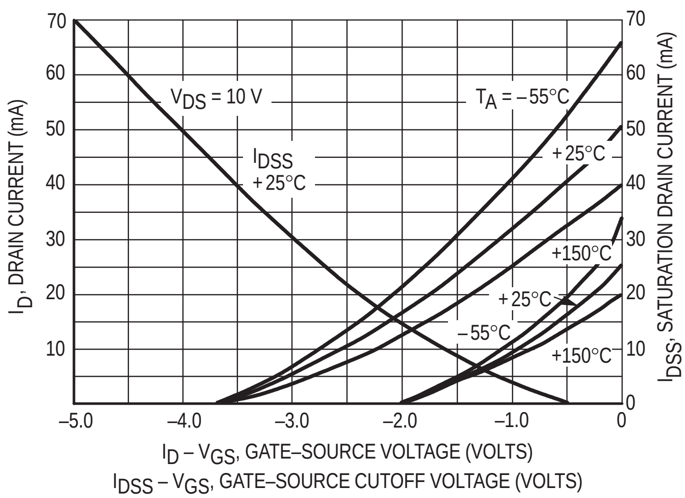


Figure 2. Drain Current and Transfer Characteristics versus Gate–Source Voltage

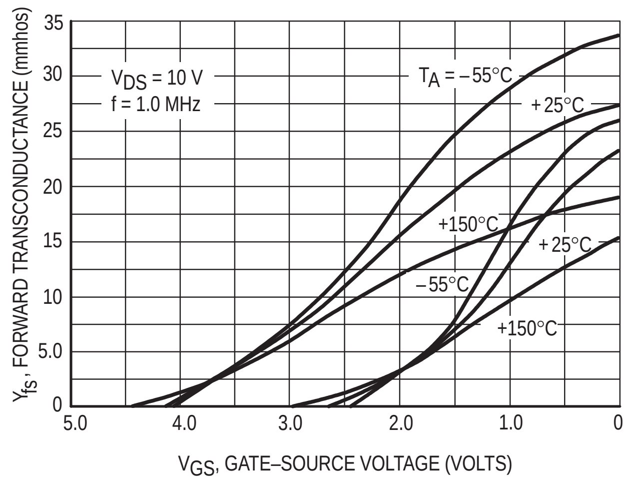


Figure 3. Forward Transconductance versus Gate–Source Voltage

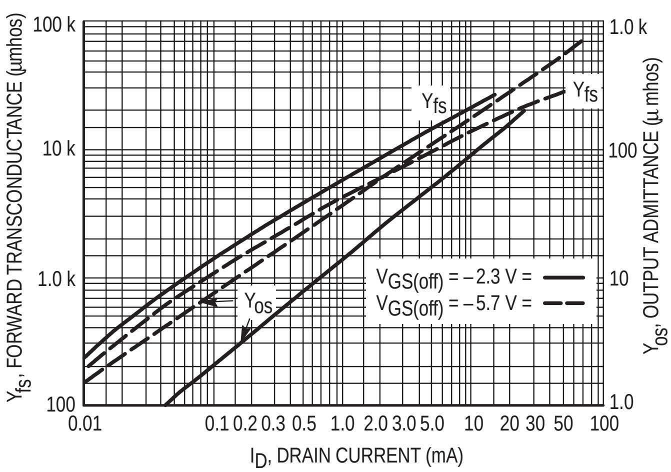


Figure 4. Common–Source Output Admittance and Forward Transconductance versus Drain Current

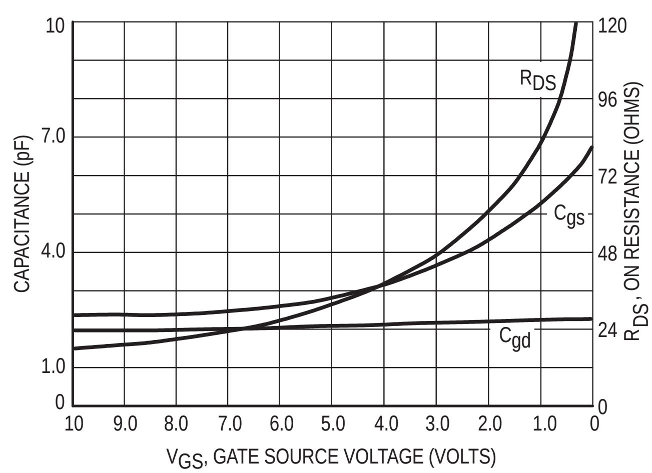


Figure 5. On Resistance and Junction Capacitance versus Gate–Source Voltage

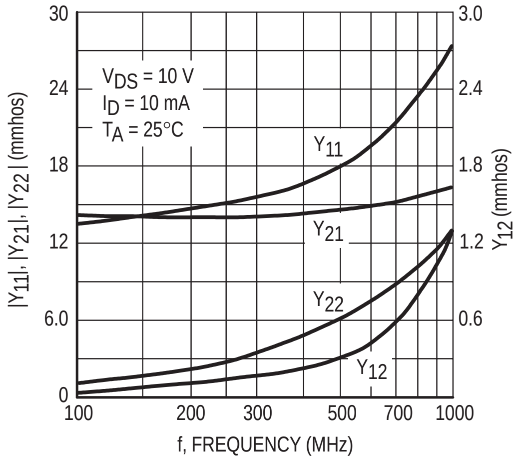


Figure 6. Common–Gate Y Parameter Magnitude versus Frequency

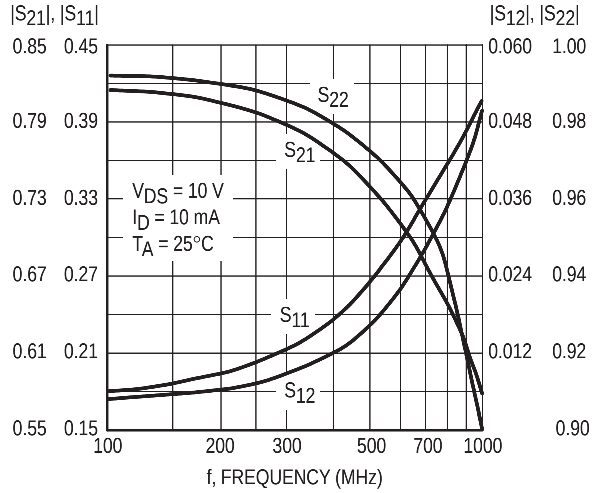


Figure 7. Common–Gate S Parameter Magnitude versus Frequency

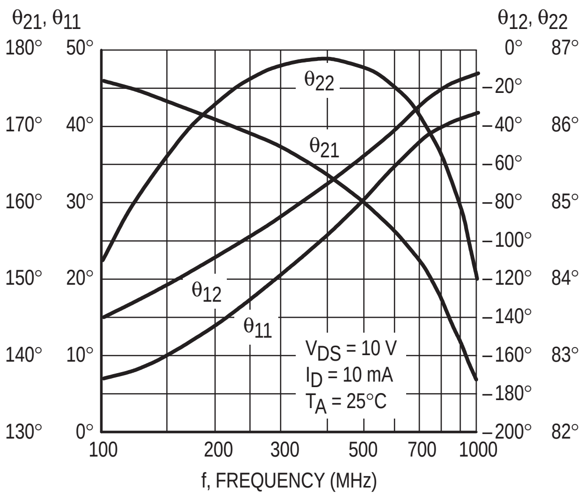


Figure 8. Common–Gate Y Parameter Phase–Angle versus Frequency

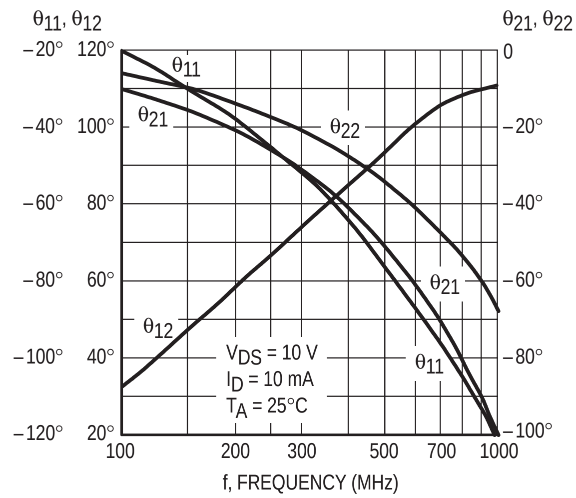


Figure 9. S Parameter Phase–Angle versus Frequency

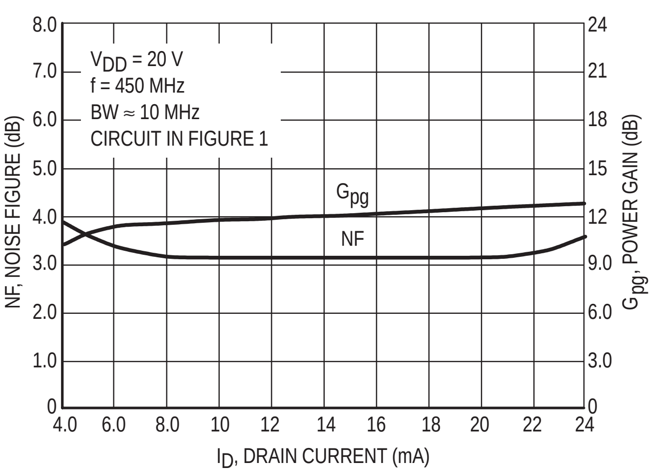


Figure 10. Noise Figure and Power Gain versus Drain Current

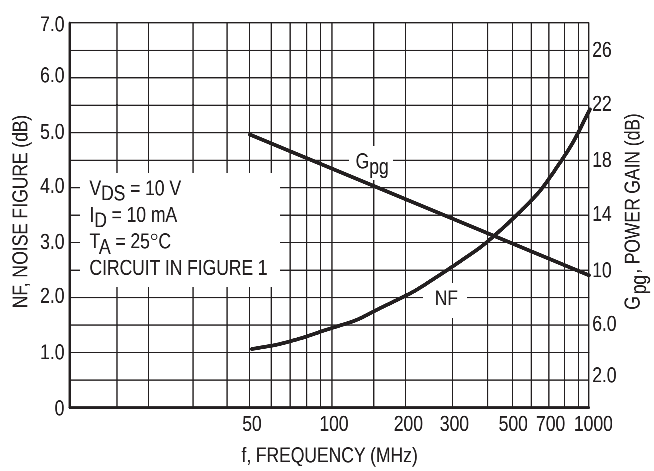
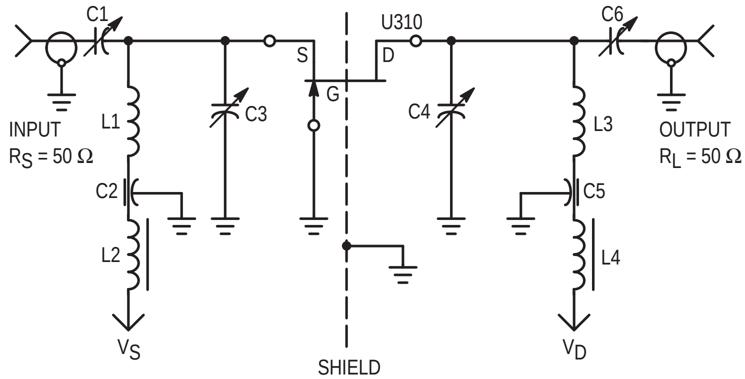


Figure 11. Noise Figure and Power Gain versus Frequency



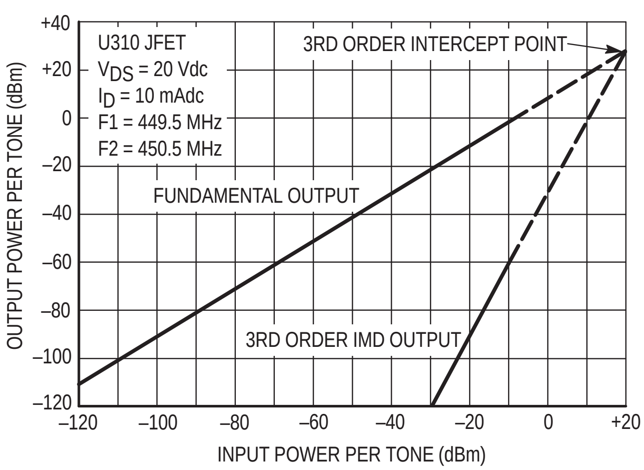
B_W (3 dB) – 36.5 MHz
I_D – 10 mAdc
V_{DS} – 20 Vdc
Device case grounded
IM test tones – f1 = 449.5 MHz, f2 = 450.5 MHz

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.

Figure 12. 450 MHz IMD Evaluation Amplifier

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.



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 comparison.

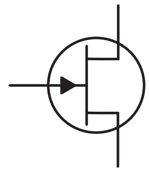
Figure 13. Two Tone 3rd Order Intercept Point

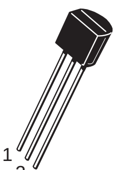
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

JFET VHF Amplifier

N–Channel — Depletion

MPF102





CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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(1) (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	2.0	20	mAdc
SMALL–SIGNAL CHARACTERISTICS				
Forward Transfer Admittance(1) (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

1. Pulse Test; Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

POWER GAIN

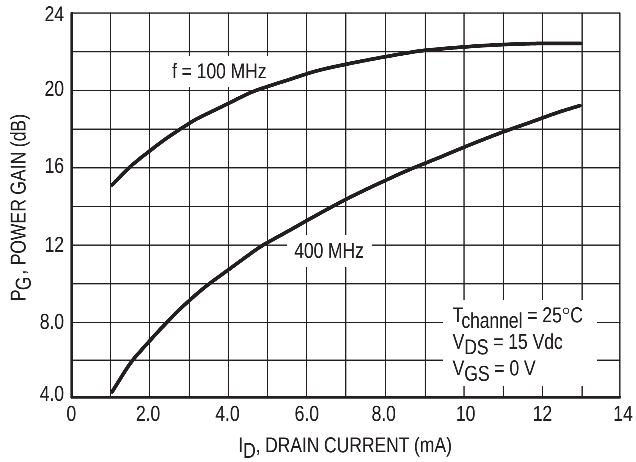
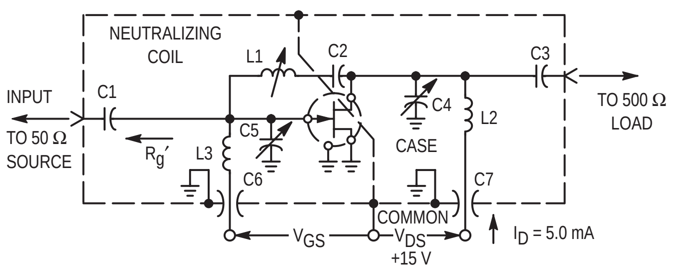


Figure 1. Effects of Drain Current



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).

Figure 2. 100 MHz and 400 MHz Neutralized Test Circuit

NOISE FIGURE

($T_{channel}$ = 25°C)

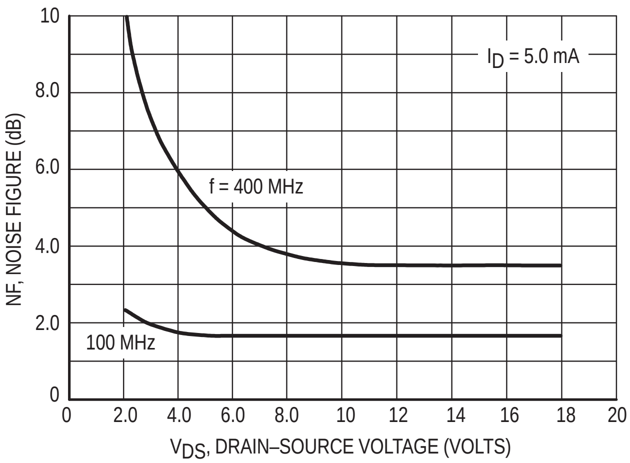


Figure 3. Effects of Drain–Source Voltage

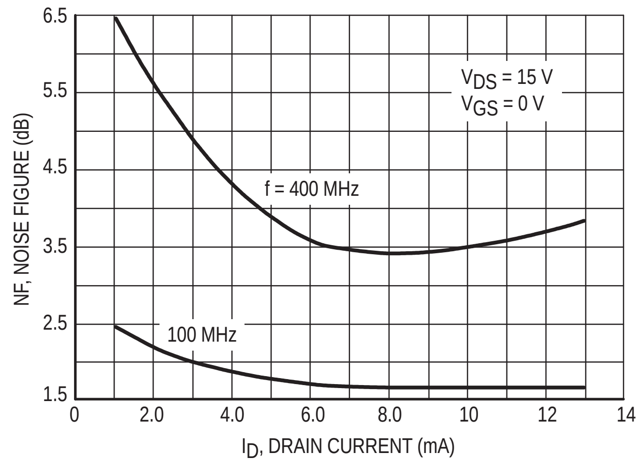


Figure 4. Effects of Drain Current

INTERMODULATION CHARACTERISTICS

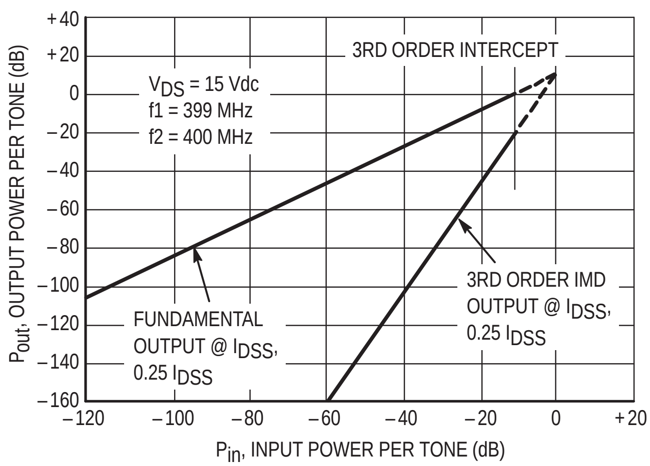


Figure 5. Third Order Intermodulation Distortion

COMMON SOURCE CHARACTERISTICS
ADMITTANCE PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

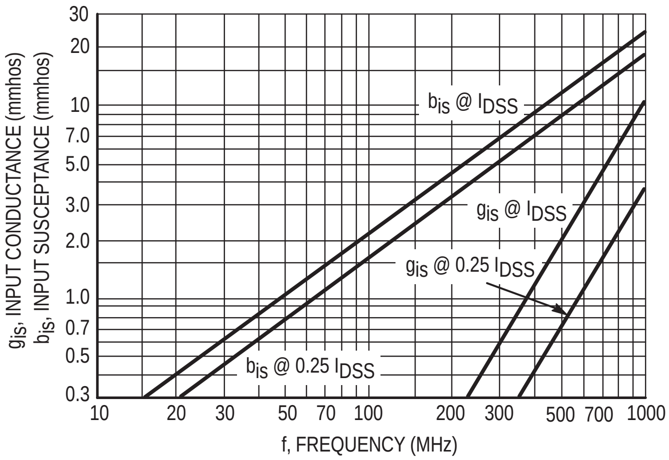


Figure 6. Input Admittance (y_{is})

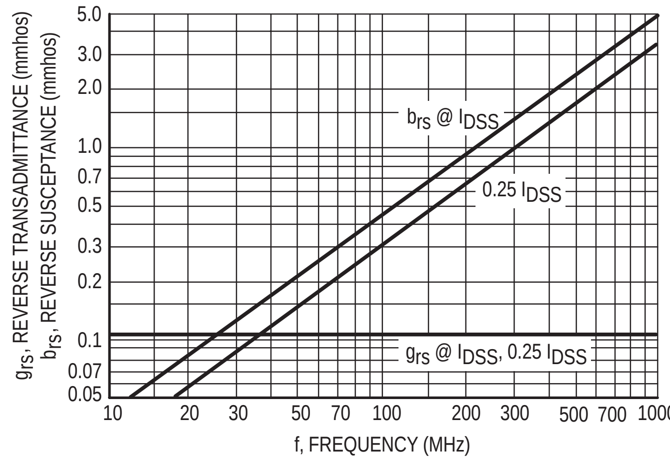


Figure 7. Reverse Transfer Admittance (y_{rs})

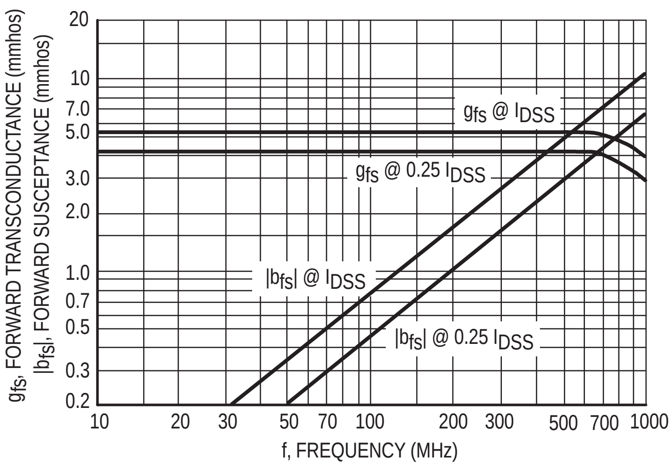


Figure 8. Forward Transadmittance (y_{fs})

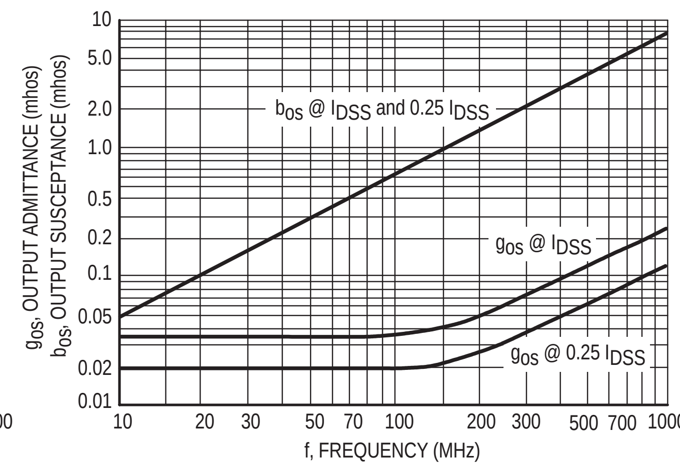


Figure 9. Output Admittance (y_{os})

COMMON SOURCE CHARACTERISTICS
S–PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

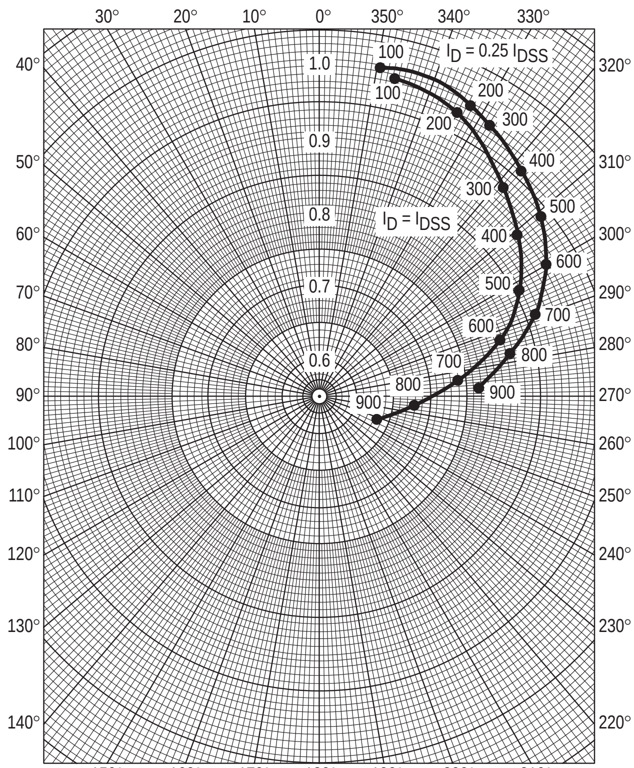


Figure 10. S_{11s}

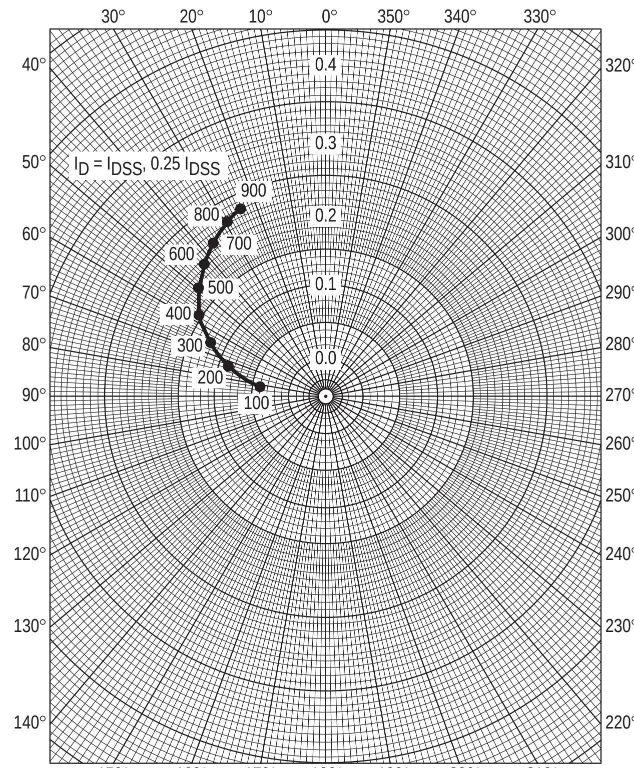


Figure 11. S_{12s}

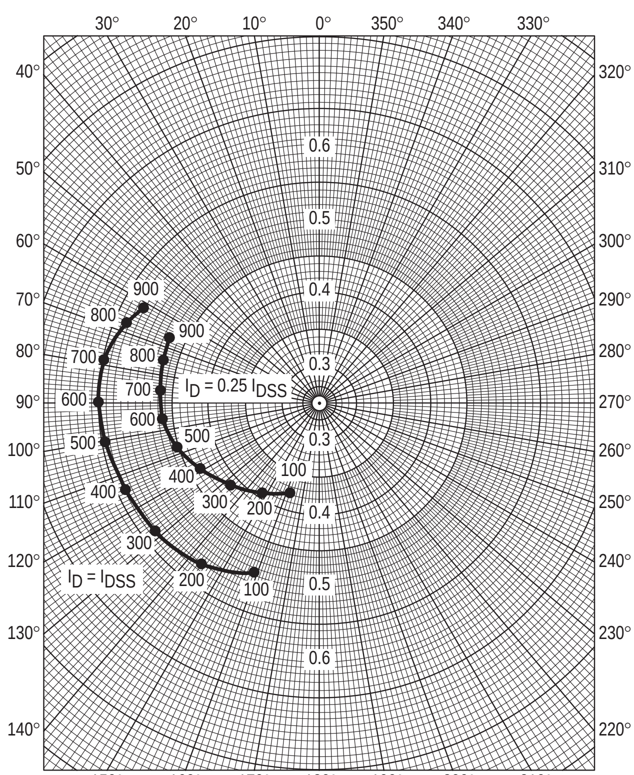


Figure 12. S_{21s}

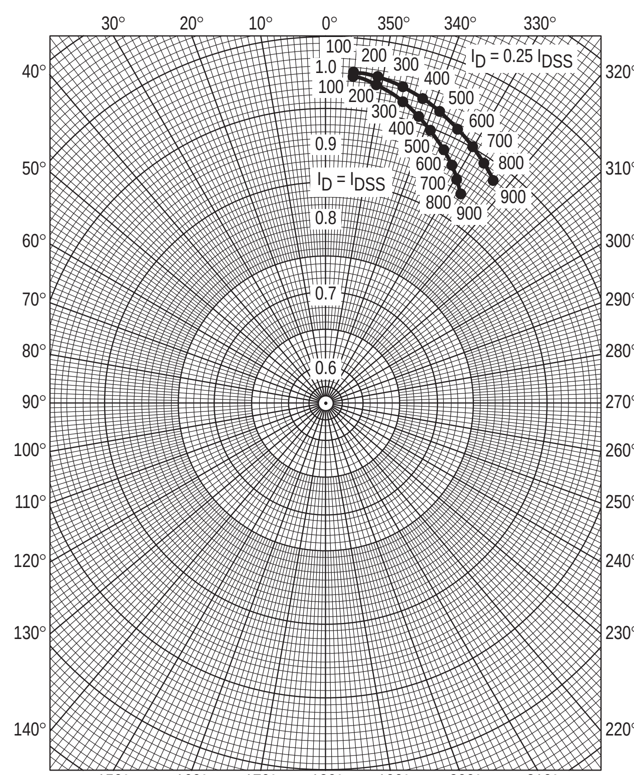


Figure 13. S_{22s}

COMMON GATE CHARACTERISTICS
ADMITTANCE PARAMETERS
(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

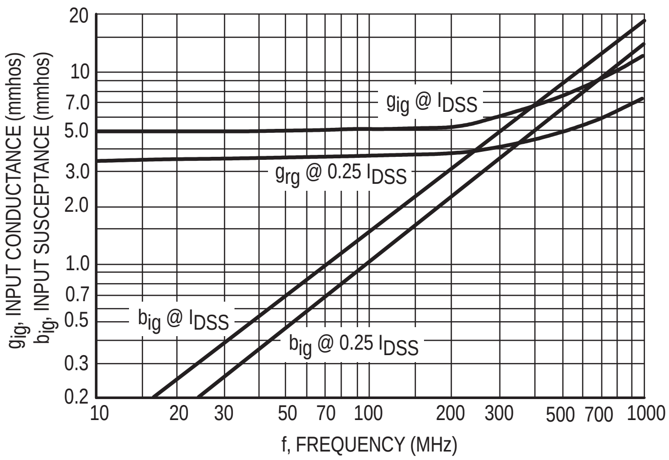


Figure 14. Input Admittance (y_{ig})

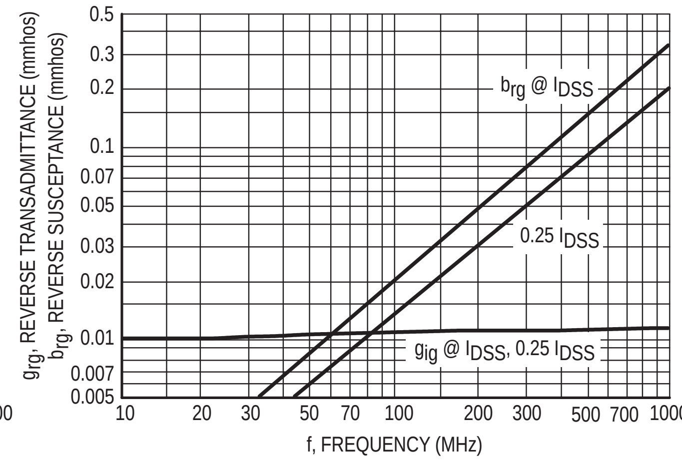


Figure 15. Reverse Transfer Admittance (y_{rg})

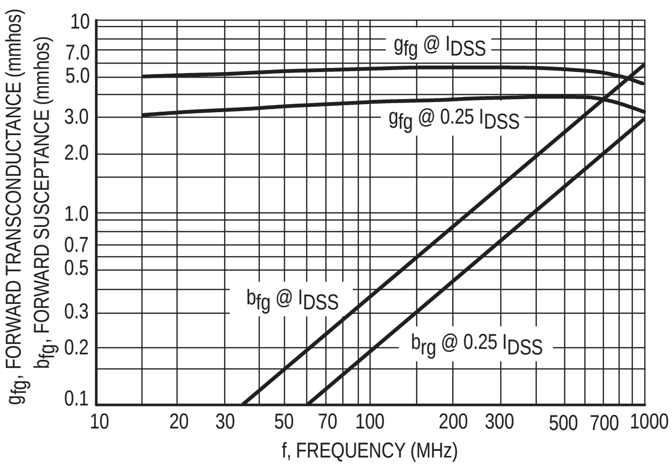


Figure 16. Forward Transfer Admittance (y_{fg})

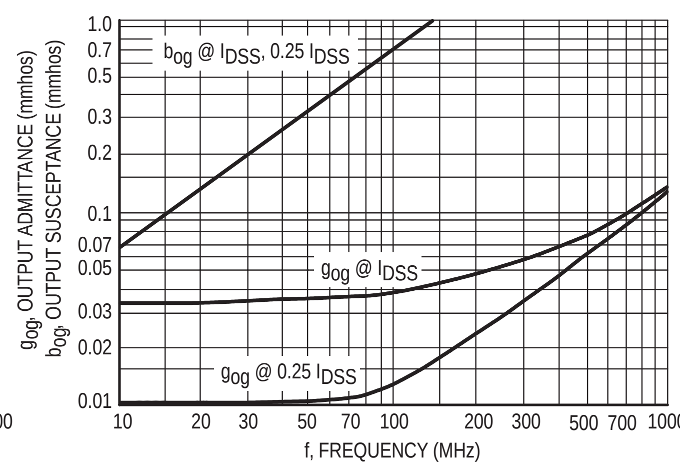


Figure 17. Output Admittance (y_{og})

COMMON GATE CHARACTERISTICS
S–PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

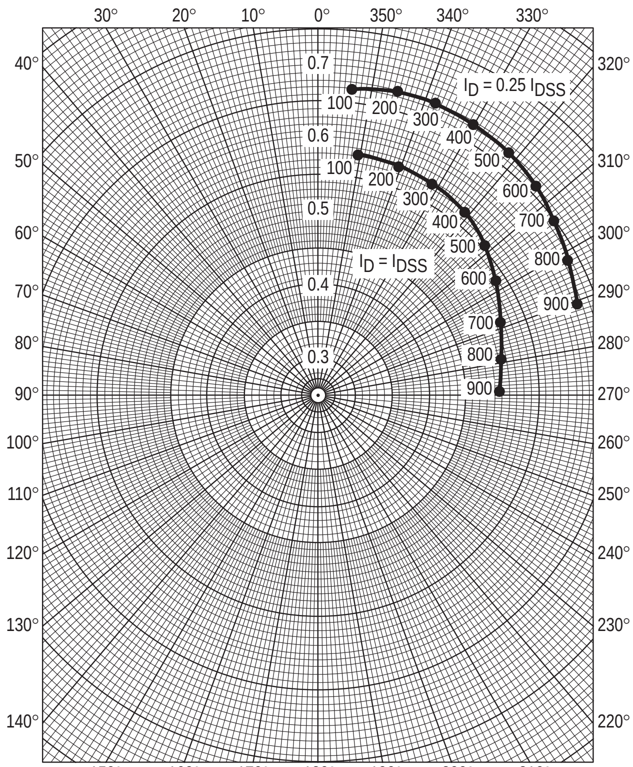


Figure 18. S_{11g}

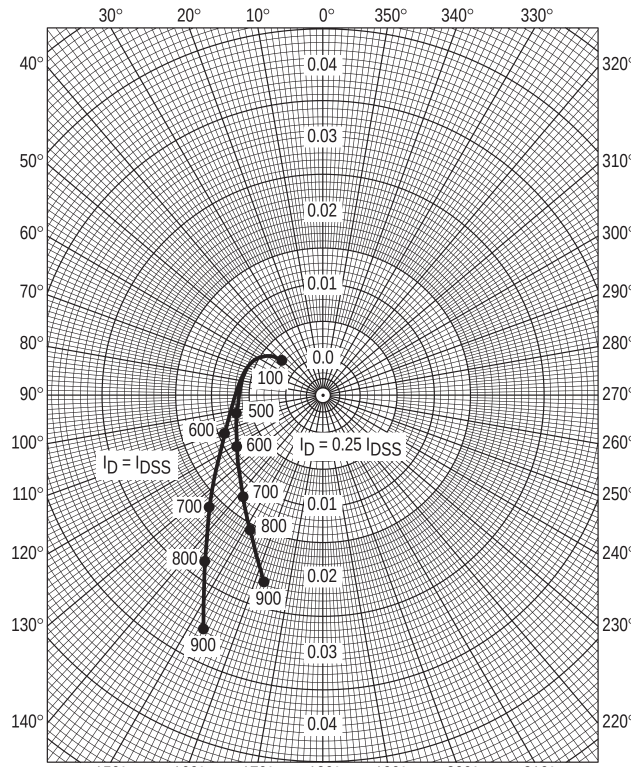


Figure 19. S_{12g}

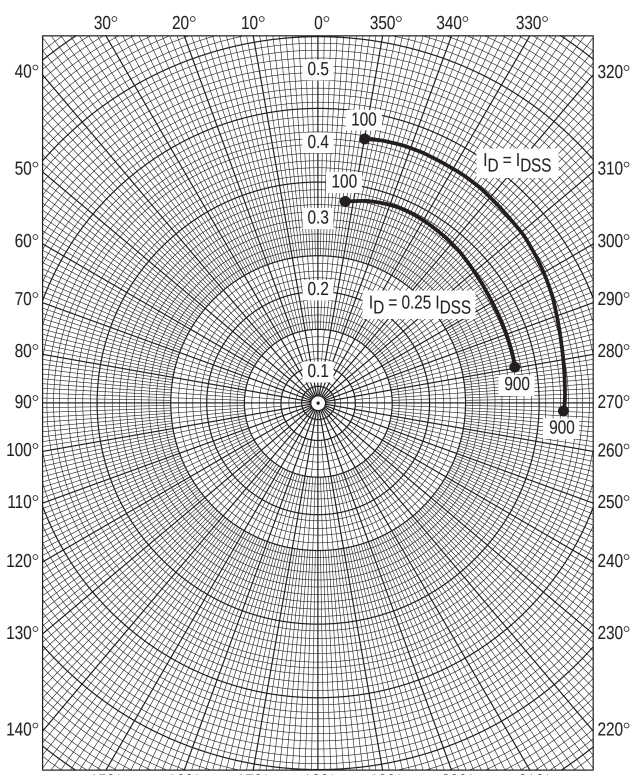


Figure 20. S_{21g}

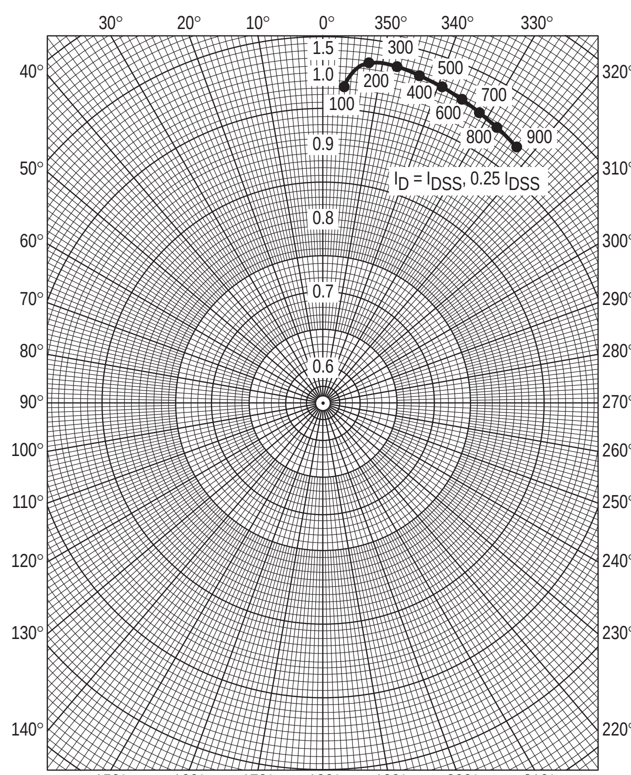
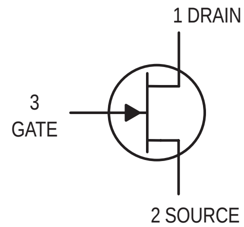


Figure 21. S_{22g}

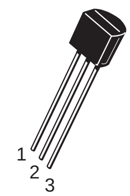
JFETs Switching

N–Channel — Depletion



MPF4392
MPF4393

Motorola Preferred Devices



CASE 29–04, STYLE 5
TO–92 (TO–226AA)

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 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 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	Ω
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

1. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 3.0%.

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

REV 1

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

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL–SIGNAL CHARACTERISTICS (continued)						
Drain–Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MPF4392 MPF4393	$r_{ds(on)}$	— —	— —	60 100	Ω
Input Capacitance (V_{GS} = 15 Vdc, V_{DS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	10	pF
Reverse Transfer Capacitance (V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz) (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{rss}	— —	2.5 3.2	3.5 —	pF
SWITCHING CHARACTERISTICS						
Rise Time (See Figure 2) ($I_{D(on)}$ = 6.0 mAdc) ($I_{D(on)}$ = 3.0 mAdc)	MPF4392 MPF4393	t_r	— —	2.0 2.5	5.0 5.0	ns
Fall Time (See Figure 4) ($V_{GS(off)}$ = 7.0 Vdc) ($V_{GS(off)}$ = 5.0 Vdc)	MPF4392 MPF4393	t_f	— —	15 29	20 35	ns
Turn–On Time (See Figures 1 and 2) ($I_{D(on)}$ = 6.0 mAdc) ($I_{D(on)}$ = 3.0 mAdc)	MPF4392 MPF4393	t_{on}	— —	4.0 6.5	15 15	ns
Turn–Off Time (See Figures 3 and 4) ($V_{GS(off)}$ = 7.0 Vdc) ($V_{GS(off)}$ = 5.0 Vdc)	MPF4392 MPF4393	t_{off}	— —	20 37	35 55	ns

TYPICAL SWITCHING CHARACTERISTICS

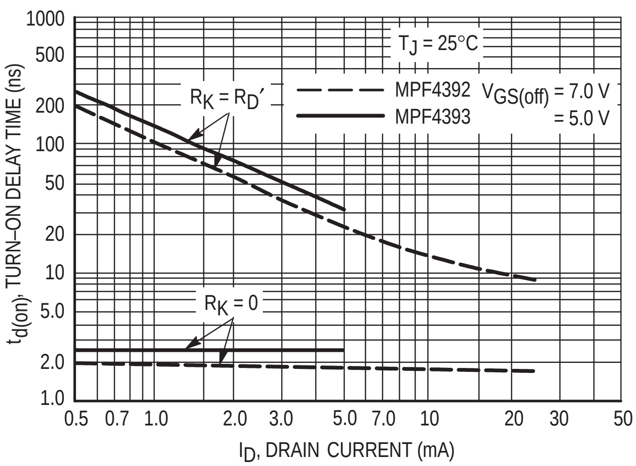


Figure 1. Turn–On Delay Time

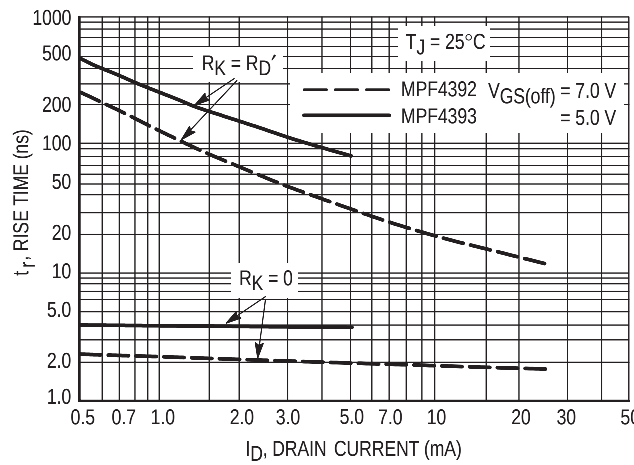


Figure 2. Rise Time

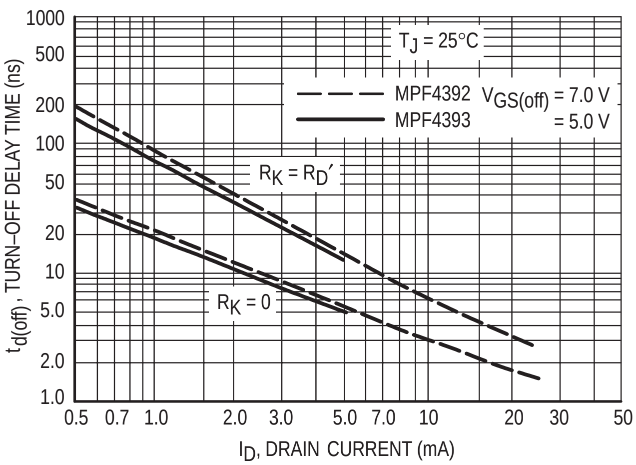


Figure 3. Turn–Off Delay Time

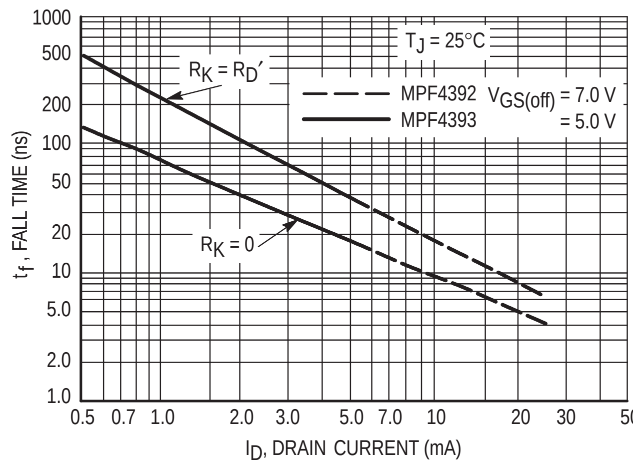


Figure 4. Fall Time

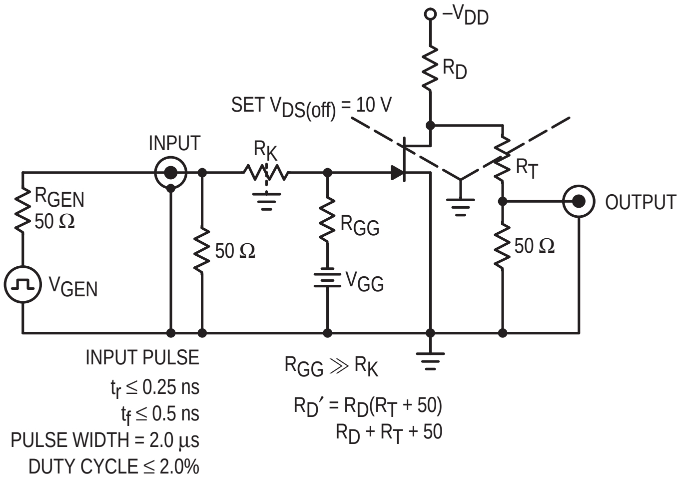


Figure 5. Switching Time Test Circuit

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.

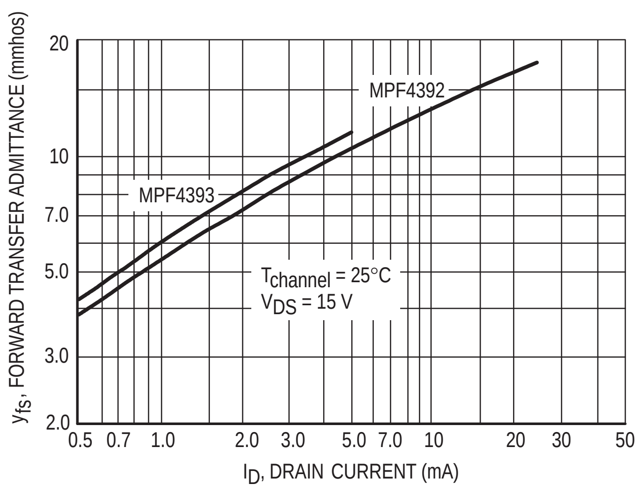


Figure 6. Typical Forward Transfer Admittance

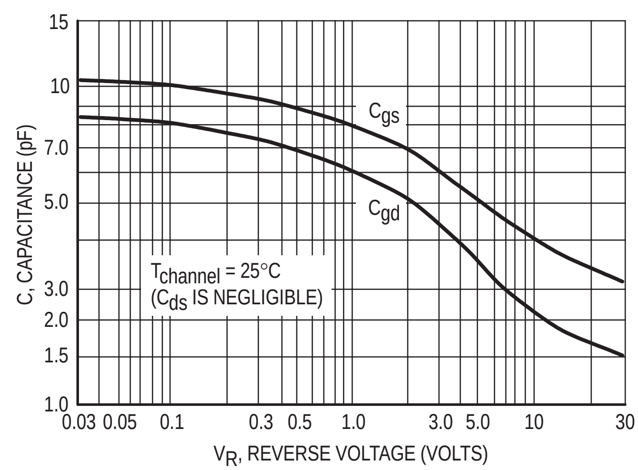


Figure 7. Typical Capacitance

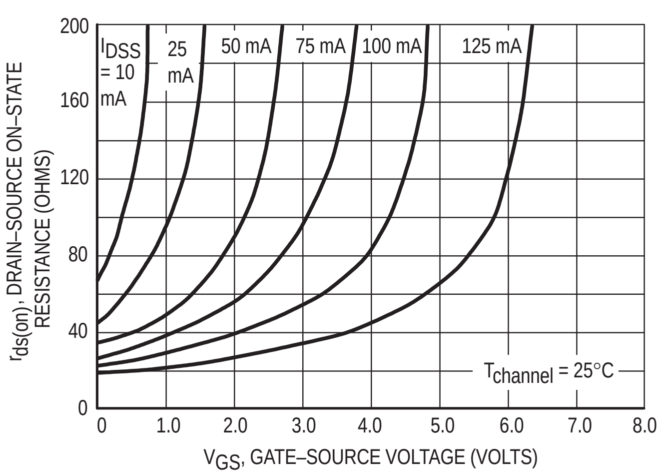


Figure 8. Effect of Gate–Source Voltage On Drain–Source Resistance

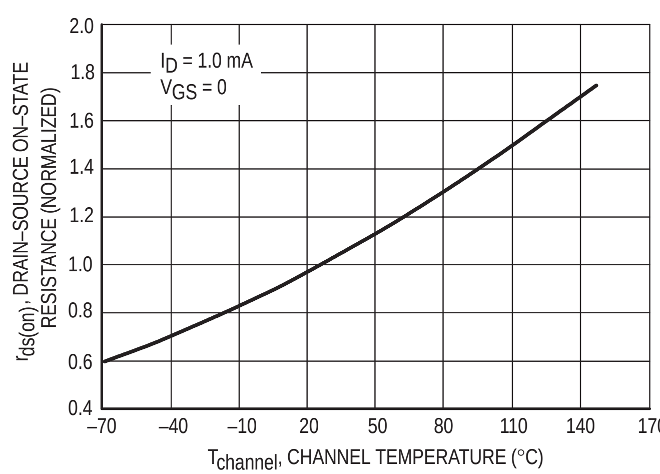


Figure 9. Effect of Temperature On Drain–Source On–State Resistance

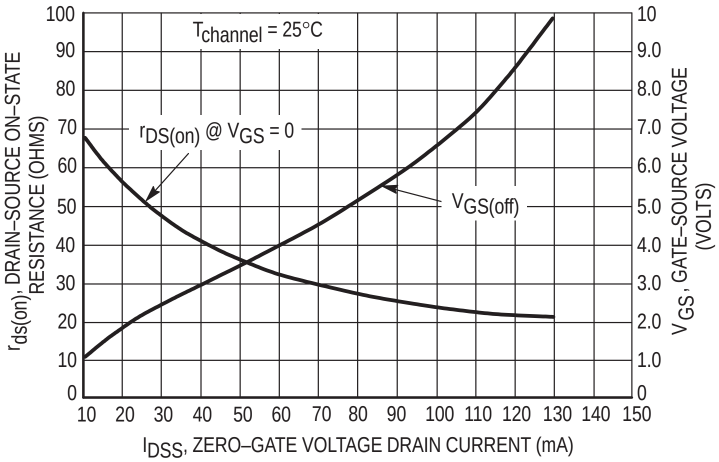


Figure 10. Effect of I_{DSS} On Drain–Source Resistance and Gate–Source Voltage

NOTE 2

The Zero–Gate–Voltage Drain Current (I_{DSS}), is the principle determinant of other J–FET characteristics. Figure 10 shows the relationship of Gate–Source Off Voltage ($V_{GS(off)}$) and Drain–Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±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.

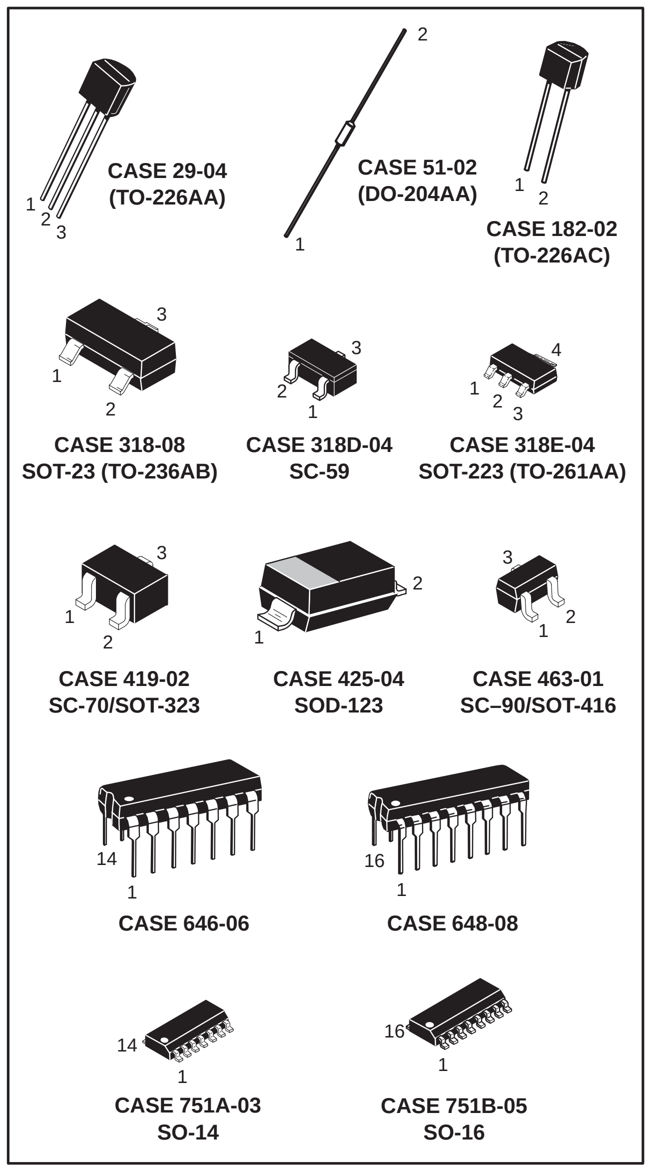
Section 5

Small–Signal Tuning and Switching Diodes

In Brief . . .

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.



EMBOSSED TAPE AND REEL

SOT-23, SC-59, SC-70/SOT-323, SOT-223, SO–14 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, SO–14 and SO-16 packages. (See Section 6 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 6 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.

Silicon Tuning Diodes

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
- Standard 10% Capacitance Tolerance
- Complete Typical Design Curves

1N5148
1N5148A

6.8 – 47 pF EPICAP
VOLTAGE–VARIABLE
CAPACITANCE DIODES

CASE 51–02
(DO–204AA)

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

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Volts
Forward Current	I_F	250	mAdc
RF Power Input(1)	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

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

1. The RF power input rating assumes that an adequate heatsink is provided.

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc, f = 50 MHz	α V_R = 4.0 Vdc, f = 1.0 MHz		TR, Tuning Ratio C_4/C_{60} f = 1.0 MHz	
	Min	Typ	Max	Min	Min	Typ	Min	Typ
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:

$$TC_C = \left| \frac{C_T(+85°C) - C_T(-65°C)}{85 + 65} \right| \cdot \frac{10^6}{C_T(25°C)}$$

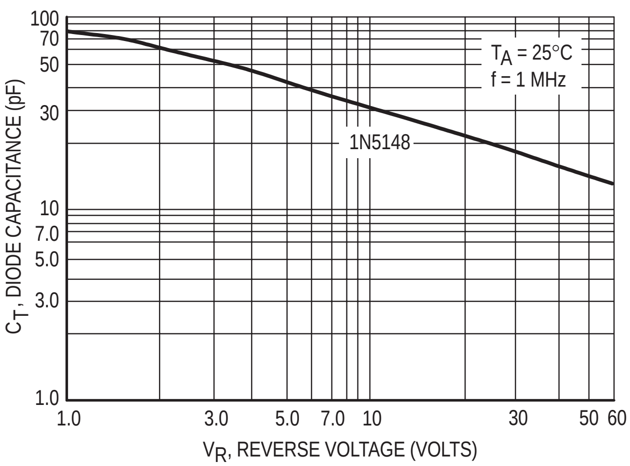


Figure 1. Diode Capacitance versus Reverse Voltage

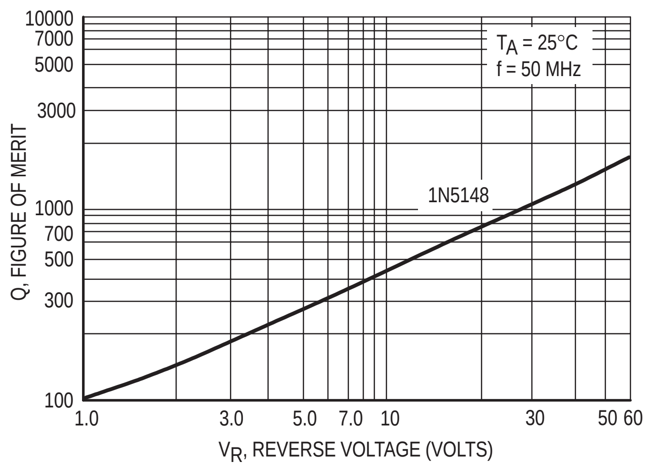


Figure 2. Figure of Merit versus Reverse Voltage

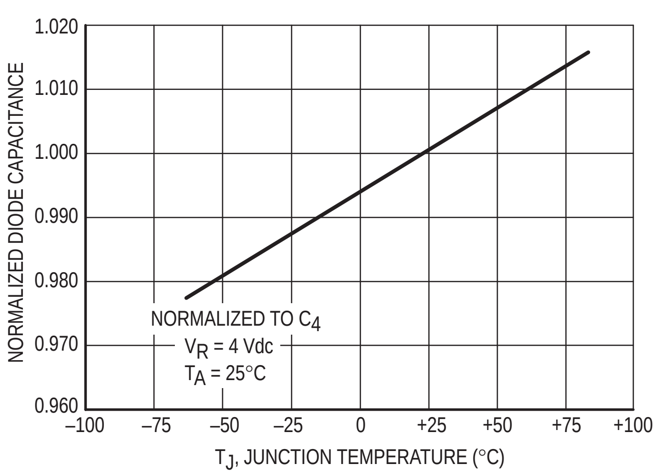


Figure 3. Normalized Diode Capacitance versus Junction Temperature

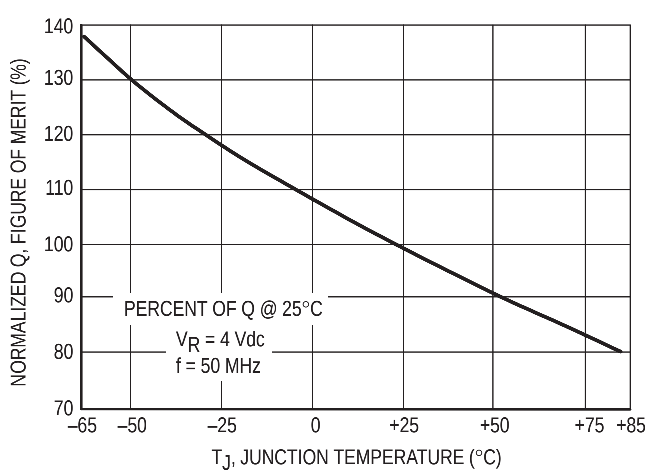


Figure 4. Normalized Figure of Merit versus Junction Temperature

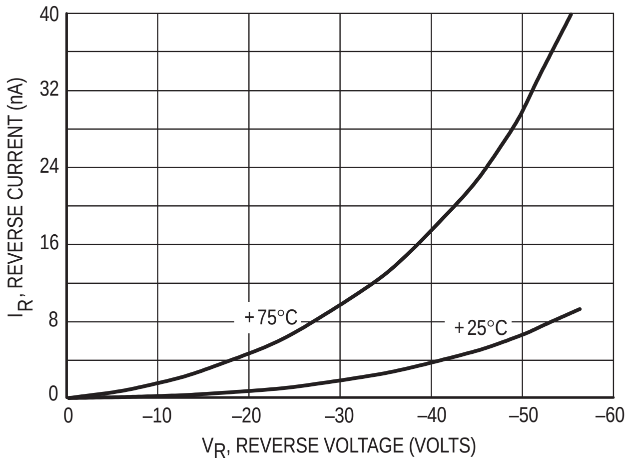


Figure 5. Reverse Current versus Reverse Bias Voltage

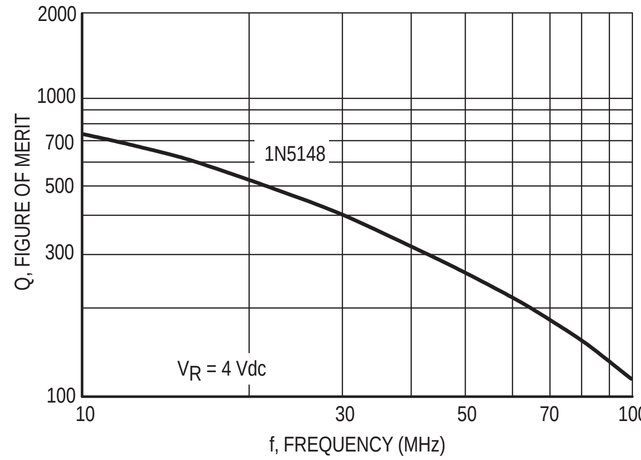


Figure 6. Figure of Merit versus Frequency

Silicon Tuning Diodes

These are 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

1N5446ARL
1N5448ARL
1N5456A

6.8 – 100 pF
30 VOLTS
VOLTAGE–VARIABLE
CAPACITANCE DIODES

CASE 51–02
(DO–204AA)

MAXIMUM RATINGS[1]

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

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 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
1N5446ARL	16.2	18	19.8	2.6	3.2	350
1N5448ARL	19.8	22	24.2	2.6	3.2	350
1N5456A	90	100	110	2.7	3.3	175

1. Indicates JEDEC Registered Data.

(Replaces 1N5441A/D)

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).

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:

$$TC_C = \left|\frac{C_T(+85°C) - C_T(-65°C)}{85 + 65}\right| \cdot \frac{10^6}{C_T(25°C)}$$

Accuracy limited by C_T measurement to ±0.1 pF.

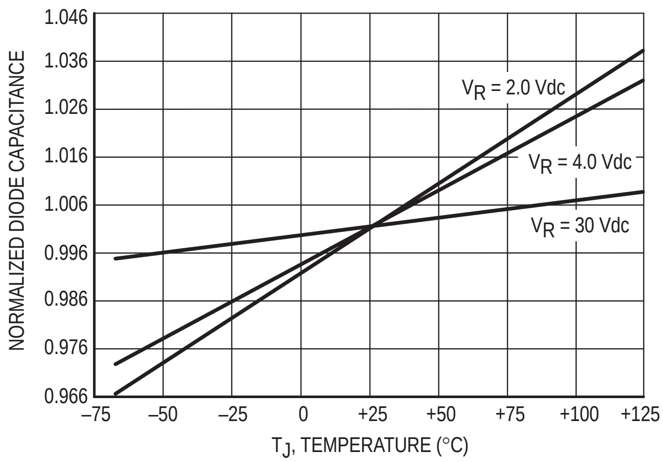


Figure 1. Normalized Diode Capacitance versus Junction Temperature

TYPICAL DEVICE PERFORMANCE

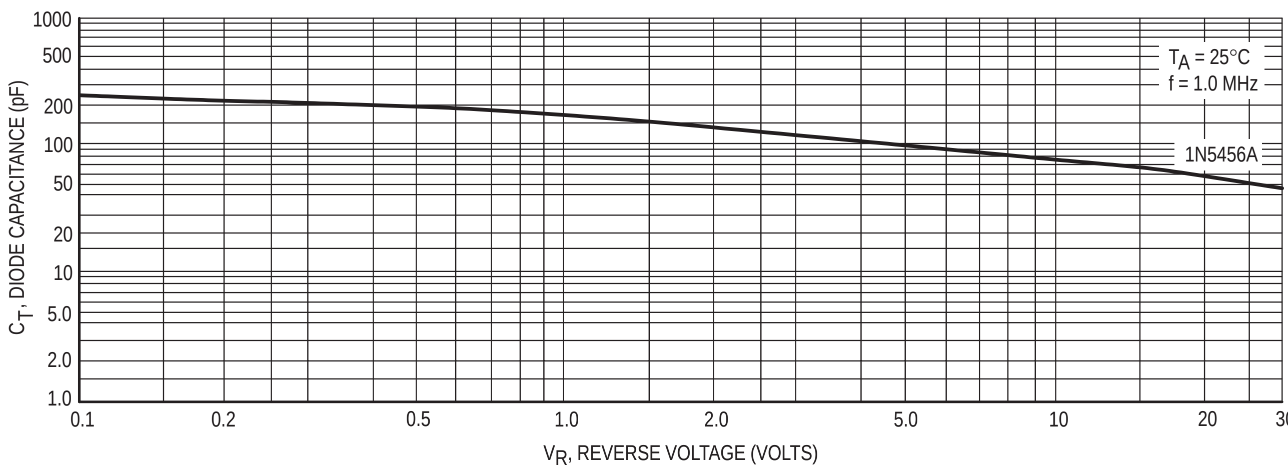


Figure 2. Diode Capacitance versus Reverse Voltage

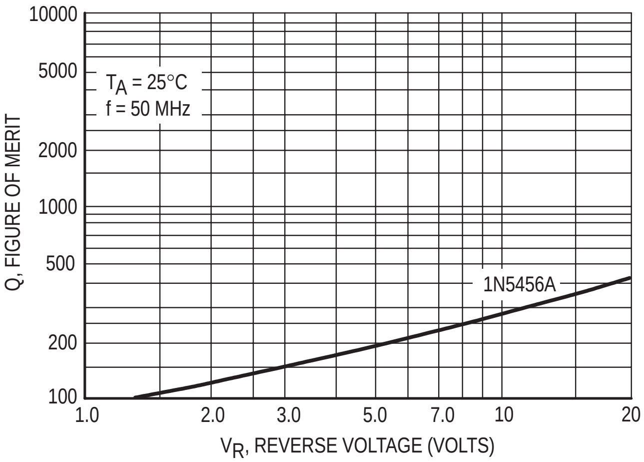


Figure 3. Figure of Merit versus Reverse Voltage

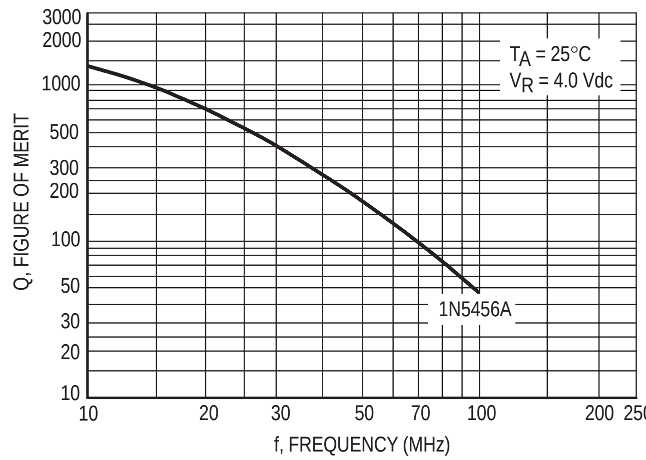


Figure 4. Figure of Merit versus Frequency

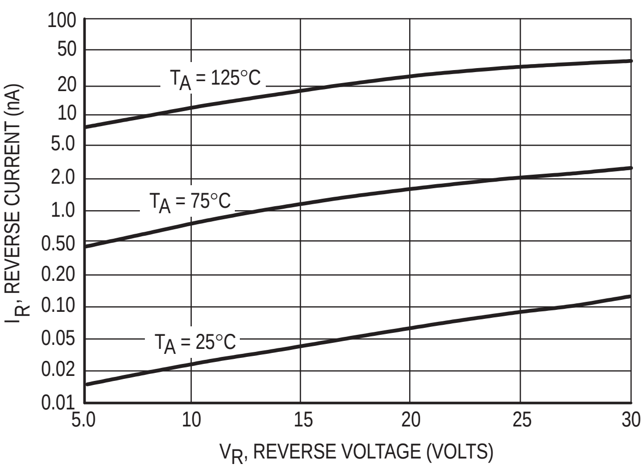


Figure 5. Reverse Current versus Reverse Bias Voltage

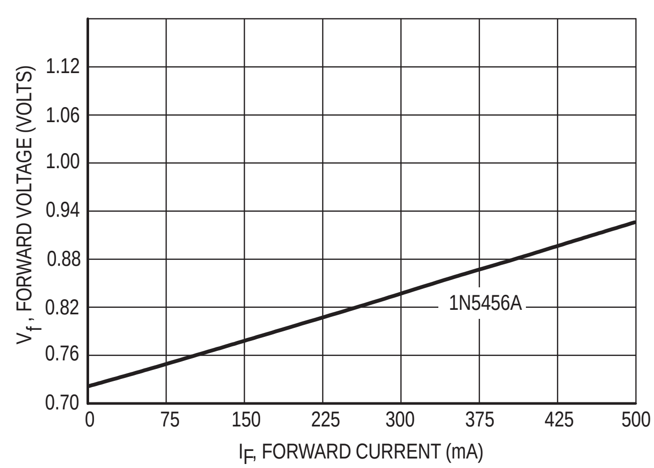
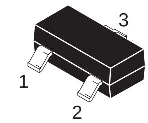


Figure 6. Forward Voltage versus Forward Current

Switching Diode

BAL99LT1



CASE 318–08, STYLE 18
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

BAL99LT1 = JF

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 70 Vdc) (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc, T_J = 150°C)	I_R	 — — —	 2.5 30 50	μAdc
Reverse Breakdown Voltage (I_R = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mAdc)	V_F	 — — — —	 715 855 1000 1250	mV
Recovery Current (I_F = 10 mAdc, V_R = 5.0 Vdc, 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 mAdc, R_L = 100 Ω, measured at I_R = 1.0 mAdc)	t_{rr}	—	6.0	ns
Forward Recovery Voltage (I_F = 10 mAdc, t_r = 20 ns)	V_{FR}	—	1.75	Vdc

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

TYPICAL CHARACTERISTICS

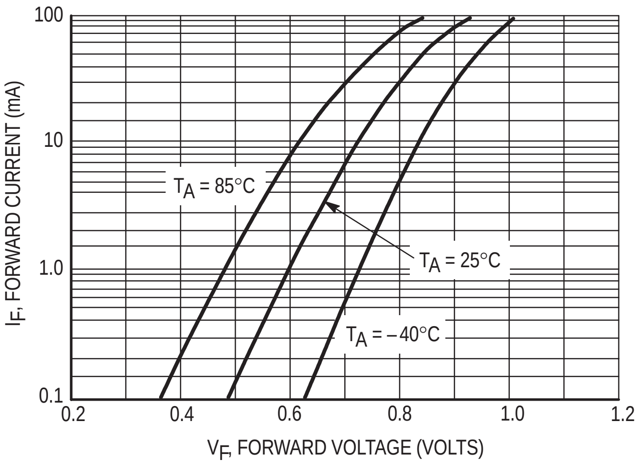


Figure 1. Forward Voltage

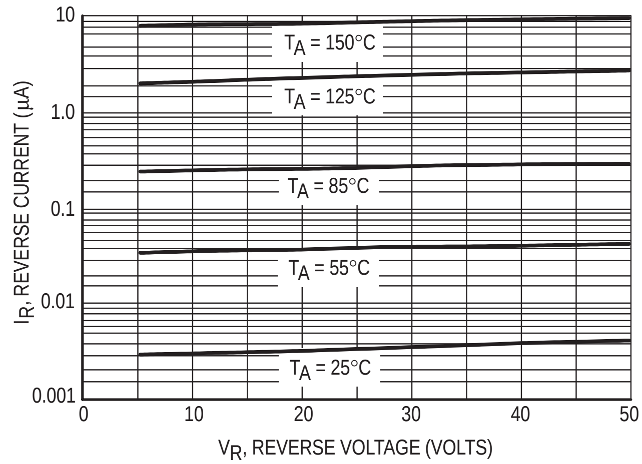


Figure 2. Leakage Current

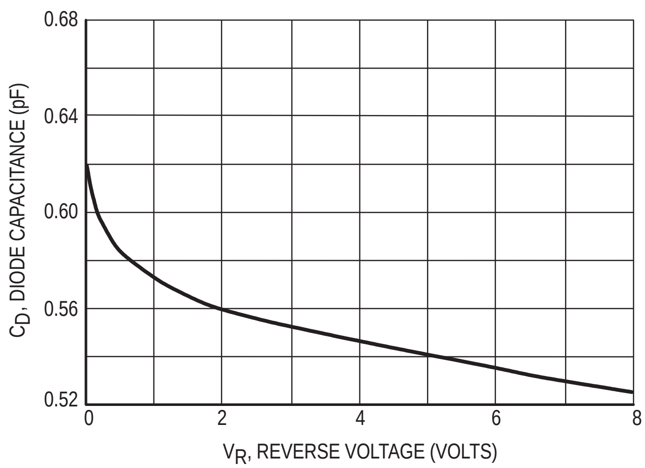
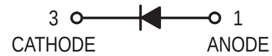


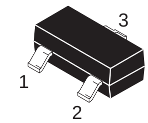
Figure 3. Capacitance

Switching Diode

BAS16LT1

Motorola Preferred Device





CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

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	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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,(2) 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

DEVICE MARKING

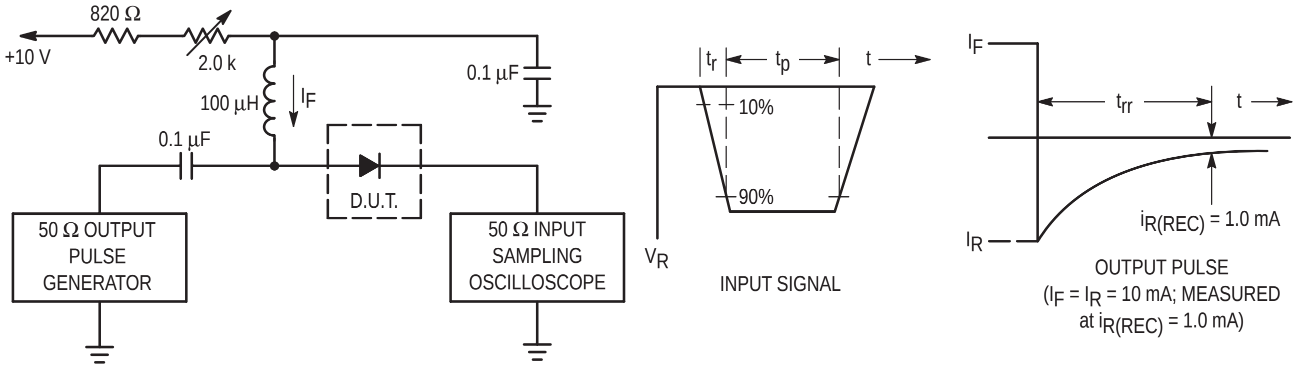
BAS16LT1 = A6

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 75 Vdc) (V_R = 75 Vdc, T_J = 150°C) (V_R = 25 Vdc, T_J = 150°C)	I_R	 — — —	 1.0 50 30	µAdc
Reverse Breakdown Voltage (I_{BR} = 100 µAdc)	$V_{(BR)}$	75	—	Vdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mAdc)	V_F	 — — — —	 715 855 1000 1250	mV
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	2.0	pF
Forward Recovery Voltage (I_F = 10 mAdc, t_r = 20 ns)	V_{FR}	—	1.75	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, R_L = 50 Ω)	t_{rr}	—	6.0	ns
Stored Charge (I_F = 10 mAdc to V_R = 5.0 Vdc, R_L = 500 Ω)	Q_S	—	45	pC

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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



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 1. Recovery Time Equivalent Test Circuit

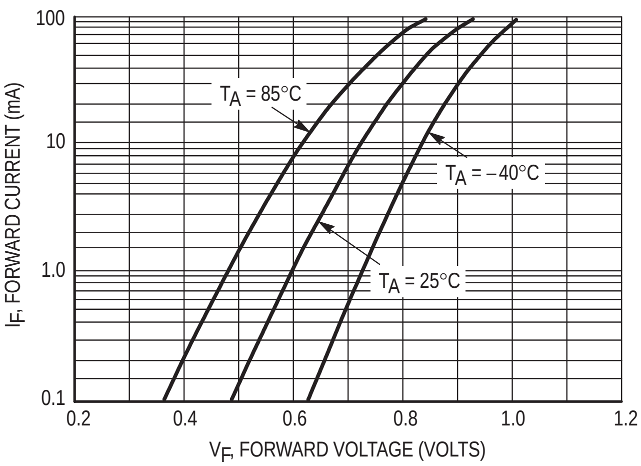


Figure 2. Forward Voltage

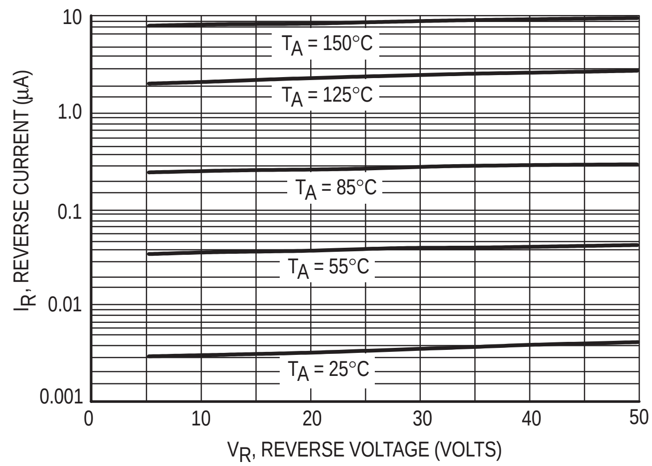


Figure 3. Leakage Current

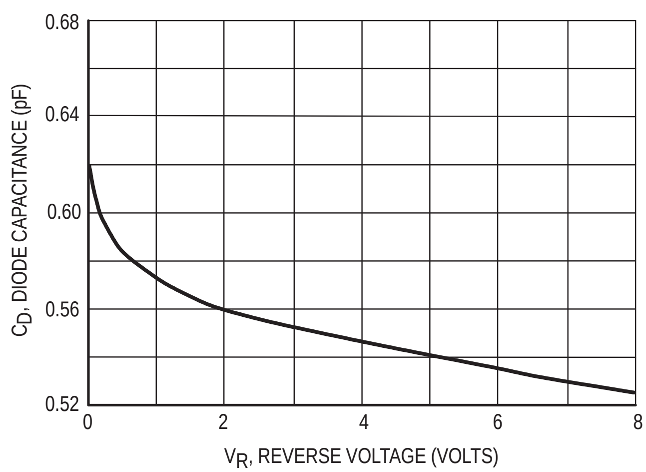
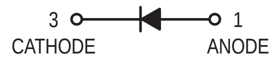


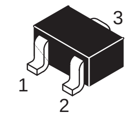
Figure 4. Capacitance

Silicon Switching Diode

BAS16WT1

Motorola Preferred Device





CASE 419–02, STYLE 2
SC–70/SOT–323

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Max	Unit
Continuous Reverse Voltage	V_R	75	V
Recurrent Peak Forward Current	I_R	200	mA
Peak Forward Surge Current Pulse Width = 10 µs	$I_{FM(surge)}$	500	mA
Total Power Dissipation, One Diode Loaded T_A = 25°C Derate above 25°C Mounted on a Ceramic Substrate (10 x 8 x 0.6 mm)	P_D	200 1.6	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 One Diode Loaded Mounted on a Ceramic Substrate (10 x 8 x 0.6 mm)	$R_{\theta JA}$	0.625	°C/mW

DEVICE MARKING

BAS16WT1 = A6

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

Characteristic	Symbol	Min	Max	Unit
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA) (I_F = 50 mA) (I_F = 150 mA)	V_F	 — — — —	 715 866 1000 1250	mV
Reverse Current (V_R = 75 V) (V_R = 75 V, T_J = 150°C) (V_R = 25 V, T_J = 150°C)	I_R	 — — —	 1.0 50 30	µA
Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mA, R_L = 50 Ω) (Figure 1)	t_{rr}	—	6.0	ns
Stored Charge (I_F = 10 mA to V_R = 6.0 V, R_L = 500 Ω) (Figure 2)	QS	—	45	PC
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns) (Figure 3)	V_{FR}	—	1.75	V

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

REV 1

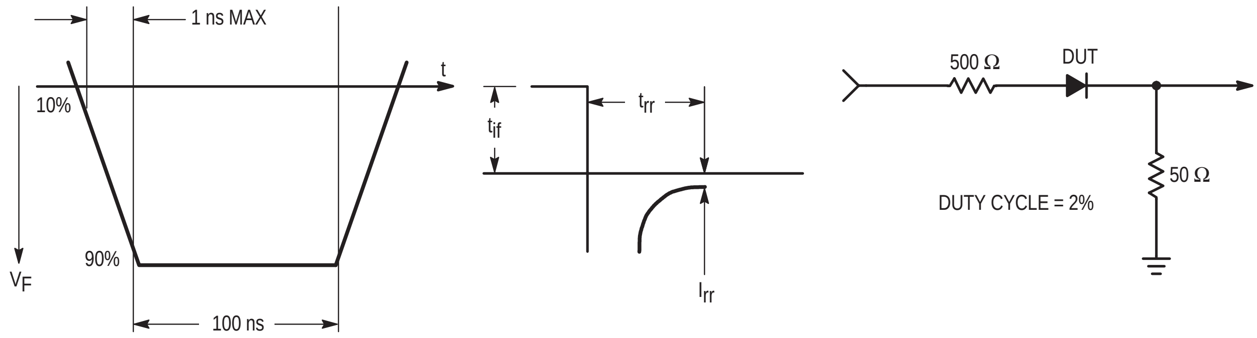


Figure 1. Reverse Recovery Time Equivalent Test Circuit

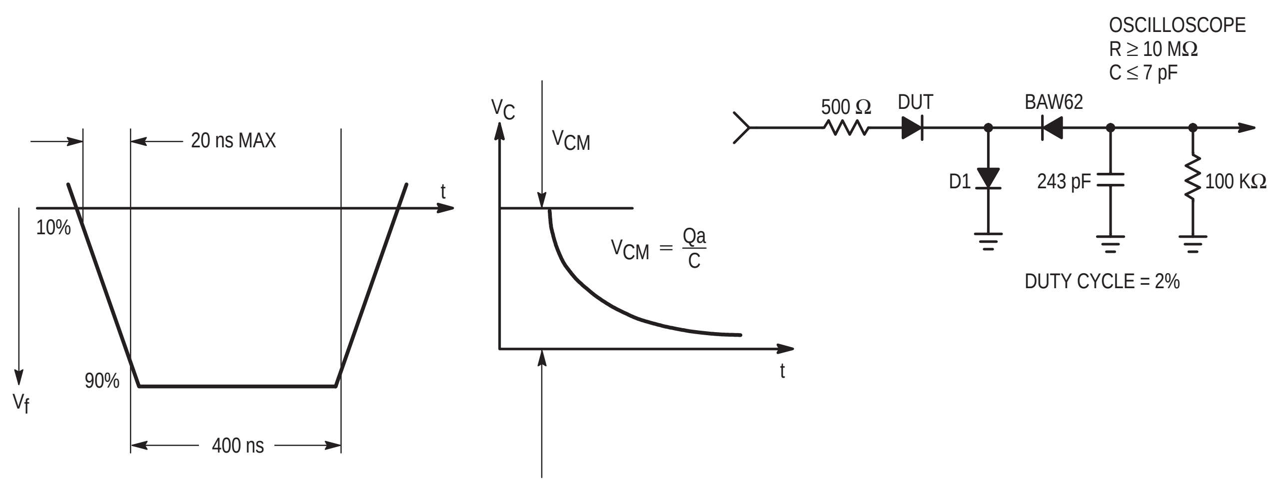


Figure 2. Recovery Charge Equivalent Test Circuit

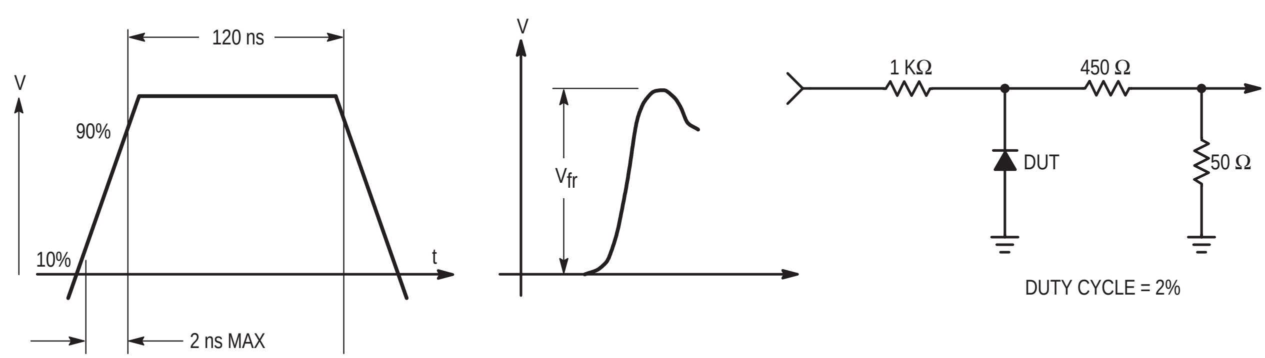


Figure 3. Forward Recovery Voltage Equivalent Test Circuit

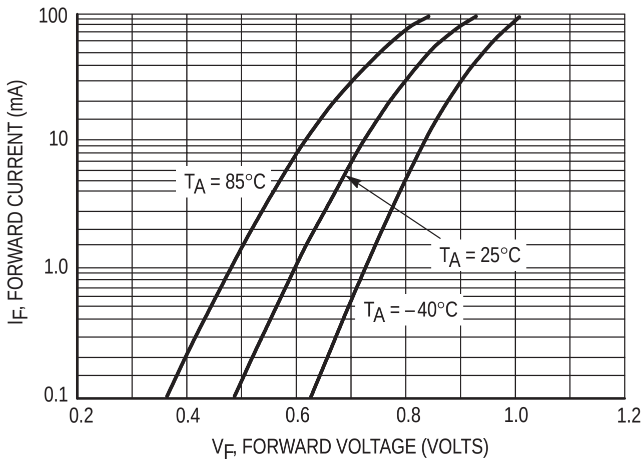


Figure 4. Forward Voltage

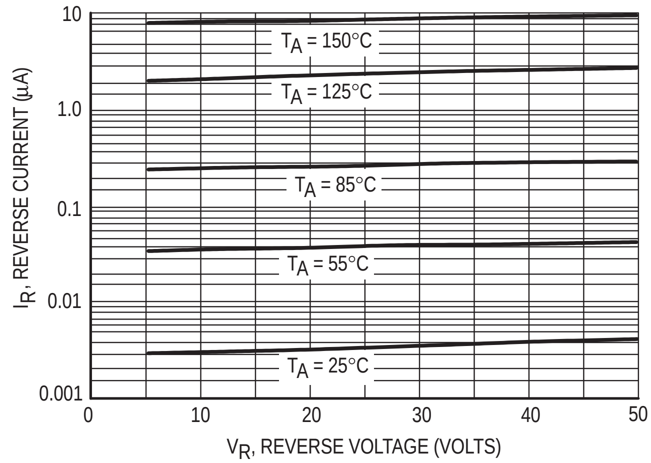


Figure 5. Leakage Current

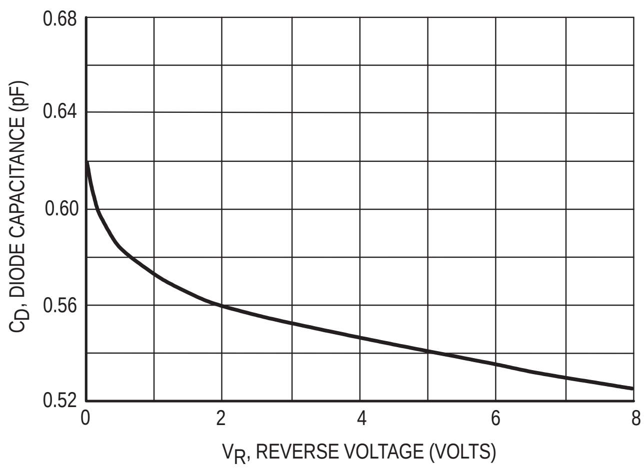
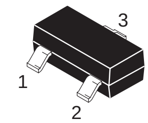


Figure 6. Capacitance

High Voltage Switching Diode

BAS21LT1

Motorola Preferred Device



CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

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	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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,(2) 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

DEVICE MARKING

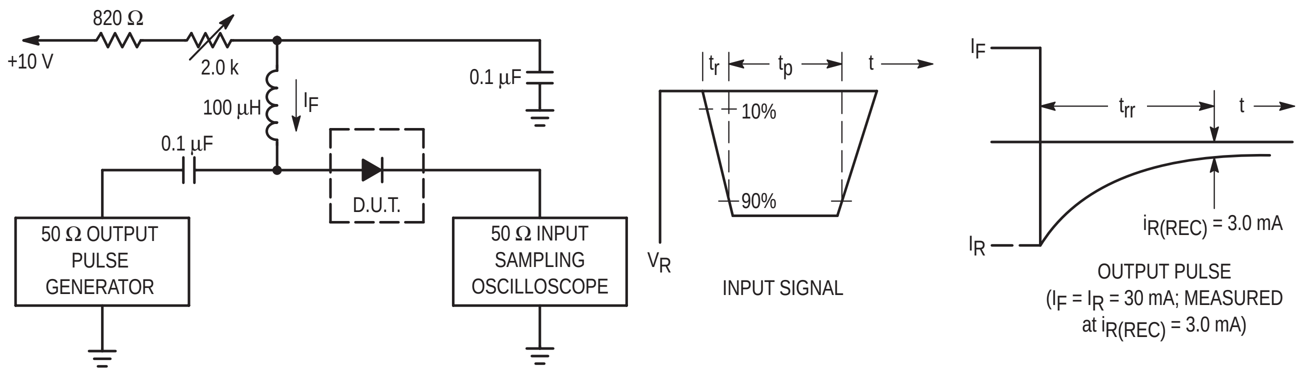
BAS21LT1 = JS

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 200 Vdc) (V_R = 200 Vdc, T_J = 150°C)	I_R	 — —	 1.0 100	µAdc
Reverse Breakdown Voltage (I_{BR} = 100 µAdc)	$V_{(BR)}$	250	—	Vdc
Forward Voltage (I_F = 100 mAdc) (I_F = 200 mAdc)	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 mAdc, R_L = 100 Ω)	t_{rr}	—	50	ns

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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



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. $t_p \gg t_{rr}$

Figure 1. Recovery Time Equivalent Test Circuit

Preliminary Information

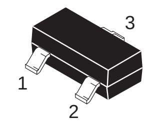
Schottky Barrier Diodes

BAS40LT1

Motorola Preferred Device

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

40 VOLTS
SCHOTTKY BARRIER DIODES



CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

MAXIMUM RATINGS (T_J = 150°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	40	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 225 1.8	 mW mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	–55 to +150	°C

DEVICE MARKING

BAS40LT1 = B1

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

Characteristic	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µA)	$V_{(BR)R}$	40	—	Volts
Total Capacitance (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	5.0	pF
Reverse Leakage (V_R = 25 V)	I_R	—	1.0	µAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	380	mVdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	500	mVdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	1.0	Vdc

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

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Preliminary Information

Common Anode Schottky Barrier Diode

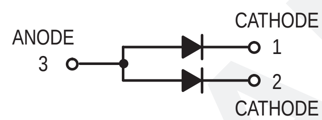
BAS40-04LT1

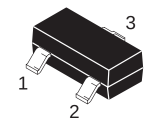
Motorola Preferred Device

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Low Forward Voltage — 0.50 Volts (Typ) @ I_F = 10 mAdc

40 VOLTS
SCHOTTKY BARRIER DIODES





CASE 318–08, STYLE 12
SOT–23 (TO–236AB)

MAXIMUM RATINGS (T_J = 150°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	40	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 225 1.8	 mW mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	–55 to +150	°C

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

Characteristic	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µA)	$V_{(BR)R}$	40	—	Volts
Total Capacitance (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	5.0	pF
Reverse Leakage (V_R = 25 V)	I_R	—	1.0	µAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	380	mVdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	500	mVdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	1.0	Vdc

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

Preliminary Information

Dual Series Schottky Barrier Diodes

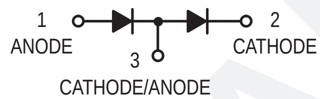
BAS40-06LT1

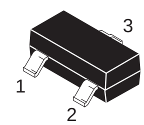
Motorola Preferred Device

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Low Forward Voltage — 0.50 Volts (Typ) @ I_F = 10 mAdc

40 VOLTS
SCHOTTKY BARRIER DIODES





CASE 318–08, STYLE 11
SOT–23 (TO–236AB)

MAXIMUM RATINGS (T_J = 150°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	40	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 225 1.8	 mW mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	–55 to +150	°C

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

Characteristic	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	40	—	Volts
Total Capacitance (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	5.0	pF
Reverse Leakage (V_R = 25 V)	I_R	—	1.0	μAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	380	mVdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	500	mVdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	1.0	Vdc

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

Preliminary Information

Schottky Barrier Diodes

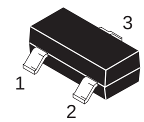
BAS70LT1

Motorola Preferred Device

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Low Forward Voltage — 0.75 Volts (Typ) @ I_F = 10 mAdc

70 VOLTS
SCHOTTKY BARRIER DIODES



CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

MAXIMUM RATINGS (T_J = 150°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 225 1.8	 mW mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	–55 to +150	°C

DEVICE MARKING

BAS70LT1 = BE

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

Characteristic	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	70	—	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	C_T	—	2.0	pF
Reverse Leakage (V_R = 50 V) (V_R = 70 V)	I_R	— —	0.1 10	μAdc
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	410	mVdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	750	mVdc
Forward Voltage (I_F = 15 mAdc)	V_F	—	1.0	Vdc

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

Preliminary Information

Common Anode Schottky Barrier Diode

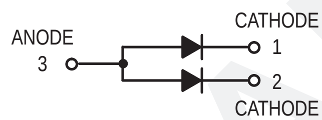
BAS70-04LT1

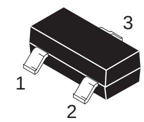
Motorola Preferred Device

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Low Forward Voltage — 0.75 Volts (Typ) @ I_F = 10 mAdc

70 VOLTS
SCHOTTKY BARRIER DIODES





CASE 318–08, STYLE 12
SOT–23 (TO–236AB)

MAXIMUM RATINGS (T_J = 150°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 225 1.8	 mW mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	–55 to +150	°C

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

Characteristic	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µA)	$V_{(BR)R}$	70	—	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	C_T	—	2.0	pF
Reverse Leakage (V_R = 50 V) (V_R = 70 V)	I_R	— —	0.1 10	µAdc
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	410	mVdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	750	mVdc
Forward Voltage (I_F = 15 mAdc)	V_F	—	1.0	Vdc

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

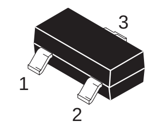
Switching Diode

This switching diode has the following features:

- Low Leakage Current Applications
- Medium Speed Switching Times
- Available in 8 mm Tape and Reel
  Use BAS116LT1 to order the 7 inch/3,000 unit reel
  Use BAS116LT3 to order the 13 inch/10,000 unit reel

BAS116LT1

Motorola Preferred Device



CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

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	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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(2) 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

DEVICE MARKING

BAS116LT1 = JV

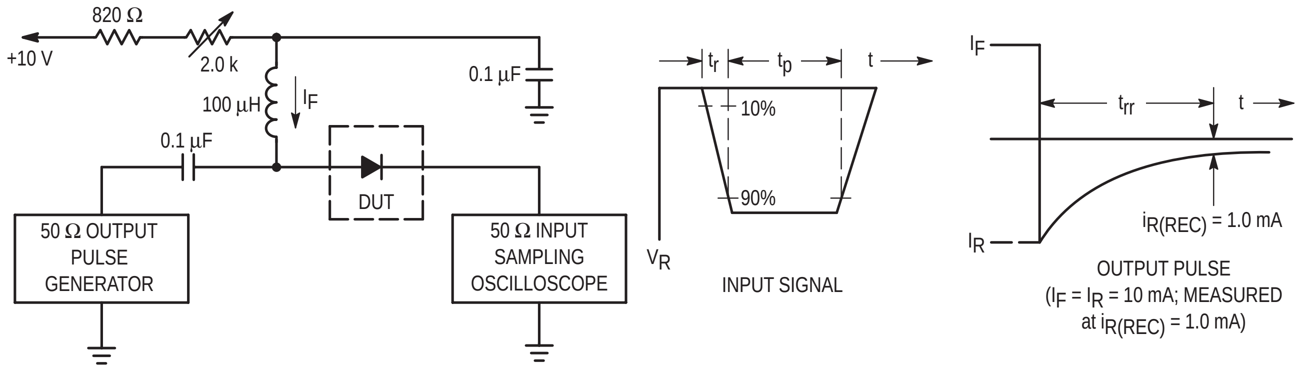
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_{BR} = 100 μAdc)	$V_{(BR)}$	75	—	Vdc
Reverse Voltage Leakage Current (V_R = 75 Vdc) (V_R = 75 Vdc, T_J = 150°C)	I_R	— —	5.0 80	nAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mAdc)	V_F	— — — —	900 1000 1100 1250	mV
Diode Capacitance (V_R = 0 V, f = 1.0 MHz)	C_D	—	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc) (Figure 1)	t_{rr}	—	3.0	μs

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

REV 1



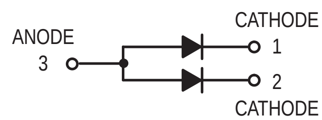
Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

Figure 1. Recovery Time Equivalent Test Circuit

Schottky Barrier Diodes

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

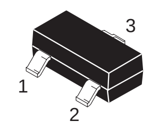
- Extremely Fast Switching Speed
- Low Forward Voltage — 0.35 Volts (Typ) @ I_F = 10 mAdc



BAT54ALT1

Motorola Preferred Device

**30 VOLTS
SCHOTTKY BARRIER
DETECTOR AND SWITCHING
DIODES**



**CASE 318–08, STYLE 12
SOT–23 (TO–236AB)**

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 225 1.8	 mW mW/°C
Operating Junction Temperature Range	T_J	 –55 to +150	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

DEVICE MARKING

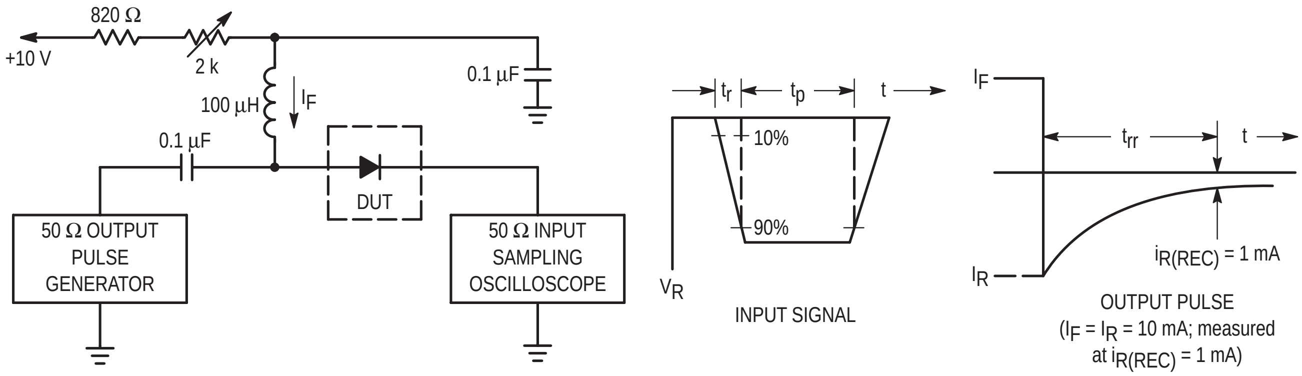
BAT54ALT1 = B6

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µA)	$V_{(BR)R}$	30	—	—	Volts
Total Capacitance (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	7.6	10	pF
Reverse Leakage (V_R = 25 V)	I_R	—	0.5	2.0	µAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	0.22	0.24	Vdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	0.41	0.5	Vdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	0.52	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) Figure 1	t_{rr}	—	—	5.0	ns
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	0.29	0.32	Vdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.35	0.40	Vdc

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

REV 1



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 1. Recovery Time Equivalent Test Circuit

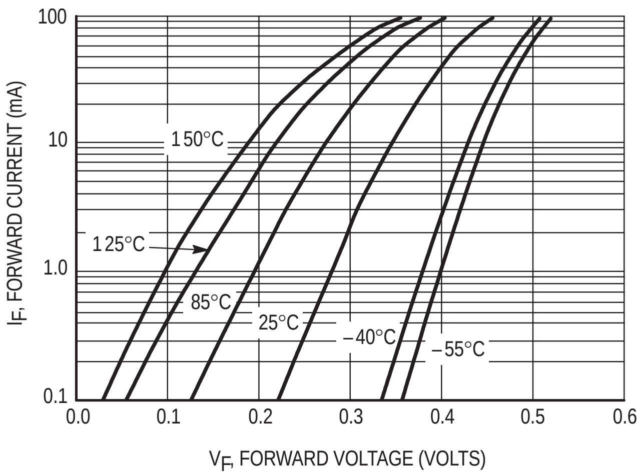


Figure 2. Forward Voltage

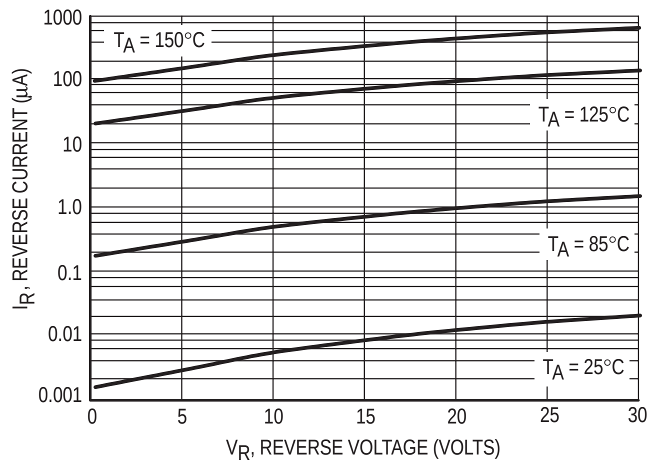


Figure 3. Leakage Current

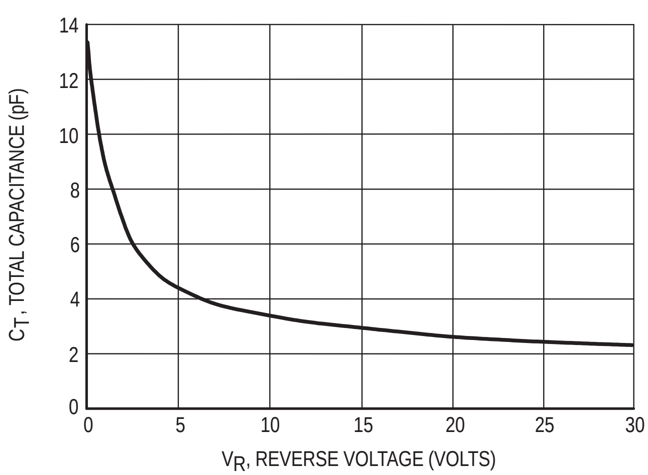


Figure 4. Total Capacitance

Schottky Barrier Diodes

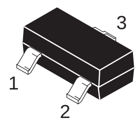
These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Low Forward Voltage — 0.35 Volts (Typ) @ I_F = 10 mAdc

BAT54LT1

Motorola Preferred Device

**30 VOLTS
SILICON HOT–CARRIER
DETECTOR AND SWITCHING
DIODES**



**CASE 318–08, STYLE 8
SOT–23 (TO–236AB)**

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 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

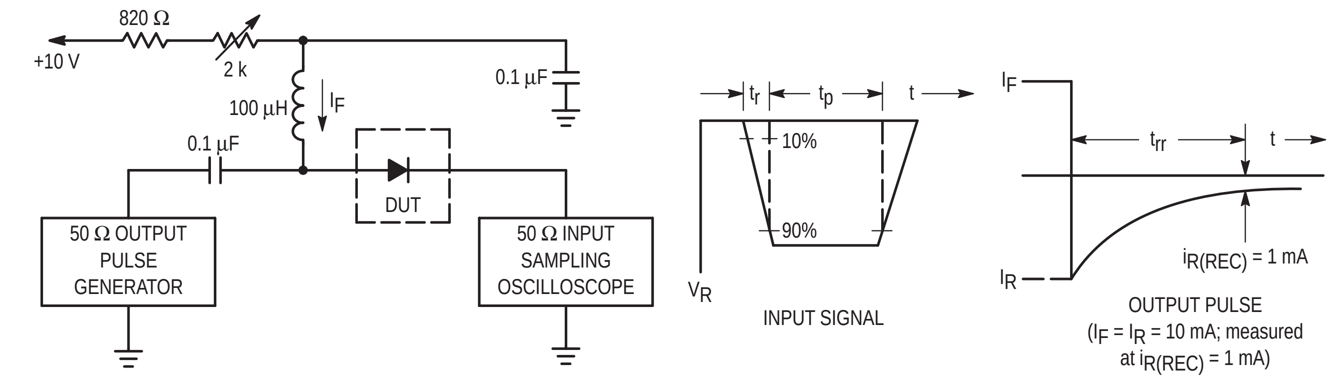
BAT54LT1 = LV3

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 (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	7.6	10	pF
Reverse Leakage (V_R = 25 V)	I_R	—	0.5	2.0	μAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	0.22	0.24	Vdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	0.41	0.5	Vdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	0.52	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) Figure 1	t_{rr}	—	—	5.0	ns
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	0.29	0.32	Vdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.35	0.40	Vdc

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

REV 2



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 1. Recovery Time Equivalent Test Circuit

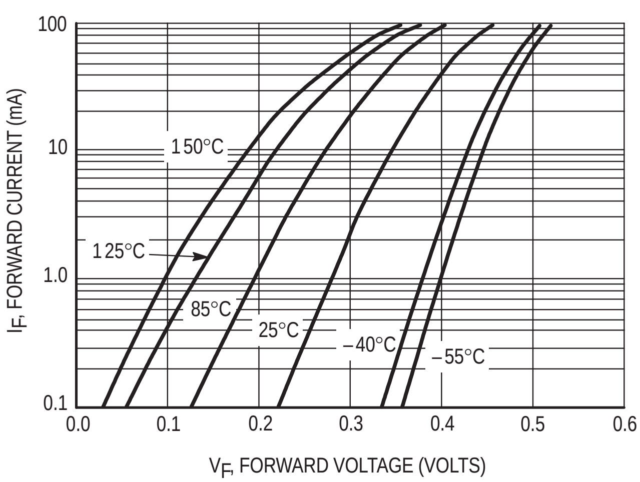


Figure 2. Forward Voltage

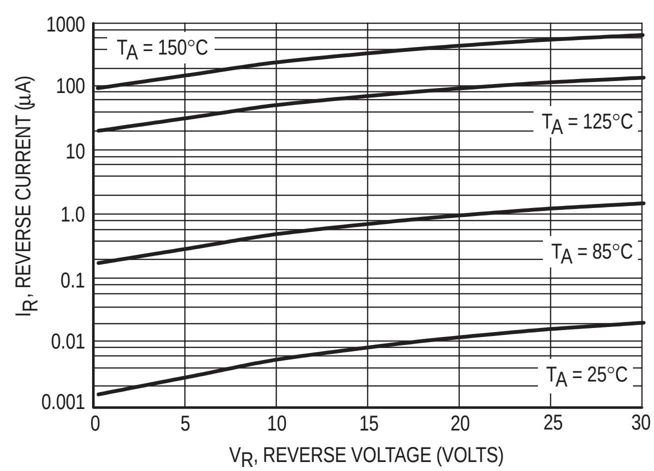


Figure 3. Leakage Current

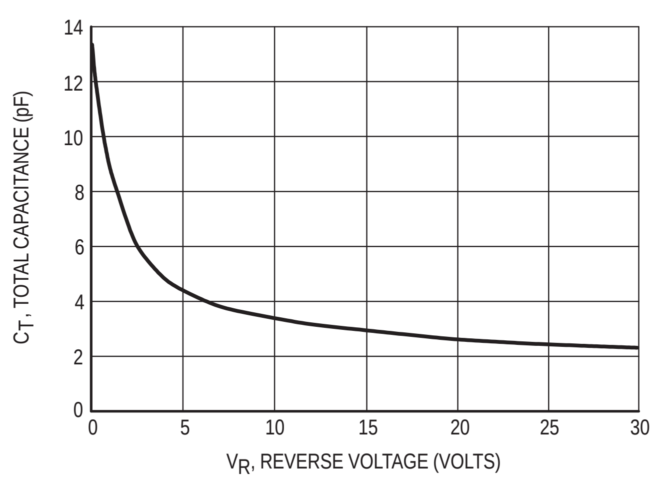


Figure 4. Total Capacitance

Dual Series Schottky Barrier Diodes

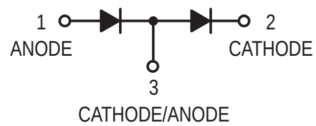
BAT54SLT1

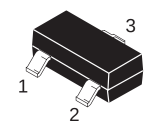
Motorola Preferred Device

30 VOLTS DUAL HOT–CARRIER DETECTOR AND SWITCHING DIODES

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Low Forward Voltage — 0.35 Volts (Typ) @ I_F = 10 mAdc





CASE 318–08, STYLE 11
SOT–23 (TO–236AB)

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 225 1.8	 mW mW/°C
Operating Junction Temperature Range	T_J	–55 to +125	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

DEVICE MARKING

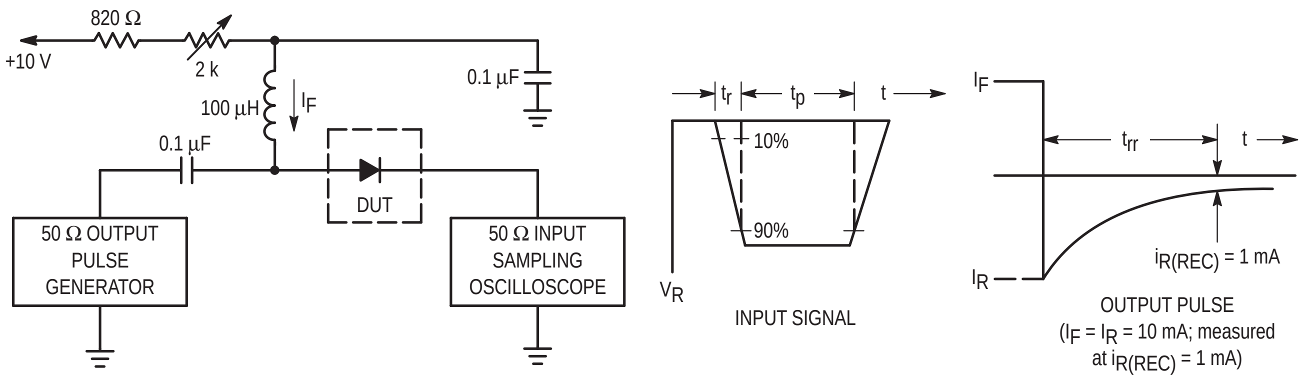
BAT54S = LD3

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µA)	$V_{(BR)R}$	30	—	—	Volts
Total Capacitance (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	7.6	10	pF
Reverse Leakage (V_R = 25 V)	I_R	—	0.5	2.0	µAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	0.22	0.24	Vdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	0.41	0.5	Vdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	0.52	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) Figure 1	t_{rr}	—	—	5.0	ns
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	0.29	0.32	Vdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.35	0.40	Vdc

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

REV 2



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 1. Recovery Time Equivalent Test Circuit

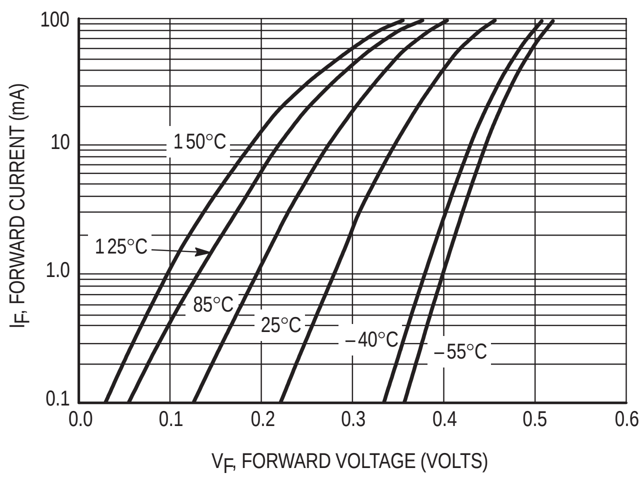


Figure 2. Forward Voltage

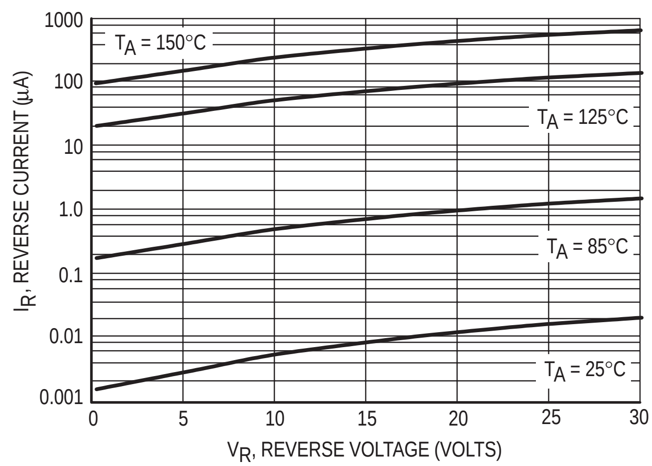


Figure 3. Leakage Current

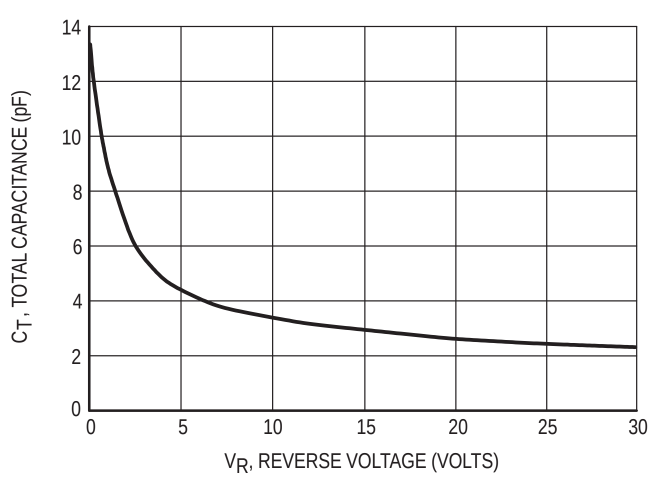


Figure 4. Total Capacitance

Dual Series Schottky Barrier Diodes

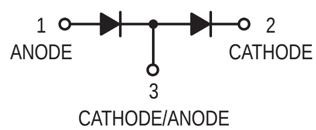
BAT54SWT1

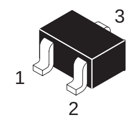
Motorola Preferred Device

**30 VOLT
DUAL SERIES
SCHOTTKY BARRIER
DIODES**

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Low Forward Voltage — 0.35 Volts (Typ) @ I_F = 10 mAdc





**CASE 419–02, STYLE 9
SOT–323 (SC–70)**

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 200 1.6	 mW mW/°C
Operating Junction Temperature Range	T_J	–55 to +150	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

DEVICE MARKING

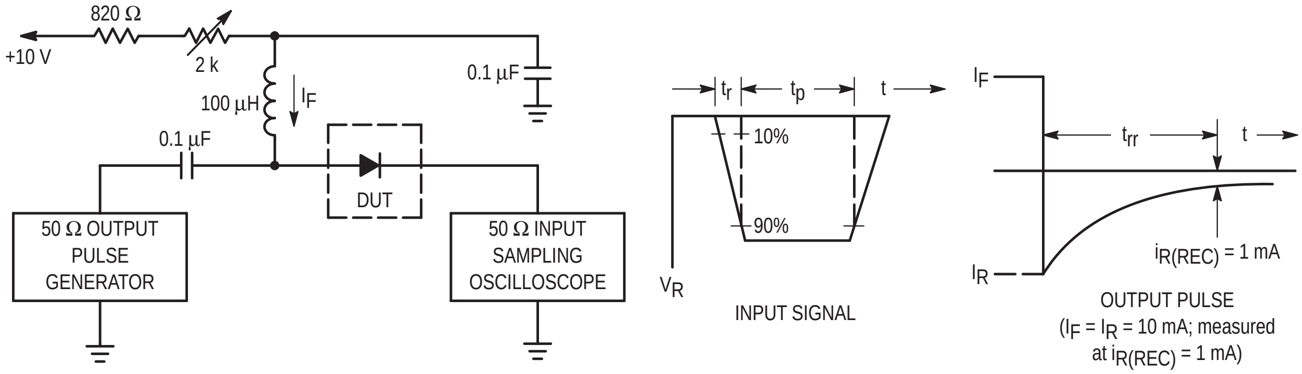
BAT54SWT1 = B8

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µA)	$V_{(BR)R}$	30	—	—	Volts
Total Capacitance (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	7.6	10	pF
Reverse Leakage (V_R = 25 V)	I_R	—	0.5	2.0	µAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	0.22	0.24	Vdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	0.41	0.5	Vdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	0.52	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) Figure 1	t_{rr}	—	—	5.0	ns
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	0.29	0.32	Vdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.35	0.40	Vdc

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

REV 1



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 1. Recovery Time Equivalent Test Circuit

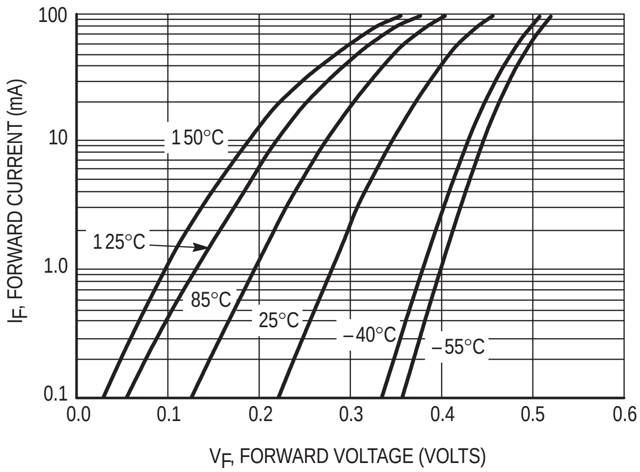


Figure 2. Forward Voltage

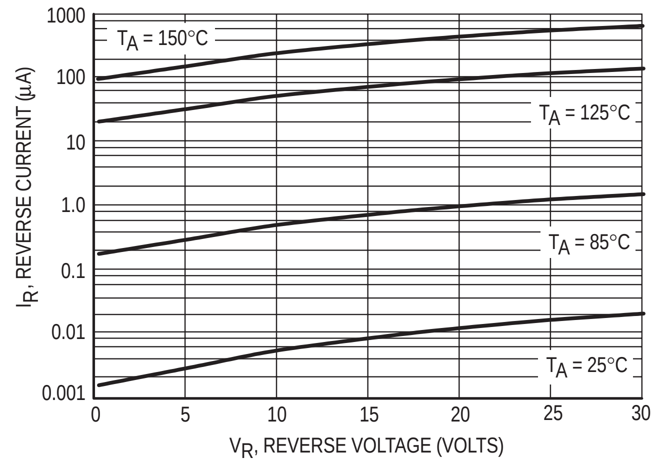


Figure 3. Leakage Current

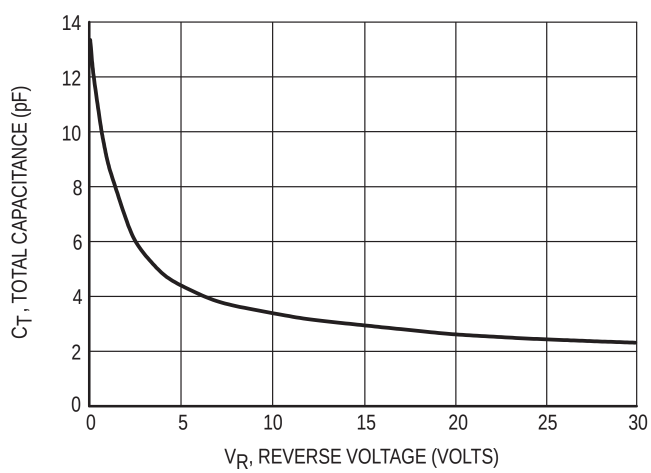


Figure 4. Total Capacitance

Schottky Barrier Diode

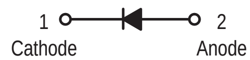
BAT54T1

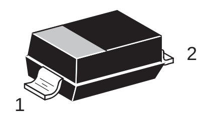
Motorola Preferred Device

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Low Forward Voltage — 0.35 Volts (Typ) @ I_F = 10 mAdc

30 VOLT SCHOTTKY BARRIER DETECTOR AND SWITCHING DIODE





CASE 425–04, STYLE 1
SOD–123

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 400 3.2	 mW mW/°C
Operating Junction Temperature Range	T_J	–55 to +150	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

DEVICE MARKING

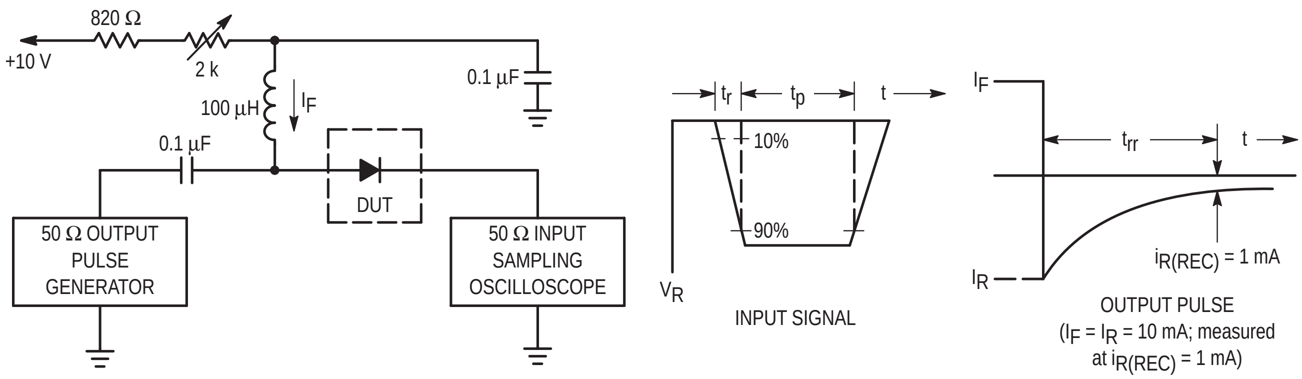
BAT54T1 = BU

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 (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	7.6	10	pF
Reverse Leakage (V_R = 25 V)	I_R	—	0.5	2.0	μAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	0.22	0.24	Vdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	0.41	0.5	Vdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	0.52	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) Figure 1	t_{rr}	—	—	5.0	ns
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	0.29	0.32	Vdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.35	0.40	Vdc

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

REV 1



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 1. Recovery Time Equivalent Test Circuit

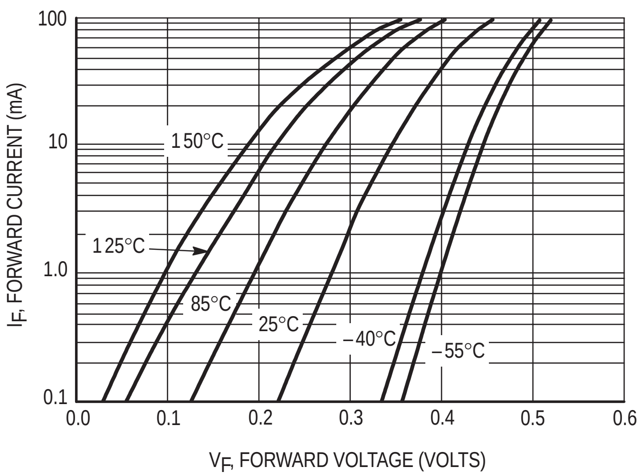


Figure 2. Forward Voltage

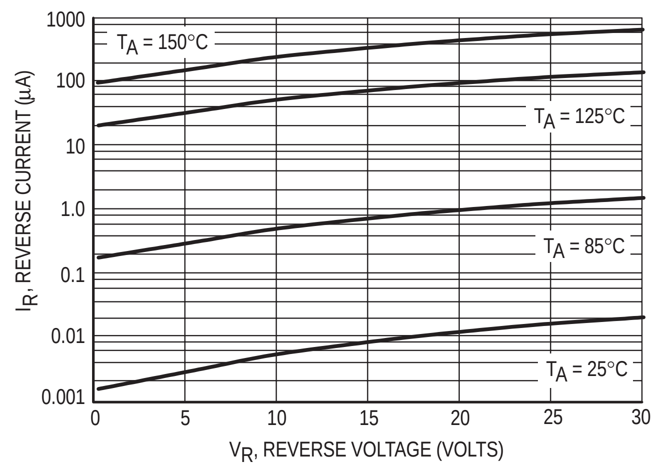


Figure 3. Leakage Current

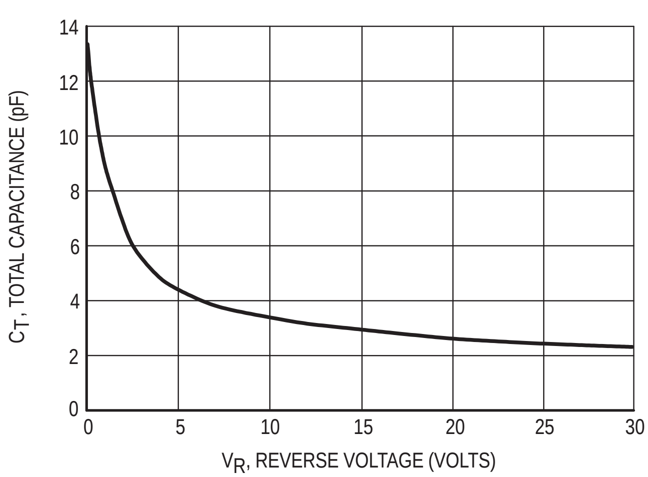


Figure 4. Total Capacitance

Schottky Barrier Diode

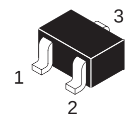
These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Extremely Low Forward Voltage — 0.35 Volts (Typ) @ I_F = 10 mAdc

BAT54WT1

Motorola Preferred Device

**30 VOLTS
SCHOTTKY BARRIER
DETECTOR AND SWITCHING
DIODE**



**CASE 419–02, STYLE 2
SOT–323 (SC–70)**

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 200 1.6	 mW mW/°C
Operating Junction Temperature Range	T_J	–55 to +150	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

DEVICE MARKING

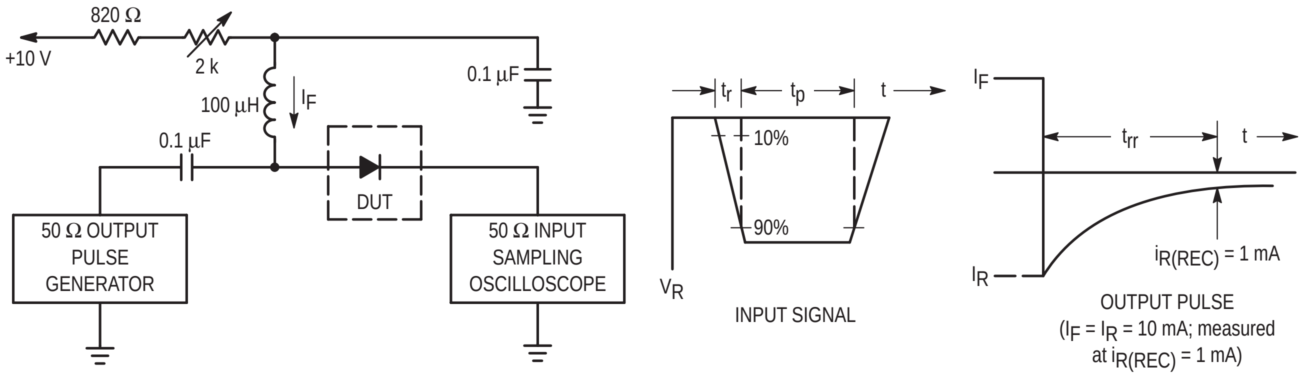
BAT54WT1 = B4

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 (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	7.6	10	pF
Reverse Leakage (V_R = 25 V)	I_R	—	0.5	2.0	μAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	0.22	0.24	Vdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	0.41	0.5	Vdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	0.52	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) Figure 1	t_{rr}	—	—	5.0	ns
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	0.29	0.32	Vdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.35	0.40	Vdc

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

REV 1



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 1. Recovery Time Equivalent Test Circuit

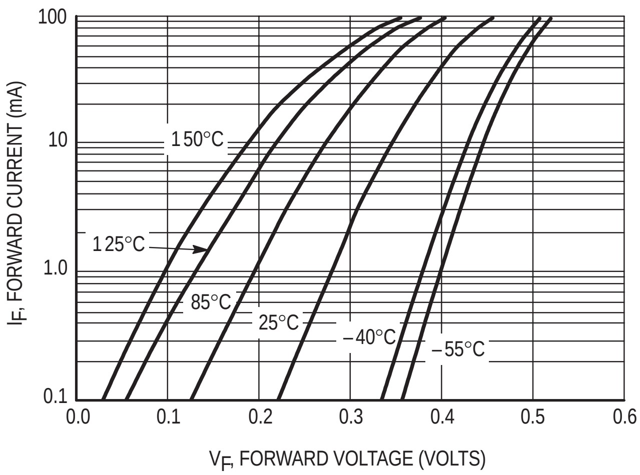


Figure 2. Forward Voltage

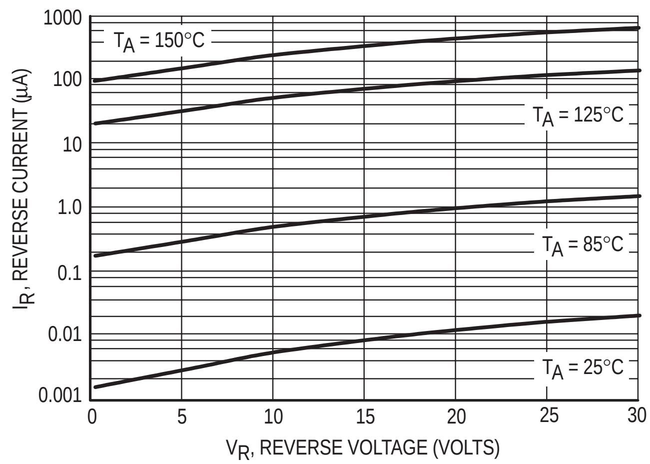


Figure 3. Leakage Current

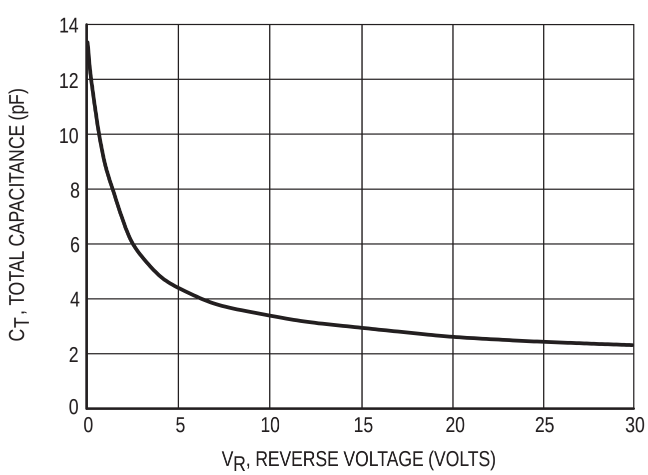
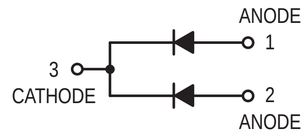


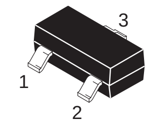
Figure 4. Total Capacitance

Monolithic Dual Switching Diode Common Cathode

BAV70LT1

Motorola Preferred Device





CASE 318–08, STYLE 9
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

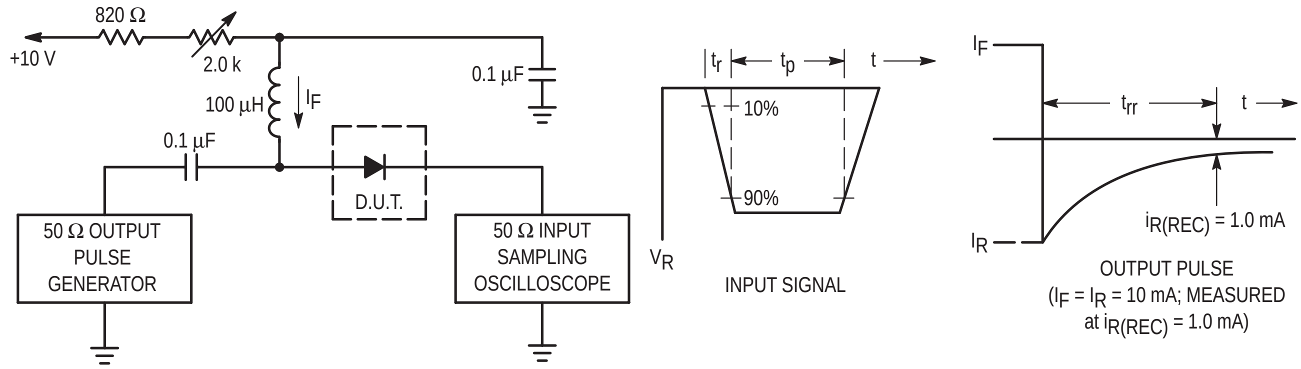
BAV70LT1 = A4

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	 — — —	 60 2.5 100	µAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mAdc)	V_F	 — — — —	 715 855 1000 1250	mVdc
Reverse Recovery Time R_L = 100 Ω (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, $I_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	6.0	ns

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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



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 1. Recovery Time Equivalent Test Circuit

Curves Applicable to Each Anode

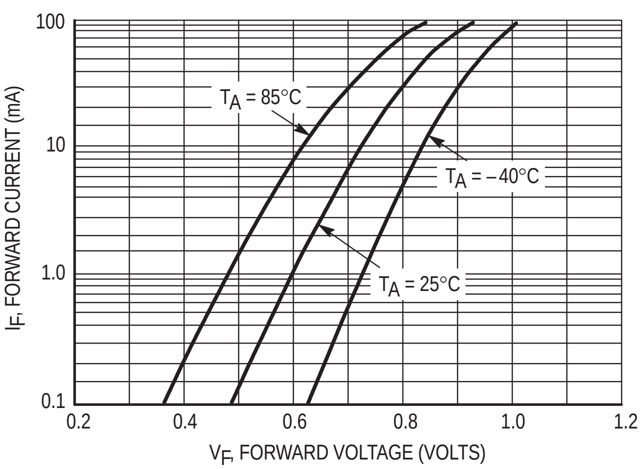


Figure 2. Forward Voltage

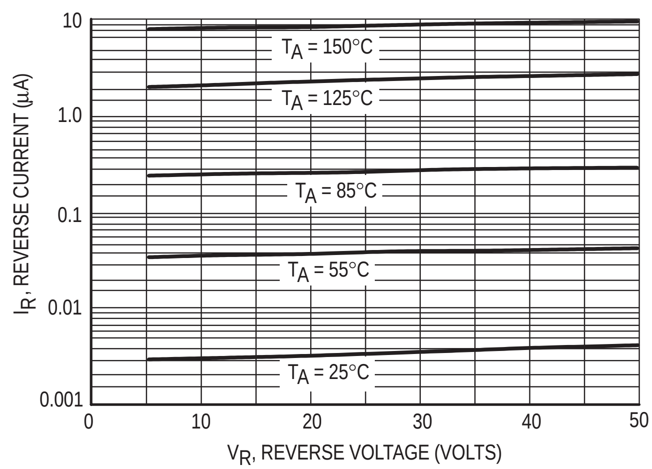


Figure 3. Leakage Current

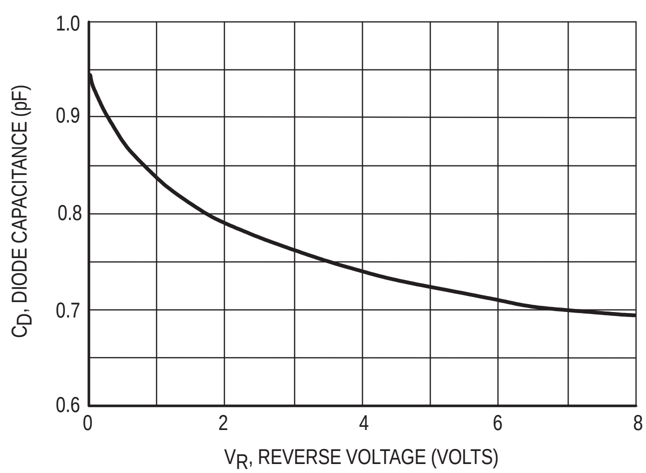
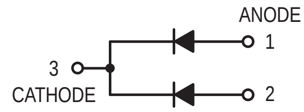


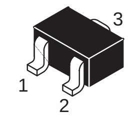
Figure 4. Capacitance

Dual Switching Diode

BAV70WT1

Motorola Preferred Device





CASE 419–02, STYLE 5
SC–70/SOT–323

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Max	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(1) T_A = 25°C Derate above 25°C	P_D	200 1.6	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.625	°C/W
Total Device Dissipation Alumina Substrate(2) 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

DEVICE MARKING

BAV70WT1 = A4

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 = 70 Vdc) (V_R = 50 Vdc)	 I_{R1} I_{R2}	 — —	 5.0 100	 μAdc nAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mAdc)	V_F	 — — — —	 715 855 1000 1250	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, R_L = 100 Ω, $I_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	6.0	ns
Forward Recovery Voltage (I_F = 10 mAdc, t_r = 20 ns) (Figure 2)	V_{RF}	—	1.75	V

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

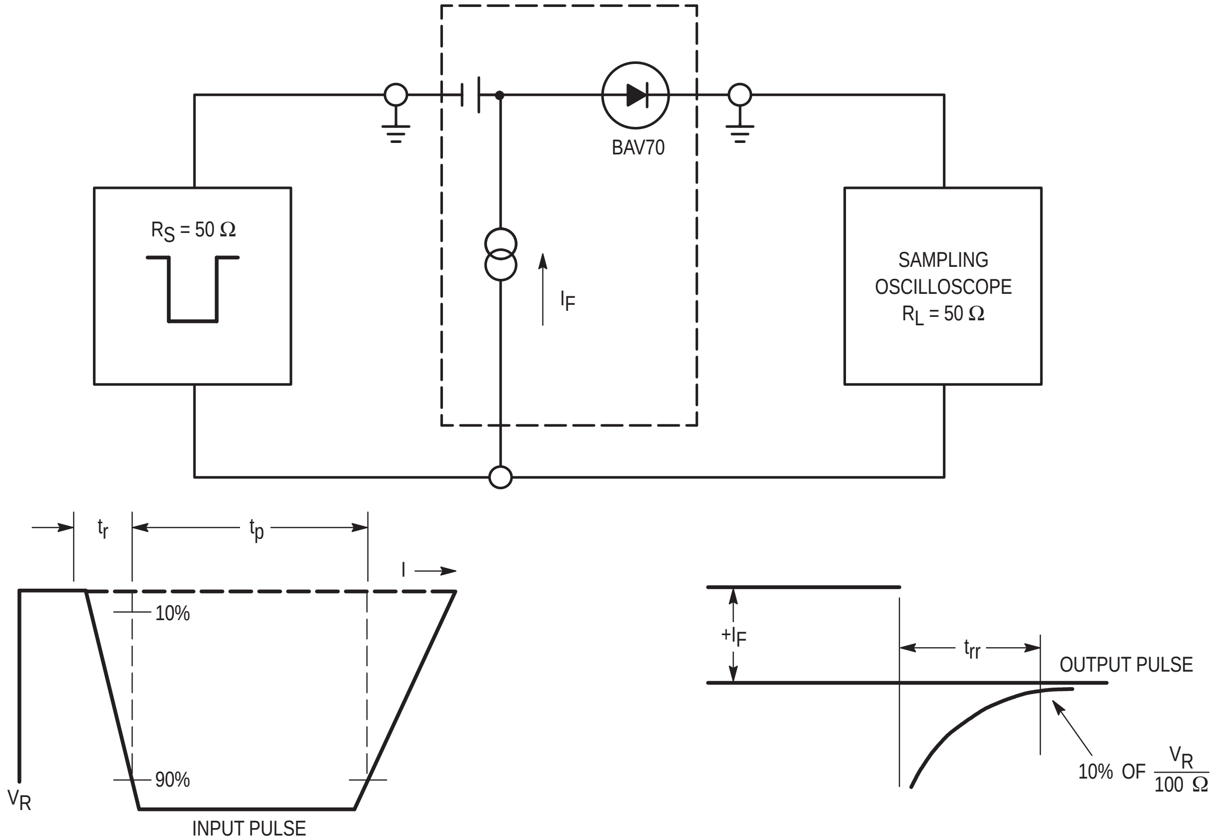


Figure 1. Recovery Time Equivalent Test Circuit

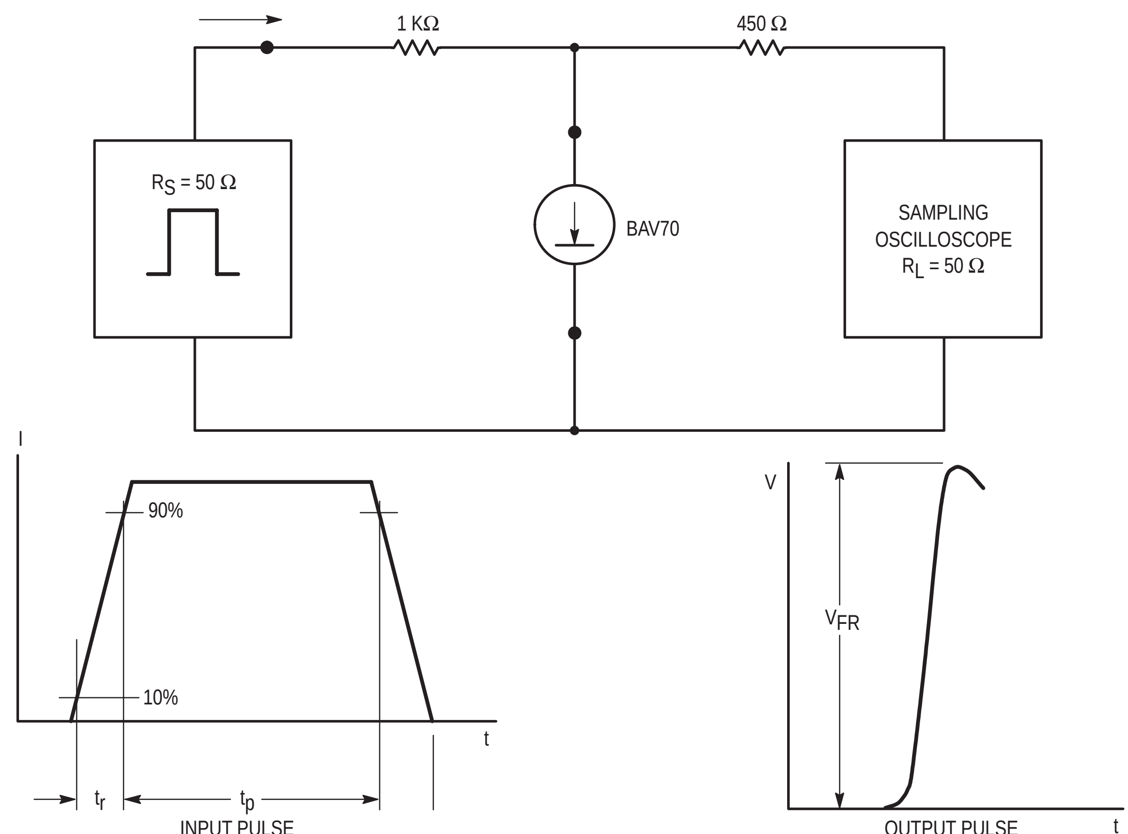


Figure 2.

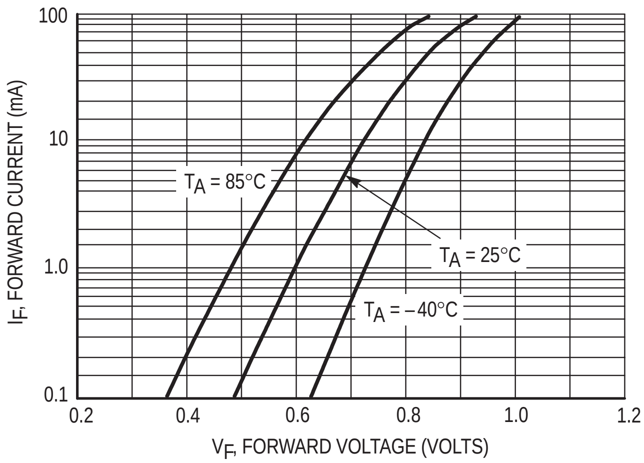


Figure 3. Forward Voltage

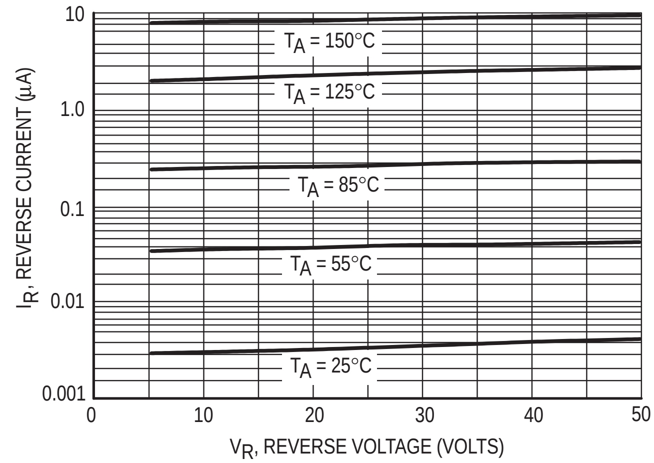


Figure 4. Leakage Current

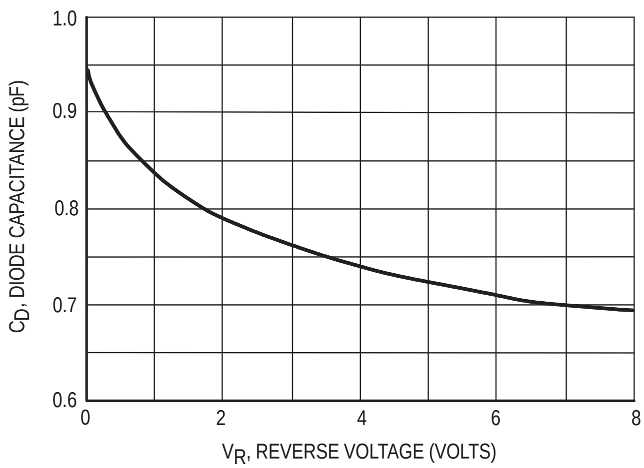
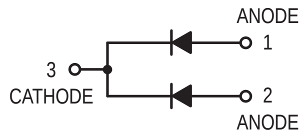
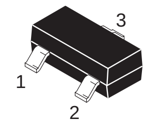


Figure 5. Capacitance

Monolithic Dual Switching Diode

BAV74LT1





CASE 318–08, STYLE 9
SOT–23 (TO–236AB)

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(1) 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,(2) 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

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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

Curves Applicable to Each Anode

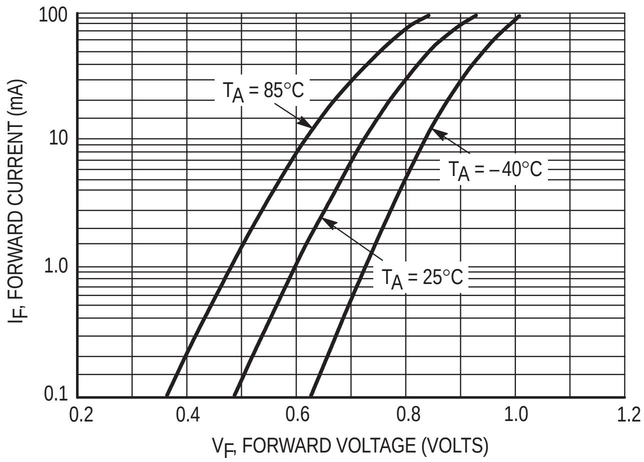


Figure 1. Forward Voltage

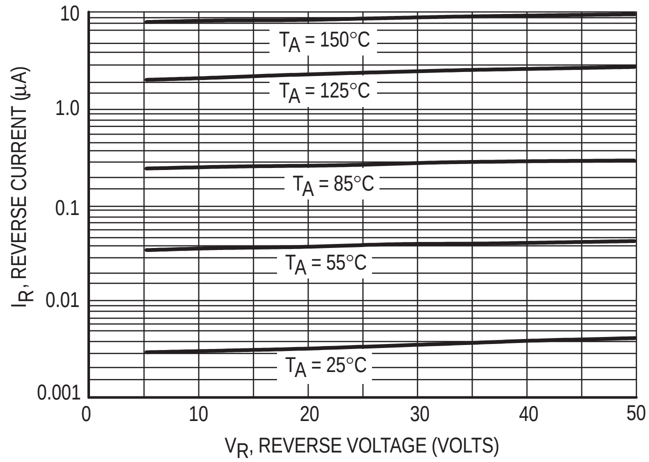


Figure 2. Leakage Current

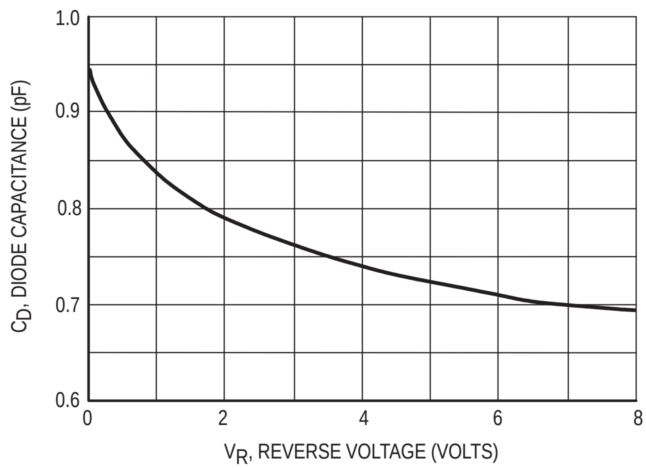
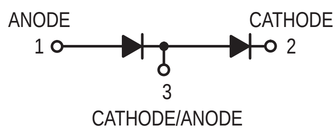


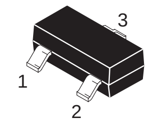
Figure 3. Capacitance

Dual Series Switching Diode

BAV99LT1

Motorola Preferred Device





CASE 318–08, STYLE 11
SOT–23 (TO–236AB)

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(1) (averaged over any 20 ms period)	$I_{F(AV)}$	715	mA
Repetitive Peak Forward Current	I_{FRM}	450	mA
Non–Repetitive Peak Forward Current t = 1.0 μs t = 1.0 ms t = 1.0 S	I_{FSM}	 2.0 1.0 0.5	A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board,(1) 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,(2) 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}	–65 to +150	°C

DEVICE MARKING

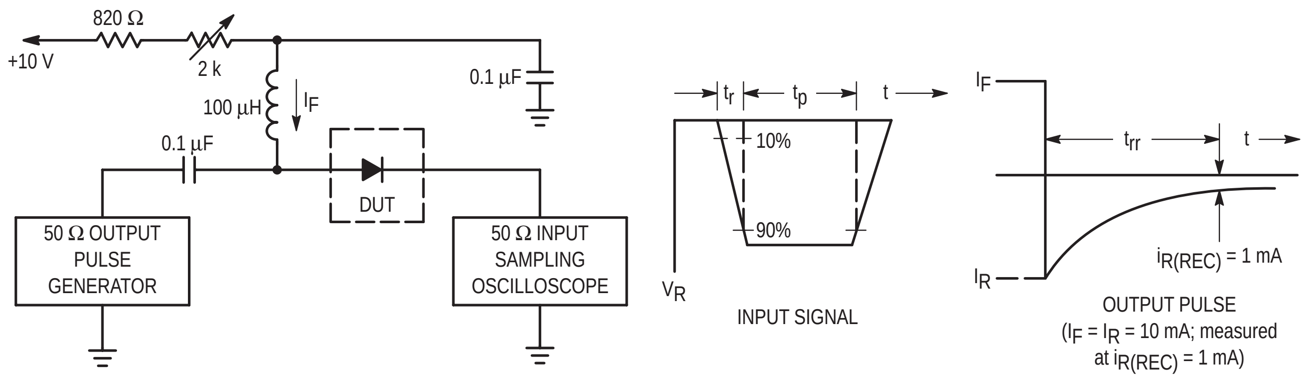
BAV99LT1 = A7

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

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

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued) **(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) (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc, T_J = 150°C)	I_R	— — —	2.5 30 50	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mAdc)	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
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V



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 1. Recovery Time Equivalent Test Circuit

CURVES APPLICABLE TO EACH DIODE

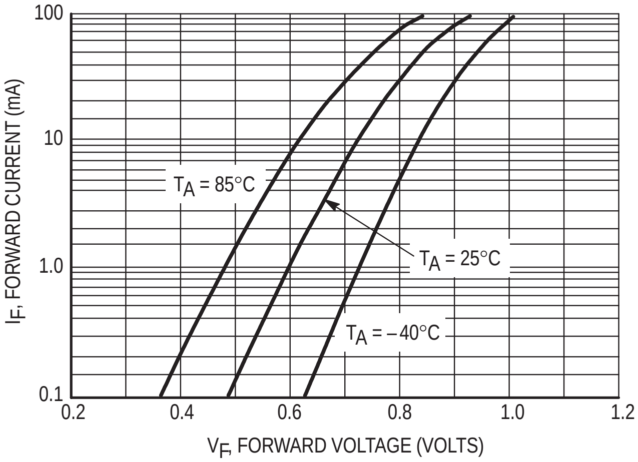


Figure 2. Forward Voltage

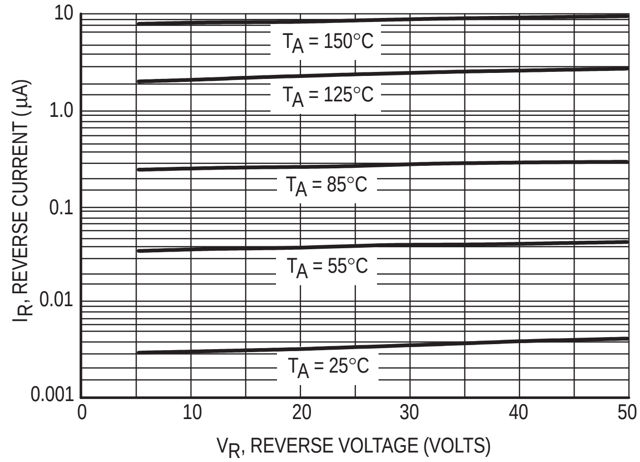


Figure 3. Leakage Current

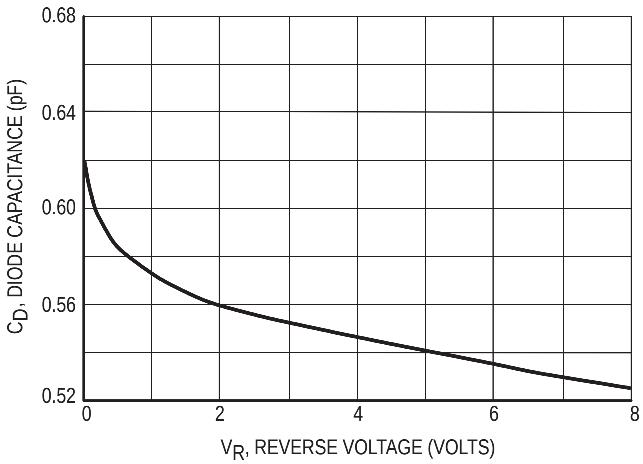


Figure 4. Capacitance

SC-70/SOT-323 Dual Series Switching Diode

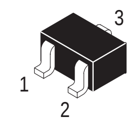
BAV99WT1
BAV99RWT1

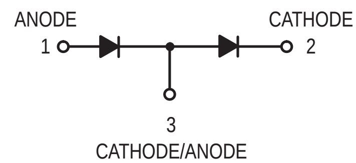
Motorola Preferred Devices

The BAV99WT1 is a smaller package, equivalent to the BAV99LT1.

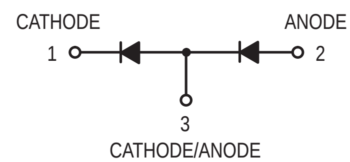
Suggested Applications

- ESD Protection
- Polarity Reversal Protection
- Data Line Protection
- Inductive Load Protection
- Steering Logic





BAV99WT1
CASE 419–02, STYLE 9
SC–70/SOT–323



BAV99RWT1
CASE 419–02, STYLE 10
SC–70/SOT–323

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(1) (averaged over any 20 ms period)	$I_{F(AV)}$	715	mA
Repetitive Peak Forward Current	I_{FRM}	450	mA
Non–Repetitive Peak Forward Current t = 1.0 μs t = 1.0 ms t = 1.0 S	I_{FSM}	 2.0 1.0 0.5	A

DEVICE MARKING

BAV99WT1 = A7
BAV99RWT1 = F7

THERMAL CHARACTERISTICS

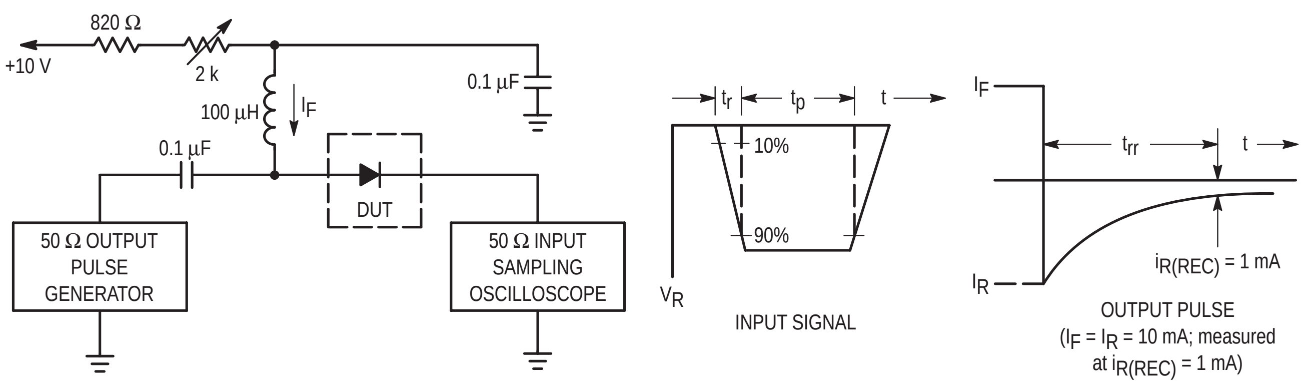
Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board,(1) T_A = 25°C Derate above 25°C	P_D	200 1.6	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	625	°C/W
Total Device Dissipation Alumina Substrate,(2) T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	–65 to +150	°C

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

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) (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc, T_J = 150°C)	I_R	— — —	2.5 30 50	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mAdc)	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 = 100 Ω	t_{rr}	—	6.0	ns
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V



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 1. Recovery Time Equivalent Test Circuit

CURVES APPLICABLE TO EACH DIODE

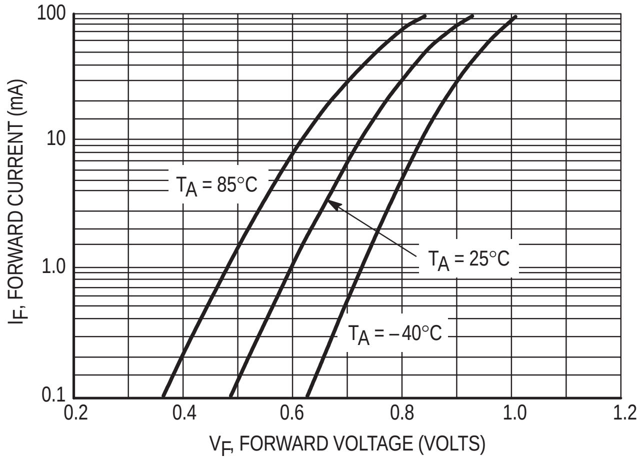


Figure 2. Forward Voltage

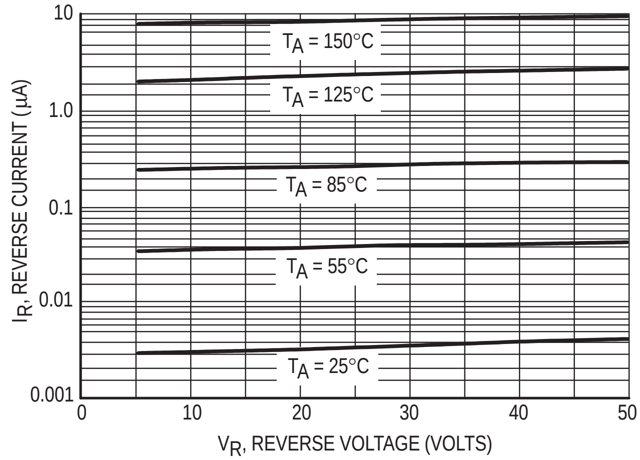


Figure 3. Leakage Current

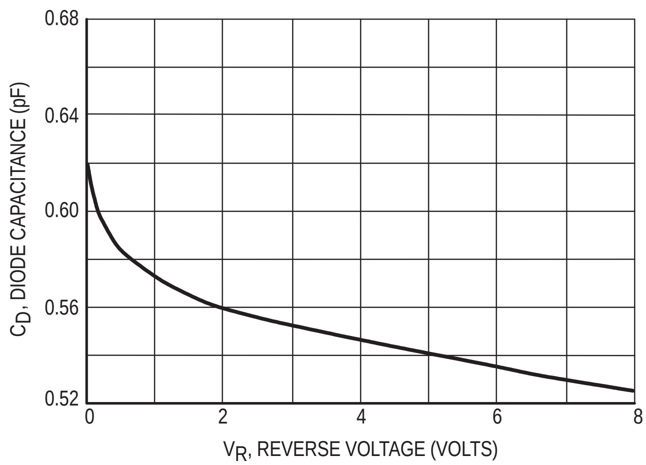


Figure 4. Capacitance

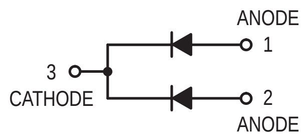
Monolithic Dual Switching Diode

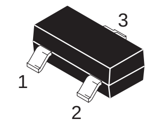
BAV170LT1

Motorola Preferred Device

This switching diode has the following features:

- Low Leakage Current Applications
- Medium Speed Switching Times
- Available in 8 mm Tape and Reel
  Use BAV170LT1 to order the 7 inch/3,000 unit reel
  Use BAV170LT3 to order the 13 inch/10,000 unit reel





CASE 318–08, STYLE 9
SOT–23 (TO–236AB)

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(1) 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(2) 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

DEVICE MARKING

BAV170LT1 = JX

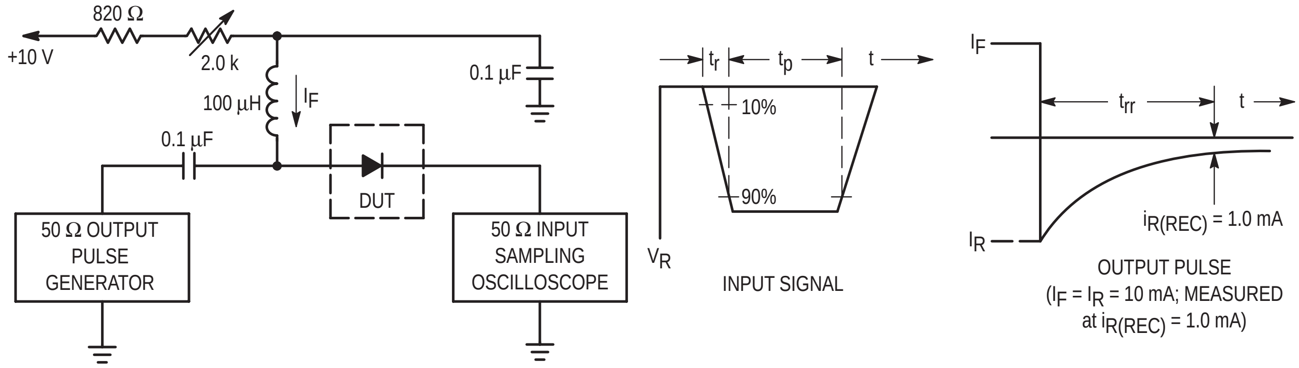
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (EACH DIODE)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	— —	5.0 80	nAdc
Diode Capacitance (V_R = 0 V, 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 mAdc)	V_F	— — — —	900 1000 1100 1250	mVdc
Reverse Recovery Time R_L = 100 Ω (I_F = I_R = 10 mAdc) (Figure 1)	t_{rr}	—	3.0	μs

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

REV 1



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 1. Recovery Time Equivalent Test Circuit

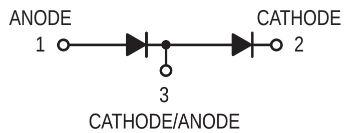
Dual Series Switching Diode

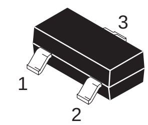
BAV199LT1

Motorola Preferred Device

This switching diode has the following features:

- Low Leakage Current Applications
- Medium Speed Switching Times
- Available in 8 mm Tape and Reel
  Use BAV199LT1 to order the 7 inch/3,000 unit reel
  Use BAV199LT3 to order the 13 inch/10,000 unit reel





CASE 318–08, STYLE 11
SOT–23 (TO–236AB)

MAXIMUM RATINGS

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	Vdc
Average Rectified Forward Current(1) (averaged over any 20 ms period)	$I_{F(AV)}$	715	mAdc
Repetitive Peak Forward Current	I_{FRM}	450	mAdc
Non–Repetitive Peak Forward Current t = 1.0 µs t = 1.0 ms t = 1.0 A	I_{FSM}	2.0 1.0 0.5	Adc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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(2) 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}	–65 to +150	°C

DEVICE MARKING

BAV199LT1 = JY

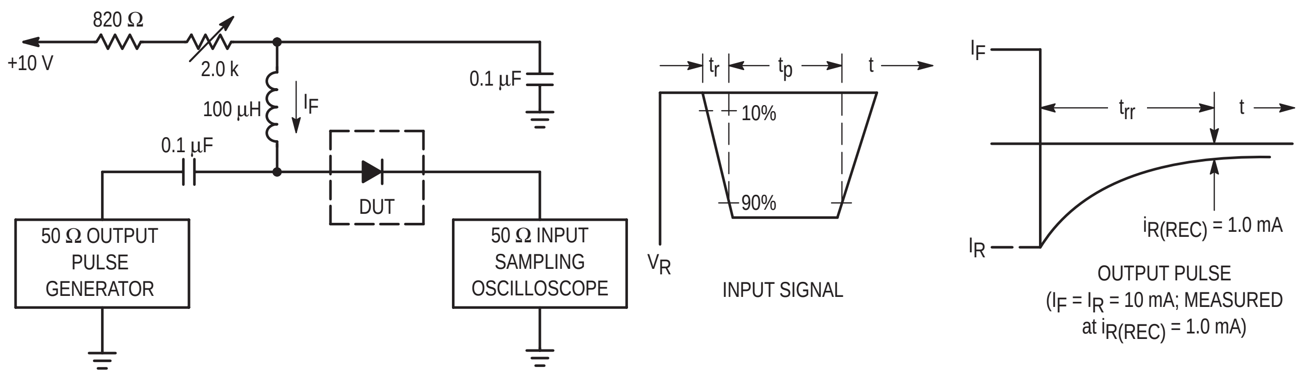
1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

REV 1

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 = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	 — —	 5.0 80	nAdc
Diode Capacitance (V_R = 0 V, 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 mAdc)	V_F	 — — — —	 900 1000 1100 1250	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc) (Figure 1)	t_{rr}	—	3.0	μs



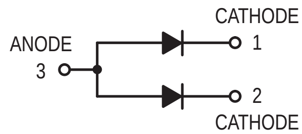
Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

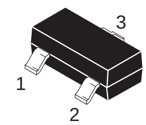
Figure 1. Recovery Time Equivalent Test Circuit

Monolithic Dual Switching Diode Common Anode

BAW56LT1

Motorola Preferred Device





CASE 318–08, STYLE 12
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

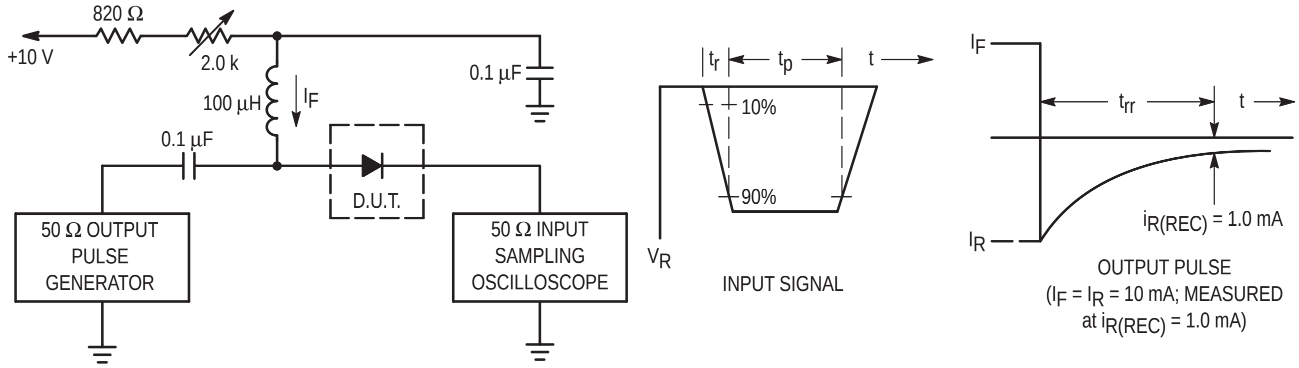
BAW56LT1 = A1

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 mAdc)	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 = 100 Ω	t_{rr}	—	6.0	ns

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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



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 1. Recovery Time Equivalent Test Circuit

Curves Applicable to Each Cathode

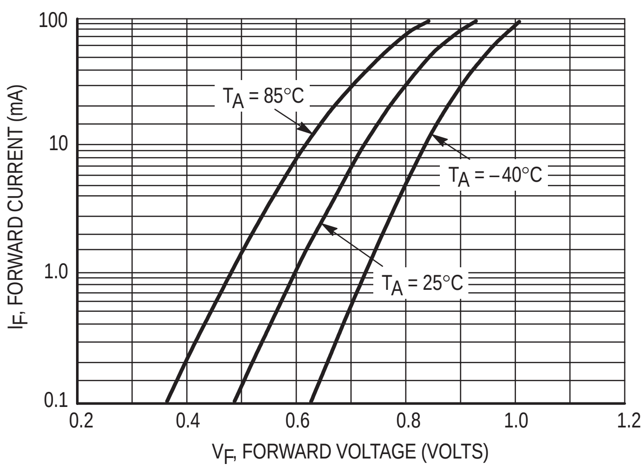


Figure 2. Forward Voltage

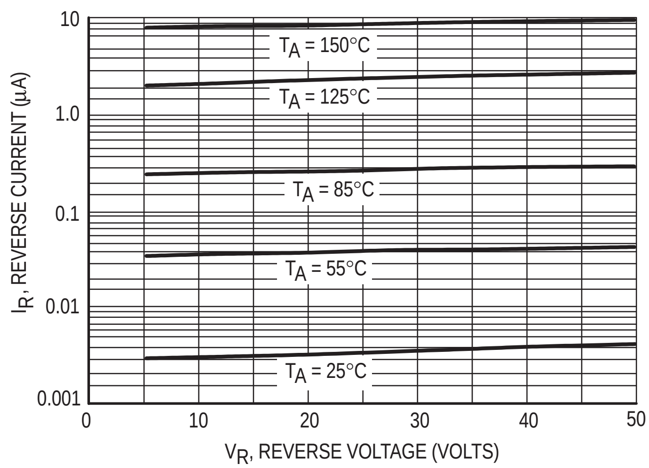


Figure 3. Leakage Current

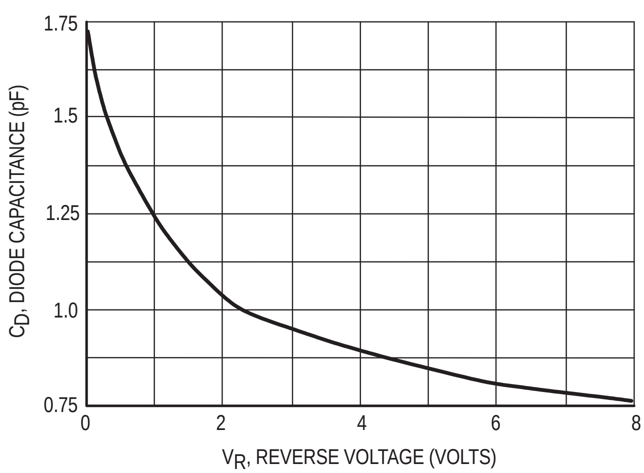
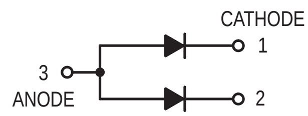


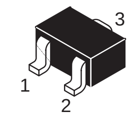
Figure 4. Capacitance

Dual Switching Diode

BAW56WT1

Motorola Preferred Device





CASE 419–02, STYLE 4
SC–70/SOT–323

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Max	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(1) T_A = 25°C Derate above 25°C	P_D	200 1.6	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.625	°C/W
Total Device Dissipation Alumina Substrate(2) 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

DEVICE MARKING

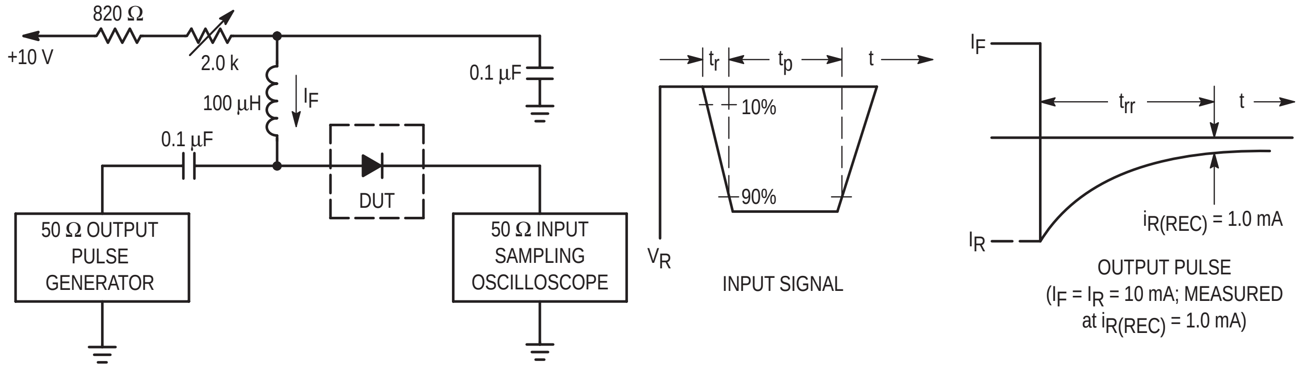
BAW56WT1 = A1

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 = 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 = 60 mAdc) (I_F = 150 mAdc)	V_F	 — — — —	 715 855 1000 1250	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, R_L = 100 Ω, $I_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	6.0	ns

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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



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 1. Recovery Time Equivalent Test Circuit

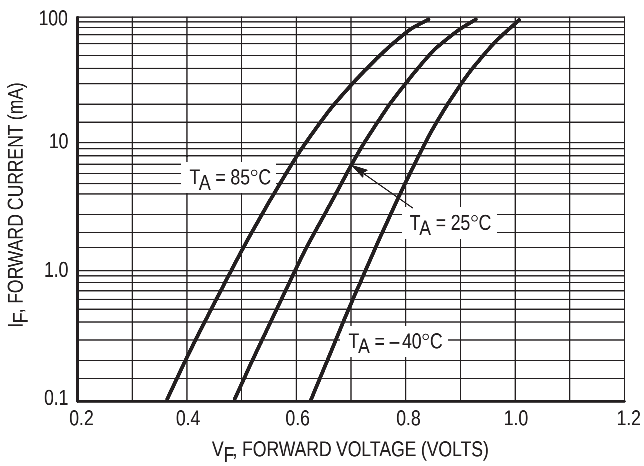


Figure 2. Forward Voltage

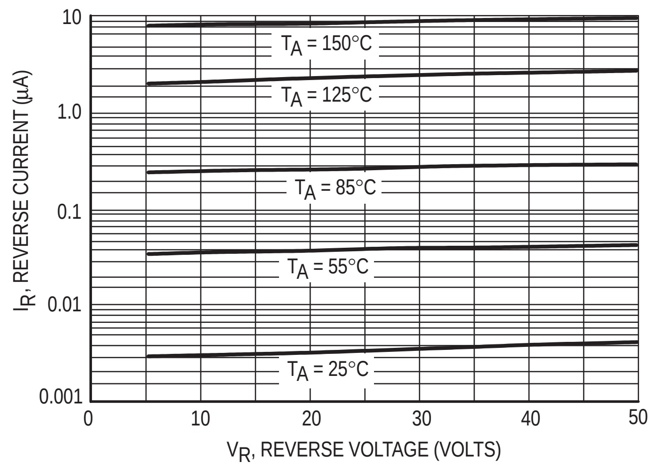


Figure 3. Leakage Current

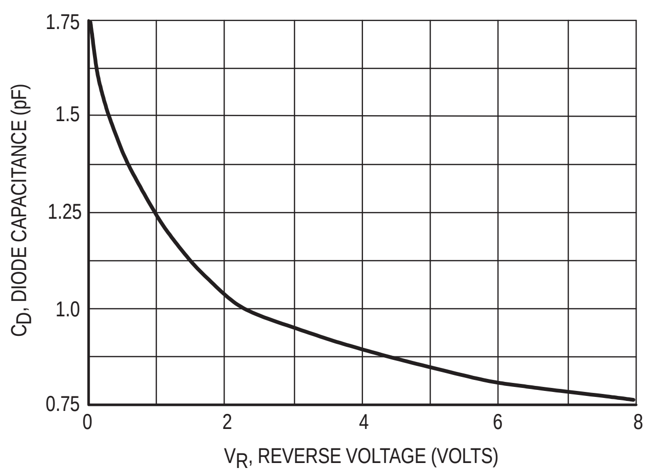


Figure 4. Capacitance

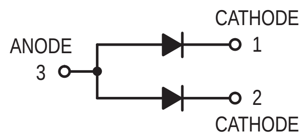
Monolithic Dual Switching Diode

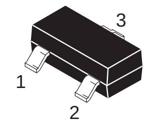
BAW156LT1

Motorola Preferred Device

This switching diode has the following features:

- Low Leakage Current Applications
- Medium Speed Switching Times
- Available in 8 mm Tape and Reel
  Use BAW156LT1 to order the 7 inch/3,000 unit reel
  Use BAW156LT3 to order the 13 inch/10,000 unit reel





CASE 318–08, STYLE 12
SOT–23 (TO–236AB)

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(1) 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(2) 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

DEVICE MARKING

BAW156LT1 = JZ

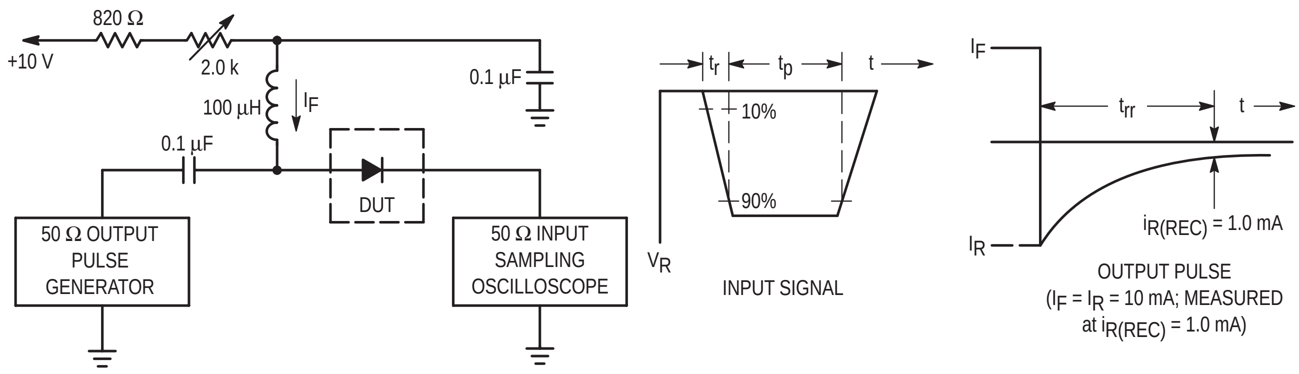
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (EACH DIODE)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 µAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	— —	5.0 80	nAdc
Diode Capacitance (V_R = 0 V, 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 mAdc)	V_F	— — — —	900 1000 1100 1250	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc) (Figure 1)	t_{rr}	—	3.0	µs

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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

REV 1



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 1. Recovery Time Equivalent Test Circuit

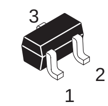
DAN222

Common Cathode Silicon Dual Switching Diode

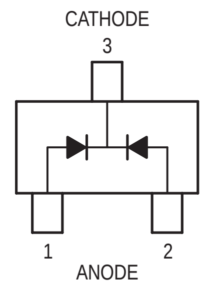
This Common Cathode Silicon Epitaxial Planar Dual Diode is designed for use in ultra high speed switching applications. This device is housed in the SOT–416/SC–90 package which is designed for low power surface mount applications, where board space is at a premium.

- Fast t_{rr}
- Low C_D
- Available in 8 mm Tape and Reel

SOT–416/SC–90 PACKAGE
COMMON CATHODE
DUAL SWITCHING DIODE
SURFACE MOUNT



CASE 463–01, STYLE 4
SOT–416/SC–90



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	80	Vdc
Peak Reverse Voltage	V_{RM}	80	Vdc
Forward Current	I_F	100	mAdc
Peak Forward Current	I_{FM}	300	mAdc
Peak Forward Surge Current	I_{FSM}(1)	2.0	Adc

DEVICE MARKING

DAN222 = N9

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	I_R	V_R = 70 V	—	0.1	µAdc
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 µA	80	—	Vdc
Diode Capacitance	C_D	V_R = 6.0 V, f = 1.0 MHz	—	3.5	pF
Reverse Recovery Time	t_{rr}(2)	I_F = 5.0 mA, V_R = 6.0 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	4.0	ns

1. t = 1 µS
2. t_{rr} Test Circuit on following page.

REV 1

TYPICAL ELECTRICAL CHARACTERISTICS

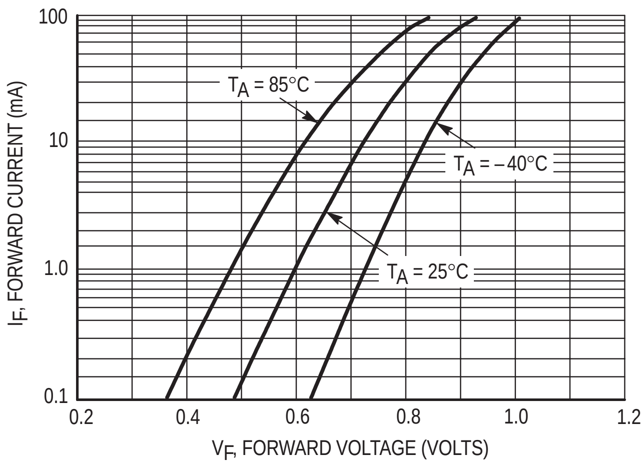


Figure 1. Forward Voltage

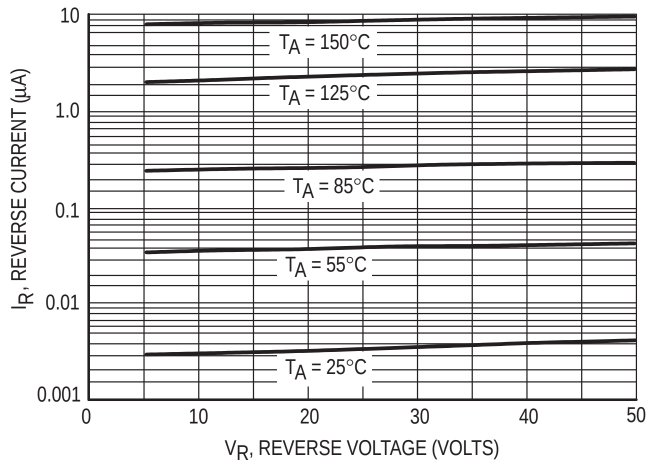


Figure 2. Reverse Current

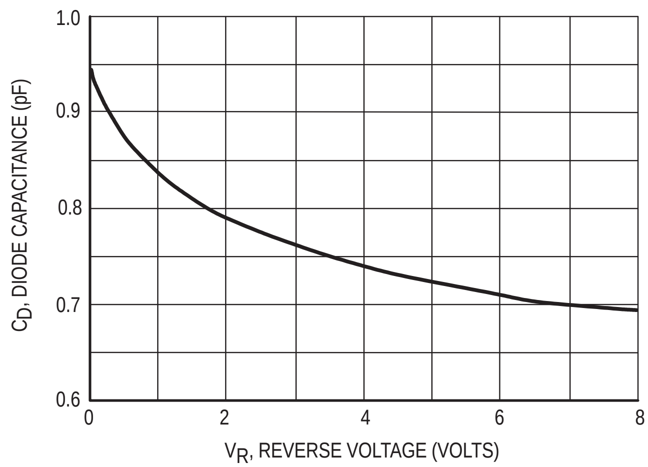
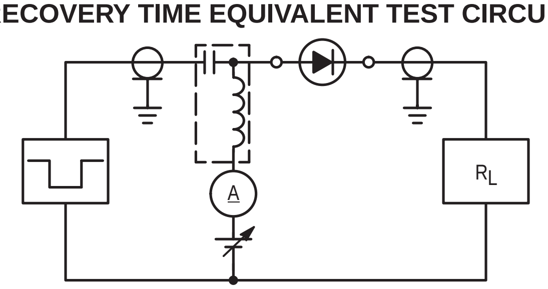
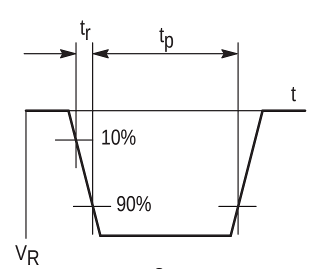


Figure 3. Diode Capacitance

RECOVERY TIME EQUIVALENT TEST CIRCUIT

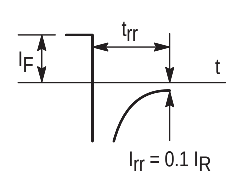


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

OUTPUT PULSE



I_F = 5.0 mA
V_R = 6 V
R_L = 100 Ω

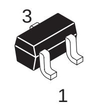
Common Anode Silicon Dual Switching Diode

DAP222

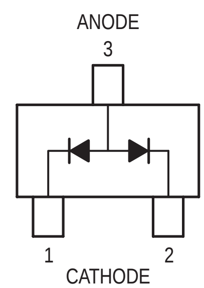
This Common Anode Silicon Epitaxial Planar Dual Diode is designed for use in ultra high speed switching applications. This device is housed in the SOT–416/SC–90 package which is designed for low power surface mount applications, where board space is at a premium.

- Fast t_{rr}
- Low C_D
- Available in 8 mm Tape and Reel

**SOT–416/SC–90 PACKAGE
COMMON ANODE
DUAL SWITCHING DIODE
SURFACE MOUNT**



**CASE 463–01, STYLE 4
SOT–416/SC–90**



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	80	Vdc
Peak Reverse Voltage	V_{RM}	80	Vdc
Forward Current	I_F	100	mAdc
Peak Forward Current	I_{FM}	300	mAdc
Peak Forward Surge Current	I_{FSM}(1)	2.0	Adc

DEVICE MARKING

DAP222 = P9

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	I_R	V_R = 70 V	—	0.1	µAdc
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 µA	80	—	Vdc
Diode Capacitance	C_D	V_R = 6.0 V, f = 1.0 MHz	—	3.5	pF
Reverse Recovery Time	t_{rr}(2)	I_F = 5.0 mA, V_R = 6.0 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	4.0	ns

1. t = 1 µS
2. t_{rr} Test Circuit on following page.

REV 1

TYPICAL ELECTRICAL CHARACTERISTICS

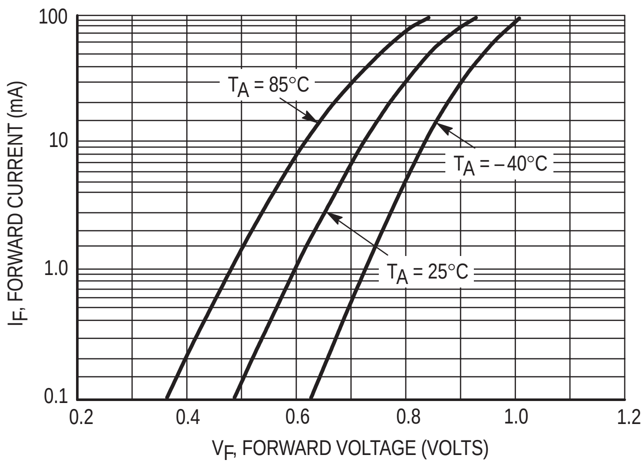


Figure 1. Forward Voltage

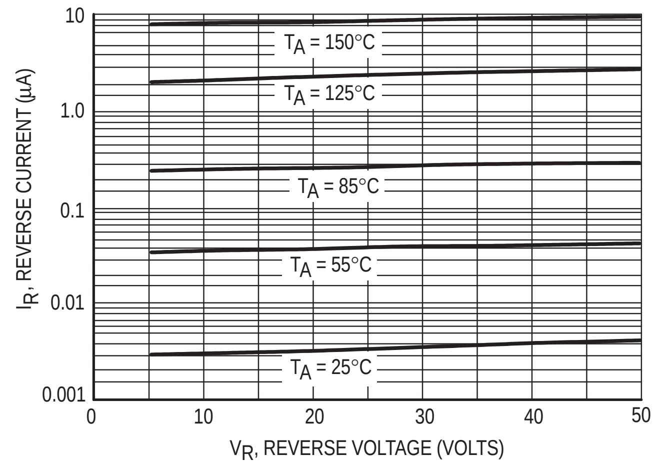


Figure 2. Reverse Current

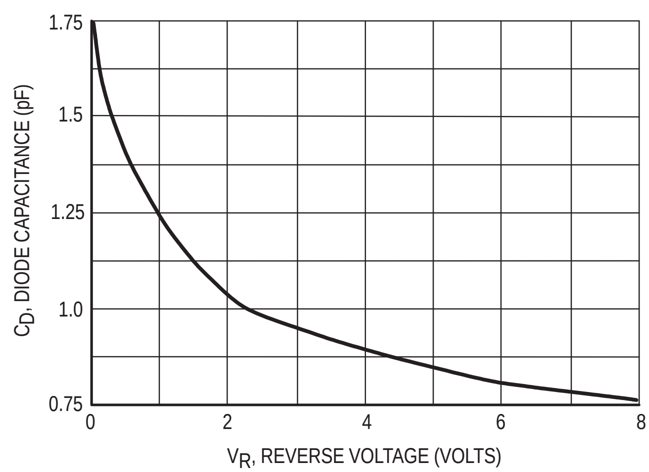
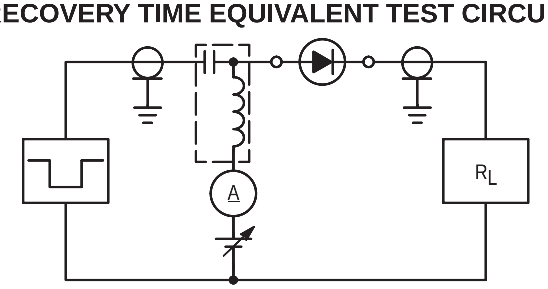
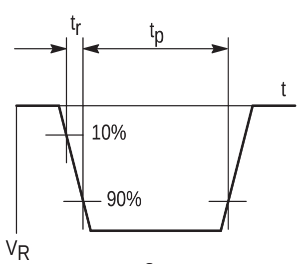


Figure 3. Diode Capacitance

RECOVERY TIME EQUIVALENT TEST CIRCUIT

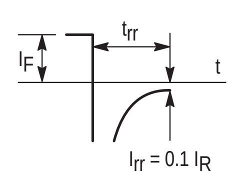


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

OUTPUT PULSE



I_F = 5.0 mA
V_R = 6 V
R_L = 100 Ω

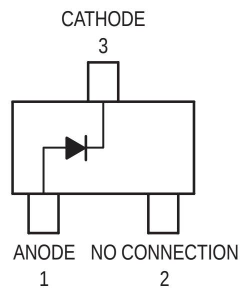
Single Silicon Switching Diode

M1MA141KT1
M1MA142KT1

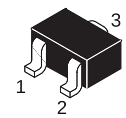
Motorola Preferred Devices

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

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

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)

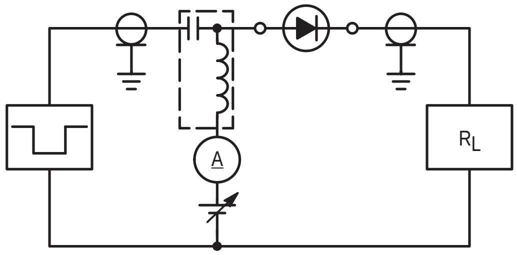
Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA141KT1	I_R	V_R = 35 V	—	0.1	µAdc
	M1MA142KT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA141KT1	V_R	I_R = 100 µA	40	—	Vdc
	M1MA142KT1			80	—	
Diode Capacitance		C_D	V_R = 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

1. t = 1 SEC
2. t_{rr} Test Circuit

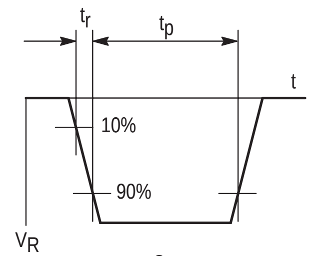
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

RECOVERY TIME EQUIVALENT TEST CIRCUIT

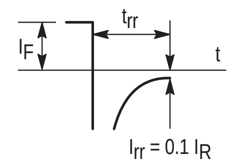


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

OUTPUT PULSE

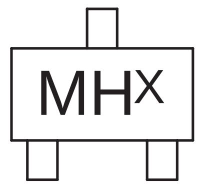


I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING — 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.

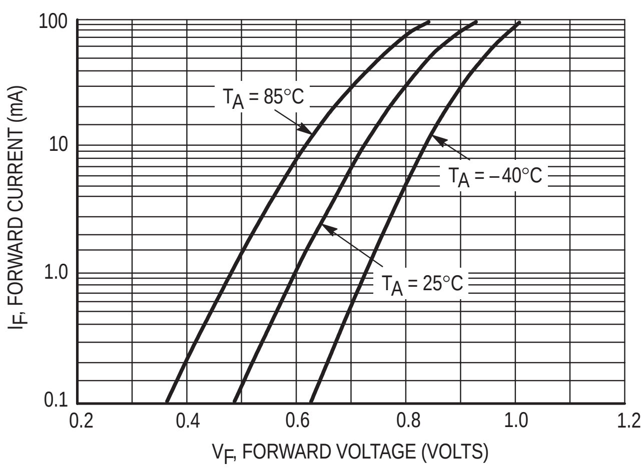


Figure 1. Forward Voltage

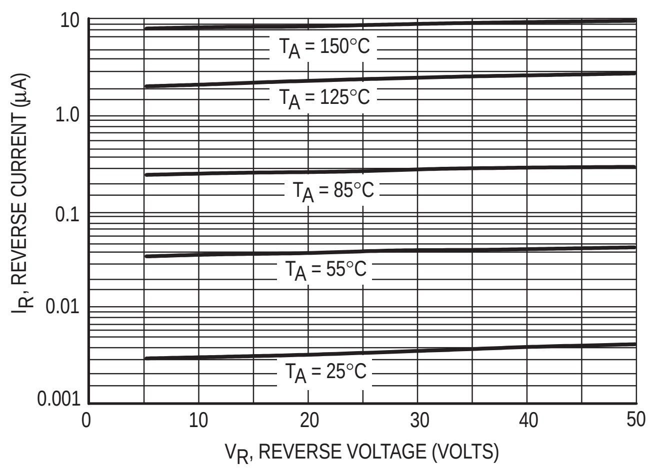


Figure 2. Reverse Current

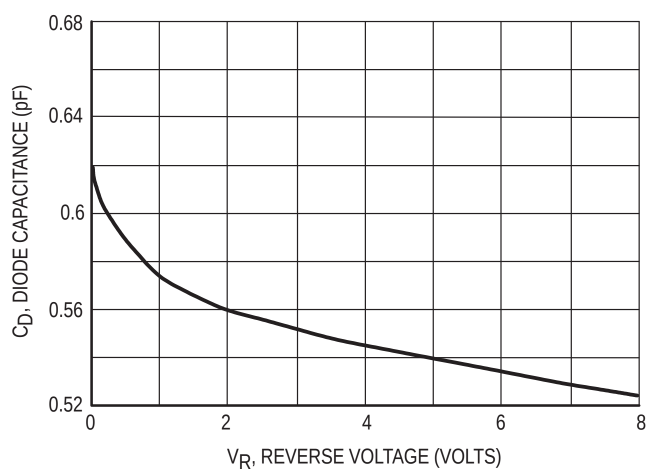


Figure 3. Diode Capacitance

Common Anode Silicon Dual Switching Diode

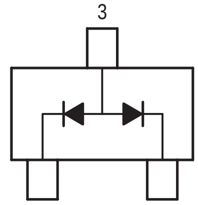
M1MA141WAT1
M1MA142WAT1

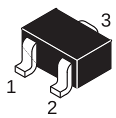
Motorola Preferred Devices

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–70 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

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	

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)

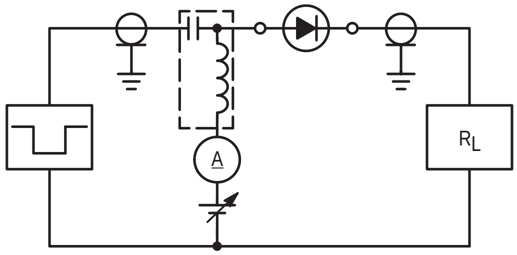
Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA141WAT1	I_R	V_R = 35 V	—	0.1	µAdc
	M1MA142WAT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA141WAT1	V_R	I_R = 100 µA	40	—	Vdc
	M1MA142WAT1			80	—	
Diode Capacitance		C_D	V_R = 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

1. t = 1 SEC
2. t_{rr} Test Circuit

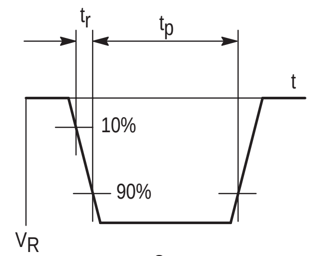
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

RECOVERY TIME EQUIVALENT TEST CIRCUIT

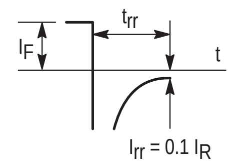


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

OUTPUT PULSE

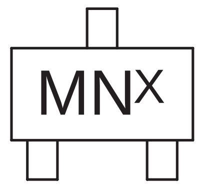


I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING — 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.

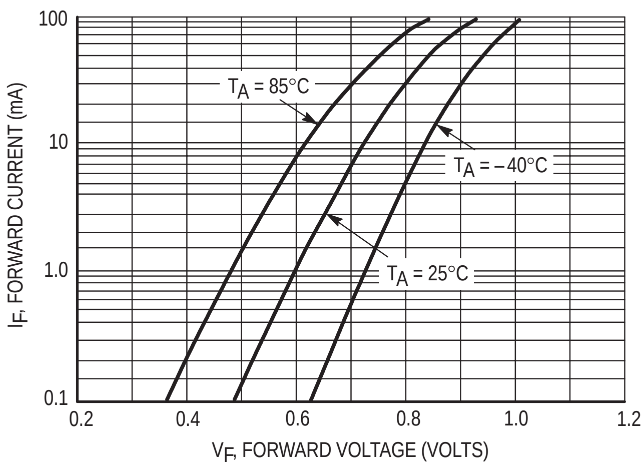


Figure 1. Forward Voltage

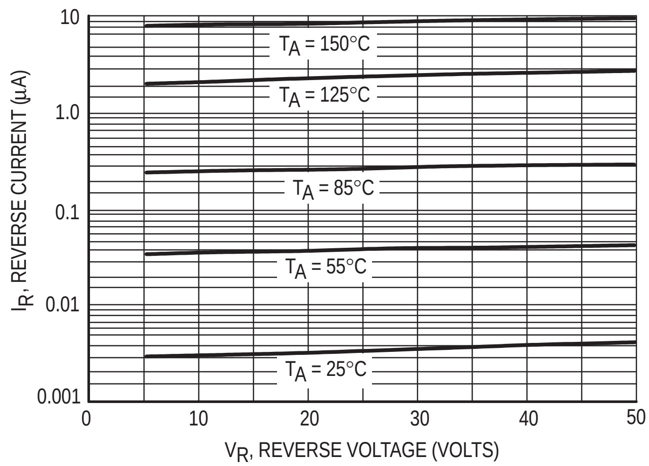


Figure 2. Reverse Current

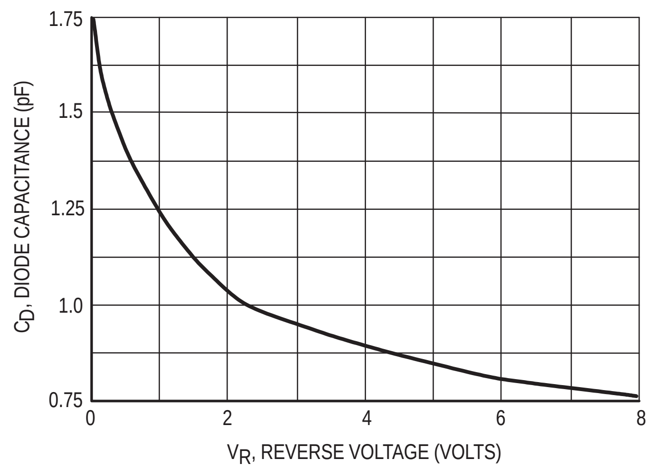


Figure 3. Diode Capacitance

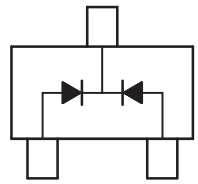
Common Cathode Silicon Dual Switching Diode

M1MA141WKT1
M1MA142WKT1

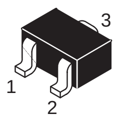
Motorola Preferred Devices

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–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 M1MA141/2WKT1 to order the 7 inch/3000 unit reel.
  Use M1MA141/2WKT3 to order the 13 inch/10,000 unit reel.



**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**

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	

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)

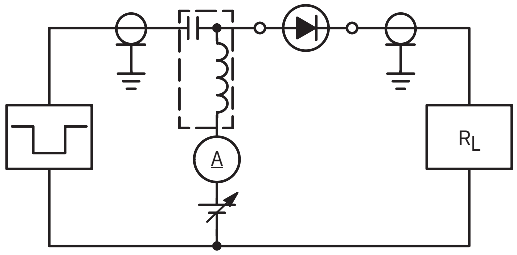
Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA141WKT1	I_R	V_R = 35 V	—	0.1	µAdc
	M1MA142WKT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA141WKT1	V_R	I_R = 100 µA	40	—	Vdc
	M1MA142WKT1			80	—	
Diode Capacitance		C_D	V_R = 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

1. t = 1 SEC
2. t_{rr} Test Circuit

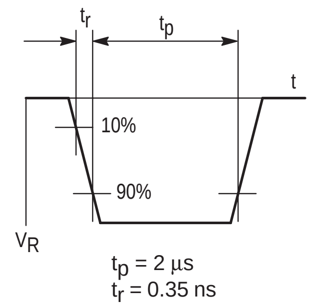
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

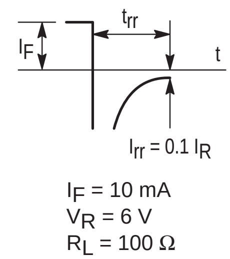
RECOVERY TIME EQUIVALENT TEST CIRCUIT



INPUT PULSE



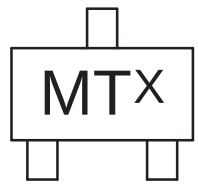
OUTPUT PULSE



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.

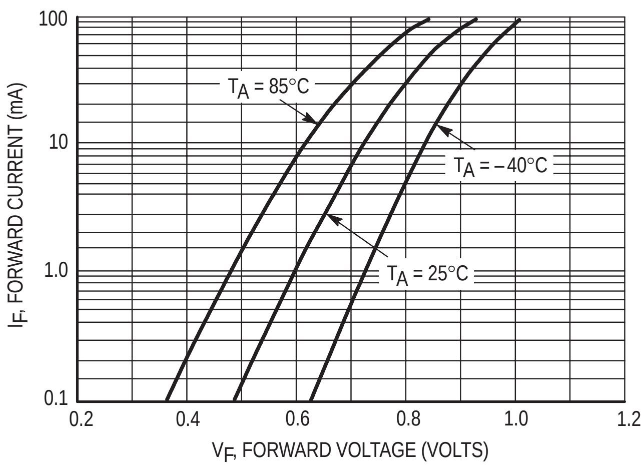


Figure 1. Forward Voltage

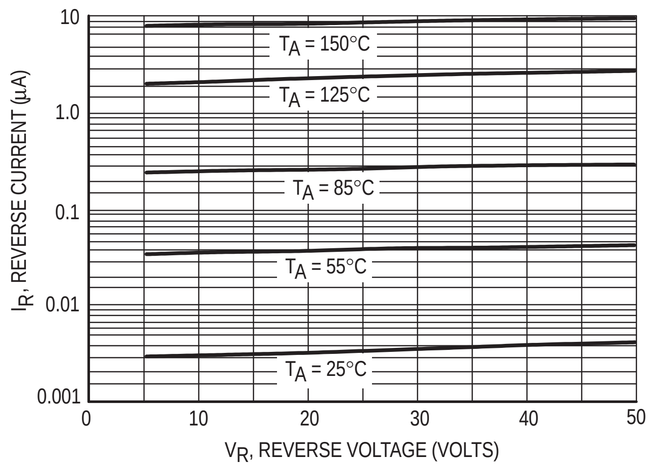


Figure 2. Reverse Current

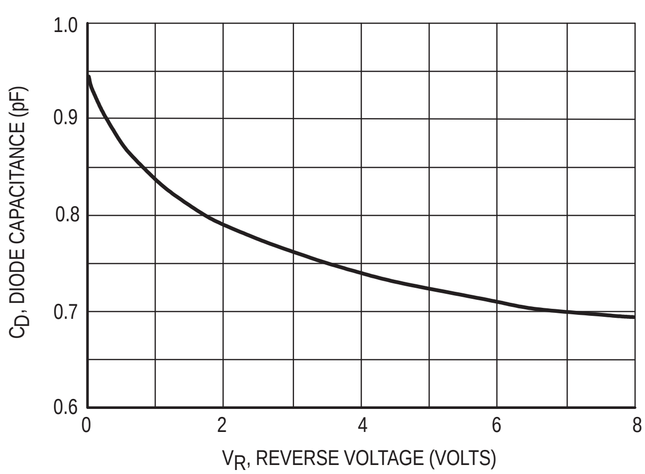


Figure 3. Diode Capacitance

Single Silicon Switching Diodes

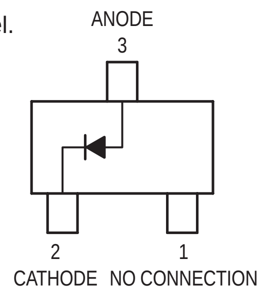
These Silicon Epitaxial Planar Diodes are designed for use in ultra high speed switching applications. These devices are housed in the SC–59 package which is designed for low power surface mount applications.

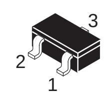
- Fast t_{rr}, < 3.0 ns
- Low C_D, < 2.0 pF
- Available in 8 mm Tape and Reel
  Use M1MA151/2AT1 to order the 7 inch/3000 unit reel.
  Use M1MA151/2AT3 to order the 13 inch/10,000 unit reel.

M1MA151AT1
M1MA152AT1

Motorola Preferred Devices

SC–59 PACKAGE
SINGLE SILICON
SWITCHING DIODES
40/80 V–100 mA
SURFACE MOUNT





CASE 318D–03, STYLE 4
SC–59

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage	M1MA151AT1	V_R	40	Vdc
	M1MA152AT1		80	
Peak Reverse Voltage	M1MA151AT1	V_{RM}	40	Vdc
	M1MA152AT1		80	
Forward Current		I_F	100	mAdc
Peak Forward Current		I_{FM}	225	mAdc
Peak Forward Surge Current		I_{FSM}(1)	500	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

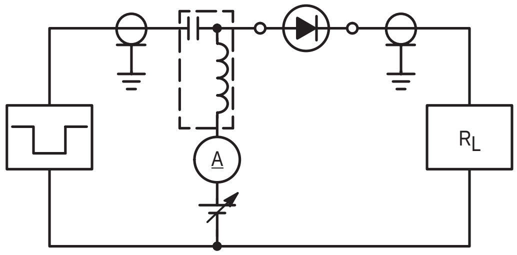
Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA151AT1	I_R	V_R = 35 V	—	0.1	µAdc
	M1MA152AT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA151AT1	V_R	I_R = 100 µA	40	—	Vdc
	M1MA152AT1			80	—	
Diode Capacitance		C_D	V_R = 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

1. t = 1 SEC
2. t_{rr} Test Circuit

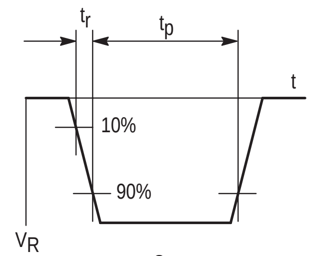
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 3

RECOVERY TIME EQUIVALENT TEST CIRCUIT

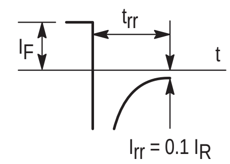


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

OUTPUT PULSE

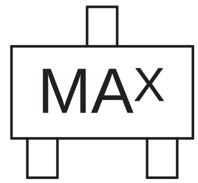


I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING

Marking Symbol

Type No.	151A	152A
Symbol	MA	MB



The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

Single Silicon Switching Diodes

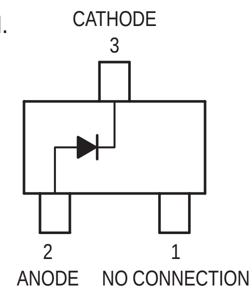
M1MA151KT1
M1MA152KT1

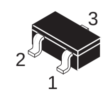
Motorola Preferred Devices

These Silicon Epitaxial Planar Diodes are designed for use in ultra high speed switching applications. These devices are 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 M1MA151/2KT1 to order the 7 inch/3000 unit reel.
  Use M1MA151/2KT3 to order the 13 inch/10,000 unit reel.

**SC–59 PACKAGE
SINGLE SILICON
SWITCHING DIODES
40/80 V–100 mA
SURFACE MOUNT**





**CASE 318D–03, STYLE 2
SC–59**

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage	M1MA151KT1	V_R	40	Vdc
	M1MA152KT1		80	
Peak Reverse Voltage	M1MA151KT1	V_{RM}	40	Vdc
	M1MA152KT1		80	
Forward Current		I_F	100	mAdc
Peak Forward Current		I_{FM}	225	mAdc
Peak Forward Surge Current		$I_{FSM}^{(1)}$	500	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

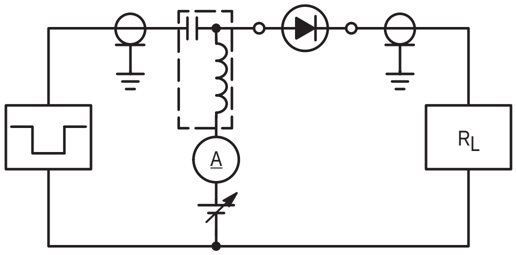
Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA151KT1	I_R	V_R = 35 V	—	0.1	µAdc
	M1MA152KT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA151KT1	V_R	I_R = 100 µA	40	—	Vdc
	M1MA152KT1			80	—	
Diode Capacitance		C_D	V_R = 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

1. t = 1 SEC
2. t_{rr} Test Circuit

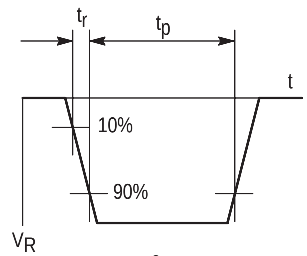
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 3

RECOVERY TIME EQUIVALENT TEST CIRCUIT

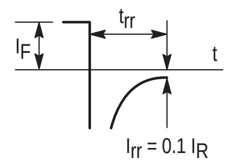


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

OUTPUT PULSE

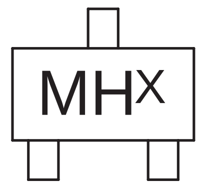


I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING — EXAMPLE

Marking Symbol

Type No.	151K	152K
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.

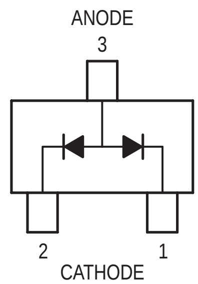
Common Anode Silicon Dual Switching Diodes

M1MA151WAT1
M1MA152WAT1

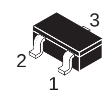
Motorola Preferred Devices

These Common Anode Silicon Epitaxial Planar Dual Diodes are designed for use in ultra high speed switching applications. These devices are 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 M1MA151/2WAT1 to order the 7 inch/3000 unit reel.
  Use M1MA151/2WAT3 to order the 13 inch/10,000 unit reel.



SC–59 PACKAGE
COMMON ANODE
DUAL SWITCHING DIODES
40/80 V–100 mA
SURFACE MOUNT



CASE 318D–03, STYLE 5
SC–59

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage	M1MA151WAT1	V_R	40	Vdc
	M1MA152WAT1		80	
Peak Reverse Voltage	M1MA151WAT1	V_{RM}	40	Vdc
	M1MA152WAT1		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	

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

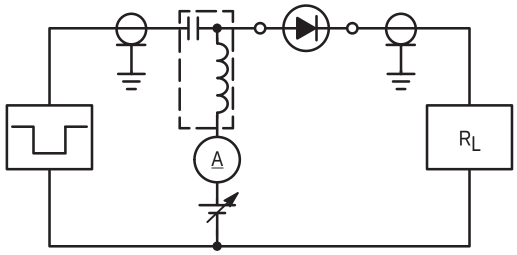
Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA151WAT1	I_R	V_R = 35 V	—	0.1	µAdc
	M1MA152WAT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA151WAT1	V_R	I_R = 100 µA	40	—	Vdc
	M1MA152WAT1			80	—	
Diode Capacitance		C_D	V_R = 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

1. t = 1 SEC
2. t_{rr} Test Circuit

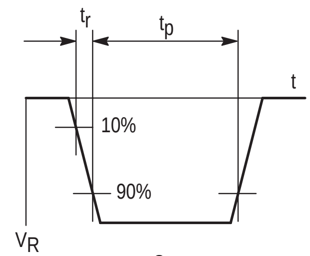
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 3

RECOVERY TIME EQUIVALENT TEST CIRCUIT

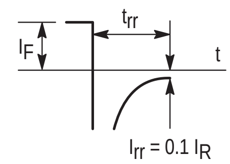


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

OUTPUT PULSE

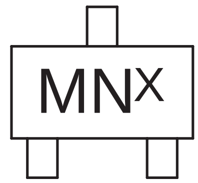


I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING — EXAMPLE

Marking Symbol

Type No.	151WA	152WA
Symbol	MN	MO

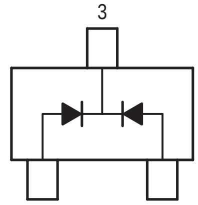


The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

Common Cathode Silicon Dual Switching Diodes

These Common Cathode Silicon Epitaxial Planar Dual Diodes are designed for use in ultra high speed switching applications. These devices are housed in the SC–59 package which is designed for low power surface mount applications.

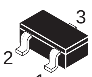
- Fast t_{rr}, < 3.0 ns
- Low C_D, < 2.0 pF
- Available in 8 mm Tape and Reel
  Use M1MA151/2WKT1 to order the 7 inch/3000 unit reel.
  Use M1MA151/2WKT3 to order the 13 inch/10,000 unit reel.



M1MA151WKT1
M1MA152WKT1

Motorola Preferred Devices

**SC–59 PACKAGE
COMMON CATHODE
DUAL SWITCHING DIODES
40/80 V–100 mA
SURFACE MOUNT**



**CASE 318D–03, STYLE 3
SC–59**

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage	M1MA151WKT1	V_R	40	Vdc
	M1MA152WKT1		80	
Peak Reverse Voltage	M1MA151WKT1	V_{RM}	40	Vdc
	M1MA152WKT1		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	

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

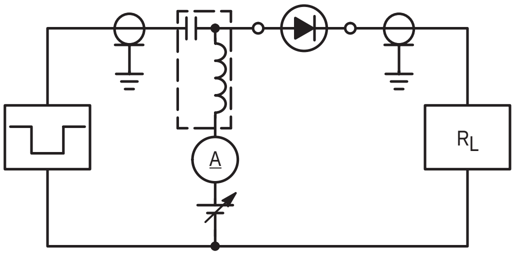
Characteristic		Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	M1MA151WKT1	I_R	V_R = 35 V	—	0.1	µAdc
	M1MA152WKT1		V_R = 75 V	—	0.1	
Forward Voltage		V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	M1MA151WKT1	V_R	I_R = 100 µA	40	—	Vdc
	M1MA152WKT1			80	—	
Diode Capacitance		C_D	V_R = 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

1. t = 1 SEC
2. t_{rr} Test Circuit

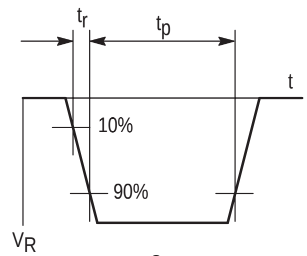
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 3

RECOVERY TIME EQUIVALENT TEST CIRCUIT

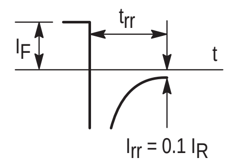


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

OUTPUT PULSE

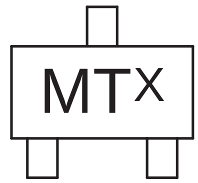


I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING — EXAMPLE

Marking Symbol

Type No.	151WK	152WK
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.

MBD54DWT1

Motorola Preferred Device

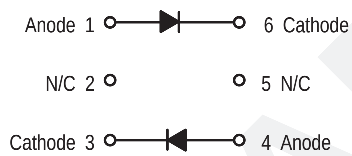
Preliminary Information

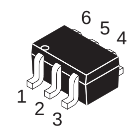
Dual Schottky Barrier Diodes

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Low Forward Voltage — 0.35 V @ I_F = 10 mAdc

**30 VOLTS
DUAL HOT–CARRIER
DETECTOR AND SWITCHING
DIODES**





**CASE 419B–01, STYLE 6
SOT–363**

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	150 1.2	mW mW/°C
Operating Junction Temperature Range	T_J	–55 to +150	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

DEVICE MARKING

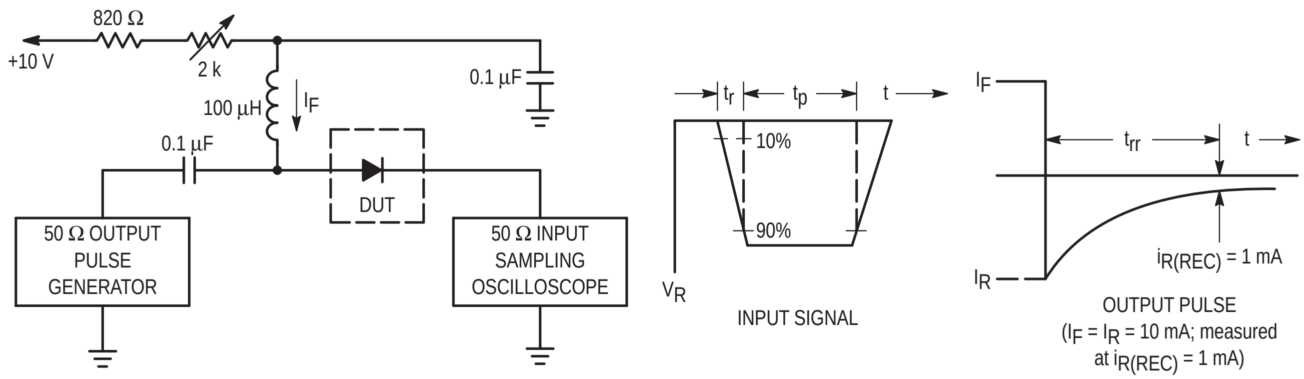
MBD54DWT1 = BL

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	30	—	—	Volts
Total Capacitance (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	7.6	10	pF
Reverse Leakage (V_R = 25 V)	I_R	—	0.5	2.0	μAdc
Forward Voltage (I_F = 0.1 mAdc)	V_F	—	0.22	0.24	Vdc
Forward Voltage (I_F = 30 mAdc)	V_F	—	0.41	0.5	Vdc
Forward Voltage (I_F = 100 mAdc)	V_F	—	0.52	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) Figure 1	t_{rr}	—	—	5.0	ns
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	0.29	0.32	Vdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.35	0.40	Vdc

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

REV 1



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 1. Recovery Time Equivalent Test Circuit

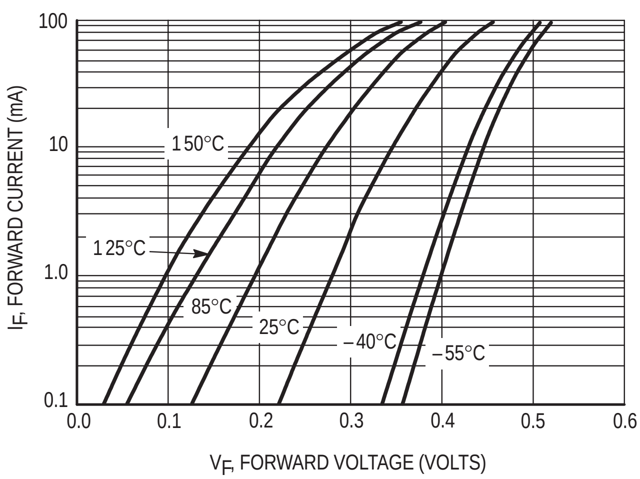


Figure 2. Forward Voltage

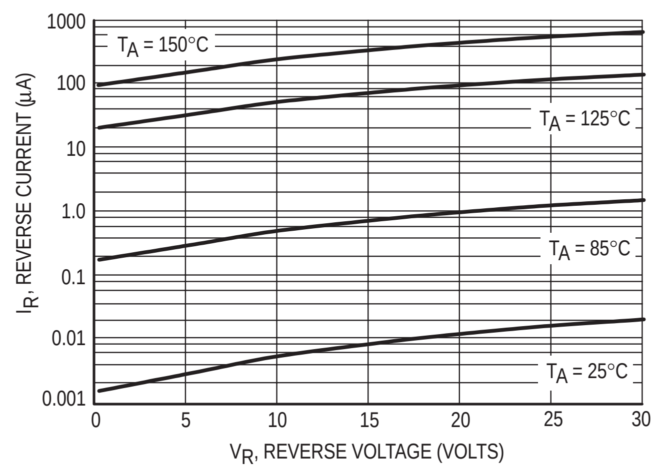


Figure 3. Leakage Current

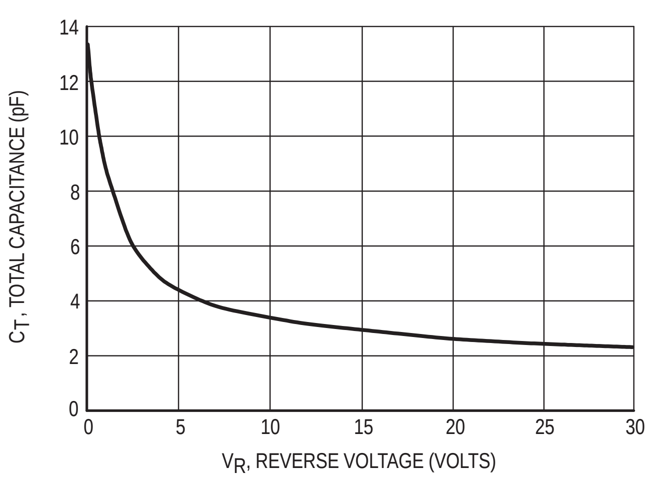


Figure 4. Total Capacitance

MBD101
MMBD101LT1

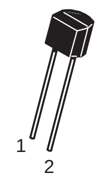
Motorola Preferred Devices

Schottky Barrier Diodes

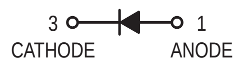
Designed primarily for UHF mixer applications but suitable also for use in detector and ultra–fast switching circuits. Supplied in an inexpensive plastic package for low–cost, high–volume consumer requirements. Also available in Surface Mount package.

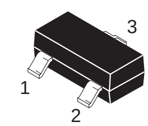
- Low Noise Figure — 6.0 dB Typ @ 1.0 GHz
- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- High Forward Conductance — 0.5 Volts (Typ) @ I_F = 10 mA

SILICON SCHOTTKY BARRIER DIODES



CASE 182–02, STYLE 1
(TO–226AC)





CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

MAXIMUM RATINGS

		MBD101	MMBD101LT1	
Rating	**Symbol**	**Value**		**Unit**
Reverse Voltage	V_R	7.0		Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	280 2.2	225 1.8	mW mW/°C
Junction Temperature	T_J	+150		°C
Storage Temperature Range	T_{stg}	–55 to +150		°C

DEVICE MARKING

MMBD101LT1 = 4M

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	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 mAdc)	V_F	—	0.5	0.6	Volts
Reverse Leakage (V_R = 3.0 Vdc)	I_R	—	0.02	0.25	μAdc

NOTE: MMBD101LT1 is also available in bulk packaging. Use MMBD101L as the device title to order this device in bulk.

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

TYPICAL CHARACTERISTICS

(T_A = 25°C unless noted)

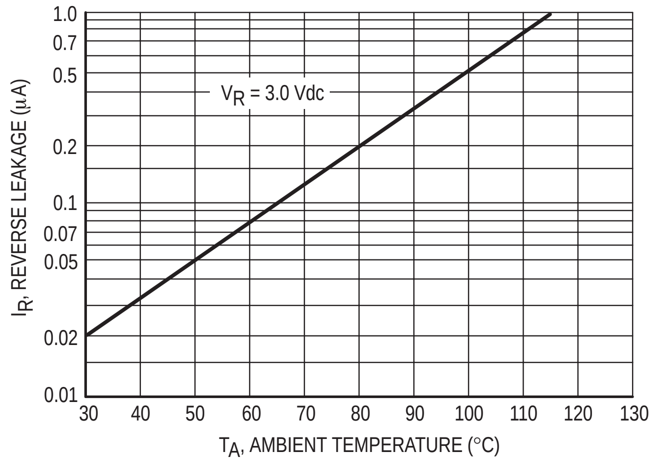


Figure 1. Reverse Leakage

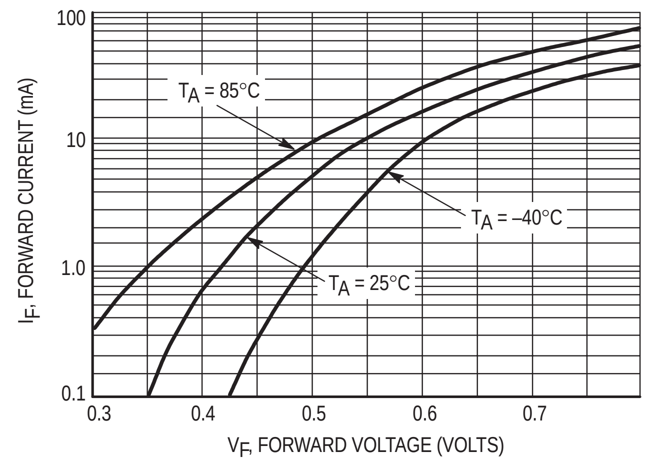


Figure 2. Forward Voltage

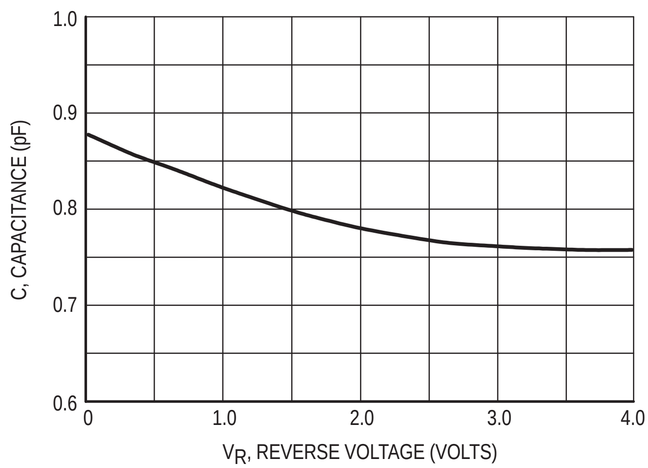


Figure 3. Capacitance

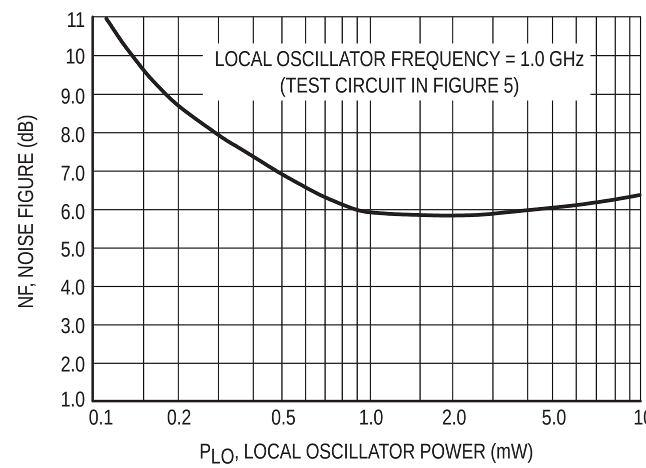


Figure 4. Noise Figure

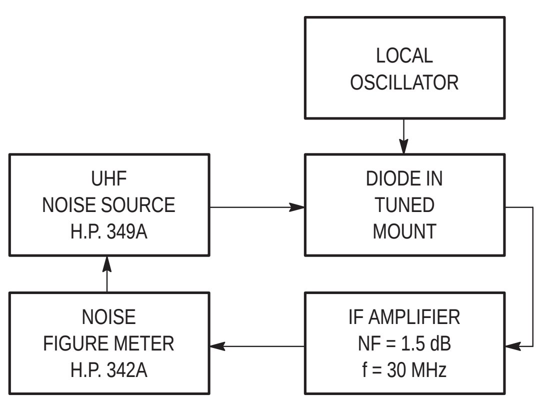


Figure 5. Noise Figure Test Circuit

NOTES ON TESTING AND SPECIFICATIONS

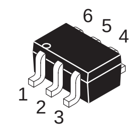
Note 1 — C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

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.

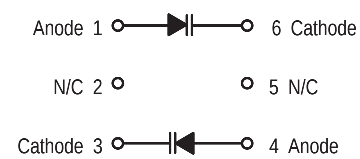
Note 3 — L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

MBD110DWT1
MBD330DWT1
MBD770DWT1

Motorola Preferred Devices



CASE 419B–01, STYLE 6
SOT–363



Dual Schottky Barrier Diodes

Application circuit designs are moving toward the consolidation of device count and into smaller packages. The new SOT–363 package is a solution which simplifies circuit design, reduces device count, and reduces board space by putting two discrete devices in one small six–leaded package. The SOT–363 is ideal for low–power surface mount applications where board space is at a premium, such as portable products.

Surface Mount Comparisons:

	SOT–363	SOT–23
Area (mm^2)	4.6	7.6
Max Package P_D (mW)	120	225
Device Count	2	1

Space Savings:

Package	1 × SOT–23	2 × SOT–23
SOT–363	40%	70%

The MBD110DW, MBD330DW, and MBD770DW devices are spin–offs of our popular MMBD101LT1, MMBD301LT1, and MMBD701LT1 SOT–23 devices. They are designed for high–efficiency UHF and VHF detector applications. Readily available to many other fast switching RF and digital applications.

- Extremely Low Minority Carrier Lifetime
- Very Low Capacitance
- Low Reverse Leakage

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Reverse Voltage	MBD110DWT1 MBD330DWT1 MBD770DWT1	V_R	7.0 30 70	Vdc
Forward Power Dissipation $T_A = 25°C$		P_F	120	mW
Junction Temperature		T_J	–55 to +125	°C
Storage Temperature Range		T_{stg}	–55 to +150	°C

DEVICE MARKING

MBD110DWT1 = M4 MBD330DWT1 = T4 MBD770DWT1 = H5

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

REV 1

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

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage		$V_{(BR)R}$				Volts
(I_R = 10 μA)	MBD110DWT1		7.0	10	—	
	MBD330DWT1		30	—	—	
	MBD770DWT1		70	—	—	
Diode Capacitance		C_T				pF
(V_R = 0, f = 1.0 MHz, Note 1)	MBD110DWT1		—	0.88	1.0	
Total Capacitance		C_T				pF
(V_R = 15 Volts, f = 1.0 MHz)	MBD330DWT1		—	0.9	1.5	
(V_R = 20 Volts, f = 1.0 MHz)	MBD770DWT1		—	0.5	1.0	
Reverse Leakage		I_R				
(V_R = 3.0 V)	MBD110DWT1		—	0.02	0.25	μA
(V_R = 25 V)	MBD330DWT1		—	13	200	nAdc
(V_R = 35 V)	MBD770DWT1		—	9.0	200	nAdc
Noise Figure		NF				dB
(f = 1.0 GHz, Note 2)	MBD110DWT1		—	6.0	—	
Forward Voltage		V_F				Vdc
(I_F = 10 mA)	MBD110DWT1		—	0.5	0.6	
(I_F = 1.0 mAdc)	MBD330DWT1		—	0.38	0.45	
(I_F = 10 mA)			—	0.52	0.6	
(I_F = 1.0 mAdc)	MBD770DWT1		—	0.42	0.5	
(I_F = 10 mA)			—	0.7	1.0	

TYPICAL CHARACTERISTICS
MBD110DWT1

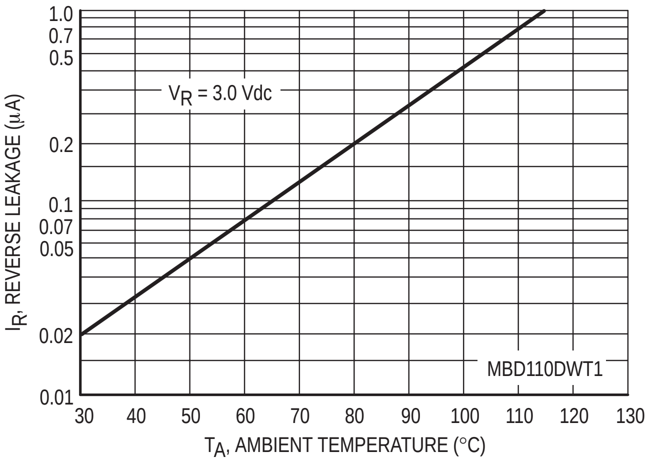


Figure 1. Reverse Leakage

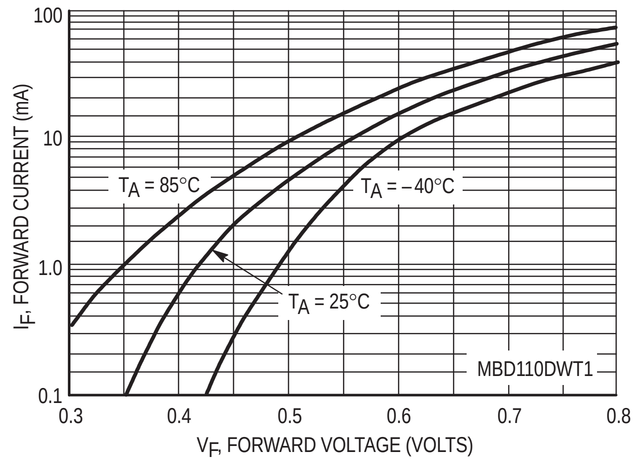


Figure 2. Forward Voltage

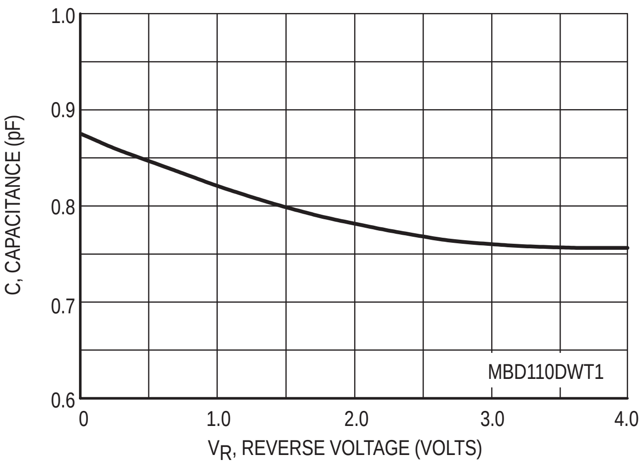


Figure 3. Capacitance

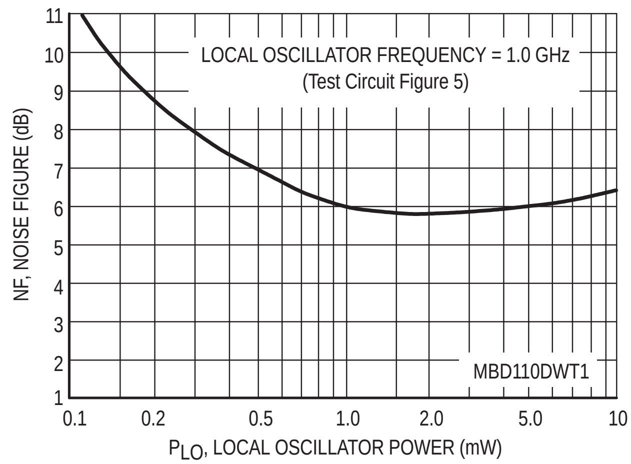


Figure 4. Noise Figure

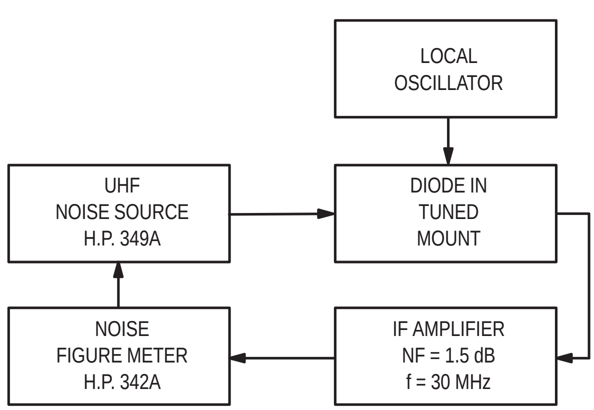


Figure 5. Noise Figure Test Circuit

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).

TYPICAL CHARACTERISTICS
MBD330DWT1

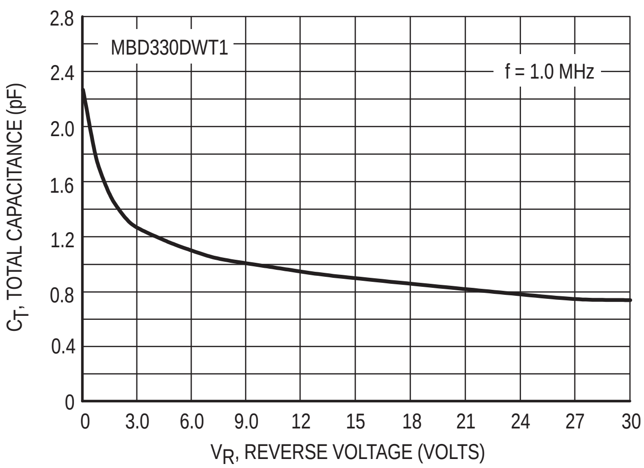


Figure 6. Total Capacitance

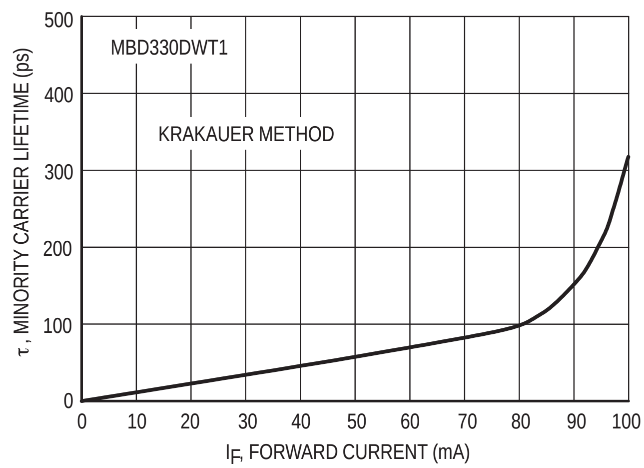


Figure 7. Minority Carrier Lifetime

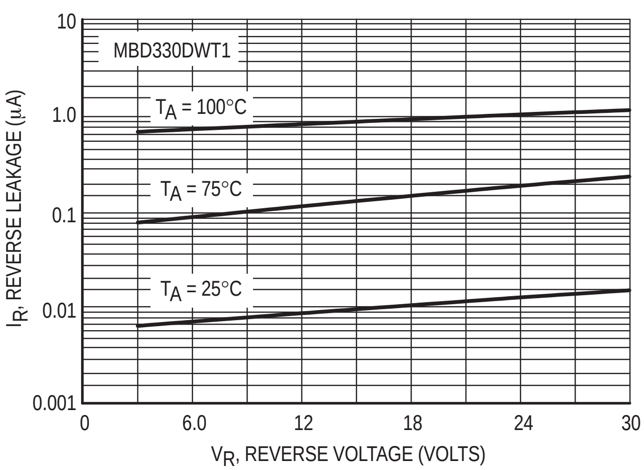


Figure 8. Reverse Leakage

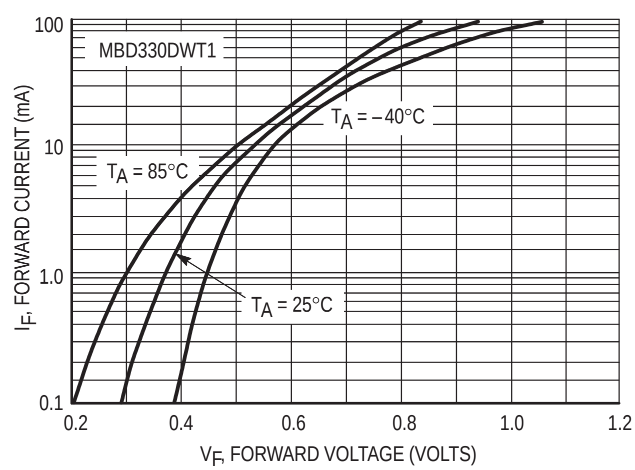


Figure 9. Forward Voltage

TYPICAL CHARACTERISTICS
MBD770DWT1

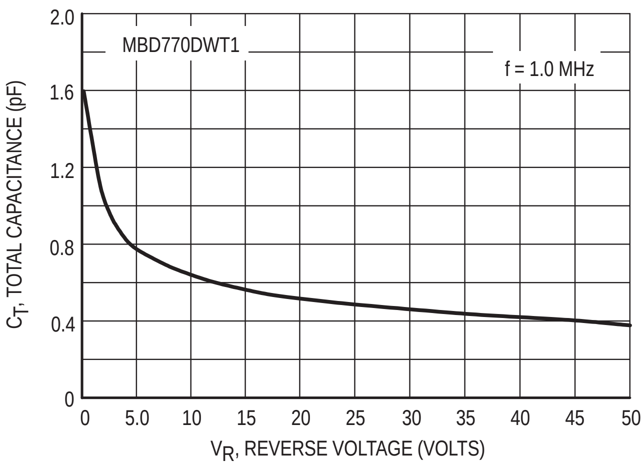


Figure 10. Total Capacitance

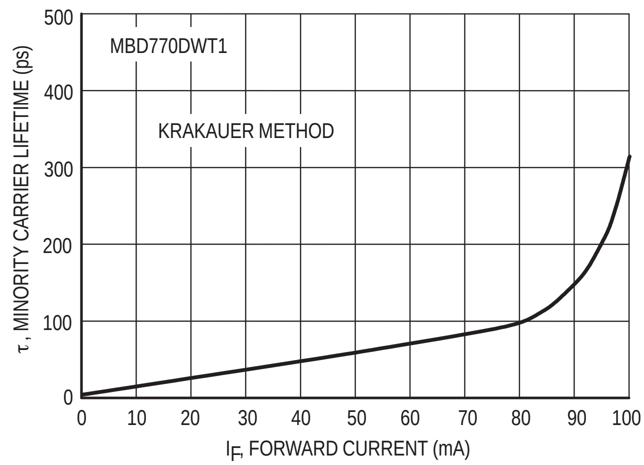


Figure 11. Minority Carrier Lifetime

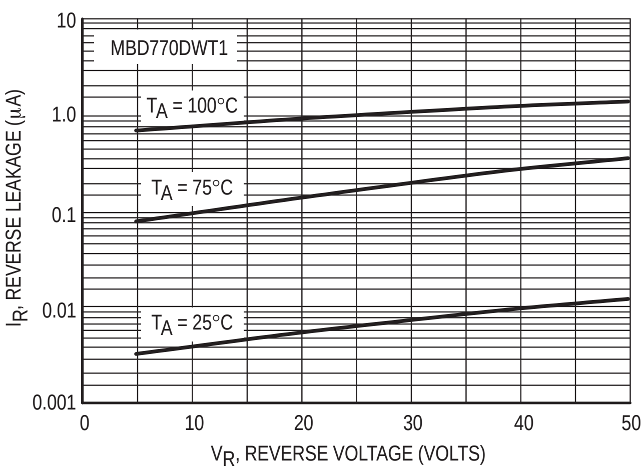


Figure 12. Reverse Leakage

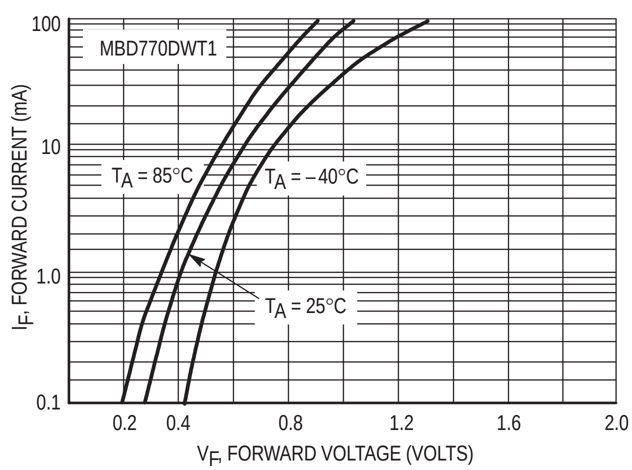


Figure 13. Forward Voltage

Silicon Hot-Carrier Diodes
Schottky Barrier Diodes

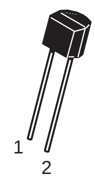
MBD301
MMBD301LT1

Motorola Preferred Devices

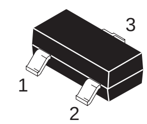
30 VOLTS
SILICON HOT–CARRIER
DETECTOR AND SWITCHING
DIODES

These devices are designed primarily for high–efficiency UHF and VHF detector applications. They are readily adaptable to many other fast switching RF and digital applications. They are supplied in an inexpensive plastic package for low–cost, high–volume consumer and industrial/commercial requirements. They are also available in a Surface Mount package.

- 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



CASE 182–02, STYLE 1
(TO–226AC)



CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

		MBD301	MMBD301LT1	
Rating	**Symbol**	**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 (V_R = 15 V, f = 1.0 MHz) Figure 1	C_T	—	0.9	1.5	pF
Reverse Leakage (V_R = 25 V) Figure 3	I_R	—	13	200	nAdc
Forward Voltage (I_F = 1.0 mAdc) Figure 4	V_F	—	0.38	0.45	Vdc
Forward Voltage (I_F = 10 mAdc) Figure 4	V_F	—	0.52	0.6	Vdc

NOTE: MMBD301LT1 is also available in bulk packaging. Use MMBD301L as the device title to order this device in bulk.

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

TYPICAL ELECTRICAL CHARACTERISTICS

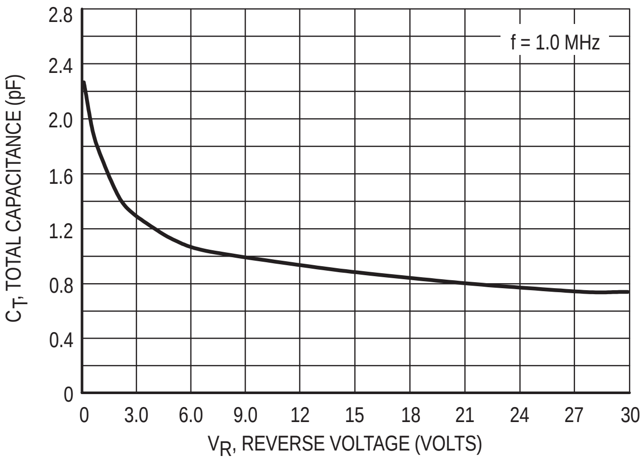


Figure 1. Total Capacitance

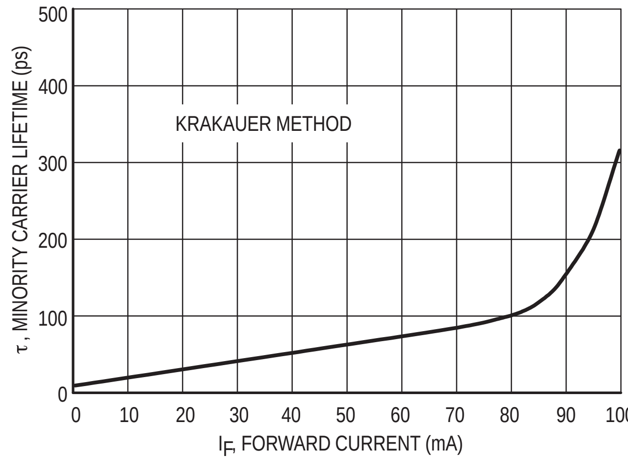


Figure 2. Minority Carrier Lifetime

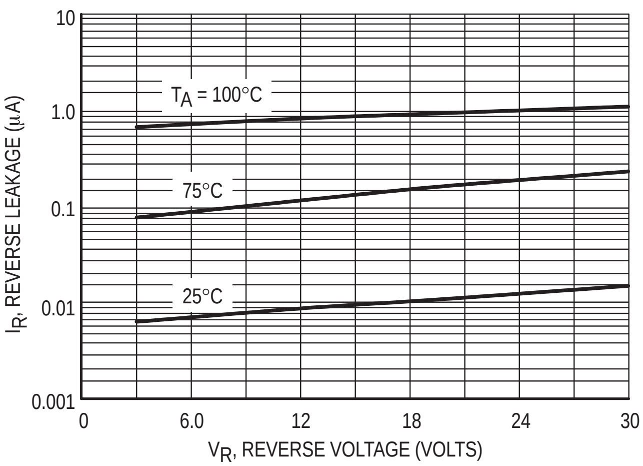


Figure 3. Reverse Leakage

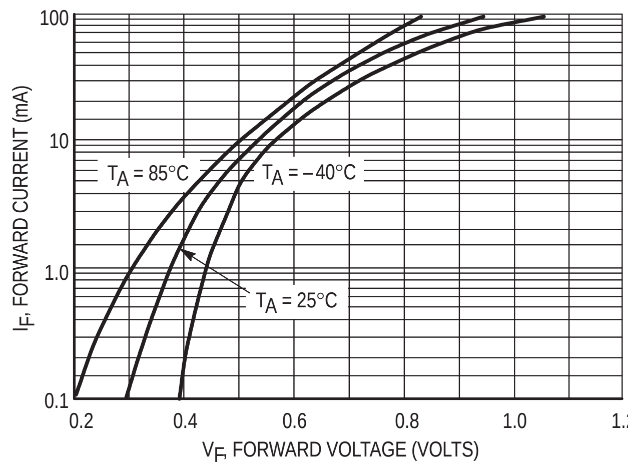


Figure 4. Forward Voltage

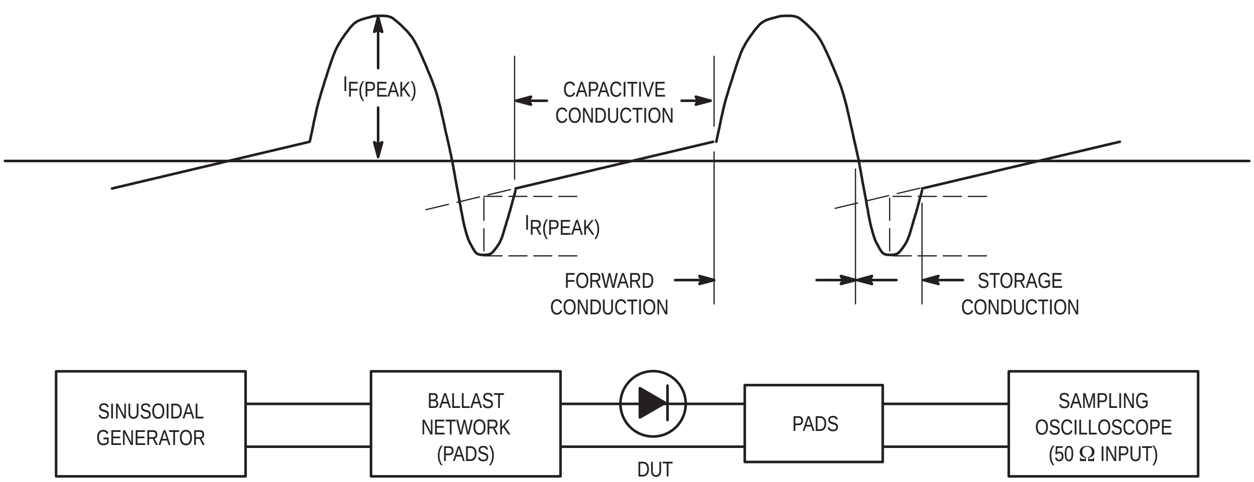


Figure 5. Krakauer Method of Measuring Lifetime

Silicon Hot-Carrier Diodes
Schottky Barrier Diodes

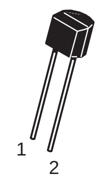
MBD701
MMBD701LT1

Motorola Preferred Devices

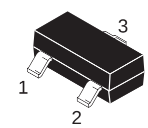
**70 VOLTS
HIGH–VOLTAGE
SILICON HOT–CARRIER
DETECTOR AND SWITCHING
DIODES**

These devices are designed primarily for high–efficiency UHF and VHF detector applications. They are readily adaptable to many other fast switching RF and digital applications. They are supplied in an inexpensive plastic package for low–cost, high–volume consumer and industrial/commercial requirements. They are also available in a Surface Mount package.

- 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)



**CASE 182–02, STYLE 1
(TO–226AC)**



**CASE 318–08, STYLE 8
SOT–23 (TO–236AB)**

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

		MBD701	MMBD701LT1	
Rating	**Symbol**	**Value**		**Unit**
Reverse Voltage	V_R	70		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

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 (V_R = 20 V, f = 1.0 MHz) Figure 1	C_T	—	0.5	1.0	pF
Reverse Leakage (V_R = 35 V) Figure 3	I_R	—	9.0	200	nAdc
Forward Voltage (I_F = 1.0 mAdc) Figure 4	V_F	—	0.42	0.5	Vdc
Forward Voltage (I_F = 10 mAdc) Figure 4	V_F	—	0.7	1.0	Vdc

NOTE: MMBD701LT1 is also available in bulk packaging. Use MMBD701L as the device title to order this device in bulk.

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

TYPICAL ELECTRICAL CHARACTERISTICS

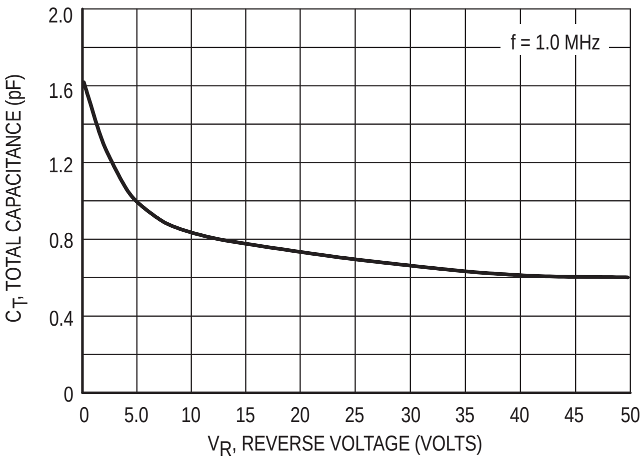


Figure 1. Total Capacitance

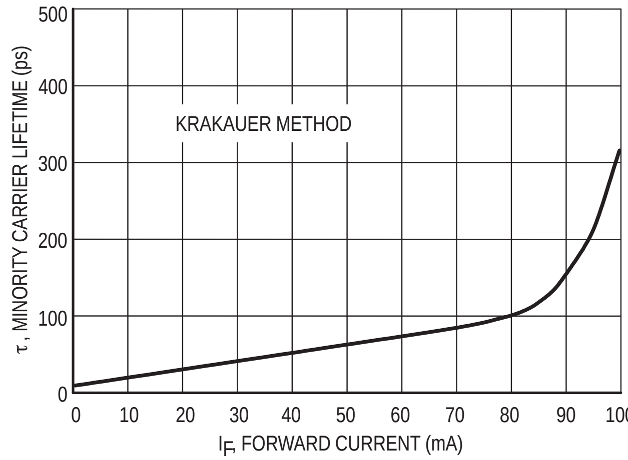


Figure 2. Minority Carrier Lifetime

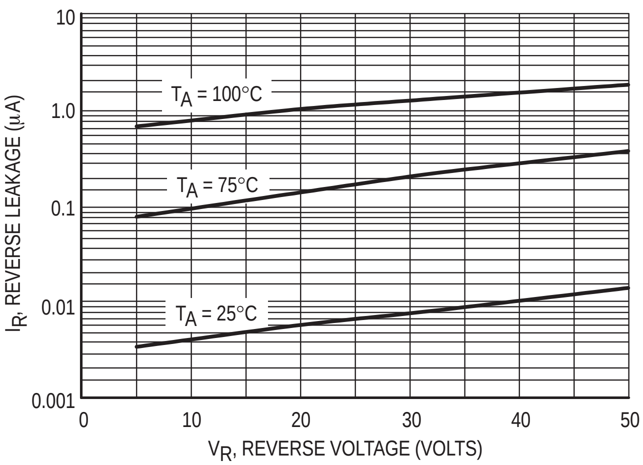


Figure 3. Reverse Leakage

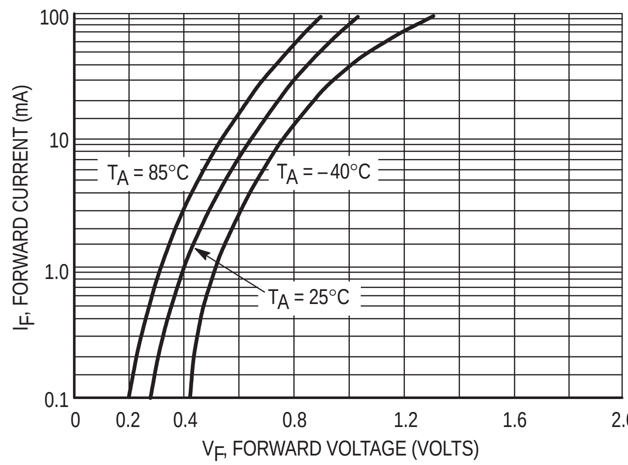


Figure 4. Forward Voltage

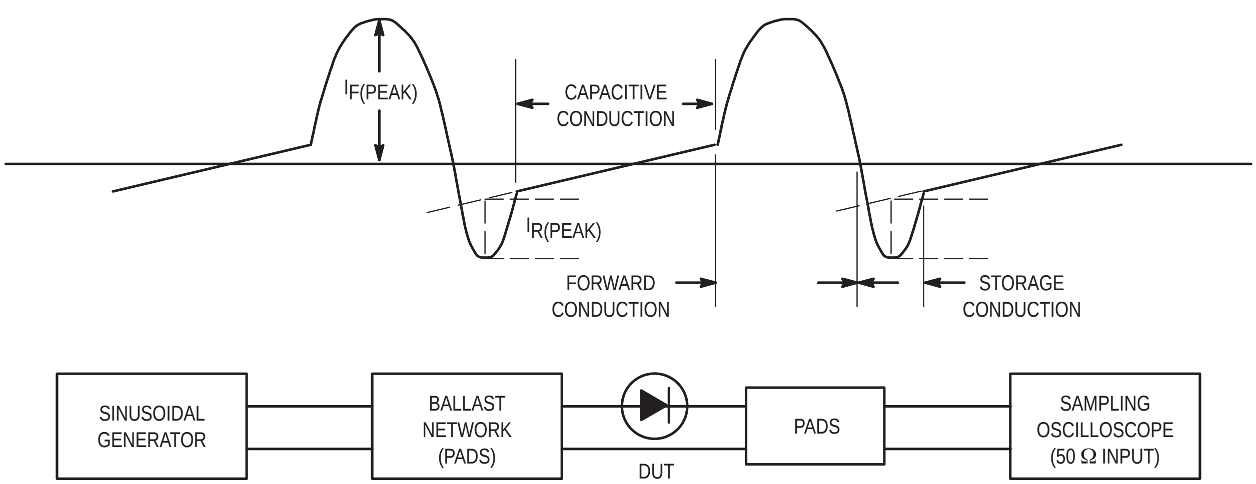


Figure 5. Krakauer Method of Measuring Lifetime

Silicon Epicap Diodes

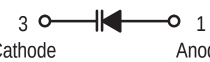
MBV109T1
MMBV109LT1*
MV209*

* Motorola Preferred Devices

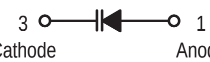
26–32 pF
VOLTAGE VARIABLE
CAPACITANCE DIODES

Designed for general frequency control and tuning applications; providing solid–state reliability in replacement of mechnaical tuning methods.

- High Q with Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Available in Surface Mount Package

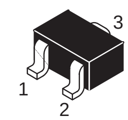


SC–70/SOT–323

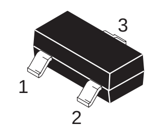


SOT–23

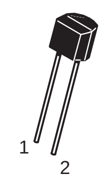
TO–92



CASE 419–02, STYLE 3
SC–70/SOT–323



CASE 318–08, STYLE 6
SOT–23 (TO–236AB)



CASE 182–02, STYLE 1
TO–92 (TO–226AC)

MAXIMUM RATINGS

Rating	Symbol	MBV109T1	MMBV109LT1	MV209	Unit
Reverse Voltage	V_R	30			Vdc
Forward Current	I_F	200			mAdc
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	200 2.0	200 1.6	mW mW/°C
Junction Temperature	T_J	+125			°C
Storage Temperature Range	T_{stg}	–55 to +150			°C

DEVICE MARKING

MBV109T1 = J4A, MMBV109LT1 = M4A, MV209 = MV209

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**
MBV109T1, 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 25 Vdc.

MMBV109LT1 is also available in bulk packaging. Use **MMBV109L** as the device title to order this device in bulk.

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

(Replaces MMBV109LT1/D)

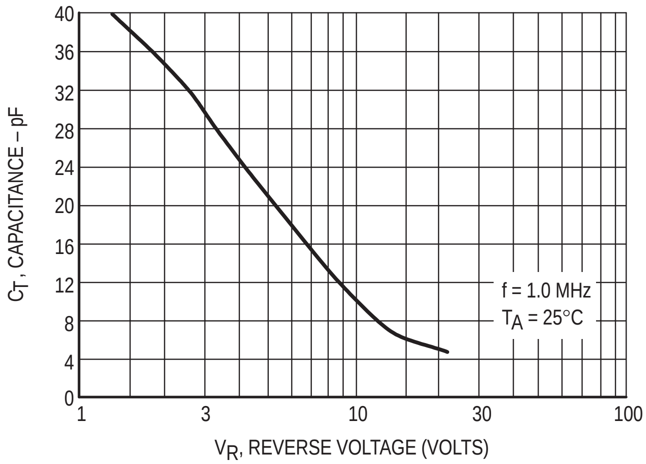


Figure 1. DIODE CAPACITANCE

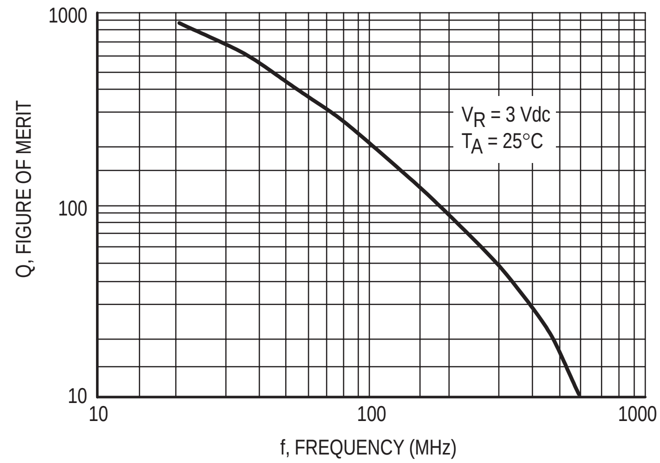


Figure 2. FIGURE OF MERIT

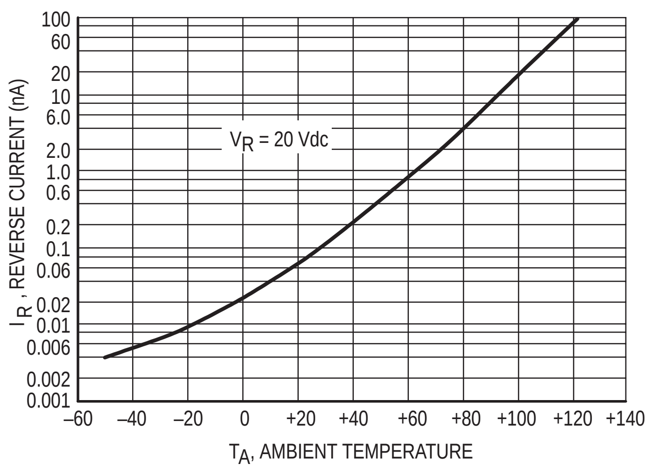


Figure 3. LEAKAGE CURRENT

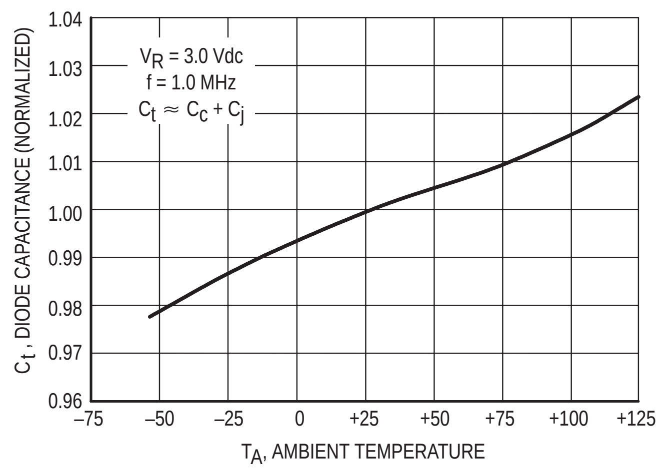


Figure 4. DIODE CAPACITANCE

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.

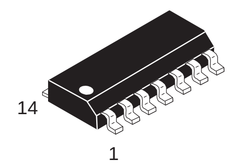
Monolithic Diode Arrays

Surface Mount Diode Arrays

MMAD130
MMAD1103
MMAD1105
MMAD1107
MMAD1109

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



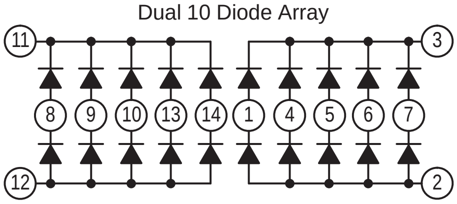
CASE 751A–03
SO–14

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	mAdc
Continuous Forward Current	I_F	400	mAdc
Power Dissipation Derating Factor	P_D	500 4.0	mW mW/°C
Operating Temperature	T_A	–65 to +150	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

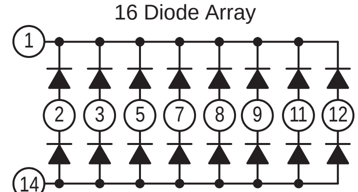
SO–14 PIN DIAGRAM

1
Dual 10 Diode Array



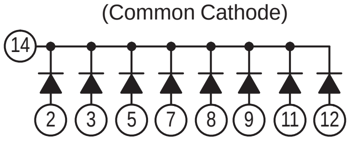
MMAD130

2
16 Diode Array



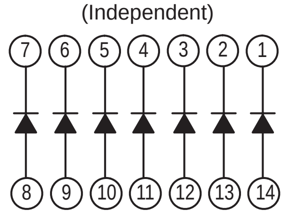
NC Pin 4, 6, 10, 13
MMAD1103

3
8 Diode Array
(Common Cathode)



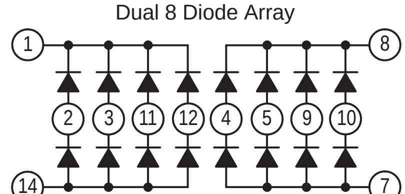
NC Pin 1, 4, 6, 10, 13
MMAD1105

5
7 Diode Array
(Independent)



MMAD1109

4
Dual 8 Diode Array



NC Pin 6, 13
MMAD1107

REV 1

Device	Description	Diagram
MMAD130	Dual 10 Diode Array	1
MMAD1103	16 Diode Array	2
MMAD1105	8 Diode Array Common Cathode	3
MMAD1107	Dual 8 Diode Array	4
MMAD1109	7 Diode Array	5

ELECTRICAL CHARACTERISTICS (@ 25°C Free–Air Temperature)

Characteristic	Symbol	Limit		Unit
		Min	Max	
Reverse Breakdown Voltage(1) (I_R = 10 µAdc)	$V_{(BR)}$	50	—	Vdc
Static Reverse Current (V_R = 40 Vdc)	I_R	—	0.1	µAdc
Static Forward Voltage (I_F = 100 mAdc) (I_F = 500 mAdc)(2)	V_F	 — —	 1.2 1.6	Vdc
Peak Forward Voltage(3) (I_F = 500 mAdc)	V_{FM}	—	5.0	Vdc

SWITCHING CHARACTERISTICS (@ 25°C Free–Air Temperature)

Characteristic	Symbol	Typical Value	Unit
Forward Recovery Time (I_F = 500 mAdc)	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

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.

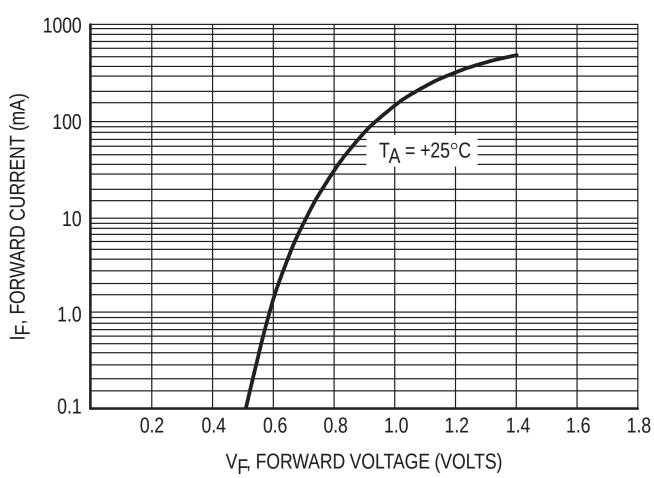


Figure 1. Typical Characteristics Static Forward Voltage

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 MMAD1103, 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.

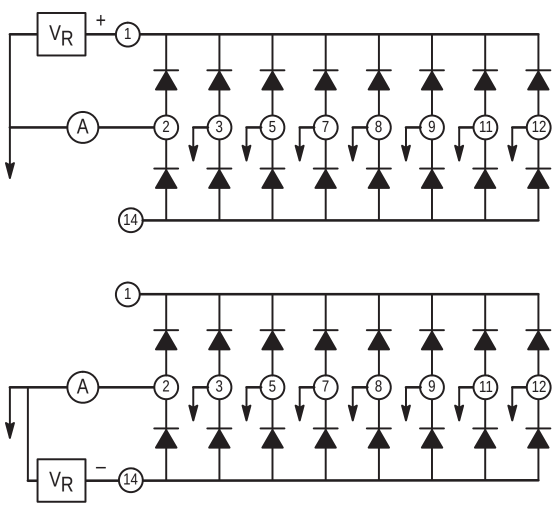


Figure 1

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.

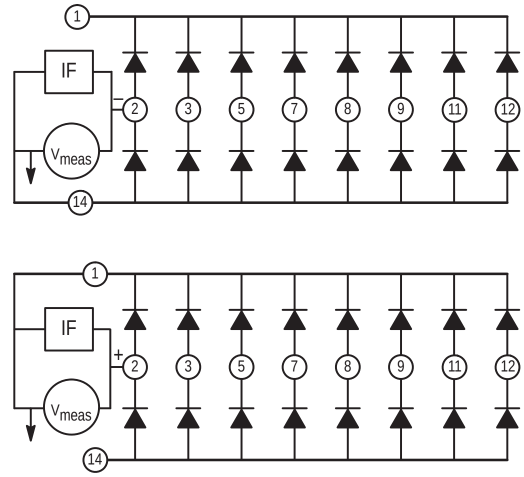


Figure 2

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.

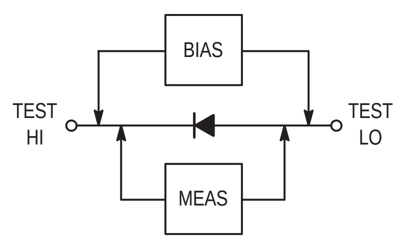


Figure 3

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

Monolithic Diode Array

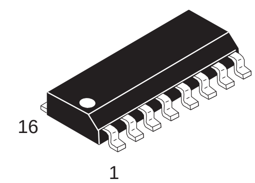
Surface Mount Isolated 8–Diode Array

MMAD1108

Motorola Preferred Device

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
  - Thin–Film Memories
  - Plated–Wire Memories
  - Decoding or Encoding

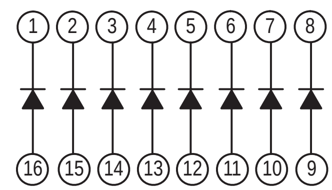


CASE 751B–05
SO–16

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	mAdc
Continuous Forward Current	I_F	400	mAdc
Power Dissipation Derating Factor	P_D	500 4.0	mW mW/°C
Operating Temperature	T_A	–65 to +150	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

PIN CONNECTION DIAGRAM



ELECTRICAL CHARACTERISTICS (@ 25°C Free–Air Temperature)

Characteristic	Symbol	Limit Min	Limit Max	Unit
Reverse Breakdown Voltage(1) (I_R = 10 μAdc)	$V_{(BR)}$	50	—	Vdc
Static Reverse Current (V_R = 40 Vdc)	I_R	—	0.1	μAdc
Static Forward Voltage (I_F = 100 mAdc) (I_F = 500 mAdc)(2)	V_F	 — —	 1.2 1.6	Vdc
Peak Forward Voltage(3) (I_F = 500 mAdc)	V_{FM}	—	5.0	Vdc

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.

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

REV 1

ELECTRICAL CHARACTERISTICS (@ 25°C Free–Air Temperature) (Continued)

Characteristic	Symbol	Typical Value	Unit
SWITCHING CHARACTERISTICS (@ 25°C Free–Air Temperature)			
Forward Recovery Time (I_F = 500 mAdc)	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

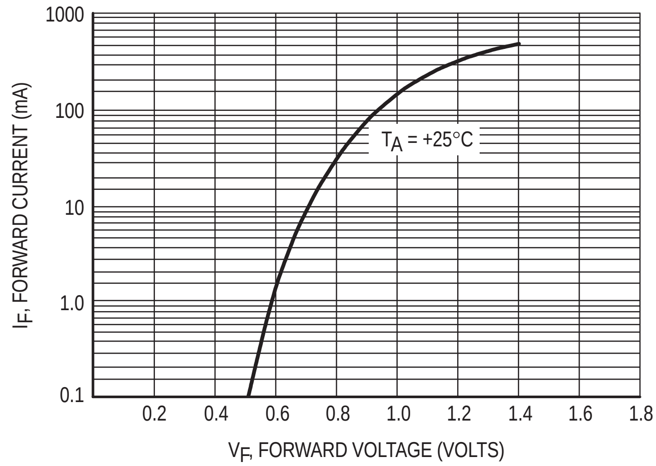


Figure 1. Typical Characteristics Static Forward Voltage

TEST PROCEDURE FOR MULTIPLE DIODES

1.0. REVERSE BIAS TESTING

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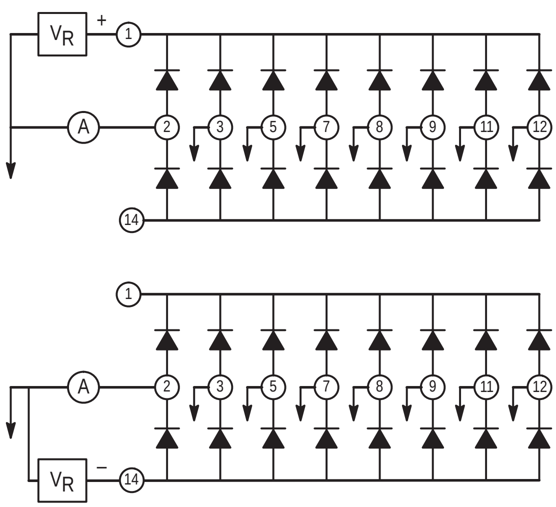


Figure 1

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.

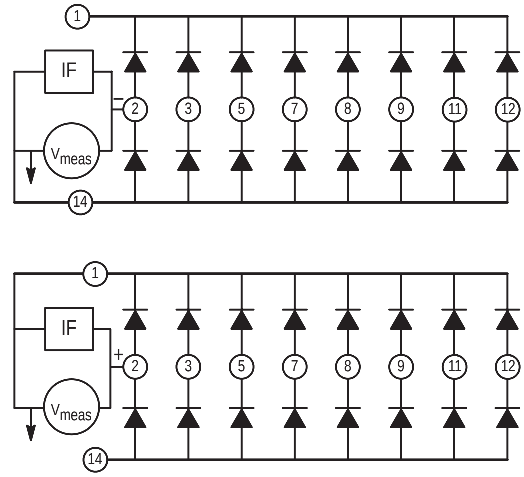


Figure 2

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.

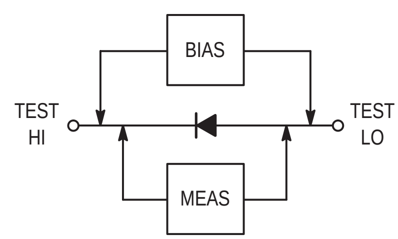


Figure 3

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:

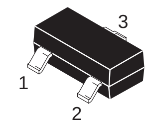
V_F @ 10 mA < 0.6 V
V_F @ 50 mA < 0.8 V
V_F @ 100 mA < 1 V
V_F @ 500 mA < 1.5 V

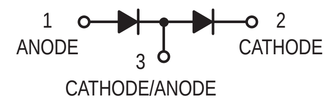
Dual Hot Carrier Mixer Diodes

MMBD352LT1
MMBD353LT1
MMBD354LT1
MMBD355LT1

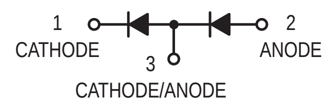
These devices are designed primarily for UHF mixer applications but are suitable also for use in detector and ultra–fast switching circuits.

- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- Low Forward Voltage — 0.5 Volts (Typ) @ I_F = 10 mA

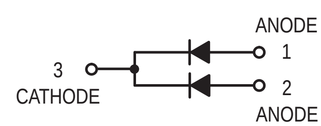




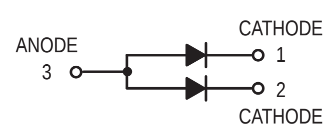
MMBD352LT1
CASE 318–08, STYLE 11
SOT–23 (TO–236AB)



MMBD353LT1
CASE 318–08, STYLE 19
SOT–23 (TO–236AB)



MMBD354LT1
CASE 318–08, STYLE 9
SOT–23 (TO–236AB)



MMBD355LT1
CASE 318–08, STYLE 12
SOT–23 (TO–236AB)

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(1) 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(2) 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

DEVICE MARKING

MMBD352LT1 = M5G; MMBD353LT1 = M4F; MMBD354LT1 = M6H; MMBD355LT1 = MJ1

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.60	V
Reverse Voltage Leakage Current (V_R = 3.0 V) (V_R = 7.0 V)	I_R	 — —	 0.25 10	μA
Capacitance (V_R = 0 V, f = 1.0 MHz)	C	—	1.0	pF

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

REV 2

TYPICAL CHARACTERISTICS

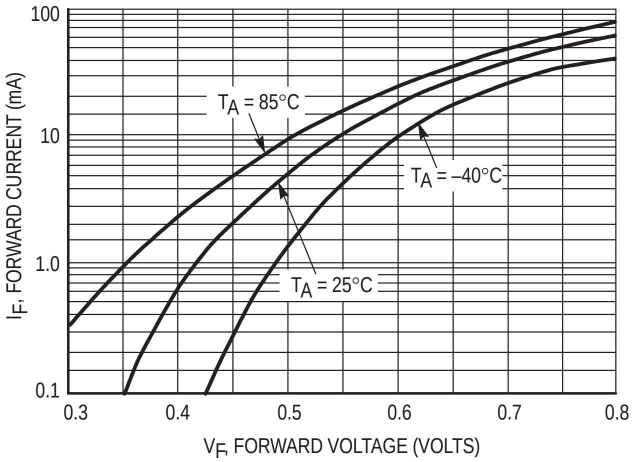


Figure 1. Forward Voltage

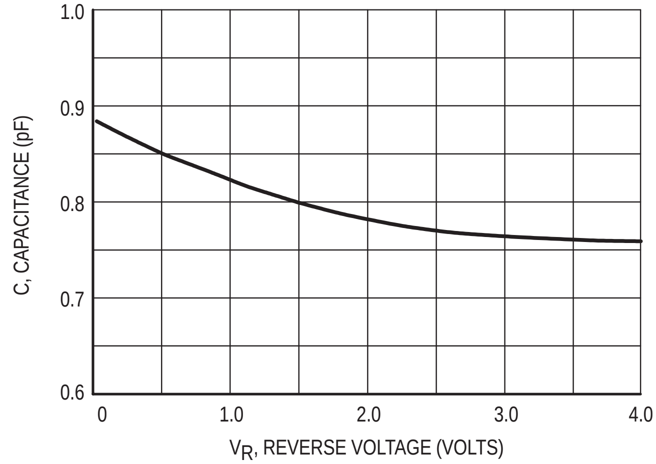


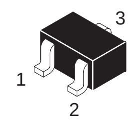
Figure 2. Capacitance

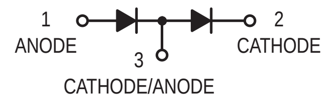
Dual Schottky Barrier Diode

MMBD352WT1

These devices are designed primarily for UHF mixer applications but are suitable also for use in detector and ultra–fast switching circuits.

- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- Low Forward Voltage — 0.5 Volts (Typ) @ I_F = 10 mA





MMBD352WT1
CASE 419–02, STYLE 9
SOT–323 (SC–70)

MAXIMUM RATINGS

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(1) T_A = 25°C Derate above 25°C	P_D	200 1.6	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	625	°C/W
Total Device Dissipation Alumina Substrate(2) 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

DEVICE MARKING

MMBD352WT1 = M5

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.60	V
Reverse Voltage Leakage Current (V_R = 3.0 V) (V_R = 7.0 V)	I_R	 — —	 0.25 10	μA
Capacitance (V_R = 0 V, f = 1.0 MHz)	C	—	1.0	pF

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

TYPICAL CHARACTERISTICS

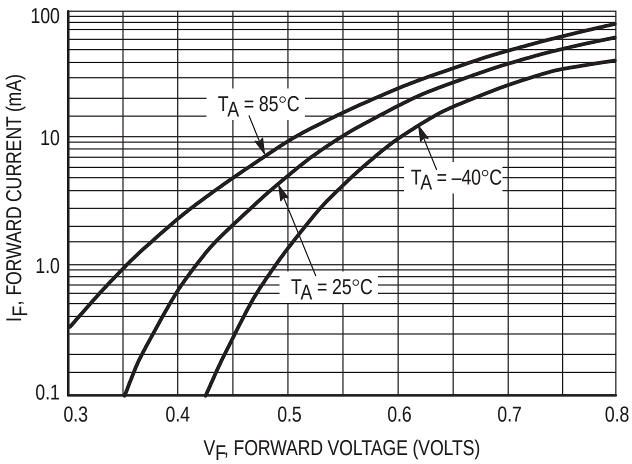


Figure 1. Forward Voltage

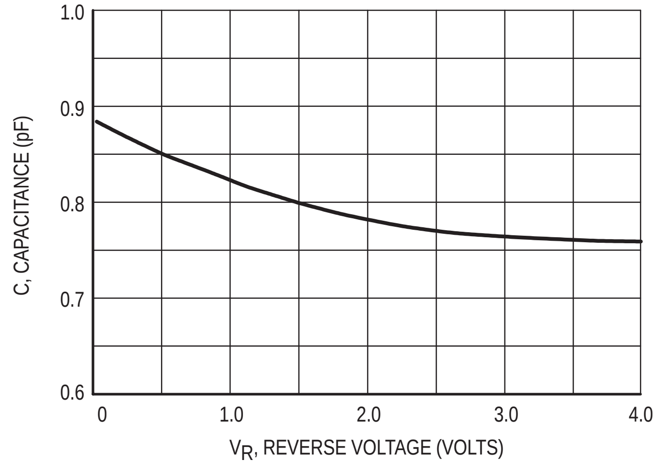


Figure 2. Capacitance

Dual Hot-Carrier Diodes

Schottky Barrier Diodes

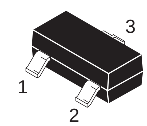
These devices are designed primarily for high–efficiency UHF and VHF detector applications. They are readily adaptable to many other fast switching RF and digital applications. They are supplied in an inexpensive plastic package for low–cost, high–volume consumer and industrial/commercial requirements.

- Extremely Low Minority Carrier Lifetime
- Very Low Capacitance
- Low Reverse Leakage

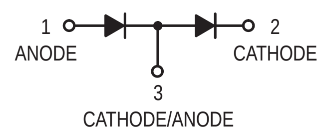
MMBD452LT1

Motorola Preferred Devices

30 VOLTS
DUAL HOT–CARRIER
DETECTOR AND SWITCHING
DIODES



CASE 318 – 08, STYLE 11
SOT– 23 (TO – 236AB)



MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	225 1.8	mW mW/°C
Operating Junction Temperature Range	T_J	– 55 to +125	°C
Storage Temperature Range	T_{stg}	– 55 to +150	°C

DEVICE MARKING

MMBD452LT1 = 5N

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µA)	$V_{(BR)R}$	30	—	—	Volts
Total Capacitance (V_R = 15 V, f = 1.0 MHz) Figure 1	C_T	—	0.9	1.5	pF
Reverse Leakage (V_R = 25 V) Figure 3	I_R	—	13	200	nAdc
Forward Voltage (I_F = 1.0 mAdc) Figure 4	V_F	—	0.38	0.45	Vdc
Forward Voltage (I_F = 10 mAdc) Figure 4	V_F	—	0.52	0.6	Vdc

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

TYPICAL ELECTRICAL CHARACTERISTICS

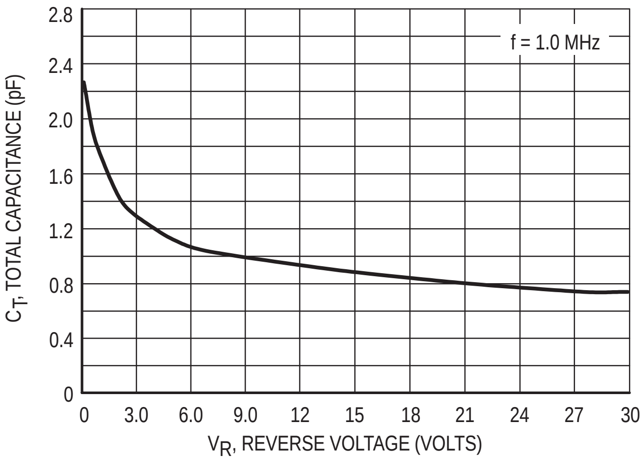


Figure 1. Total Capacitance

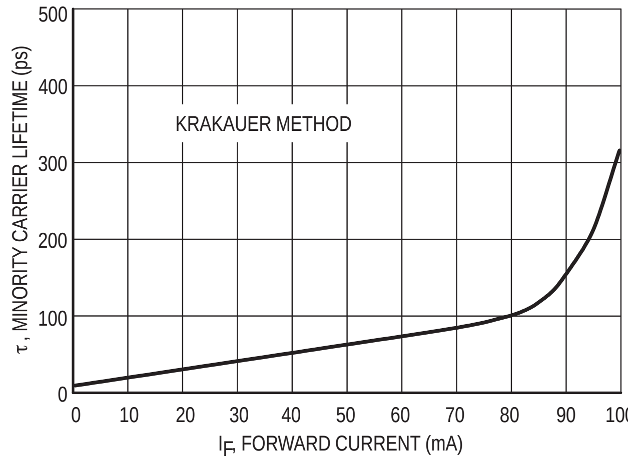


Figure 2. Minority Carrier Lifetime

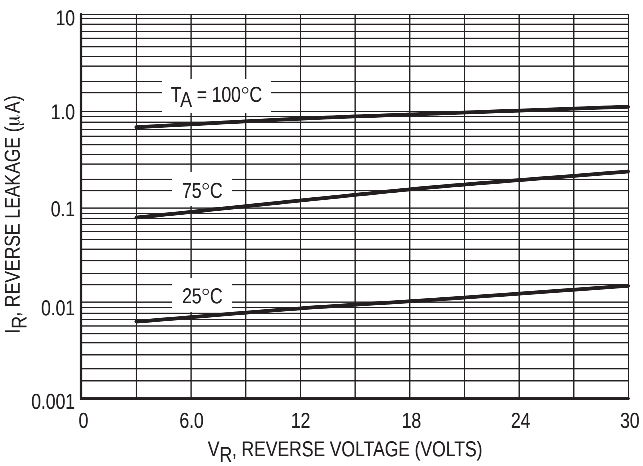


Figure 3. Reverse Leakage

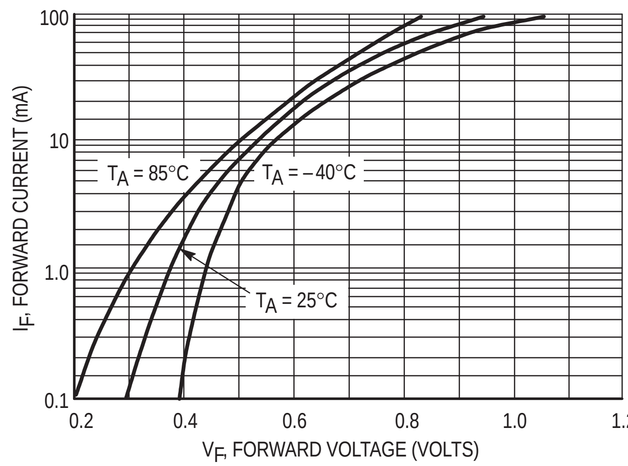


Figure 4. Forward Voltage

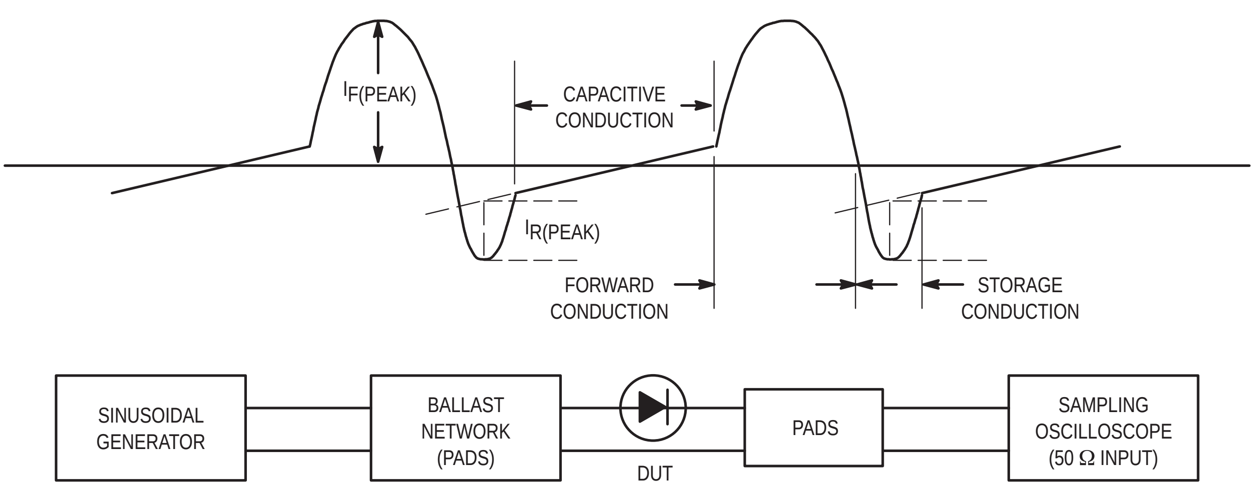


Figure 5. Krakauer Method of Measuring Lifetime

Common Anode Schottky Barrier Diodes

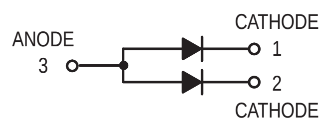
MMBD717LT1

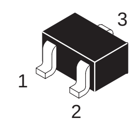
Motorola Preferred Device

20 VOLT SCHOTTKY BARRIER DETECTOR AND SWITCHING DIODES

These Schottky barrier diodes are designed for high speed switching applications, circuit protection, and voltage clamping. Extremely low forward voltage reduces conduction loss. Miniature surface mount package is excellent for hand held and portable applications where space is limited.

- Extremely Fast Switching Speed
- Extremely Low Forward Voltage — 0.28 Volts (Typ) @ I_F = 1 mAdc





CASE 419–02, STYLE 2
SOT–323 (SC–70)

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 200 1.6	 mW mW/°C
Operating Junction Temperature Range	T_J	–55 to +150	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

DEVICE MARKING

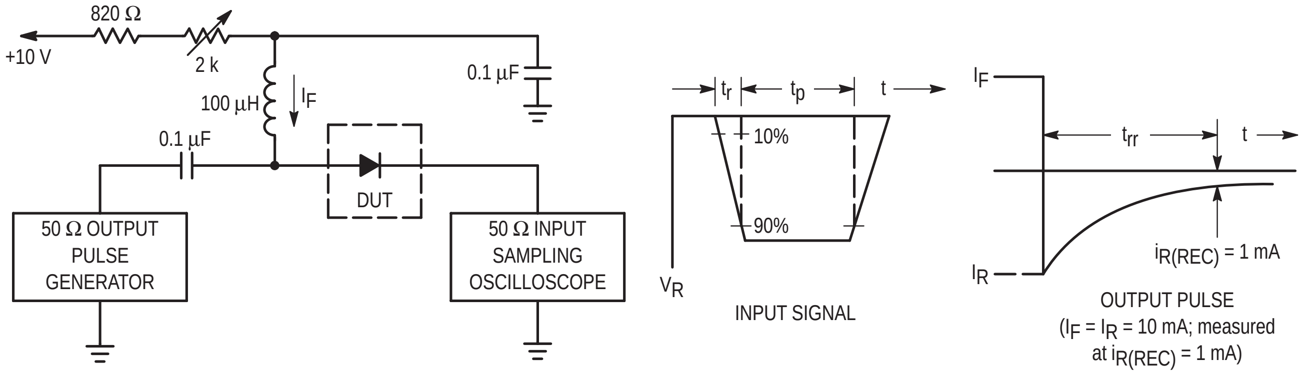
MMBD717LT1 = B3

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
Total Capacitance (V_R = 1.0 V, f = 1.0 MHz)	C_T	—	2.0	2.5	pF
Reverse Leakage (V_R = 10 V)	I_R	—	0.05	1.0	μAdc
Forward Voltage (I_F = 1.0 mAdc)	V_F	—	0.28	0.37	Vdc

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

REV 2



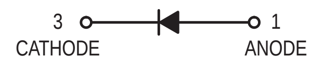
Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

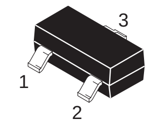
Figure 1. Recovery Time Equivalent Test Circuit

High-Speed Switching Diode

MMBD914LT1

Motorola Preferred Device





CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

MAXIMUM RATINGS

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(1) 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,(2) 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

DEVICE MARKING

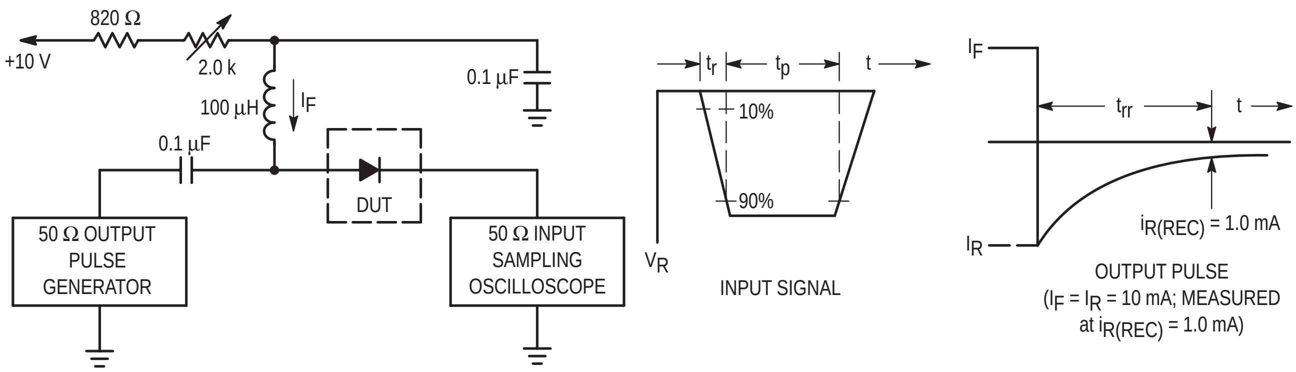
MMBD914LT1 = 5D

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 (V_R = 20 Vdc) (V_R = 75 Vdc)	I_R	 — —	 25 5.0	 nAdc 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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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



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 1. Recovery Time Equivalent Test Circuit

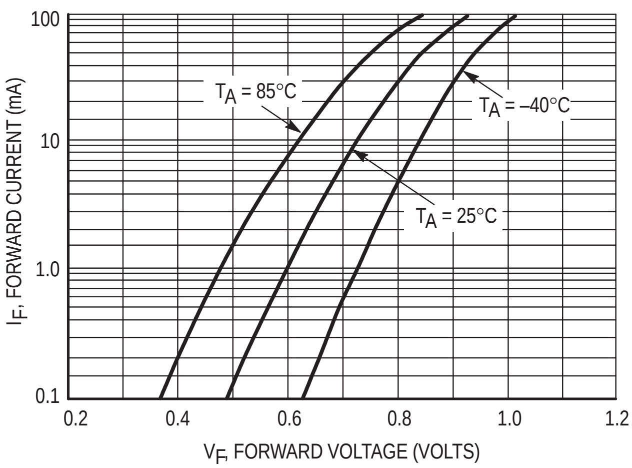


Figure 2. Forward Voltage

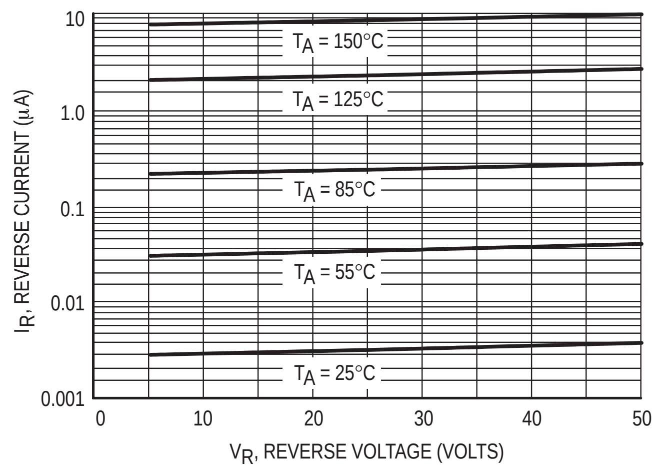


Figure 3. Leakage Current

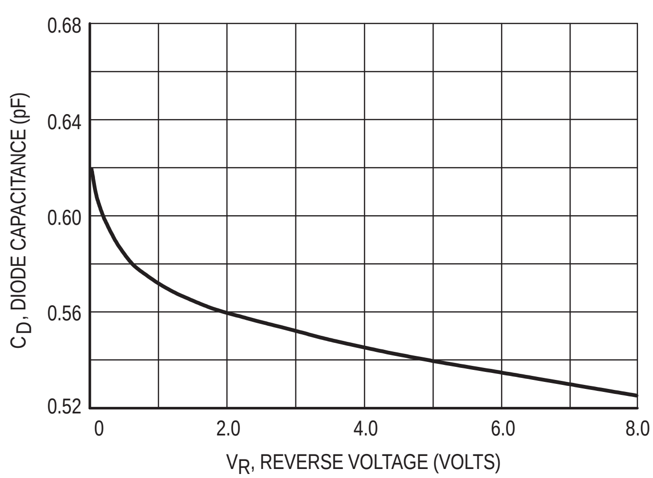


Figure 4. Capacitance

GREEN LINE™

Switching Diode

Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

This switching diode has the following features:

- Very Low Leakage (≤ 500 pA) promotes extended battery life by decreasing energy waste
- Offered in four Surface Mount package types
- Available in 8 mm Tape and Reel in quantities of 3,000

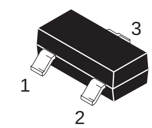
Applications

- ESD Protection
- Reverse Polarity Protection
- Steering Logic
- Medium–Speed Switching

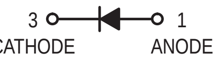
MMBD1000LT1
MMBD2000T1
MMBD3000T1
MMSD1000T1

Motorola Preferred Devices

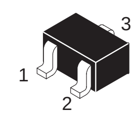
MMBD1000LT1



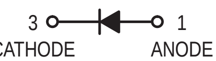
CASE 318-08, STYLE 8
SOT-23 (TO-236AB)



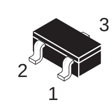
MMBD2000T1



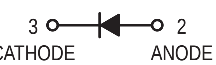
CASE 419-02, STYLE 2
SC–70/SOT–323



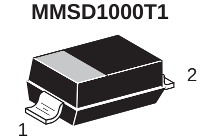
MMBD3000T1



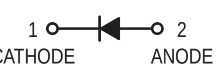
CASE 318D-04, STYLE 2
SC–59



MMSD1000T1



CASE 425-04, STYLE 1
SOD–123



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	30	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	I_{FM} (surge)	500	mA

DEVICE MARKING

MMBD1000LT1 = AY
MMBD2000T1 = DH
MMBD3000T1 = XP
MMSD1000T1 = 4K

THERMAL CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Total Device Dissipation FR-4 Board (1)		P_D		mW
T_A = 25°C	MMBD1000LT1, MMBD3000T1, MMSD1000T1		225	
	MMBD2000T1		150	
Derate above 25°C	MMBD1000LT1, MMBD3000T1, MMSD1000T1		1.8	mW/°C
	MMBD2000T1		1.2	
Thermal Resistance Junction to Ambient		$R_{\theta JA}$		°C/W
	MMBD1000LT1, MMBD3000T1, MMSD1000T1		556	
	MMBD2000T1		833	
Junction and Storage Temperature		T_J, T_{stg}	–55 to +150	°C

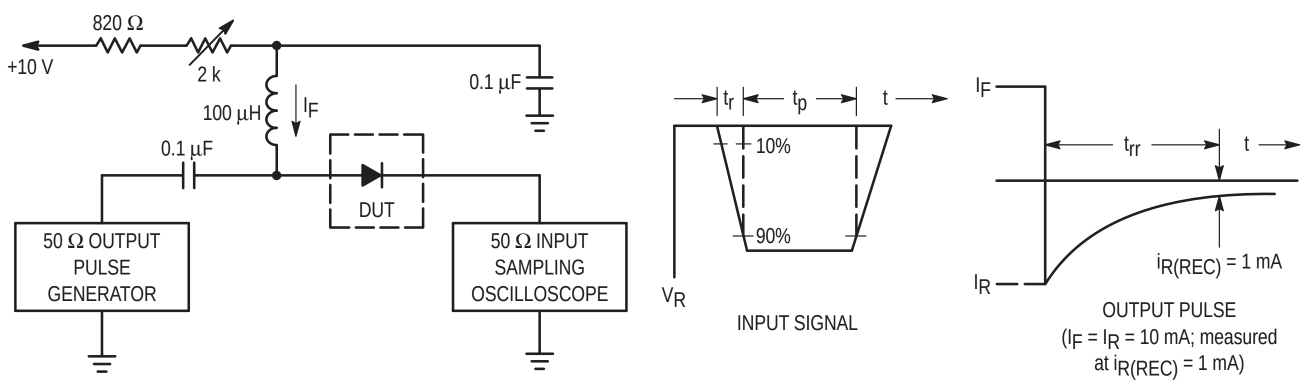
(1) Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

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

REV 1

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_{BR} = 100 µA)	$V_{(BR)}$	30	—	V
Reverse Voltage Leakage Current (V_R = 75 V)	I_R	—	500	pA
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA)	V_F	— —	850 950	mV
Diode Capacitance (V_R = 0 V, f = 1.0 MHz)	C_D	—	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mA) (Figure 1)	t_{rr}	—	3.0	µs



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 1. Recovery Time Equivalent Test Circuit

GREEN LINE™

Switching Diode

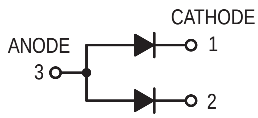
Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

This switching diode has the following features:

- Very Low Leakage (≤ 500 pA) promotes extended battery life by decreasing energy waste. Guaranteed leakage limit is for each diode in the pair contingent upon the other diode being in a non–forward–biased condition.
- Offered in four Surface Mount package types
- Available in 8 mm Tape and Reel in quantities of 3,000

Applications

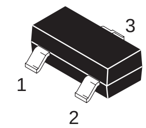
- ESD Protection
- Reverse Polarity Protection
- Steering Logic
- Medium–Speed Switching



MMBD1005LT1
MMBD2005T1
MMBD3005T1

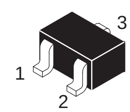
Motorola Preferred Devices

MMBD1005LT1



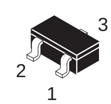
CASE 318-08, STYLE 12
SOT-23 (TO-236AB)

MMBD2005T1



CASE 419-02, STYLE 4
SC–70/SOT–323

MMBD3005T1



CASE 318D-04, STYLE 5
SC–59

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	30	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	I_{FM} (surge)	500	mA

DEVICE MARKING

MMBD1005LT1 = A3
MMBD2005T1 = DI
MMBD3005T1 = XQ

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-4 Board (1)	P_D		mW
T_A = 25°C MMBD1005LT1, MMBD3005T1		225	
MMBD2005T1		150	
Derate above 25°C MMBD1005LT1, MMBD3005T1		1.8	mW/°C
MMBD2005T1		1.2	
Thermal Resistance Junction to Ambient	$R_{\theta JA}$		°C/W
MMBD1005LT1, MMBD3005T1		556	
MMBD2005T1		833	
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

(1) Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

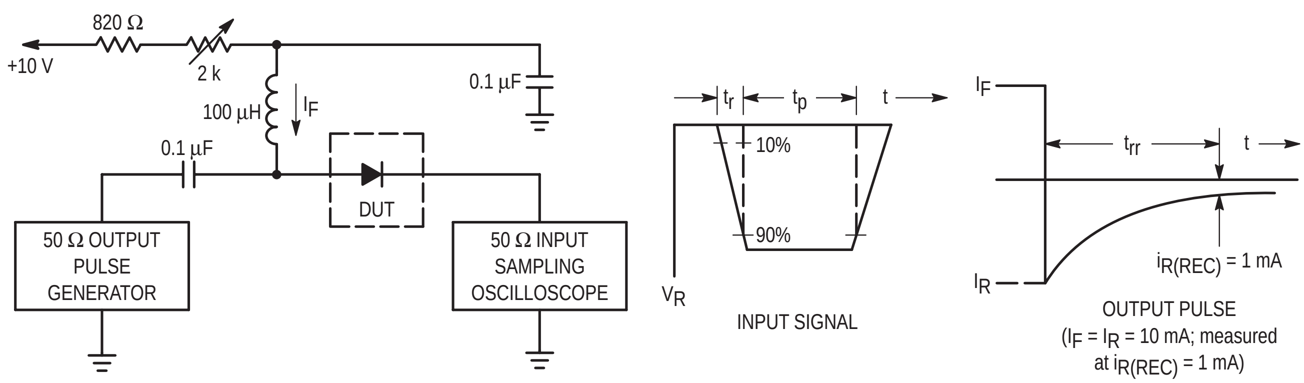
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_{BR} = 100 µA)	$V_{(BR)}$	30	—	V
Reverse Voltage Leakage Current (V_R = 75 V)(2)	I_R	—	500	pA
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA)	V_F	— —	850 950	mV
Diode Capacitance (V_R = 0 V, f = 1.0 MHz)	C_D	—	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mA) (Figure 1)	t_{rr}	—	3.0	µs

(2) Guaranteed leakage limit is for each diode in the pair contingent upon the other diode being in a non–forward–biased condition.



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 1. Recovery Time Equivalent Test Circuit

GREEN LINE™

Switching Diode

MMBD1010LT1
MMBD2010T1
MMBD3010T1

Motorola Preferred Devices

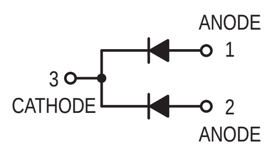
Part of the GreenLine™ Portfolio of devices with energy–conserving traits.

This switching diode has the following features:

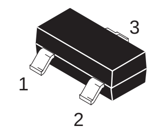
- Very Low Leakage (≤ 500 pA) promotes extended battery life by decreasing energy waste. Guaranteed leakage limit is for each diode in the pair contingent upon the other diode being in a non–forward–biased condition.
- Offered in four Surface Mount package types
- Available in 8 mm Tape and Reel in quantities of 3,000

Applications

- ESD Protection
- Reverse Polarity Protection
- Steering Logic
- Medium–Speed Switching

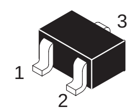


MMBD1010LT1



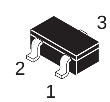
CASE 318-08, STYLE 9
SOT-23 (TO-236AB)

MMBD2010T1



CASE 419-02, STYLE 5
SC–70/SOT–323

MMBD3010T1



CASE 318D-04, STYLE 3
SC–59

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	30	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	I_{FM} (surge)	500	mA

DEVICE MARKING

MMBD1010LT1 = A5
MMBD2010T1 = DP
MMBD3010T1 = XS

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-4 Board (1)	P_D		mW
T_A = 25°C MMBD1010LT1, MMBD3010T1		225	
MMBD2010T1		150	
Derate above 25°C MMBD1010LT1, MMBD3010T1		1.8	mW/°C
MMBD2010T1		1.2	
Thermal Resistance Junction to Ambient	$R_{\theta JA}$		°C/W
MMBD1010LT1, MMBD3010T1		556	
MMBD2010T1		833	
Junction and Storage Temperature	T_J, T_{stg}	–55 to +150	°C

(1) Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

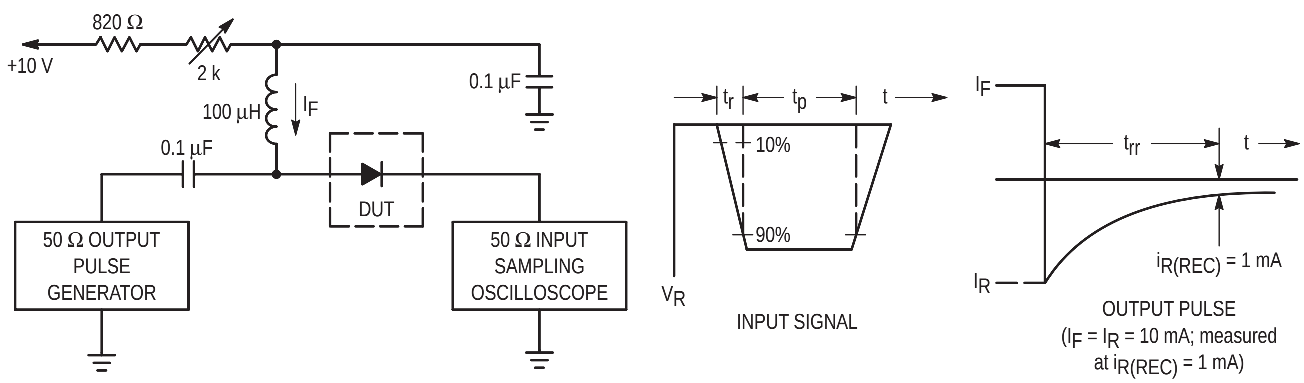
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_{BR} = 100 µA)	$V_{(BR)}$	30	—	V
Reverse Voltage Leakage Current (V_R = 75 V)(2)	I_R	—	500	pA
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA)	V_F	— —	850 950	mV
Diode Capacitance (V_R = 0 V, f = 1.0 MHz)	C_D	—	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mA) (Figure 1)	t_{rr}	—	3.0	µs

(2) Guaranteed leakage limit is for each diode in the pair contingent upon the other diode being in a non–forward–biased condition.

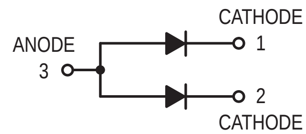


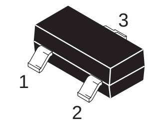
Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

Figure 1. Recovery Time Equivalent Test Circuit

Monolithic Dual Switching Diodes

MMBD2835LT1
MMBD2836LT1





CASE 318–08, STYLE 12
SOT–23 (TO–236AB)

MAXIMUM RATINGS (EACH DIODE)

Rating		Symbol	Value	Unit
Reverse Voltage	MMBD2835LT1 MMBD2836LT1	V_R	35 75	Vdc
Forward Current		I_F	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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,(2) 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

DEVICE MARKING

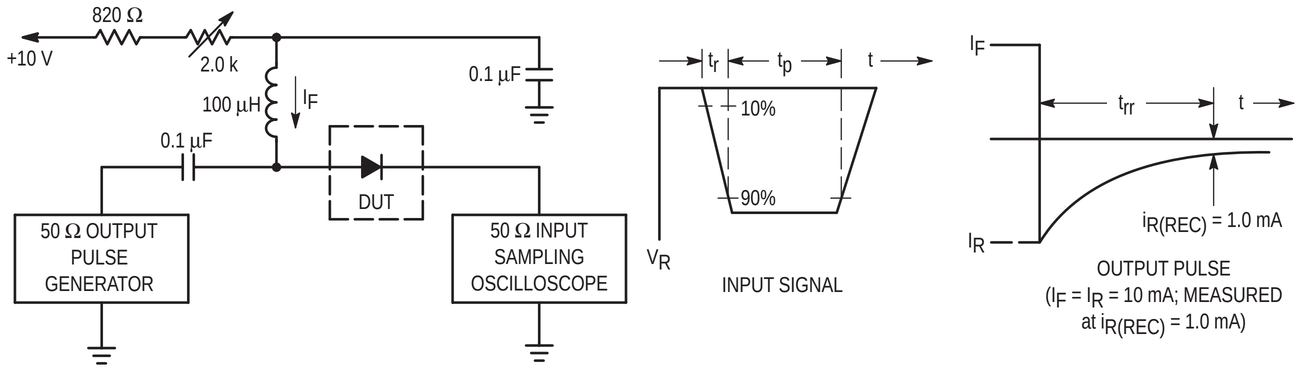
MMBD2835LT1 = A3X; MMBD2836LT1 = A2X

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 V, 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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

REV 1



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 1. Recovery Time Equivalent Test Circuit

CURVES APPLICABLE TO EACH CATHODE

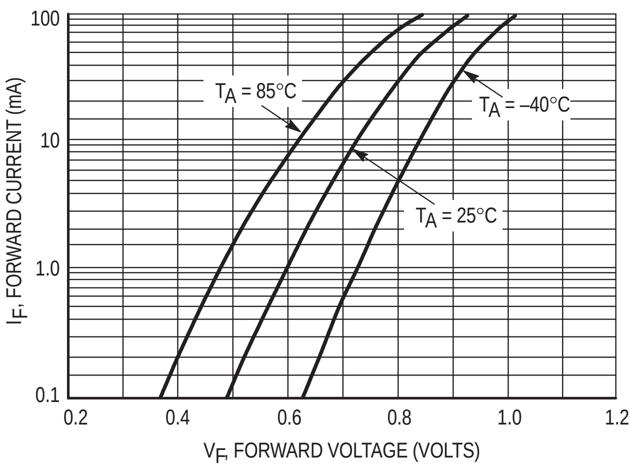


Figure 2. Forward Voltage

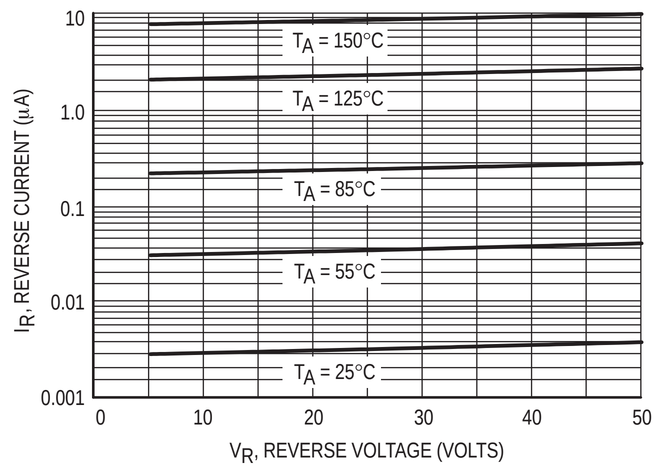


Figure 3. Leakage Current

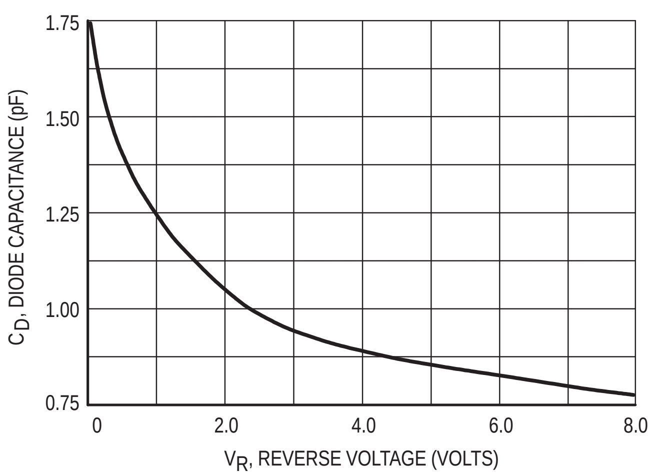
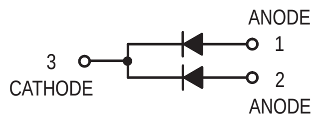
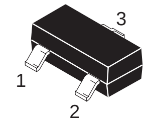


Figure 4. Capacitance

Monolithic Dual Switching Diodes

MMBD2837LT1
MMBD2838LT1





CASE 318–08, STYLE 9
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

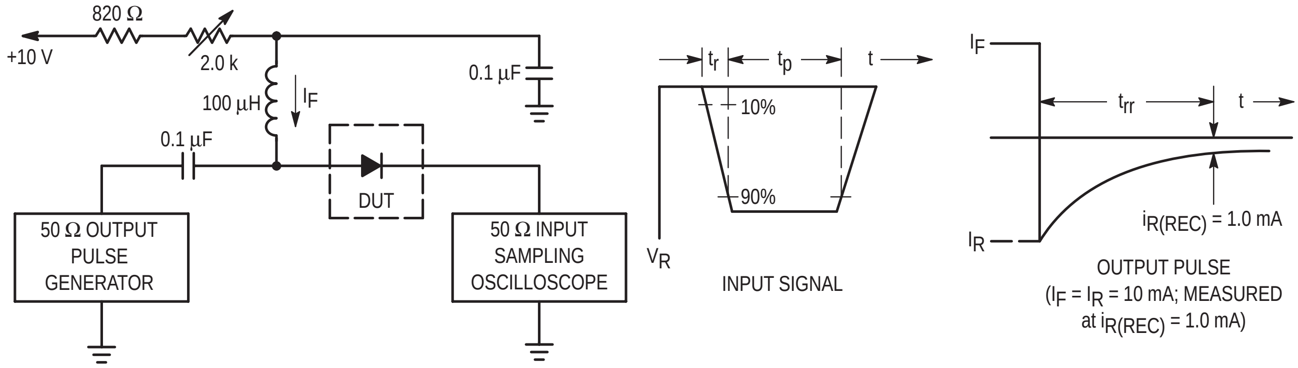
MMBD2837LT1 = A5; MMBD2838LT1 = MA6

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 V, 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

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

REV 1



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 1. Recovery Time Equivalent Test Circuit

CURVES APPLICABLE TO EACH CATHODE

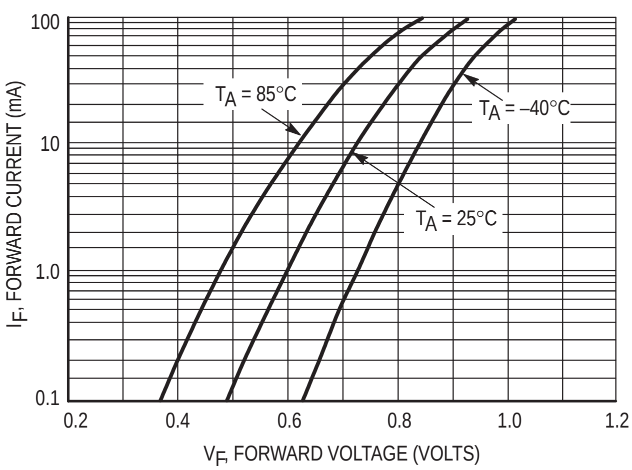


Figure 2. Forward Voltage

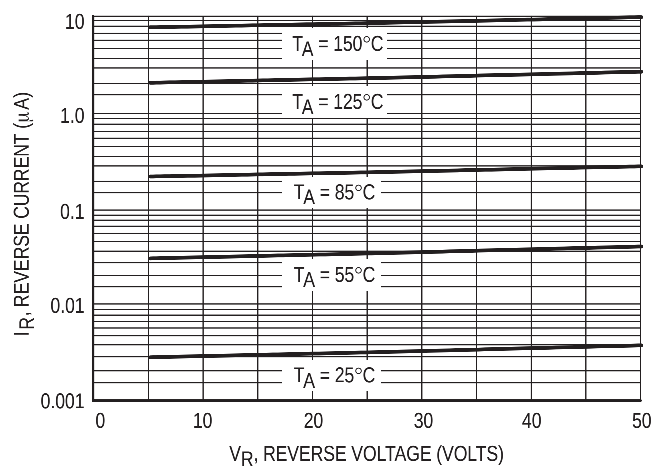


Figure 3. Leakage Current

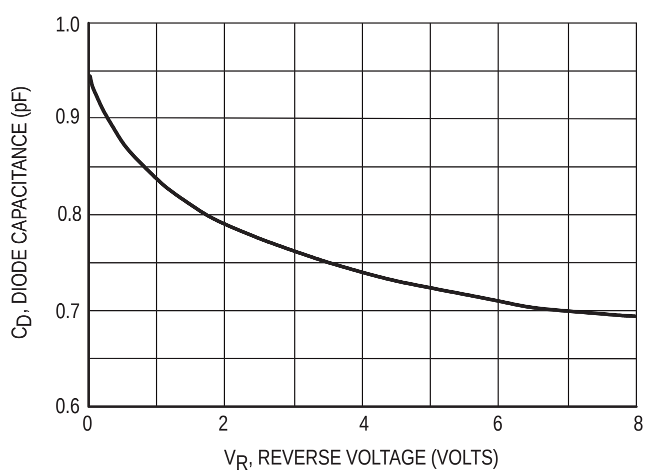
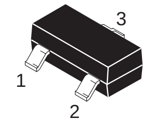


Figure 4. Capacitance

Switching Diode

MMBD6050LT1



CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

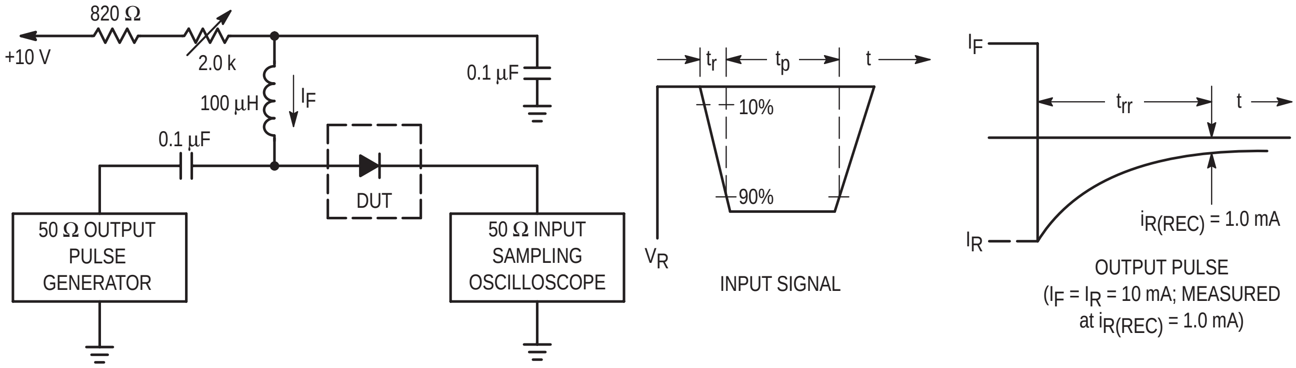
MMBD6050LT1 = 5A

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 V)	C	—	2.5	pF

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

REV 1



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 1. Recovery Time Equivalent Test Circuit

TYPICAL CHARACTERISTICS

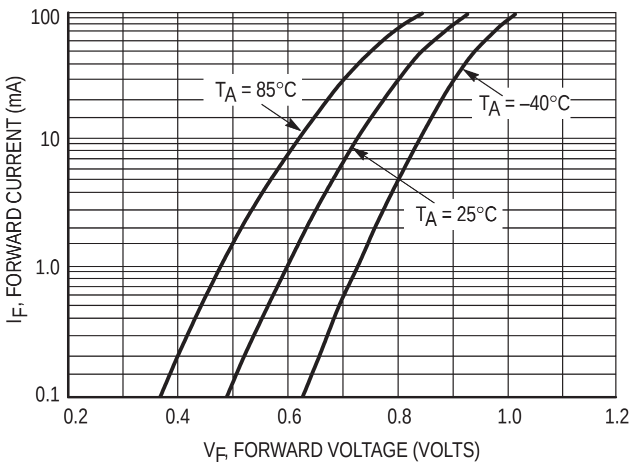


Figure 2. Forward Voltage

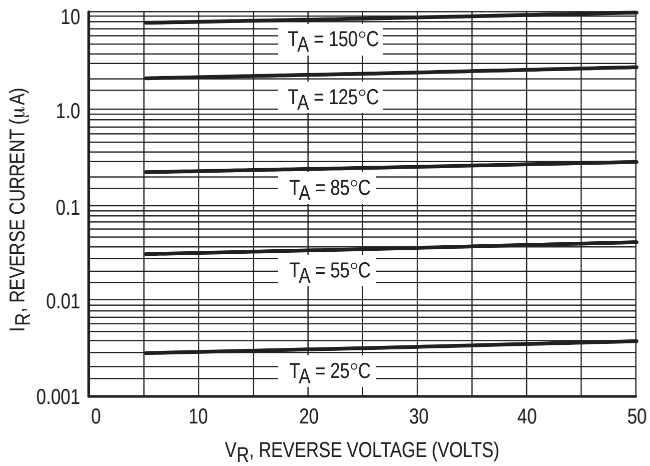


Figure 3. Leakage Current

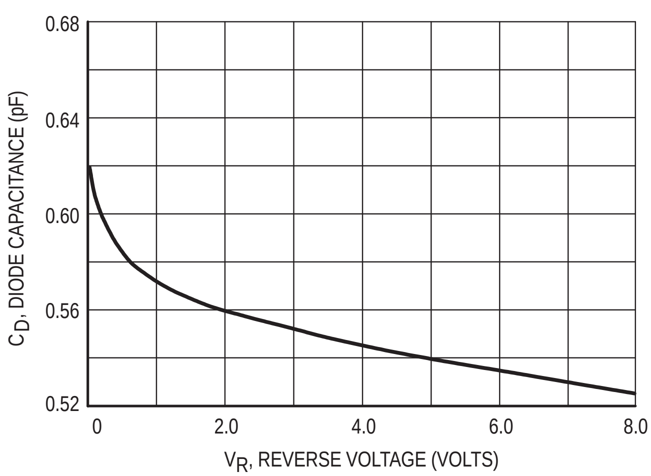
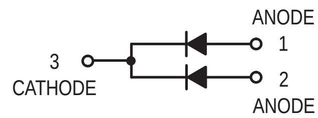
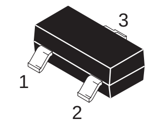


Figure 4. Capacitance

Monolithic Dual Switching Diode

MMBD6100LT1





CASE 318–08, STYLE 9
SOT–23 (TO–236AB)

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(1) 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,(2) 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

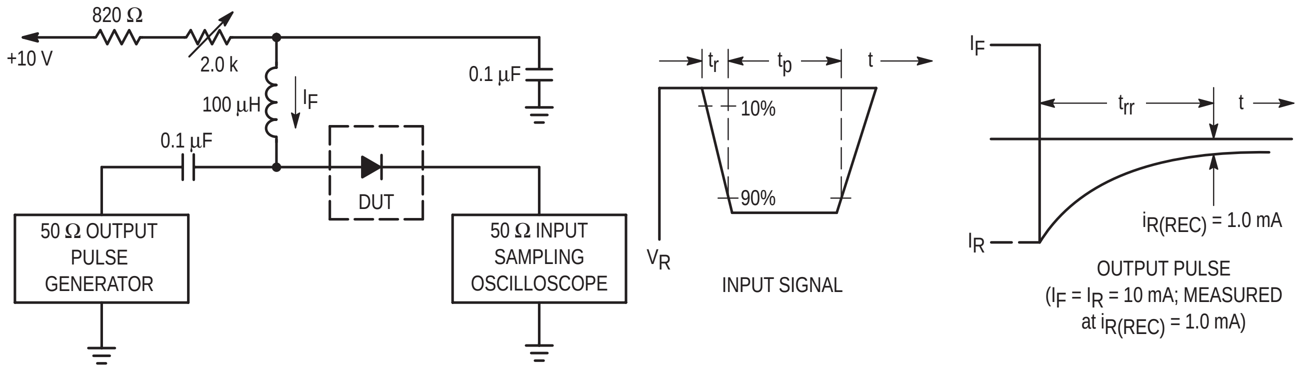
DEVICE MARKING

MMBD6100LT1 = 5BM

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 V)	C	—	2.5	pF

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.



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 1. Recovery Time Equivalent Test Circuit

CURVES APPLICABLE TO EACH CATHODE

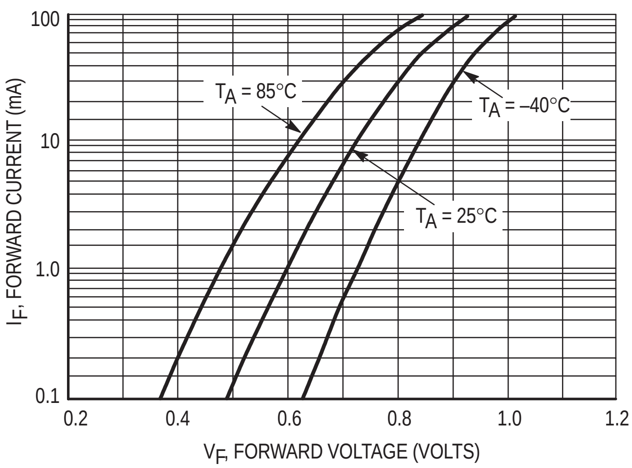


Figure 2. Forward Voltage

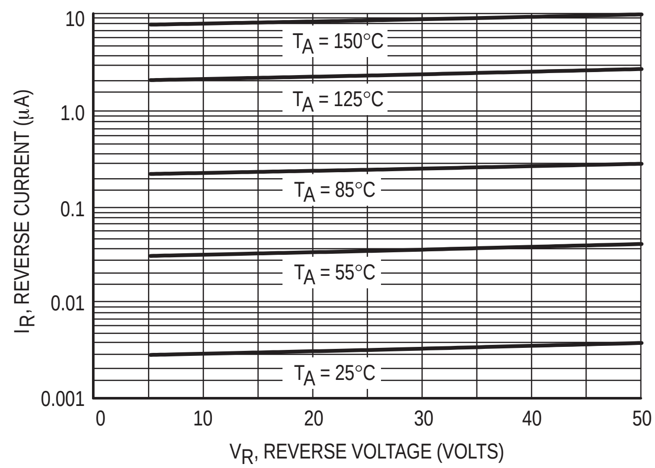


Figure 3. Leakage Current

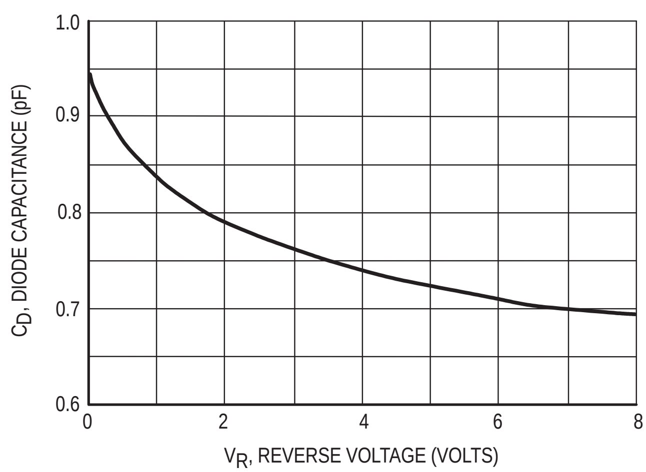
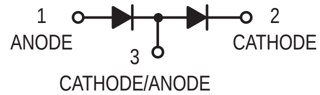


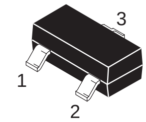
Figure 4. Capacitance

Dual Switching Diode

MMBD7000LT1

Motorola Preferred Device





CASE 318–08, STYLE 11
SOT–23 (TO–236AB)

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(1) 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,(2) 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

DEVICE MARKING

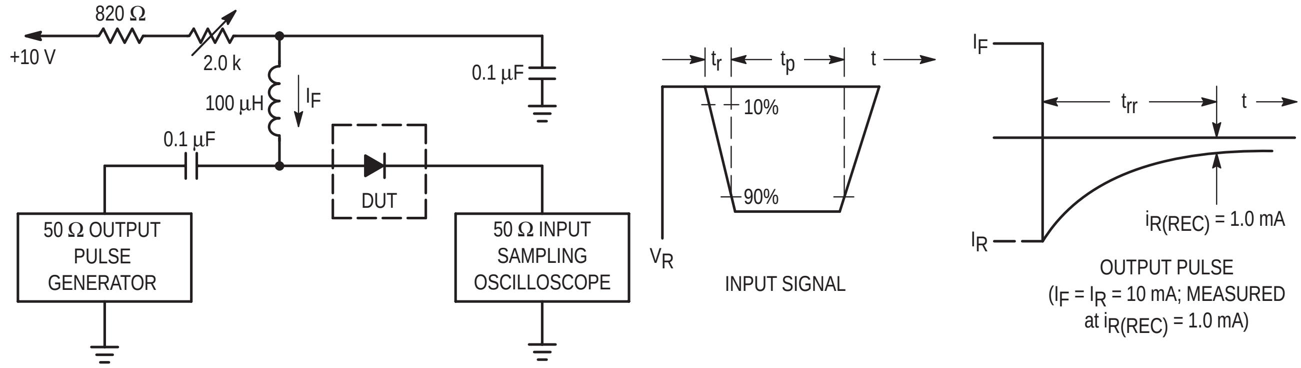
MMBD7000LT1 = M5C

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 V)	C	—	1.5	pF

1. FR–5 = 1.0 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 0.024 in. 99.5% alumina.

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



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 1. Recovery Time Equivalent Test Circuit

CURVES APPLICABLE TO EACH DIODE

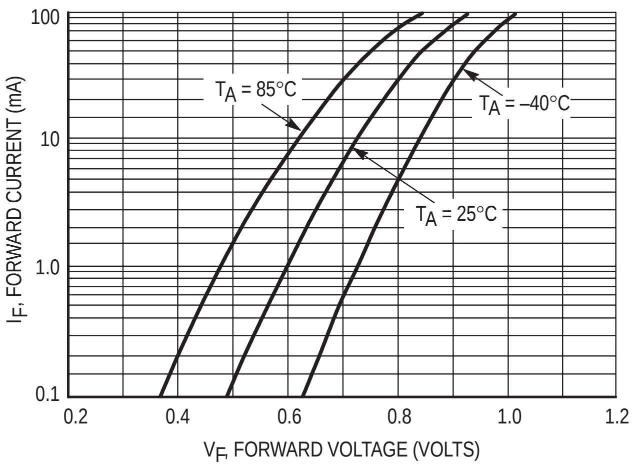


Figure 2. Forward Voltage

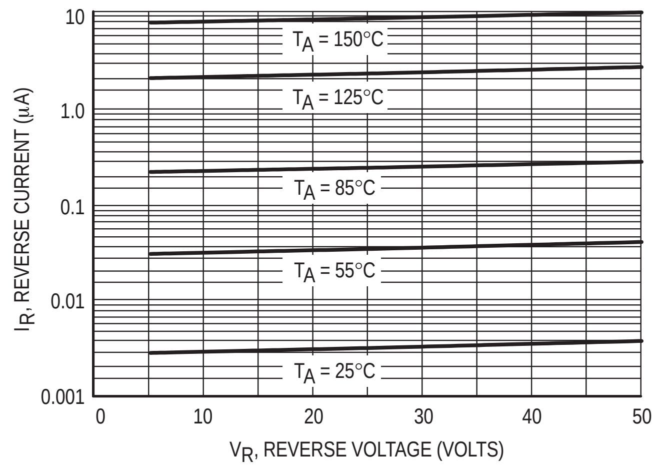


Figure 3. Leakage Current

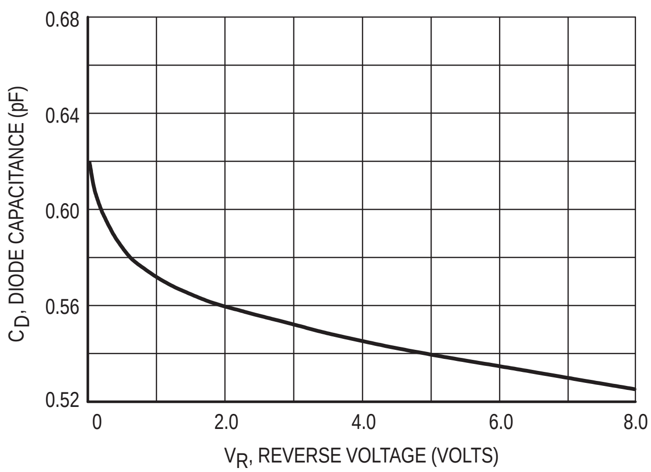


Figure 4. Capacitance

Silicon Tuning Diode

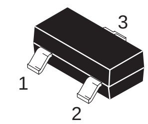
This device is designed in the Surface Mount package for general frequency control and tuning applications. It provides solid–state reliability in replacement of mechanical tuning methods.

- Controlled and Uniform Tuning Ratio

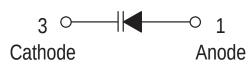
MMBV105GLT1

Motorola Preferred Device

**30 VOLT
VOLTAGE VARIABLE
CAPACITANCE DIODE**



**CASE 318–08, STYLE 8
SOT–23 (TO–236AB)**



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	225 1.8	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 (V_R = 28 Vdc)	I_R	—	50	nAdc

Device Type	C_T V_R = 25 Vdc, f = 1.0 MHz pF		Q V_R = 3.0 Vdc f = 50 MHz	C_R C_3/C_{25} f = 1.0 MHz	
	Min	Max	Typ	Min	Max
MMBV105GLT1	1.5	2.8	250	4.0	6.5

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

REV 1

TYPICAL CHARACTERISTICS

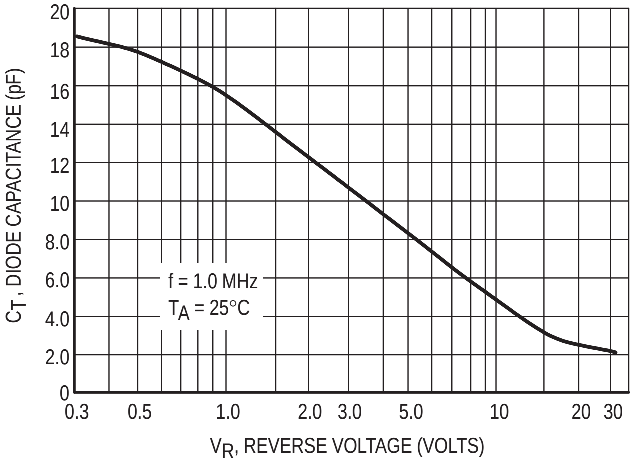


Figure 1. Diode Capacitance

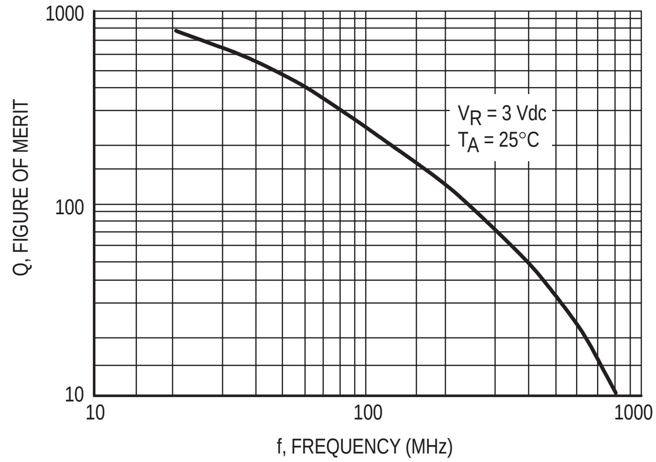


Figure 2. Figure of Merit

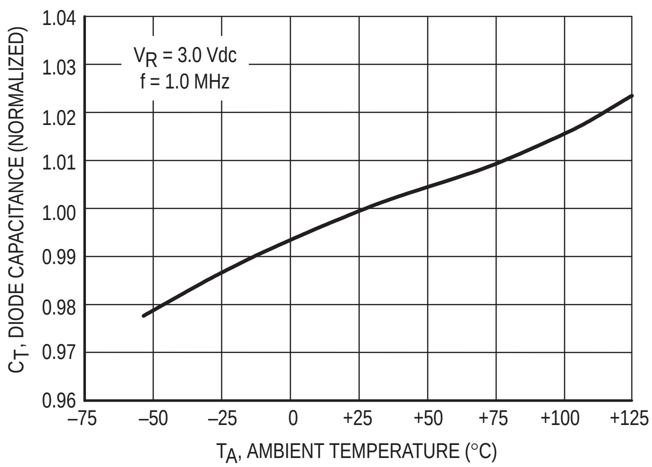


Figure 3. Diode Capacitance

Silicon Tuning Diodes

MMBV409LT1
MV409

Motorola Preferred Devices

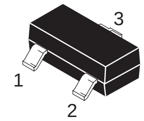
These devices are designed for general frequency control and tuning applications. They provide solid–state reliability in replacement of mechanical tuning methods.

- High Q with Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Available in Surface Mount Package

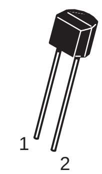
VOLTAGE VARIABLE CAPACITANCE DIODES

SOT–23

TO–92



CASE 318–08, STYLE 8
SOT–23 (TO–236AB)



CASE 182–02, STYLE 1
TO–92 (TO–226AC)

MAXIMUM RATINGS

Rating	Symbol	MBV409	MMBV409LT1	Unit
Reverse Voltage	V_R	20		Vdc
Forward Current	I_F	200		mAdc
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	 280 2.8	 225 1.8	 mW mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	–55 to +150		°C

DEVICE MARKING

MMBV409LT1 = X5, MV409 = MV409

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	20	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 15 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_8 f = 1.0 MHz(1)	
Device	Min	Nom	Max	Min	Min	Max
MMBV409LT1, MV409	26	29	32	200	1.5	1.9

1. C_R is the ratio of C_t measured at 3 Vdc divided by C_t measured at 8 Vdc.

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

TYPICAL CHARACTERISTICS

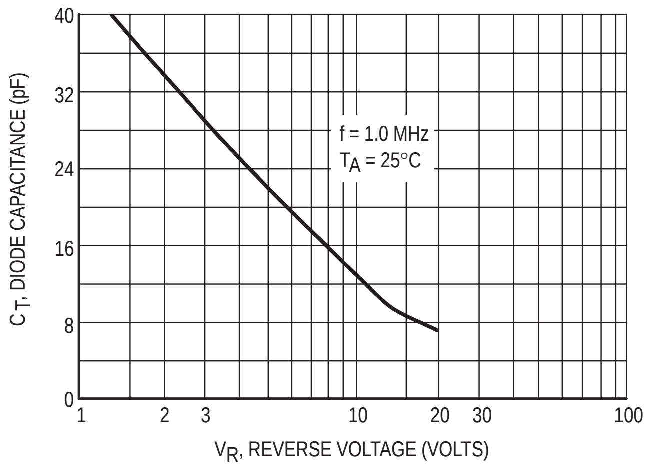


Figure 1. Diode Capacitance

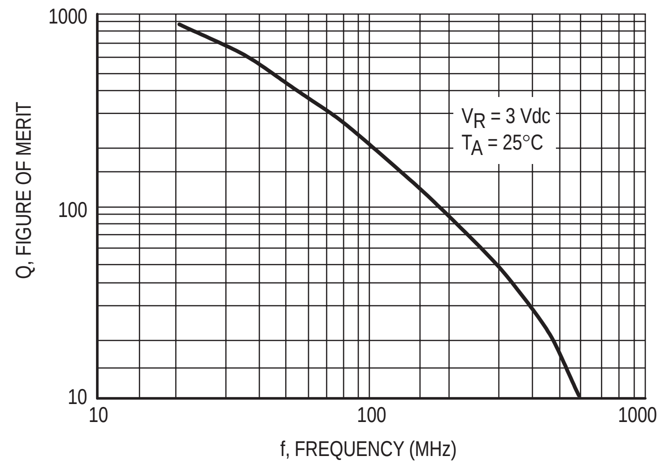


Figure 2. Figure of Merit

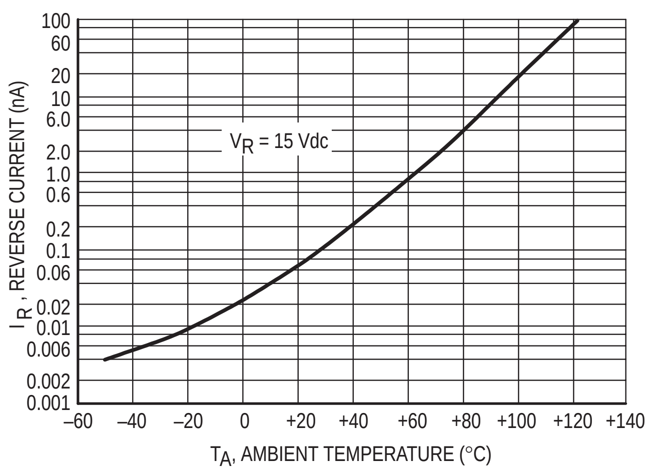


Figure 3. Leakage Current

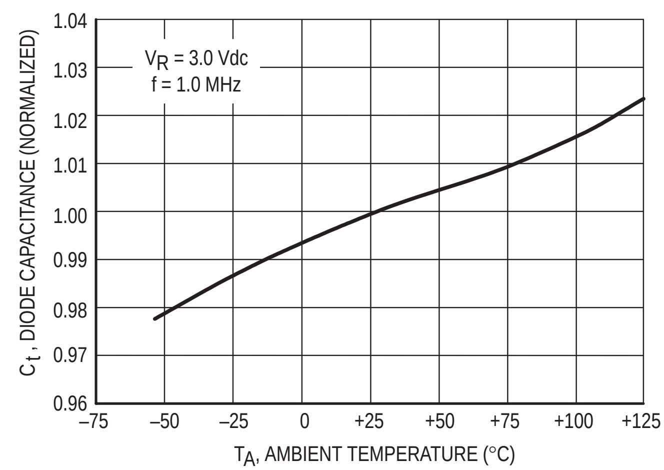
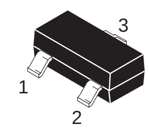


Figure 4. Diode Capacitance

MMBV432LT1

Motorola Preferred Device

**DUAL
VOLTAGE VARIABLE
CAPACITANCE DIODE**

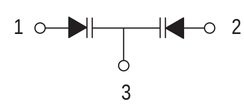


**CASE 318–08, STYLE 9
SOT–23 (TO–236AB)**

Silicon Tuning Diode

This device is 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



MAXIMUM RATINGS (Each Diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	14	Vdc
Forward Current	I_F	200	mAdc
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

MMBV432LT1 = M4B

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	—	—

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

REV 1

TYPICAL CHARACTERISTICS (Each Diode)

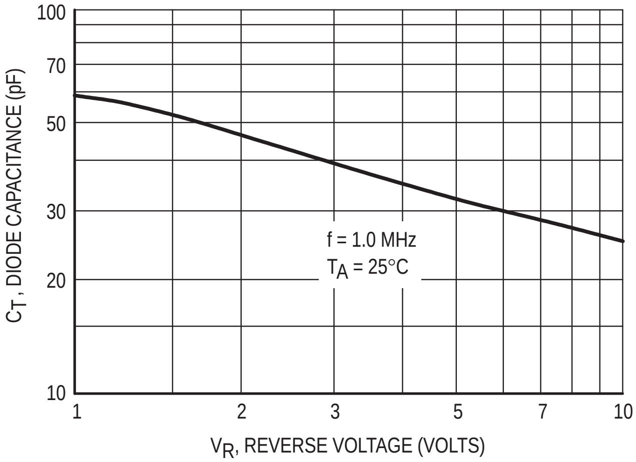


Figure 1. Diode Capacitance

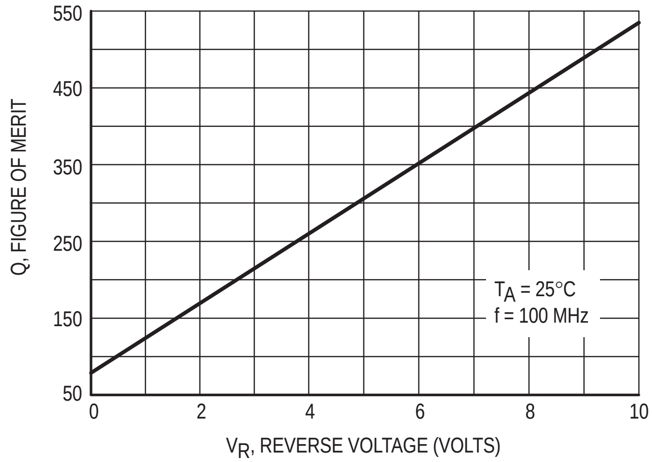


Figure 2. Figure of Merit versus Voltage

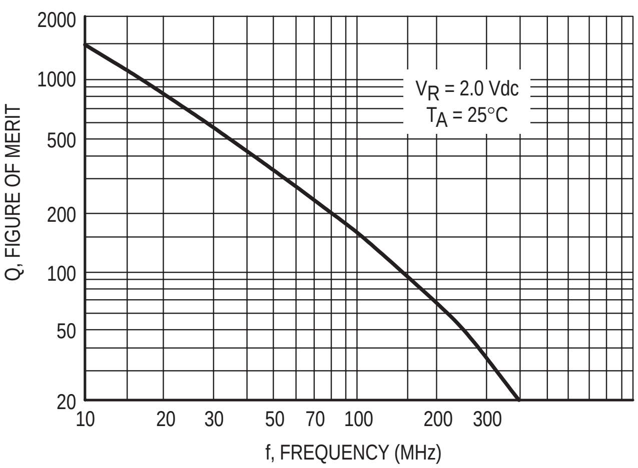


Figure 3. Figure of Merit versus Frequency

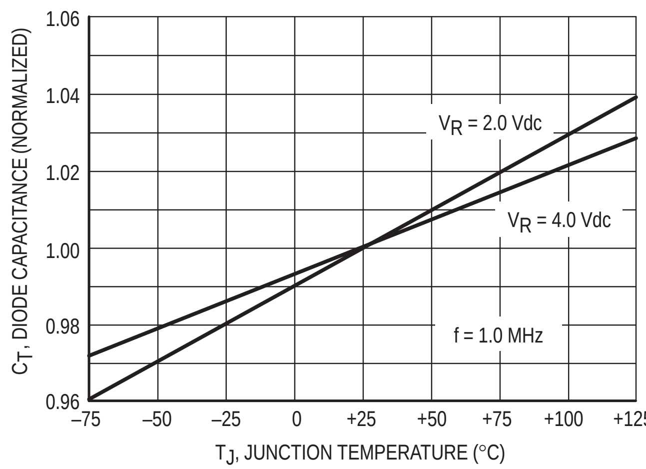


Figure 4. Diode Capacitance versus Temperature

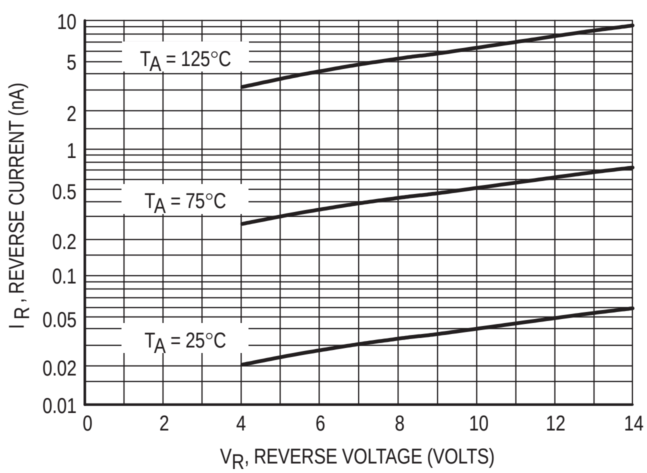


Figure 5. Reverse Current versus Reverse Voltage

Silicon Tuning Diode

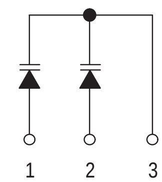
MMBV609LT1

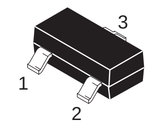
Motorola Preferred Device

DUAL VOLTAGE VARIABLE CAPACITANCE DIODE

This device is 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





CASE 318–08, STYLE 9
SOT–23 (TO–236AB)

MAXIMUM RATINGS (Each Diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Current	I_F	100	mAdc
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	—	—

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

TYPICAL CHARACTERISTICS

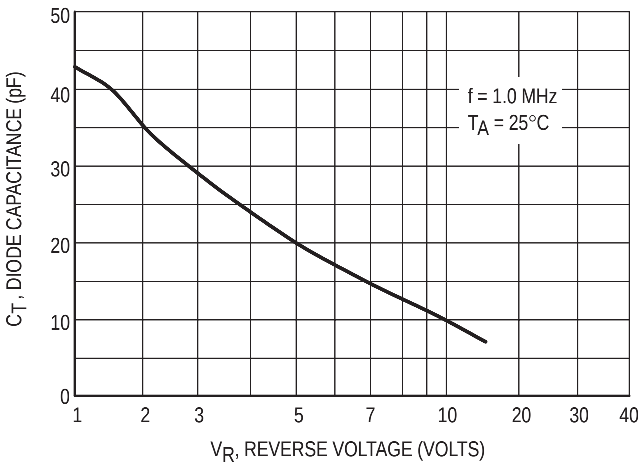


Figure 1. Diode Capacitance

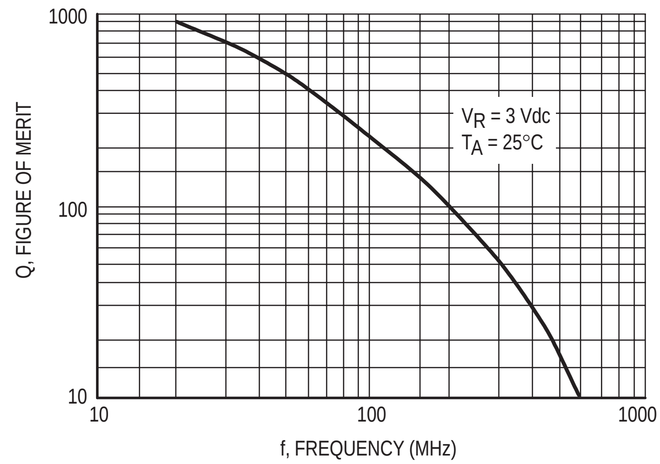


Figure 2. Figure of Merit

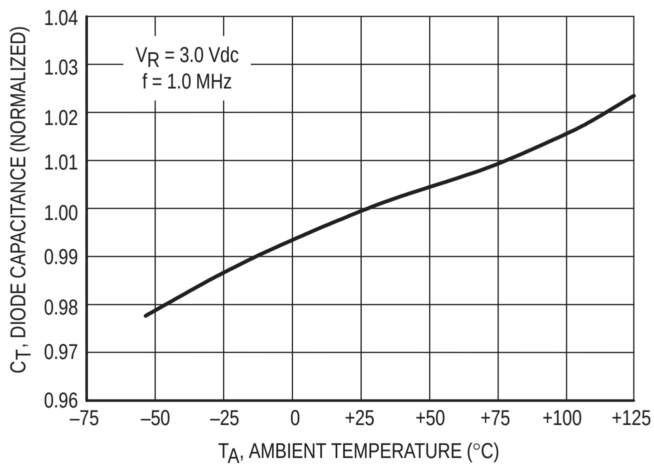


Figure 3. Diode Capacitance

Silicon Tuning Diode

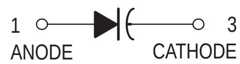
MMBV809LT1

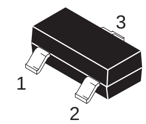
Motorola Preferred Device

This device is designed for 900 MHz frequency control and tuning applications. It provides 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

4.5–6.1 pF
VOLTAGE VARIABLE
CAPACITANCE DIODE





CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Current	I_F	20	mAdc
Total Power Dissipation(1) @ 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

1. FR5 Board 1.0 x 0.75 x 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	C_R, Capacitance Ratio C_2/C_8 f = 1.0 MHz(2)	
Device	Min	Typ	Max	Typ	Min	Max
MMBV809LT1	4.5	5.3	6.1	75	1.8	2.6

2. C_R is the ratio of C_t measured at 2.0 Vdc divided by C_t measured at 8.0 Vdc.

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

REV 1

TYPICAL CHARACTERISTICS

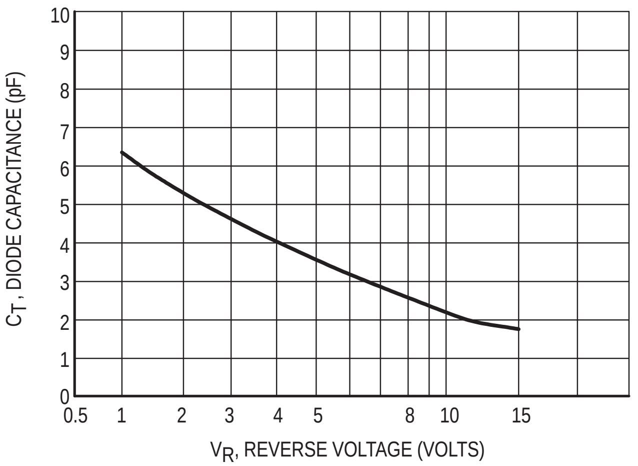


Figure 1. Diode Capacitance

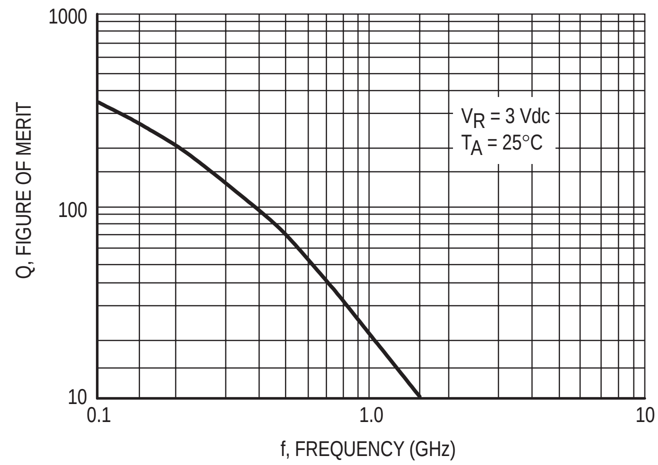


Figure 2. Figure of Merit

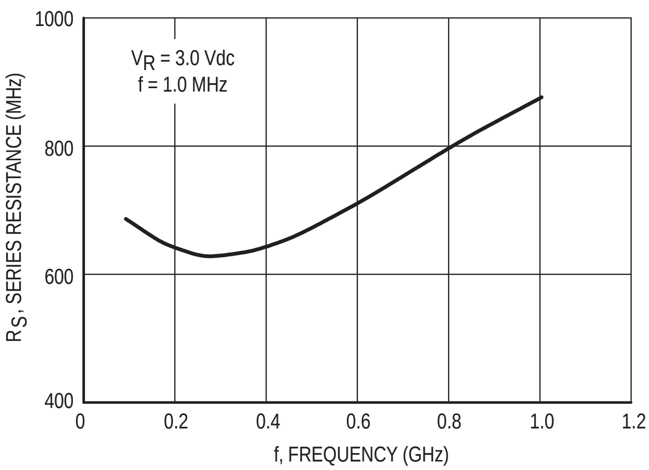


Figure 3. Series Resistance

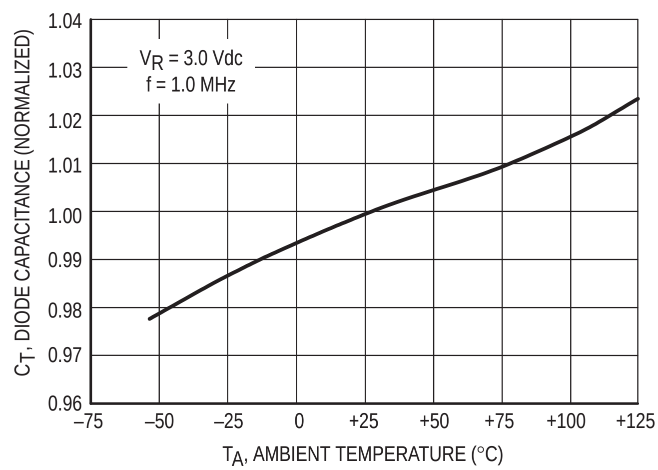


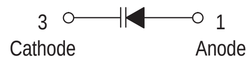
Figure 4. Diode Capacitance

MMBV2101LT1
MMBV2103LT1
MMBV2105LT1
MMBV2107LT1
MMBV2108LT1
MMBV2109LT1
MV2101 MV2104
MV2105 MV2108
MV2109 MV2111
MV2115

Silicon Tuning Diodes

These devices are designed in the popular PLASTIC PACKAGE for high volume requirements of FM Radio and TV tuning and AFC, general frequency control and tuning applications.They provide solid–state reliability in replacement of mechanical tuning methods. Also available in Surface Mount Package up to 33pF.

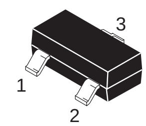
- High Q
- Controlled and Uniform Tuning Ratio
- Standard Capacitance Tolerance — 10%
- Complete Typical Design Curves



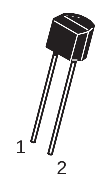
SOT–23

TO–92

6.8–100 pF
30 VOLTS
VOLTAGE VARIABLE
CAPACITANCE DIODES



CASE 318–08, STYLE 8
SOT–23 (TO–236AB)



CASE 182–02, STYLE 1
TO–92 (TO–226AC)

MAXIMUM RATINGS

Rating	Symbol	MV21xx	MMBV21xxLT1	Unit
Reverse Voltage	V_R	30		Vdc
Forward Current	I_F	200		mAdc
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	225 1.8	mW mW/°C
Junction Temperature	T_J	+150		°C
Storage Temperature Range	T_{stg}	–55 to +150		°C

DEVICE MARKING

MMBV2101LT1 = M4G	MMBV2107LT1 = 4W
MMBV2103LT1 = 4H	MMBV2108LT1 = 4X
MMBV2105LT1 = 4U	MMBV2109LT1 = 4J

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

REV 1

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc, f = 50 MHz	TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		
	Min	Nom	Max	Typ	Min	Typ	Max
MMBV2101LT1/MV2101	6.1	6.8	7.5	450	2.5	2.7	3.2
MMBV2103LT1	9.0	10	11	400	2.5	2.9	3.2
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	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
MV2115	90	100	110	100	2.6	3.0	3.3

MMBV2101LT1, MMBV2103LT1, MMBV2105LT1, 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.

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 or equivalent). 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:

$$TC_C = \left|\frac{C_T(+85°C) - C_T(-65°C)}{85 + 65}\right| \cdot \frac{10^6}{C_T(25°C)}$$

Accuracy limited by measurement of C_T to ±0.1 pF.

TYPICAL DEVICE CHARACTERISTICS

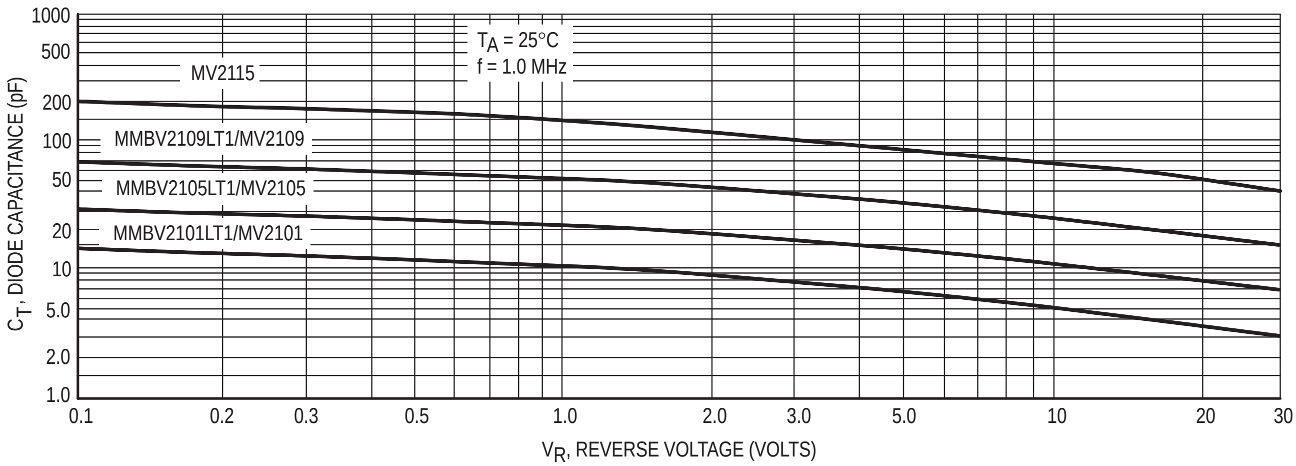


Figure 1. Diode Capacitance versus Reverse Voltage

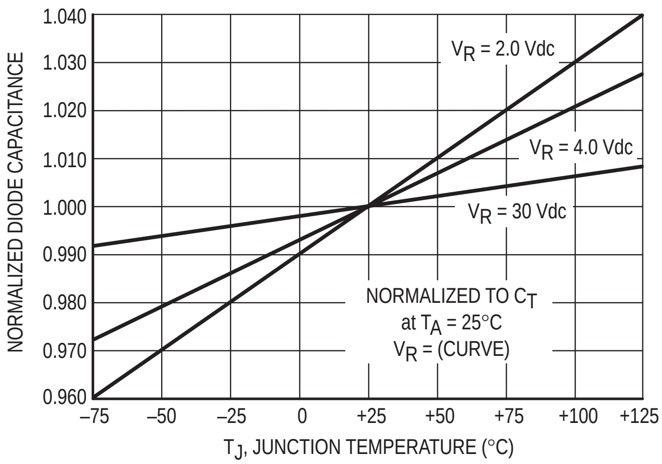


Figure 2. Normalized Diode Capacitance versus Junction Temperature

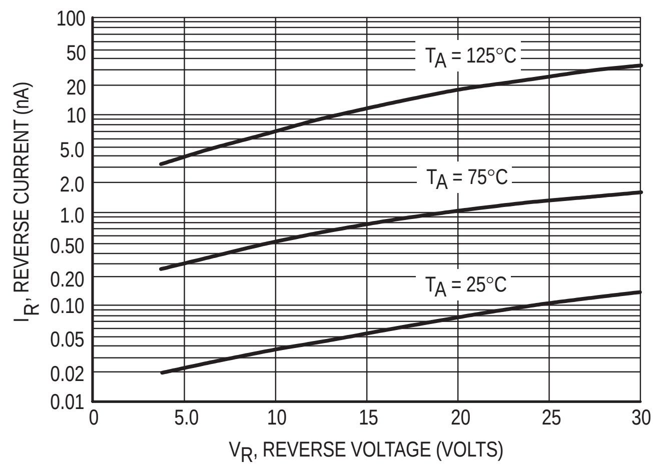


Figure 3. Reverse Current versus Reverse Bias Voltage

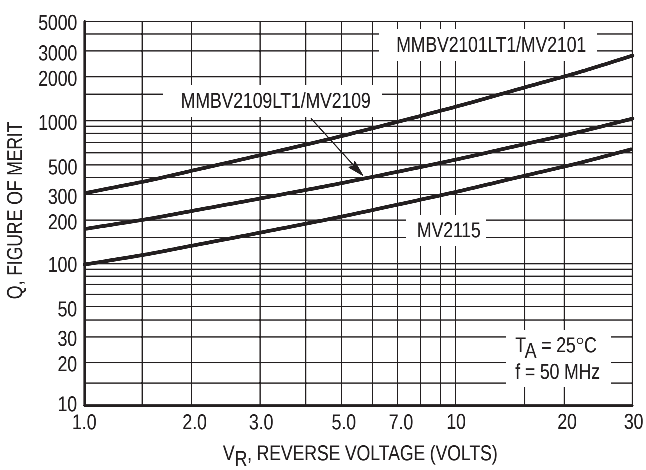


Figure 4. Figure of Merit versus Reverse Voltage

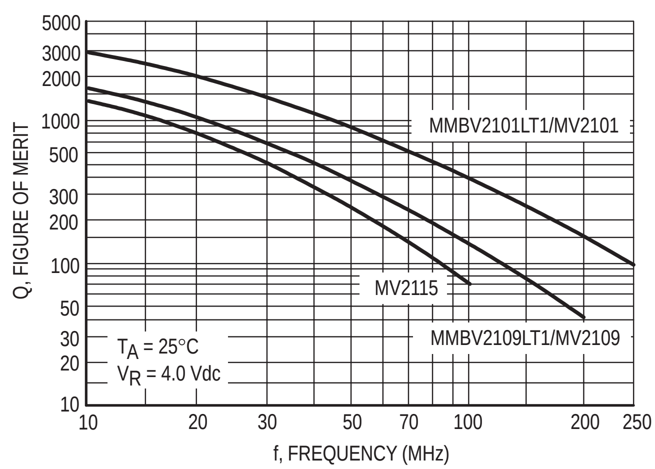


Figure 5. Figure of Merit versus Frequency

Silicon Tuning Diode

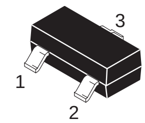
MMBV3102LT1

Motorola Preferred Device

22 pF (Nominal)
30 VOLTS
VOLTAGE VARIABLE
CAPACITANCE DIODE

This device is designed in the Surface Mount package for general frequency control and tuning applications. It provides solid–state reliability in replacement of mechanical tuning methods.

- High Q with Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio



CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

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	225 1.8	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

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

TYPICAL CHARACTERISTICS

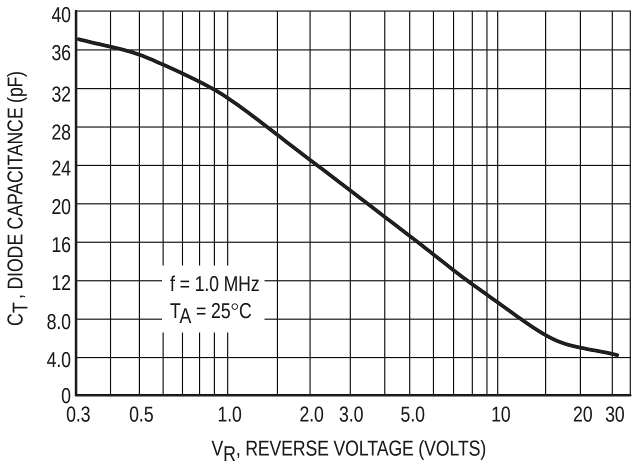


Figure 1. Diode Capacitance

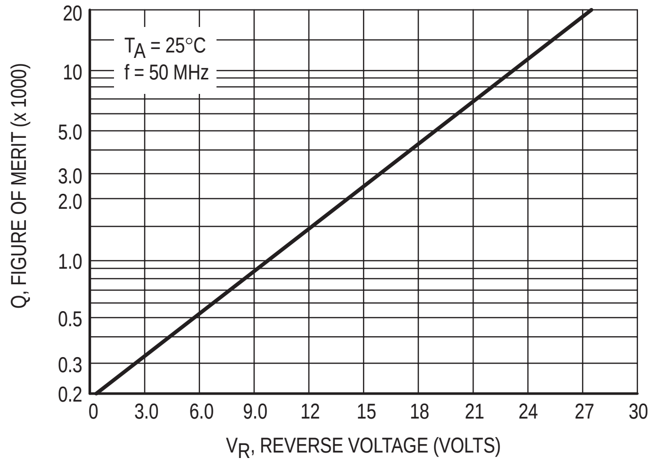


Figure 2. Figure of Merit

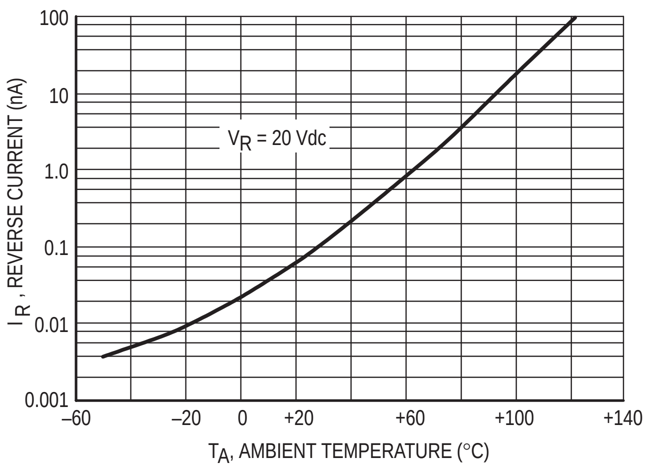


Figure 3. Leakage Current

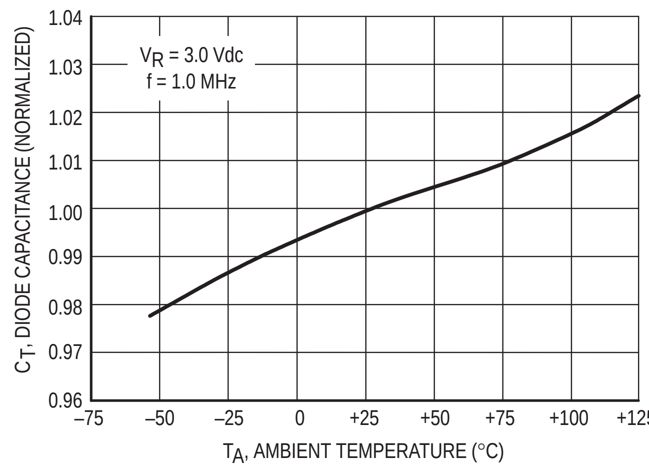


Figure 4. Diode Capacitance

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.

Silicon Pin Diode

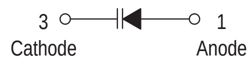
MMBV3401LT1

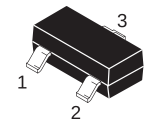
Motorola Preferred Device

SILICON PIN SWITCHING DIODE

This device is designed primarily for VHF band switching applications but is 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 Vdc
- Very Low Series Resistance at 100 MHz — 0.34 Ohms (Typ) @ I_F = 10 mAdc





CASE 318–08, STYLE 8
SOT–23 (TO–236AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Power 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

MMBV3401LT1 = 4D

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µAdc)	$V_{(BR)R}$	35	—	—	Vdc
Diode Capacitance (V_R = 20 Vdc)	C_T	—	—	1.0	pF
Series Resistance (Figure 5) (I_F = 10 mAdc, f = 100 MHz)	R_S	—	—	0.7	Ω
Reverse Leakage Current (V_R = 25 Vdc)	I_R	—	—	0.1	µAdc

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

REV 1

TYPICAL CHARACTERISTICS

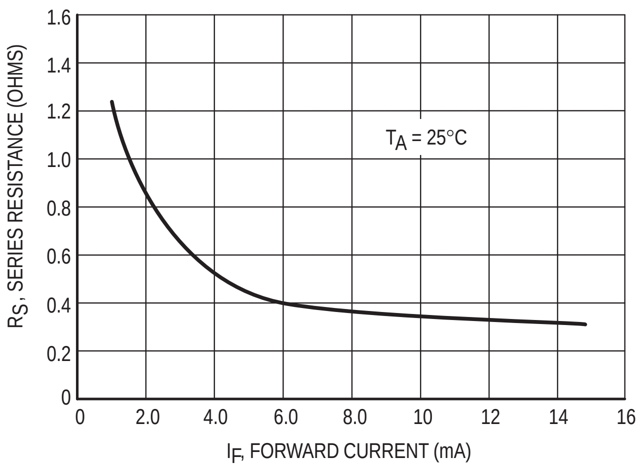


Figure 1. Series Resistance

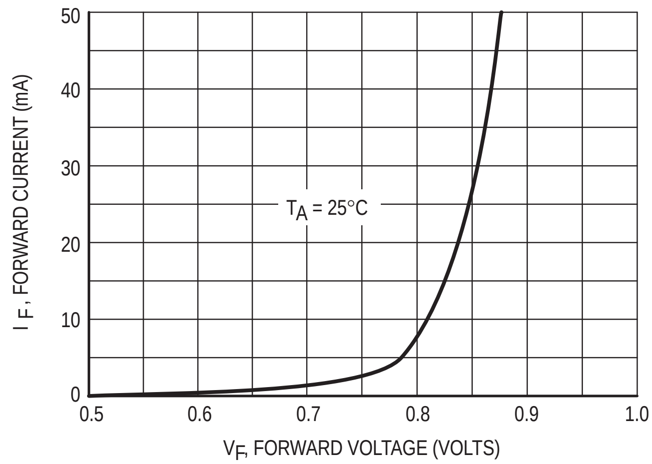


Figure 2. Forward Voltage

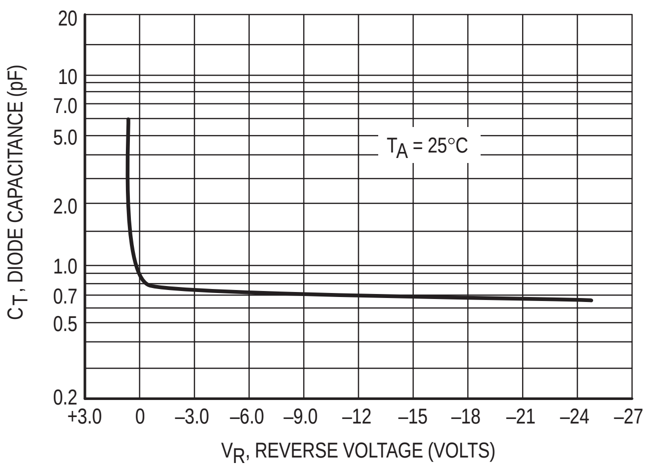


Figure 3. Diode Capacitance

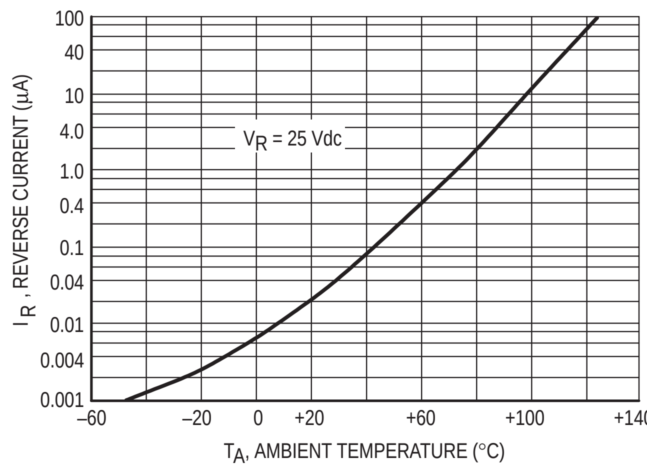


Figure 4. Leakage Current

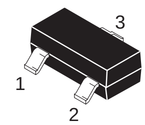
High Voltage Silicon Pin Diodes

MMBV3700LT1
MPN3700

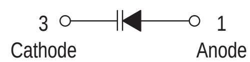
SILICON PIN SWITCHING DIODES

These devices are designed primarily for VHF band switching applications but are also suitable for use in general–purpose switching circuits. They are supplied in a cost–effective plastic package for economical, high–volume consumer and industrial requirements. They are also available in surface mount.

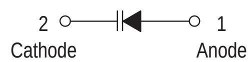
- Long Reverse Recovery Time
  t_{rr} = 300 ns (Typ)
- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Low Series Resistance @ 100 MHz —
  R_S = 0.7 Ohms (Typ) @ I_F = 10 mAdc
- Reverse Breakdown Voltage = 200 V (Min)



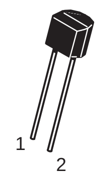
CASE 318–08, STYLE 8
SOT–23 (TO–236AB)



SOT–23



TO–92



CASE 182–02, STYLE 1
TO–92 (TO–226AC)

MAXIMUM RATINGS

Rating	Symbol	MPN3700	MMBV3700LT1	Unit
Reverse Voltage	V_R	200		Vdc
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

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µAdc)	$V_{(BR)R}$	200	—	—	Vdc
Diode Capacitance (V_R = 20 Vdc, f = 1.0 MHz)	C_T	—	—	1.0	pF
Series Resistance (Figure 5) (I_F = 10 mAdc)	R_S	—	0.7	1.0	Ω
Reverse Leakage Current (V_R = 150 Vdc)	I_R	—	—	0.1	µAdc
Reverse Recovery Time (I_F = I_R = 10 mAdc)	t_{rr}	—	300	—	ns

TYPICAL CHARACTERISTICS

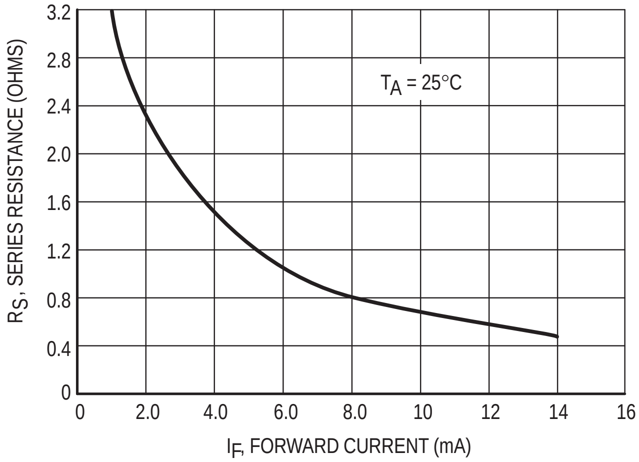


Figure 1. Series Resistance

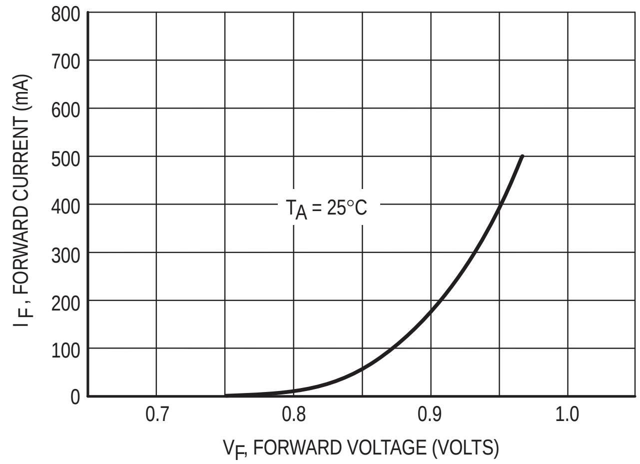


Figure 2. Forward Voltage

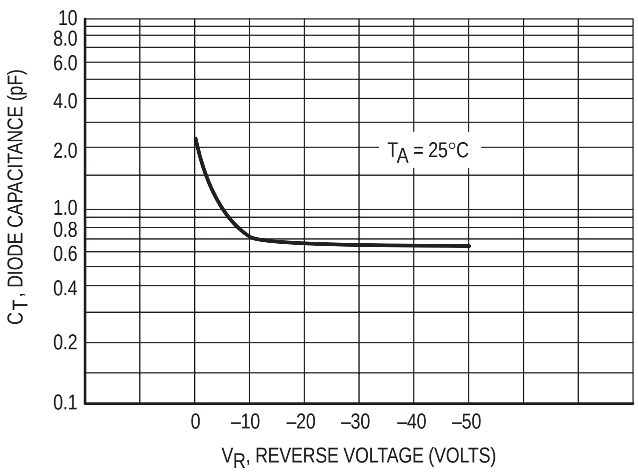


Figure 3. Diode Capacitance

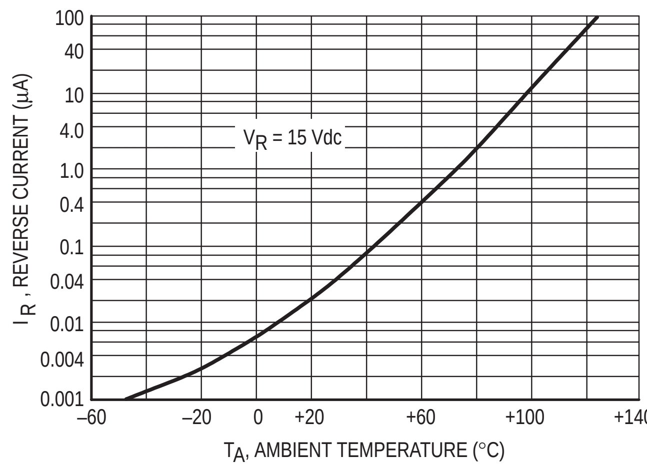


Figure 4. Leakage Current

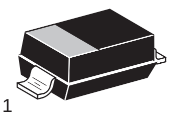
SOD-123 Schottky Barrier Diodes

MMSD301T1
MMSD701T1

Motorola Preferred Devices

The MMSD301T1, and MMSD701T1 devices are spin–offs of our popular MMBD301LT1, and MMBD701LT1 SOT–23 devices. They are designed for high–efficiency UHF and VHF detector applications. Readily available to many other fast switching RF and digital applications.

- Extremely Low Minority Carrier Lifetime
- Very Low Capacitance
- Low Reverse Leakage



CASE 425–04, STYLE 1
SOD–123

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Reverse Voltage	MMSD301T1 MMSD701T1	V_R	30 70	Vdc
Forward Power Dissipation T_A = 25°C		P_F	225	mW
Junction Temperature		T_J	–55 to +125	°C
Storage Temperature Range		T_{stg}	–55 to +150	°C

DEVICE MARKING

MMSD301T1 = XT, MMSD701T1 = XH

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

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	 MMSD301T1 MMSD701T1	$V_{(BR)R}$	 30 70	 — —	 — —	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	 MMSD301T1 MMSD701T1	C_T	 — —	 0.9 0.5	 1.5 1.0	pF
Total Capacitance (V_R = 15 Volts, f = 1.0 MHz) (V_R = 20 Volts, f = 1.0 MHz)	 MMSD301T1 MMSD701T1	C_T	 — —	 0.9 0.5	 1.5 1.0	pF
Reverse Leakage (V_R = 25 V) (V_R = 35 V)	 MMSD301T1 MMSD701T1	I_R	 — —	 13 9.0	 200 200	 nAdc nAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mA) (I_F = 1.0 mAdc) (I_F = 10 mA)	 MMSD301T1 MMSD701T1 	V_F	 — — — —	 0.38 0.52 0.42 0.7	 0.45 0.6 0.5 1.0	Vdc

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

(Replaces MMSD101T1/D)

TYPICAL CHARACTERISTICS
MMSD301T1

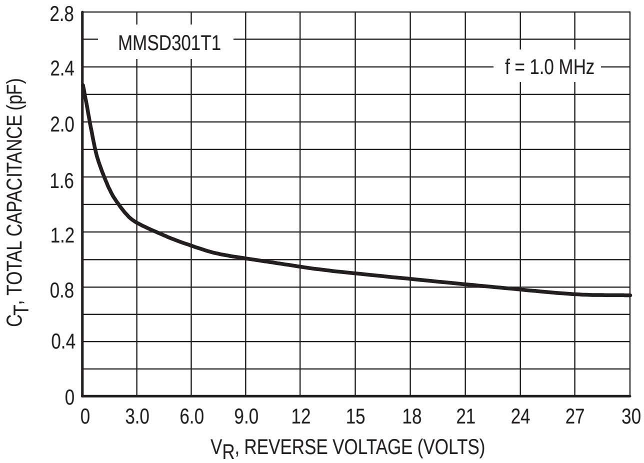


Figure 1. Total Capacitance

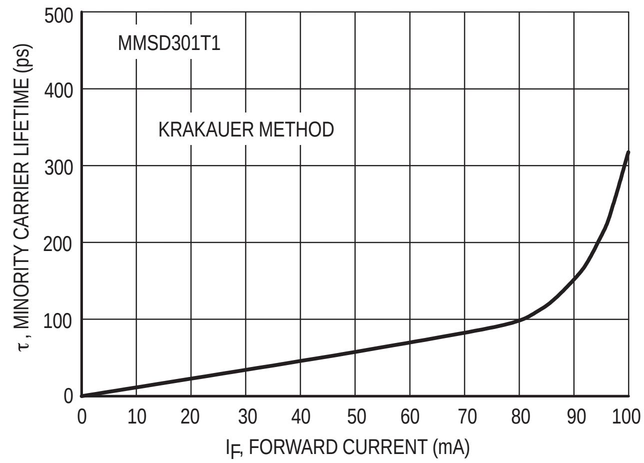


Figure 2. Minority Carrier Lifetime

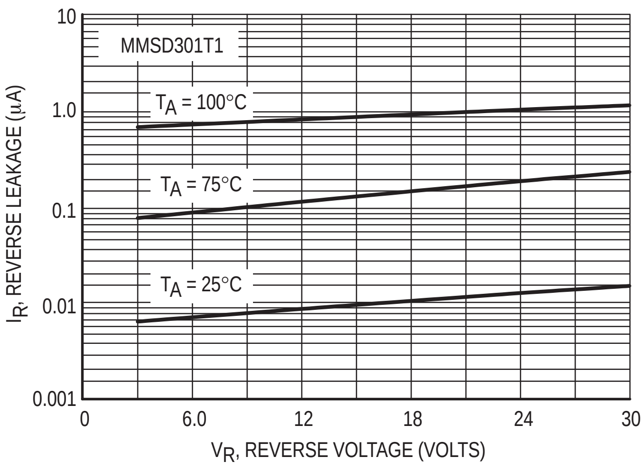


Figure 3. Reverse Leakage

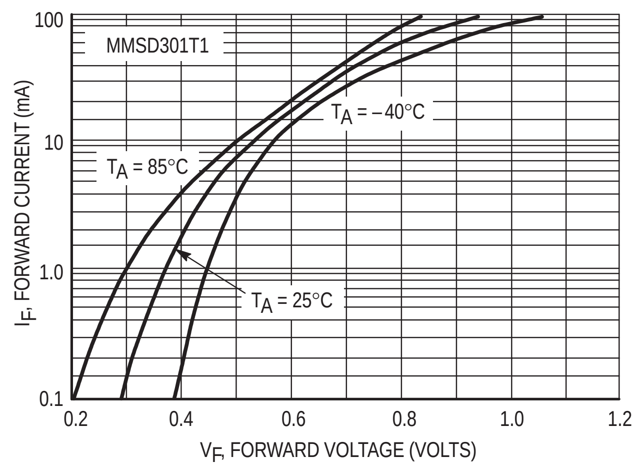


Figure 4. Forward Voltage

TYPICAL CHARACTERISTICS
MMSD701T1

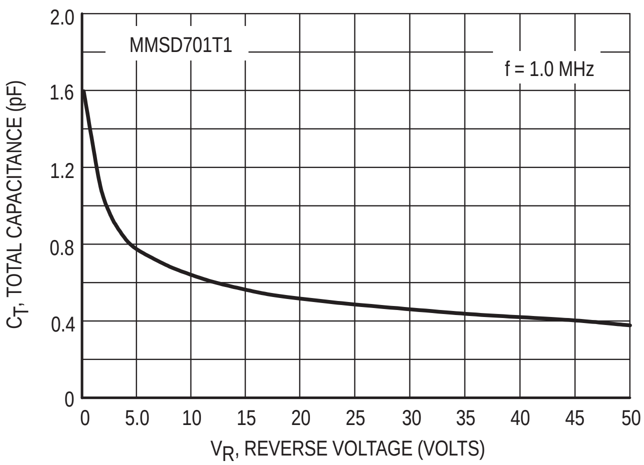


Figure 5. Total Capacitance

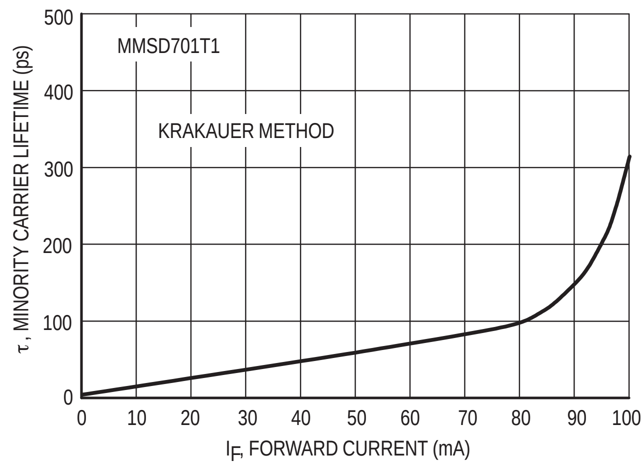


Figure 6. Minority Carrier Lifetime

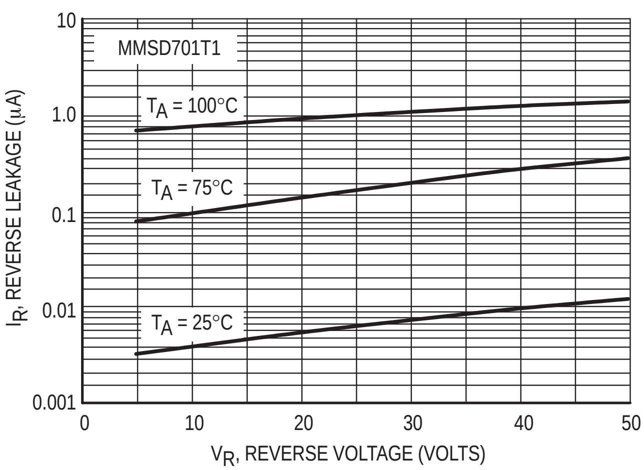


Figure 7. Reverse Leakage

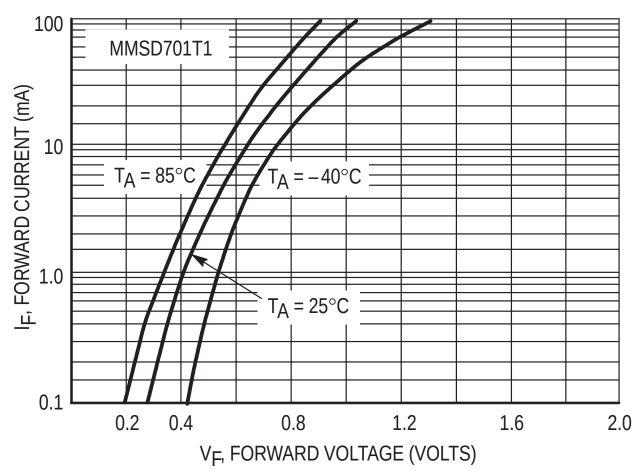


Figure 8. Forward Voltage

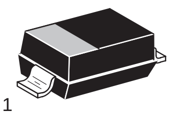
Switching Diode

The switching diode has the following features:

- SOD–123 Surface Mount Package
- High Breakdown Voltage
- Fast Speed Switching Time

MMSD914T1

Motorola Preferred Device



CASE 425–04, STYLE 1
SOD–123

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	100	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

DEVICE MARKING

MMSD914T1 = 5D

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR–5 Board(1) 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(2) 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

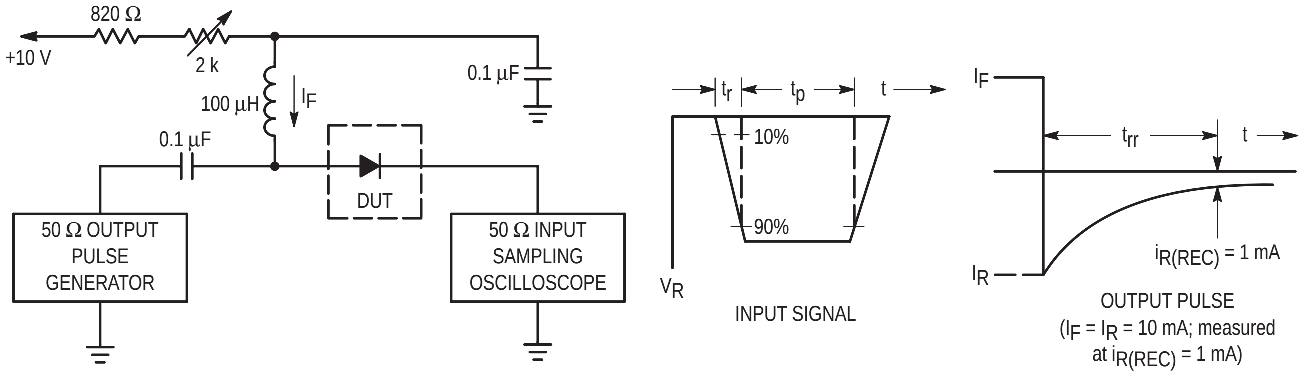
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_{BR} = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current (V_R = 20 Vdc) (V_R = 75 Vdc)	I_R	— —	25 5.0	nAdc μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	1000	mVdc
Diode Capacitance (V_R = 0 Vdc, f = 1.0 MHz)	C_D	—	4.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc) (Figure 1)	t_{rr}	—	4.0	ns

1. FR–5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina

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

REV 2



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 1. Recovery Time Equivalent Test Circuit

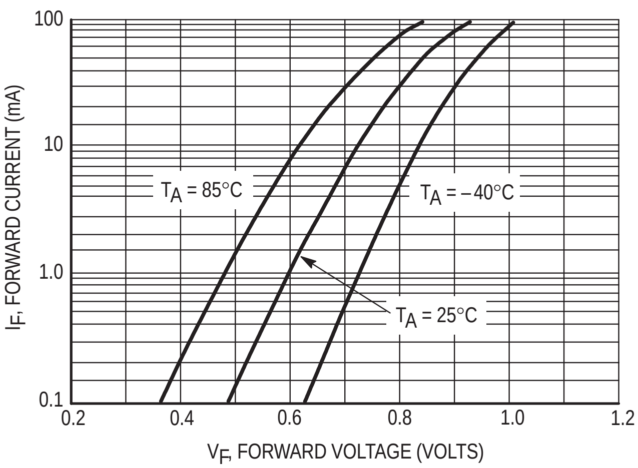


Figure 2. Forward Voltage

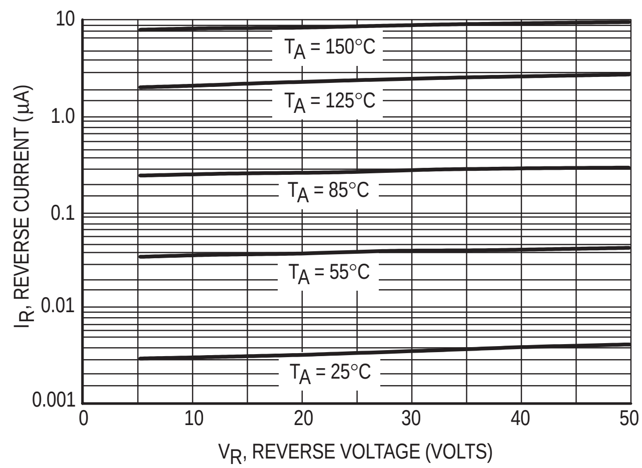


Figure 3. Leakage Current

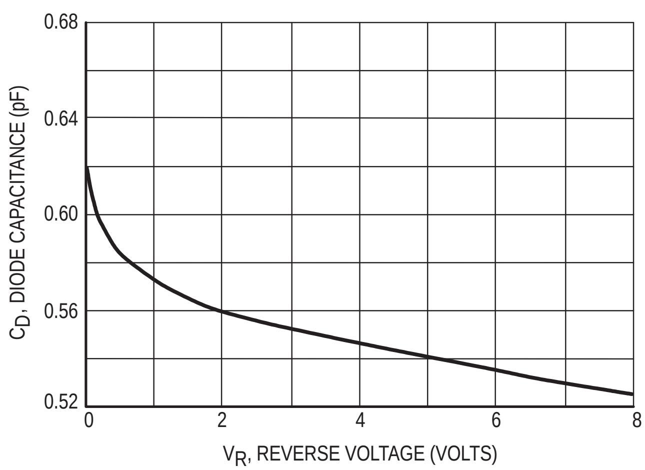


Figure 4. Capacitance

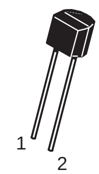
Silicon Pin Diode

MPN3404

This device is designed primarily for VHF band switching applications but is also suitable for use in general–purpose switching circuits. It is 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

SILICON PIN SWITCHING DIODE



CASE 182–02, STYLE 1
TO–92 (TO–226AC)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	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 μAdc)	$V_{(BR)R}$	20	—	—	Vdc
Diode Capacitance (V_R = 15 Vdc, f = 1.0 MHz)	C_T	—	1.3	2.0	pF
Series Resistance (Figure 5) (I_F = 10 mAdc)	R_S	—	0.7	0.85	Ω
Reverse Leakage Current (V_R = 15 Vdc)	I_R	—	—	0.1	μAdc

TYPICAL CHARACTERISTICS

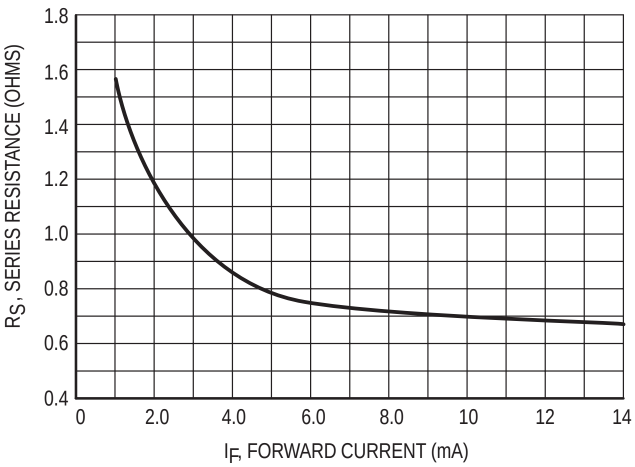


Figure 1. Series Resistance

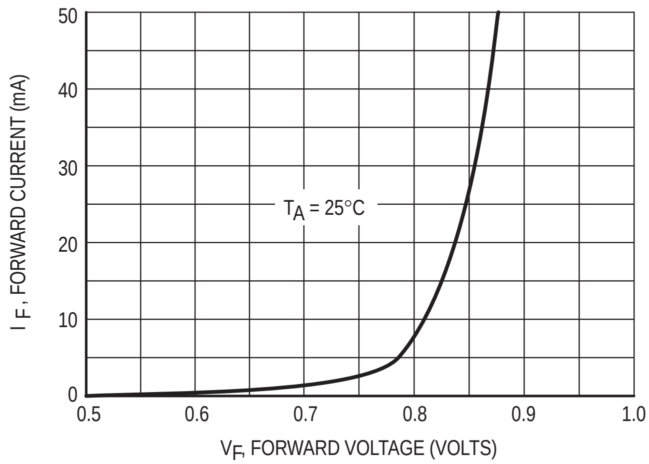


Figure 2. Forward Voltage

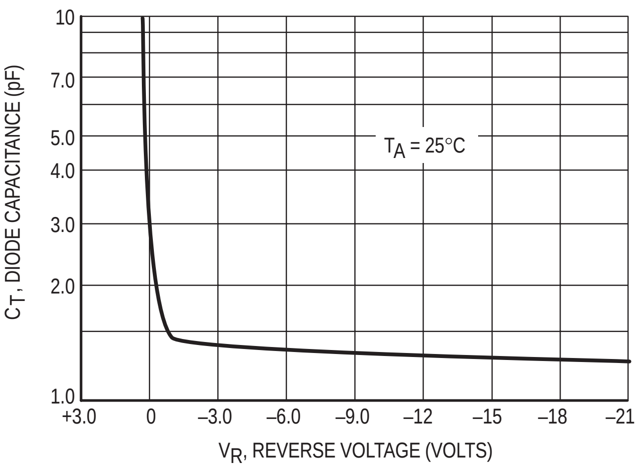


Figure 3. Diode Capacitance

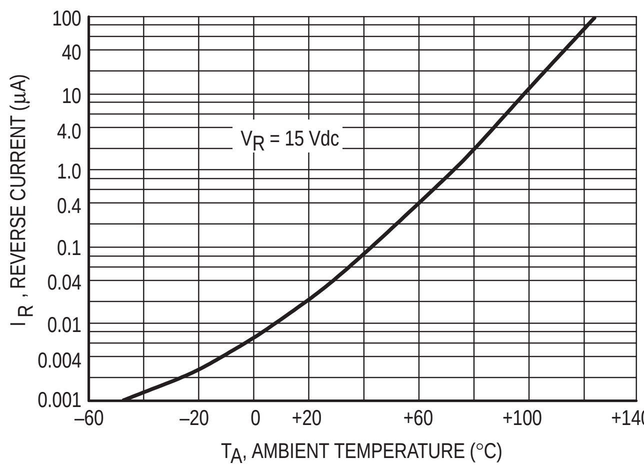
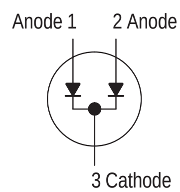
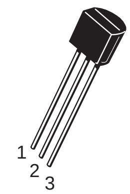


Figure 4. Leakage Current

Dual Switching Diode Common Cathode

MSD6100





CASE 29–04, STYLE 3
TO–92 (TO–226AA)

MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current (Pulse Width = 10 μsec)	$I_{FM(surge)}$	500	mAdc
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, θJC = 125°C/W.

TYPICAL CHARACTERISTICS

Curves Applicable to Each Anode

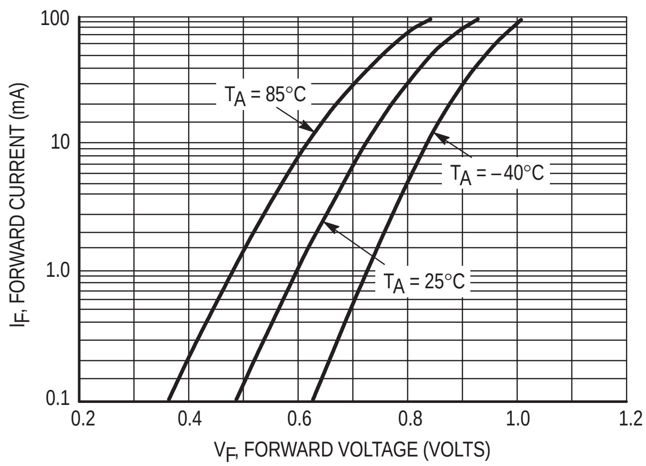


Figure 1. Forward Voltage

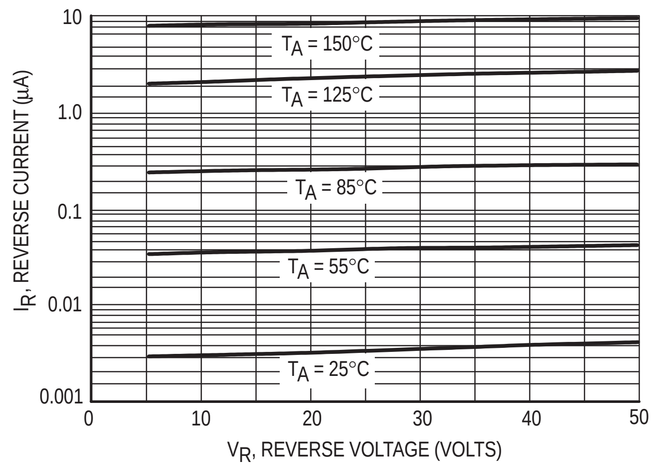


Figure 2. Leakage Current

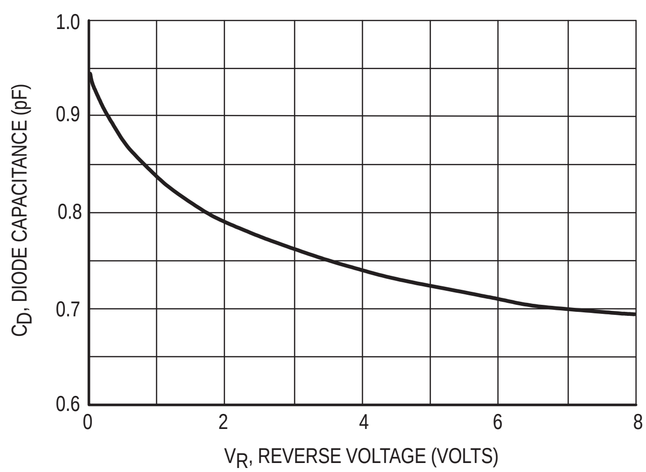
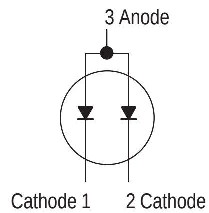
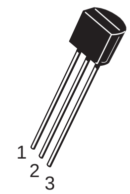


Figure 3. Capacitance

Dual Diode
Common Anode

MSD6150





CASE 29–04, STYLE 4
TO–92 (TO–226AA)

MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mAdc
Peak Forward Surge Current (Pulse Width = 10 µsec)	$I_{FM(surge)}$	500	mAdc
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°C, θJC = 12.5°C/W, θJA = 125°C.

TYPICAL CHARACTERISTICS

Curves Applicable to Each Cathode

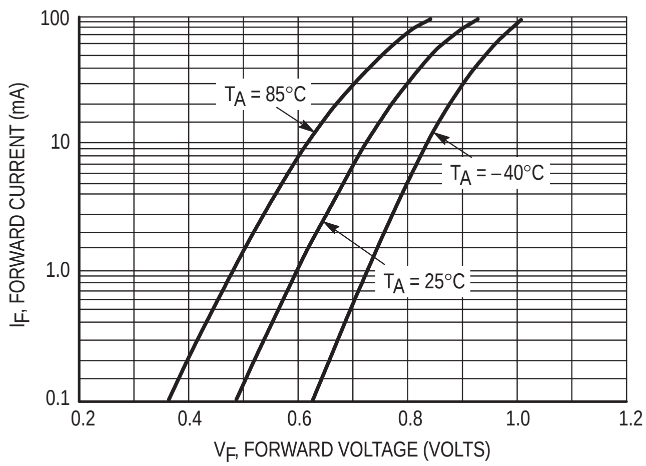


Figure 1. Forward Voltage

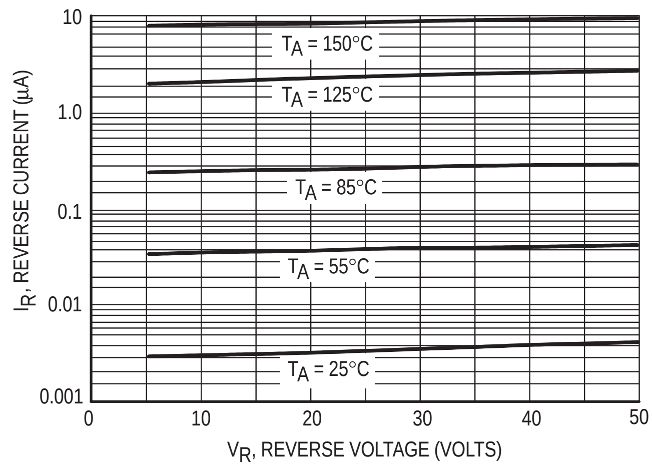


Figure 2. Leakage Current

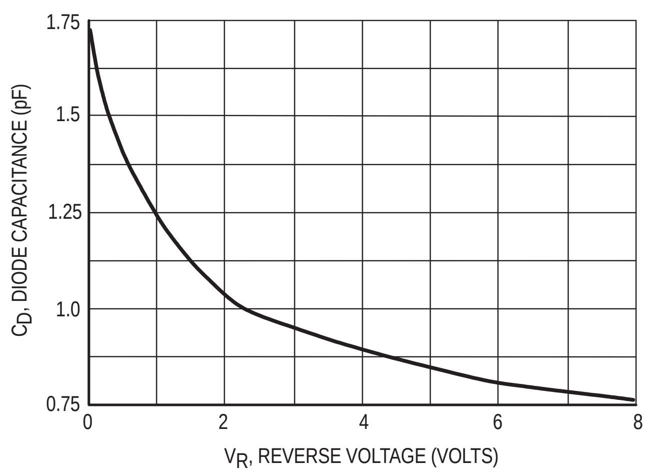


Figure 3. Capacitance

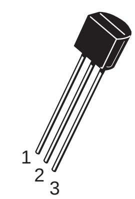
Silicon Tuning Diode

MV104

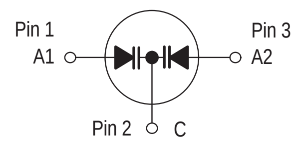
DUAL VOLTAGE VARIABLE CAPACITANCE DIODE

This device is 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.

- 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
- Monolithic Chip Provides Near Perfect Matching – Guaranteed ± 1.0% (Max) Over Specified Tuning Range



CASE 29–04, STYLE 15
TO–92 (TO–226AA)



MAXIMUM RATINGS (EACH DIODE)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	32	Vdc
Forward Current	I_F	200	mAdc
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 +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

REV 1

TYPICAL CHARACTERISTICS (Each Diode)

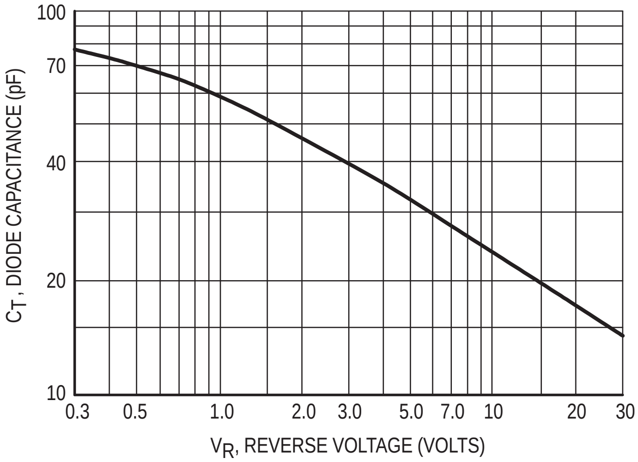


Figure 1. Diode Capacitance (Each Diode)

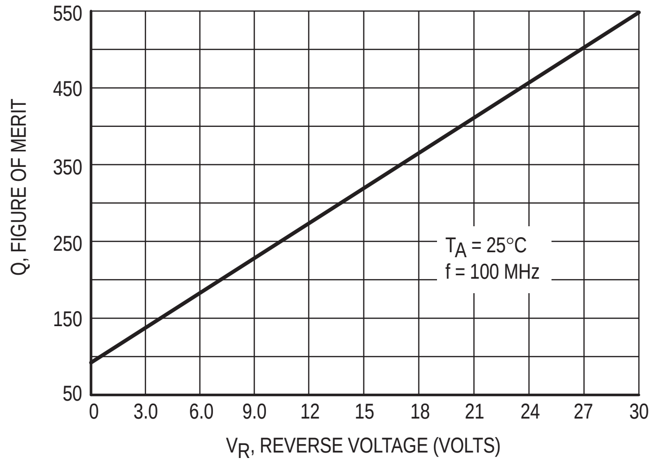


Figure 2. Figure of Merit versus Voltage

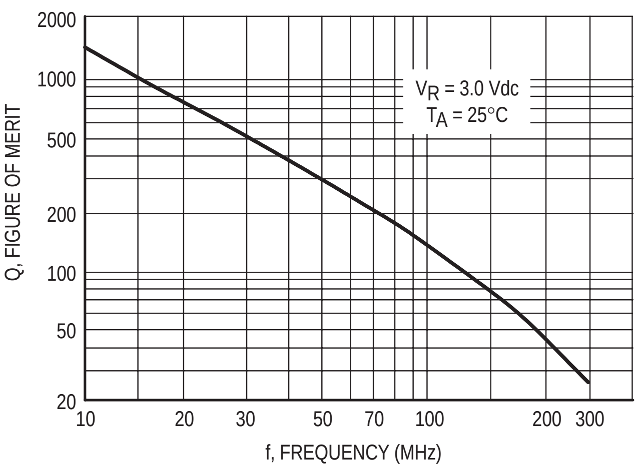


Figure 3. Figure of Merit versus Frequency

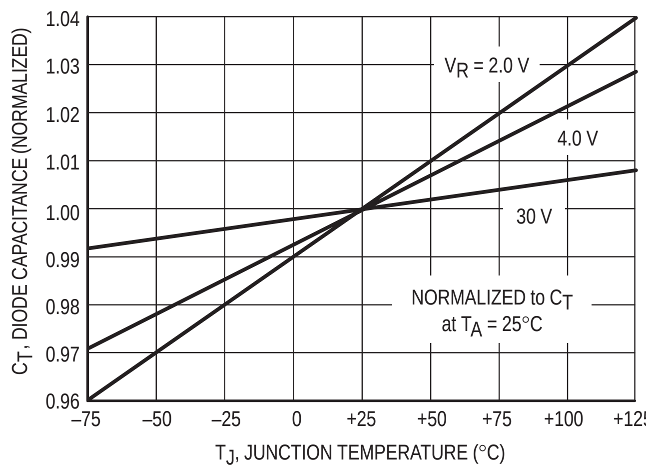


Figure 4. Diode Capacitance versus Temperature

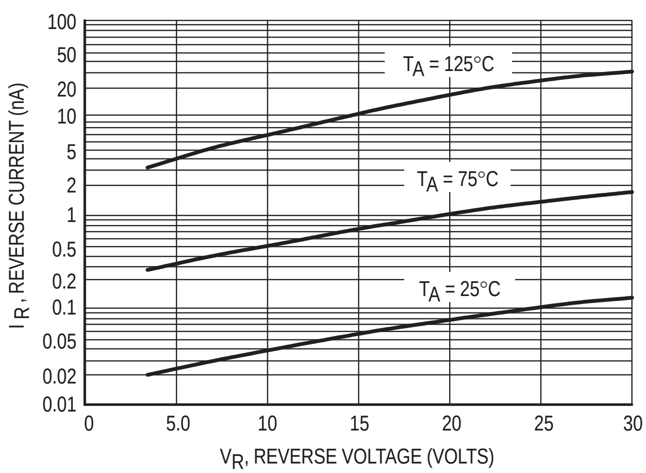


Figure 5. Reverse Current versus Reverse Voltage

Silicon Hyper-Abrupt Tuning Diodes

MV1403
MV1404
MV1405

These devices are designed with high capacitance and a capacitance change of greater than TEN TIMES for a bias change from 2.0 to 10 volts. They provide tuning over broad frequency ranges; tune 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

120–250 pF
12 VOLTS
HIGH TUNING RATIO
VOLTAGE–VARIABLE
CAPACITANCE DIODES

CASE 51–02
(DO–204AA)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	12	Vdc
Forward Current	I_F	250	mAdc
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
Reverse Voltage Leakage Current (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

Device	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
	Min	Nom	Max	Min	Min	Min
MV1403	140	175	210	200	—	10
MV1404	96	120	144	200	—	10
MV1405	200	250	300	200	—	10

TYPICAL CHARACTERISTICS

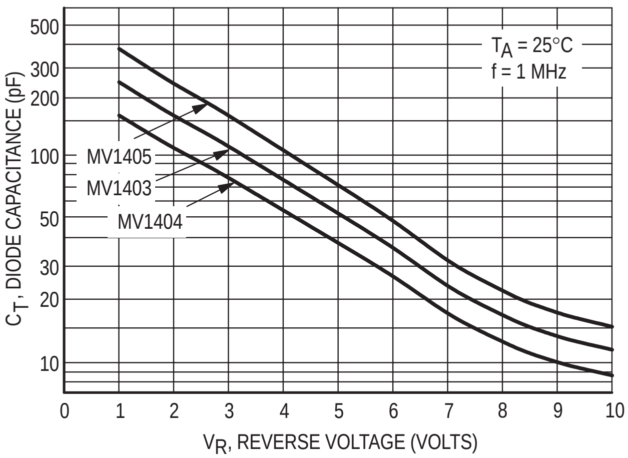


Figure 1. Diode Capacitance versus Reverse Voltage

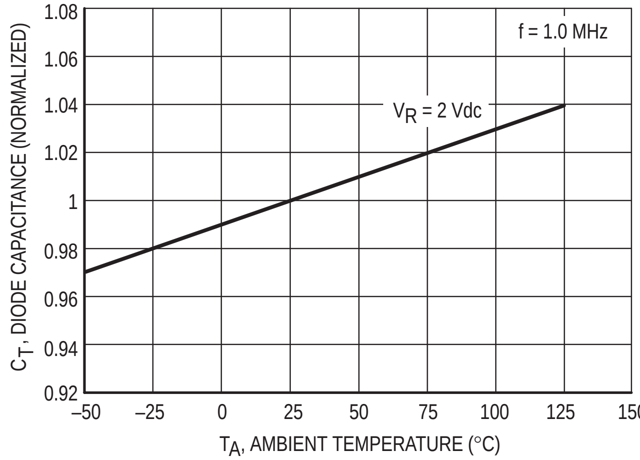


Figure 2. Diode Capacitance versus Ambient Temperature

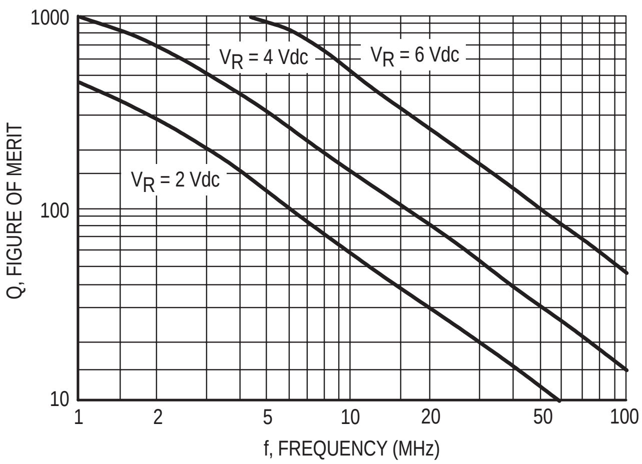


Figure 3. Figure of Merit versus Frequency

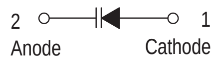
Silicon Tuning Diodes

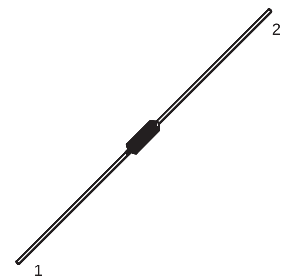
These epitaxial passivated tuning diodes are designed for AFC applications in radio, TV, and general electronic–tuning.

- Maximum Working Voltage of 20 V
- Excellent Q Factor at High Frequencies
- Solid–State Reliability to Replace Mechanical Tuning Methods

MV1626 thru MV1650

6.8 – 100 pF
20 VOLTS
VOLTAGE–VARIABLE CAPACITANCE DIODES





CASE 51–02
DO–204AA (DO–7)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Current	I_F	250	mAdc
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Junction Temperature	T_J	+175	°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)	$V_{(BR)R}$	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	TR, Tuning Ratio C_2/C_{20} f = 1.0 MHz	
Device	**Min**	**Nom**	**Max**	**Typ**	**Min**	**Max**
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
MV1638	29.7	33.0	36.3	200	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

Silicon Tuning Diode

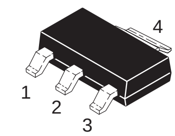
MV7005T1

Motorola Preferred Device

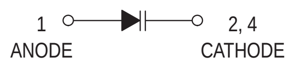
This silicon tuning diode is designed for use in high capacitance, high–tuning ratio applications. The device is housed in the SOT-223 package which is designed for medium power surface mount applications.

- Guaranteed Capacitance Range
- 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.

SOT–223 PACKAGE
HIGH CAPACITANCE
VOLTAGE VARIABLE DIODE
SURFACE MOUNT



CASE 318E–04, STYLE 2
SOT–223 (TO–261AA)



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	15	Vdc
Forward Current	I_F	50	mAdc
Total Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	800 6.4	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	–55 to +125	°C

1. FR-4 board, 0.0625 in^2, 2 oz. copper.

DEVICE MARKING

MV7005T1 = 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	—	—

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

REV 2

TYPICAL CHARACTERISTICS

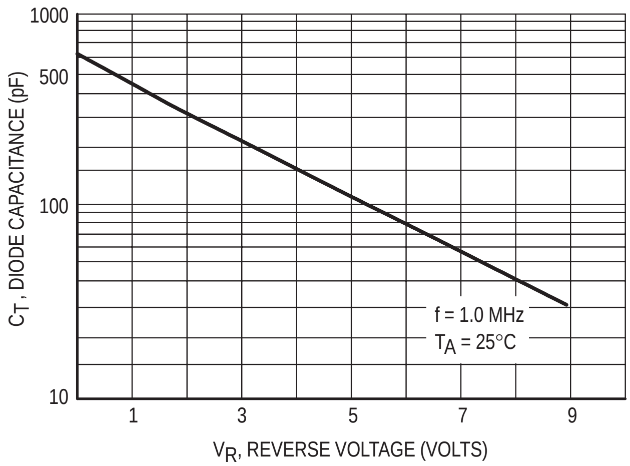


Figure 1. Diode Capacitance versus Reverse Voltage

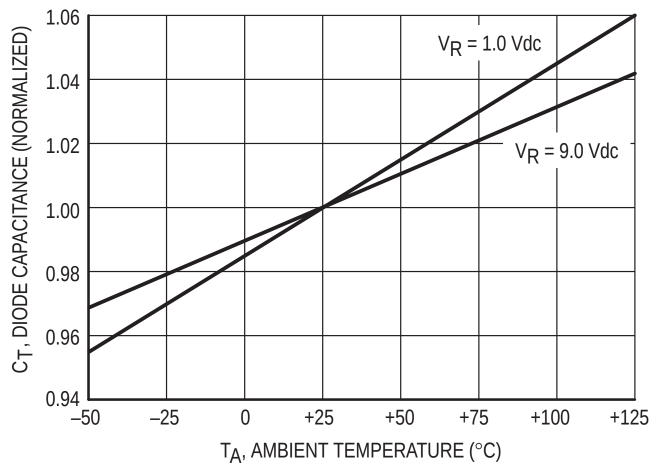


Figure 2. Diode Capacitance versus Ambient Temperature

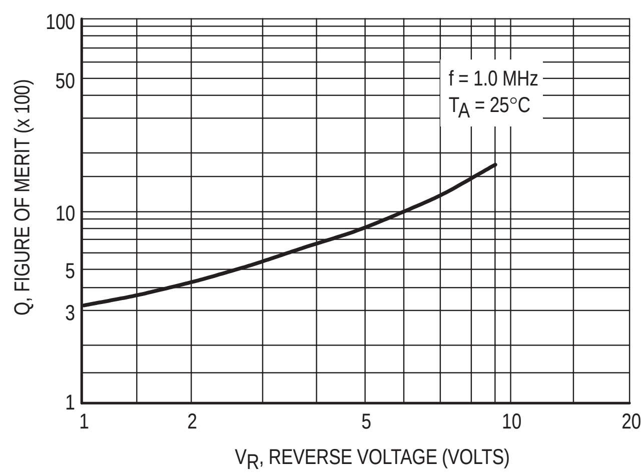


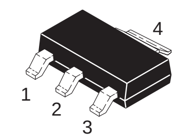
Figure 3. Figure of Merit

Silicon Hyper-Abrupt Tuning Diode

MV7404T1

Motorola Preferred Device

**SOT–223 PACKAGE
HIGH TUNING RATIO
VOLTAGE VARIABLE
SURFACE MOUNT
DIODE**



**CASE 318E–04, STYLE 2
SOT–223 (TO–261AA)**

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.

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

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	12	Vdc
Forward Current	I_F	250	mAdc
Total Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	800 6.4	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	–55 to +125	°C
Lead Temperature for Soldering Purposes, 1/6” from case Time in Solder Bath	T_L	260 10	°C Sec

1. FR-4 board, 0.0625 in^2, 2 oz. copper.

DEVICE MARKING

MV7404T1 = V7404

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
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)	T_R	10	—	—	—

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

REV 1

TYPICAL CHARACTERISTICS

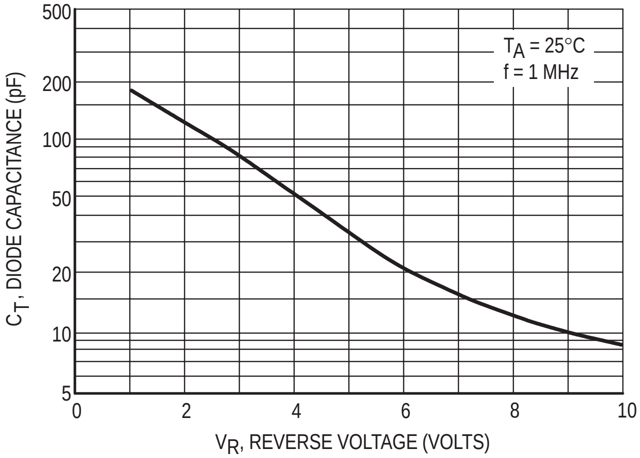


Figure 1. Diode Capacitance versus Reverse Voltage

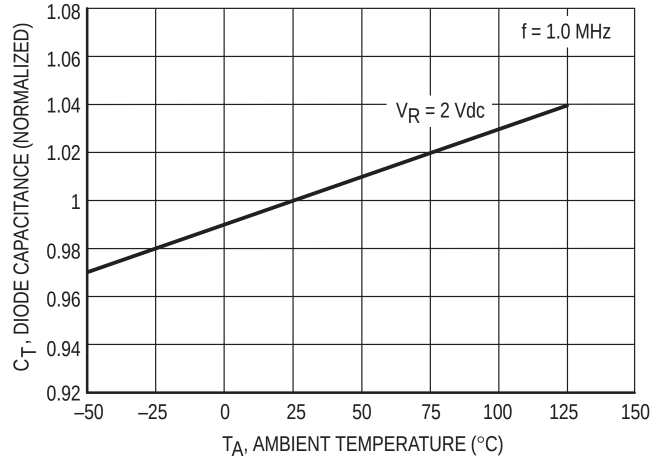


Figure 2. Diode Capacitance versus Ambient Temperature

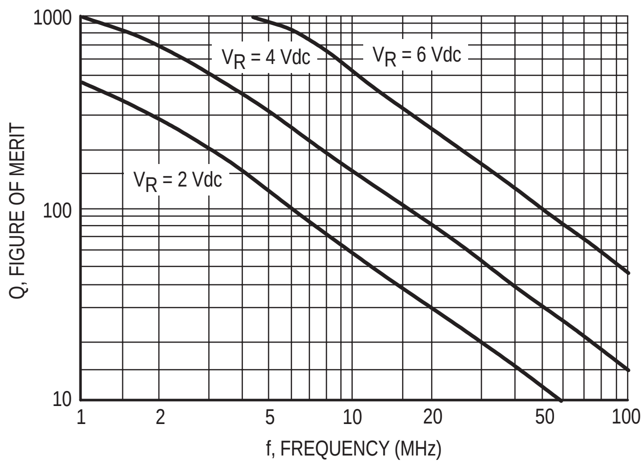


Figure 3. Figure of Merit versus Frequency

Section 6

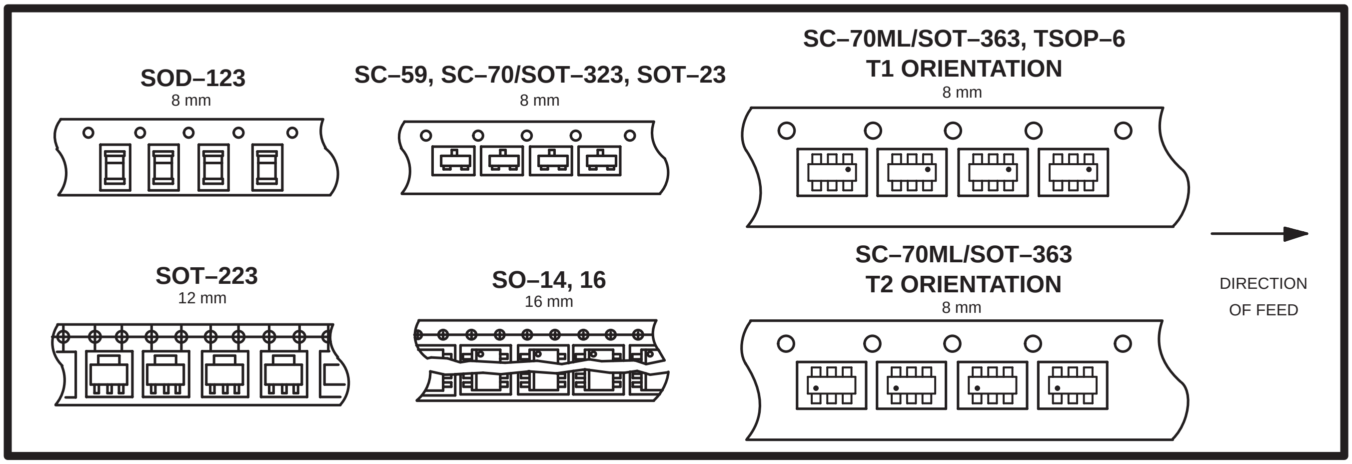
Tape and Reel Specifications and Packaging Specifications

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
- SOD–123, SC–59, SC–70/SOT–323, SC–70ML/SOT–363, SOT–23, TSOP–6, in 8 mm Tape
- 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.

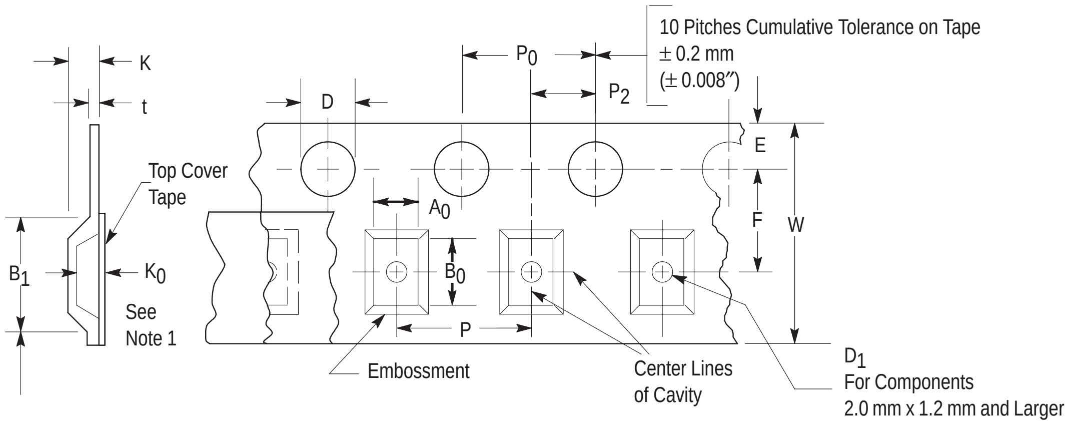


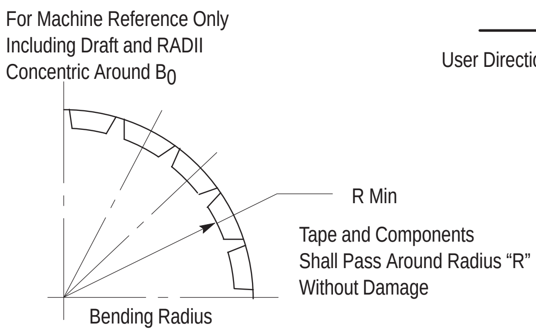
EMBOSSED TAPE AND REEL ORDERING INFORMATION

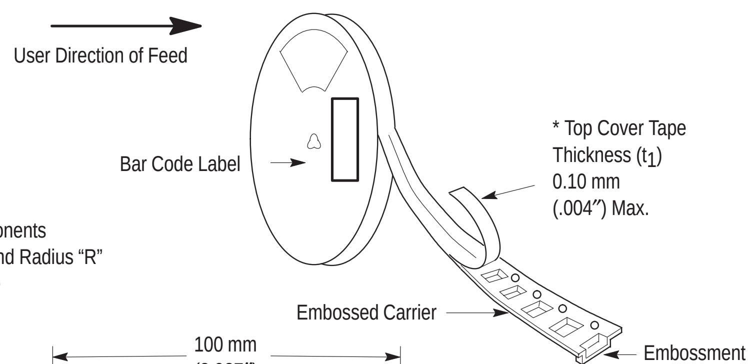
Package	Tape Width (mm)	Pitch mm (inch)	Reel Size mm (inch)	Devices Per Reel and Minimum Order Quantity	Device Suffix
SC–59	8	4.0 ± 0.1 (.157 ± .004)	178 (7)	3,000	T1
SC–70/SOT–323	8 8	4.0 ± 0.1 (.157 ± .004)	178 (7) 330 (13)	3,000 10,000	T1 T3
SO–14	16 16	8.0 ± 0.1 (.315 ± .004)	178 (7) 330 (13)	500 2,500	R1 R2
SO–16	16 16	8.0 ± 0.1 (.315 ± .004)	178 (7) 330 (13)	500 2,500	R1 R2
SOD–123	8 8	4.0 ± 0.1 (.157 ± .004)	178 (7) 330 (13)	3,000 10,000	T1 T3
SOT–23	8 8	4.0 ± 0.1 (.157 ± .004)	178 (7) 330 (13)	3,000 10,000	T1 T3
SOT–223	12 12	8.0 ± 0.1 (.315 ± .004)	178 (7) 330 (13)	1,000 4,000	T1 T3
SC–70ML/SOT–363	8 8	4.0 ± 0.1 (.157 ± .004)	178 (7) 178 (7)	3,000 3,000	T1 T2
TSOP–6	8	4.0 ± 0.1 (.157 ± .004)	178 (7)	3,000	T1

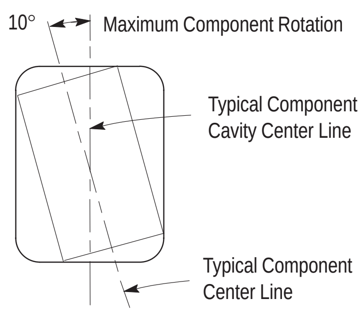
EMBOSSED TAPE AND REEL DATA FOR DISCRETES

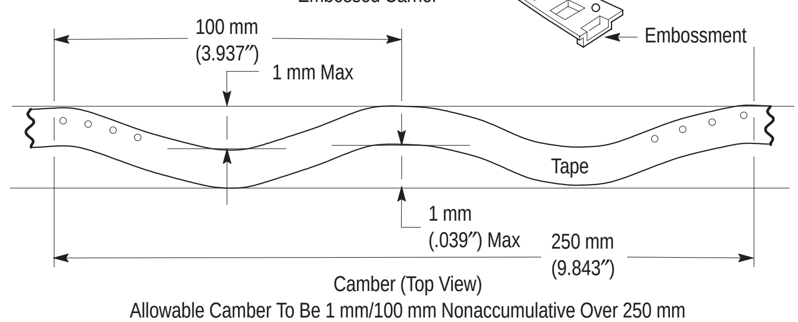
CARRIER TAPE SPECIFICATIONS











DIMENSIONS

Tape Size	B_1 Max	D	D_1	E	F	K	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″)	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″)			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″)					16.3 mm (.642″)
24 mm	20.1 mm (.791″)				11.5 ± 0.1 mm (.453 ± .004″)	11.9 mm Max (.468″)					24.3 mm (.957″)

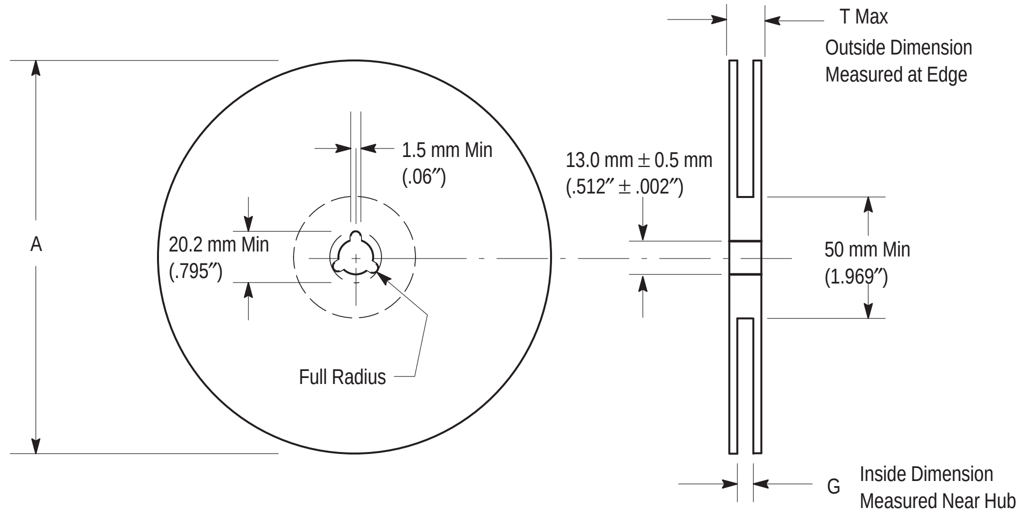
Metric dimensions govern — English are in parentheses for reference only.

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.

NOTE 2: If B_1 exceeds 4.2 mm (.165) for 8 mm embossed tape, the tape may not feed through all tape feeders.

NOTE 3: Pitch information is contained in the Embossed Tape and Reel Ordering Information on pg. 5.12–3.

EMBOSSED TAPE AND REEL DATA FOR DISCRETES



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″)

Reel Dimensions

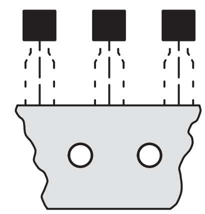
Metric Dimensions Govern — English are in parentheses for reference only

TO–92 EIA, IEC, EIAJ 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

TO–92 RADIAL TAPE IN FAN FOLD BOX OR ON REEL



Ordering Notes:

When ordering radial tape in fan fold box or on reel, specify the style per Figures 3 through 8. 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 9.
Fan Fold Box Information — Order in increments of 2000.
Reel Information — 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

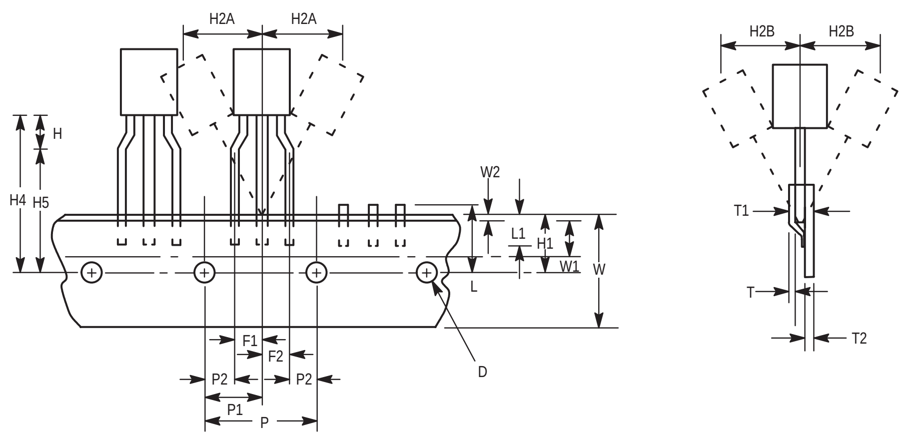


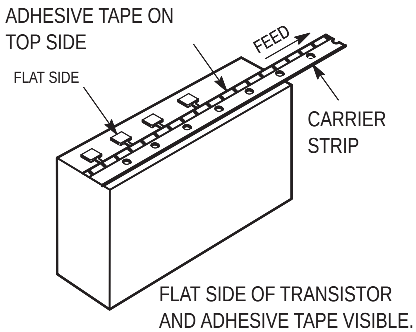
Figure 1. Device Positioning on Tape

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.

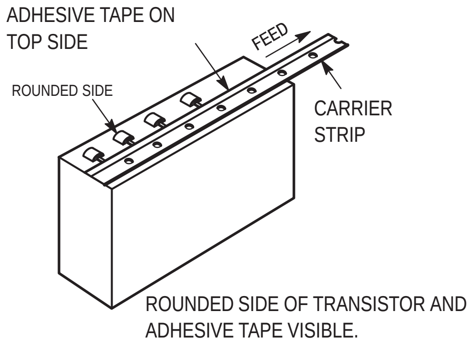
TO–92 EIA RADIAL TAPE IN FAN FOLD BOX OR ON REEL

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

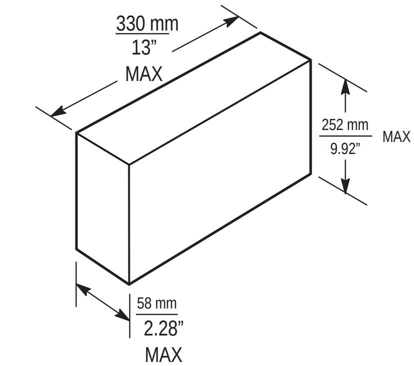
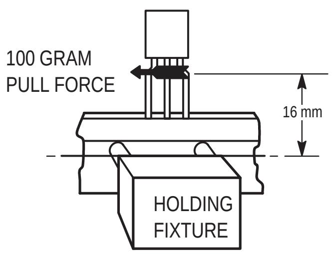


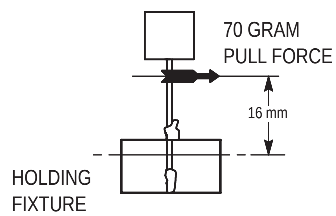
Figure 4. Fan Fold Box Dimensions

ADHESION PULL TESTS



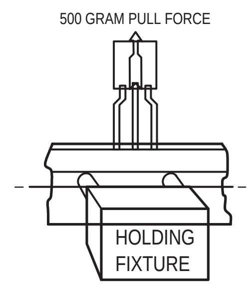
The component shall not pull free with a 300 gram load applied to the leads for 3 ± 1 second.

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

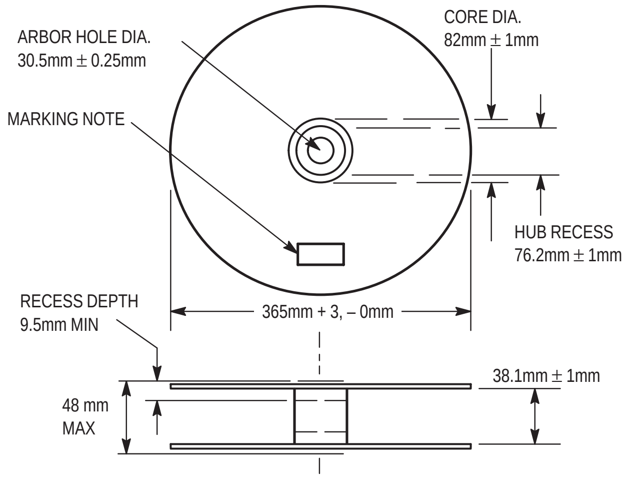


There shall be no deviation in the leads and no component leads shall be pulled free of the tape with a 500 gram load applied to the component body for 3 ± 1 second.

Figure 7. Test #3

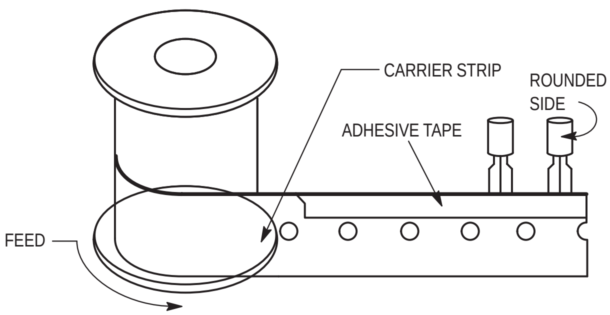
TO–92 EIA RADIAL TAPE IN FAN FOLD BOX OR ON REEL

REEL STYLES



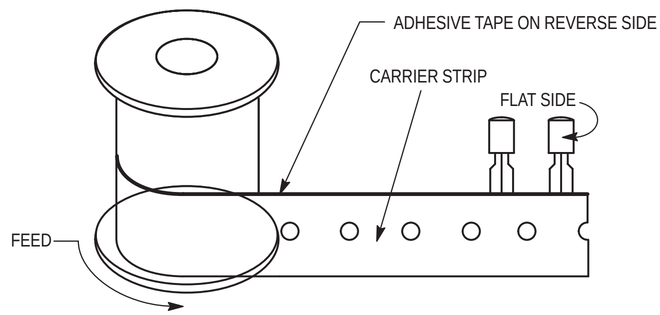
Material used must not cause deterioration of components or degrade lead solderability

Figure 8. Reel Specifications



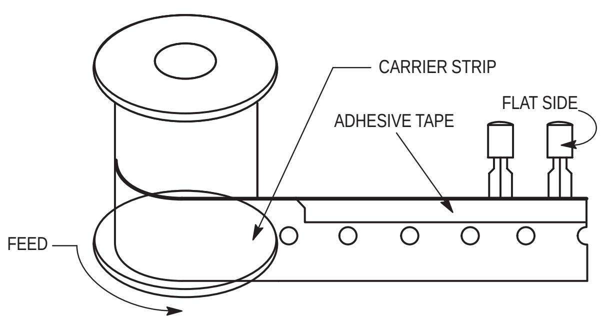
Rounded side of transistor and adhesive tape visible.

Figure 9. Style A



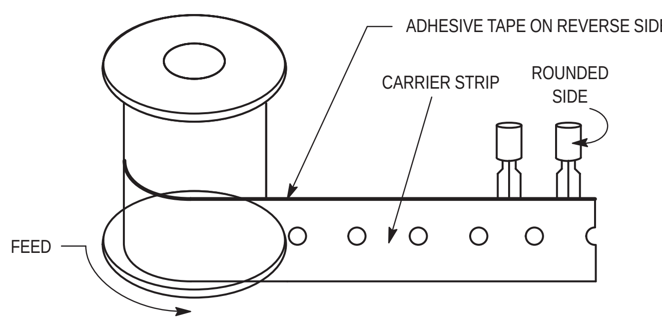
Flat side of transistor and carrier strip visible (adhesive tape on reverse side).

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

Section 7

Surface Mount Information

In Brief . . .

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.

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 ensure 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 the power dissipation can almost be doubled with this method, area is taken up 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.

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.

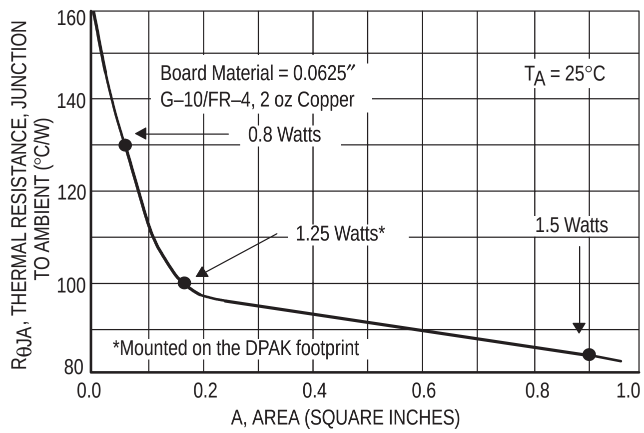


Figure 1. Thermal Resistance versus Drain Pad Area for the SOT–223 Package (Typical)

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 SOT–23, SC–59, SC–70/SOT–323, SC–90/SOT–416, SOD–123, SOT–223, SOT–363, SO–14, SO–16, and TSOP–6 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 should be a maximum of 10°C.
- The soldering temperature and time should not exceed 260°C for more than 10 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 since the use of forced cooling will increase the temperature gradient and will 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.

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.

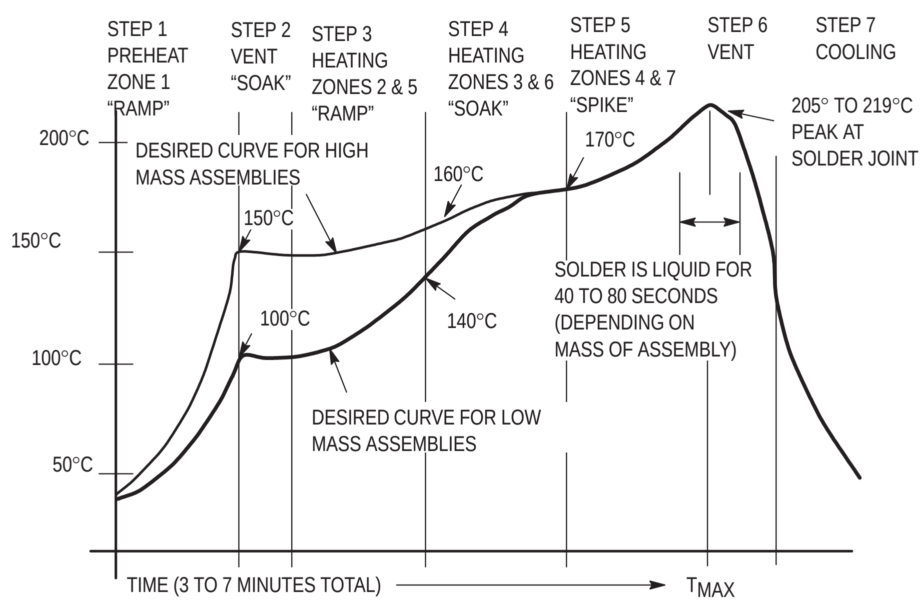
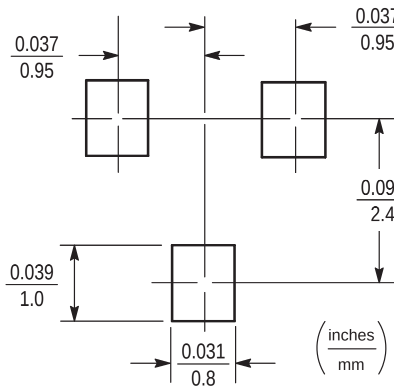
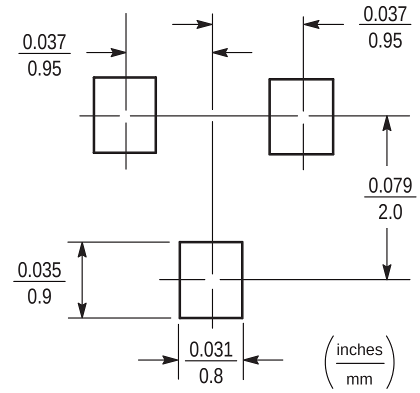


Figure 2. Typical Solder Heating Profile

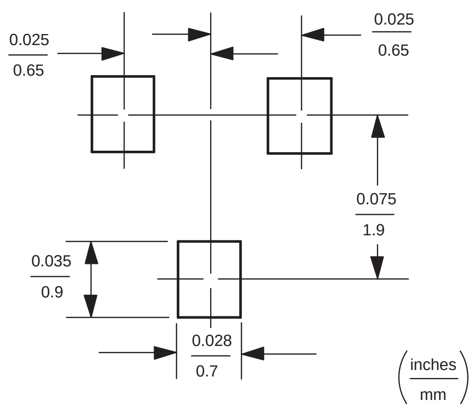
Footprints for Soldering



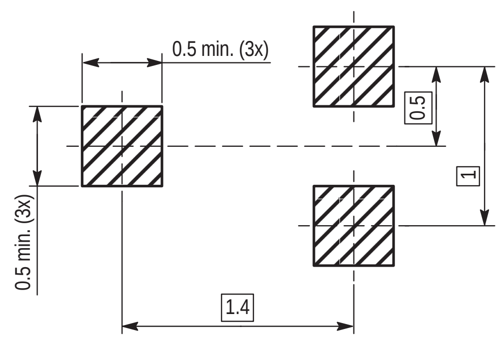
SC–59



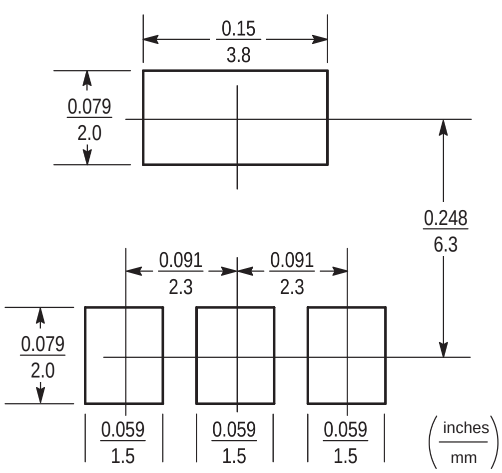
SOT–23



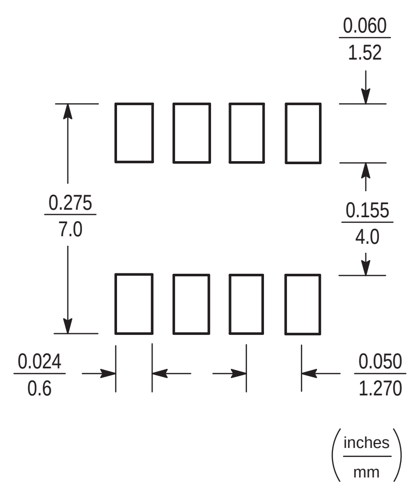
SC–70/SOT–323



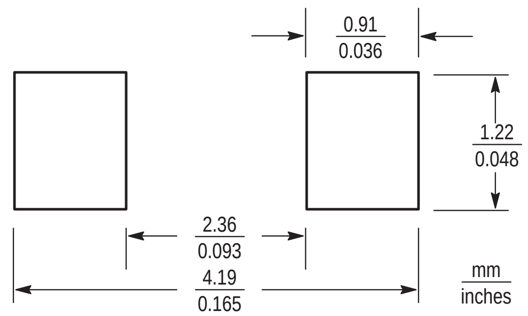
SOT 416/SC–90



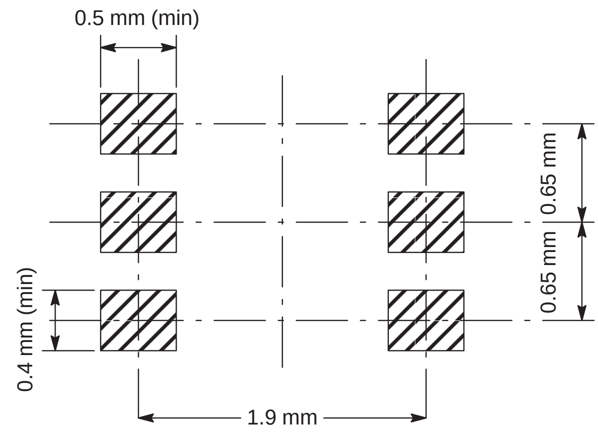
SOT–223



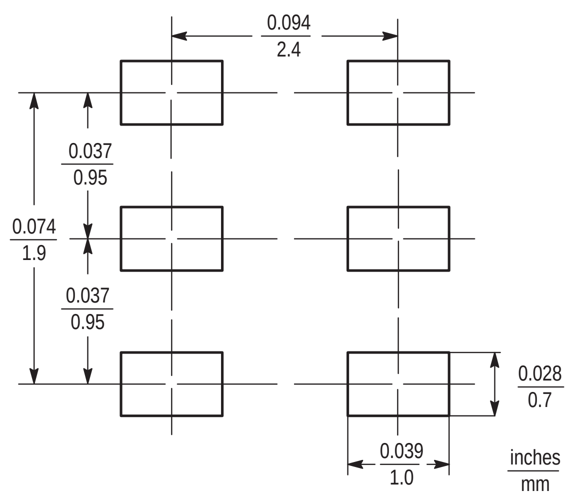
SO–14, SO–16



SOD–123



SOT–363
(SC–70 6 LEAD)



TSOP–6

Section 8

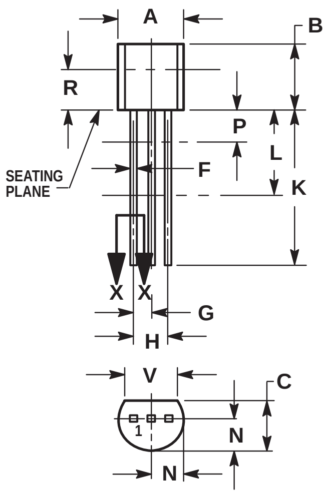
Package Outline Dimensions

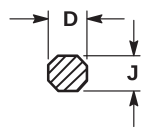
In Brief . . .

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.

Package Outline Dimensions

Dimensions are in inches unless otherwise noted.





SECTION X–X

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. DIMENSION F APPLIES BETWEEN P AND L. DIMENSION D AND J APPLY BETWEEN L AND K MINIMUM. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.19
D	0.016	0.022	0.41	0.55
F	0.016	0.019	0.41	0.48
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.015	0.020	0.39	0.50
K	0.500	—	12.70	—
L	0.250	—	6.35	—
N	0.080	0.105	2.04	2.66
P	—	0.100	—	2.54
R	0.115	—	2.93	—
V	0.135	—	3.43	—

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 7:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 14:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

STYLE 15:
PIN 1. ANODE 1
2. CATHODE
3. ANODE 2

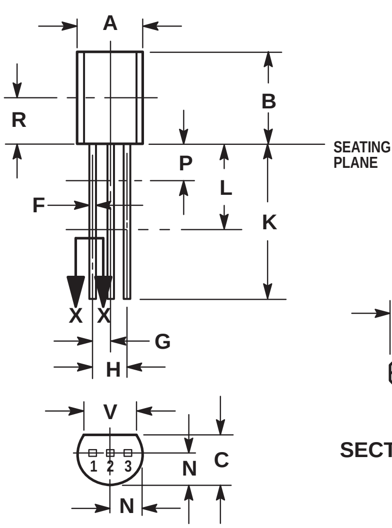
STYLE 17:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

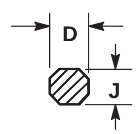
STYLE 21:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

STYLE 22:
PIN 1. SOURCE
2. GATE
3. DRAIN

STYLE 30:
PIN 1. DRAIN
2. GATE
3. SOURCE

CASE 029–04
(TO–226AA) TO–92
PLASTIC





SECTION X–X

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. DIMENSION F APPLIES BETWEEN P AND L. DIMENSIONS D AND J APPLY BETWEEN L AND K MIMIMUM. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.175	0.205	4.44	5.21
B	0.290	0.310	7.37	7.87
C	0.125	0.165	3.18	4.19
D	0.018	0.022	0.46	0.56
F	0.016	0.019	0.41	0.48
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.018	0.024	0.46	0.61
K	0.500	—	12.70	—
L	0.250	—	6.35	—
N	0.080	0.105	2.04	2.66
P	—	0.100	—	2.54
R	0.135	—	3.43	—
V	0.135	—	3.43	—

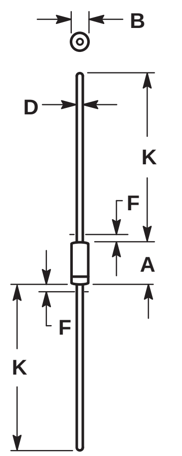
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 14:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

STYLE 22:
PIN 1. SOURCE
2. GATE
3. DRAIN

CASE 029–05
(TO–226AE) TO–92
1–WATT PLASTIC

PACKAGE OUTLINE DIMENSIONS (continued)

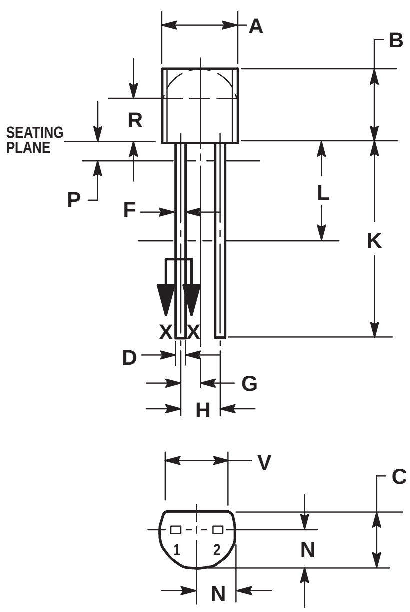


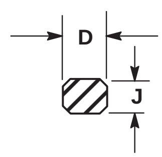
NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	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
(DO–204AA)
DO–7





SECTION X–X

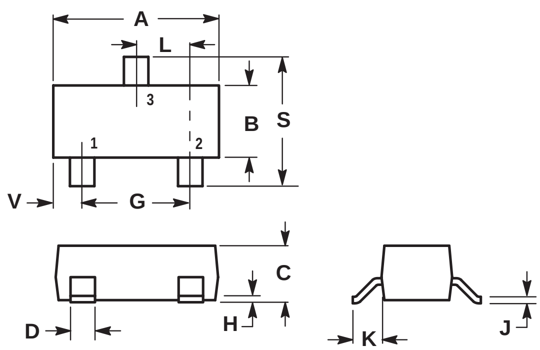
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND ZONE R IS UNCONTROLLED.
4. DIMENSION F APPLIES BETWEEN P AND L. DIMENSIONS D AND J APPLY BETWEEN L AND K MINIMUM. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIM K MINIMUM.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.21
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.49
D	0.016	0.022	0.41	0.56
F	0.016	0.019	0.407	0.482
G	0.050 BSC		1.27 BSC	
H	0.100 BSC		3.54 BSC	
J	0.014	0.016	0.36	0.41
K	0.500	—	12.70	—
L	0.250	—	6.35	—
N	0.080	0.105	2.03	2.66
P	—	0.050	—	1.27
R	0.115	—	2.93	—
V	0.135	—	3.43	—

STYLE 1:
PIN 1. ANODE
2. CATHODE

CASE 182–02
(T0–226AC) TO–92
PLASTIC

PACKAGE OUTLINE DIMENSIONS (continued)



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. MAXIUMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.1102	0.1197	2.80	3.04
B	0.0472	0.0551	1.20	1.40
C	0.0350	0.0440	0.89	1.11
D	0.0150	0.0200	0.37	0.50
G	0.0701	0.0807	1.78	2.04
H	0.0005	0.0040	0.013	0.100
J	0.0034	0.0070	0.085	0.177
K	0.0140	0.0285	0.35	0.69
L	0.0350	0.0401	0.89	1.02
S	0.0830	0.1039	2.10	2.64
V	0.0177	0.0236	0.45	0.60

STYLE 6:
PIN 1. BASE
2. EMITTER
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

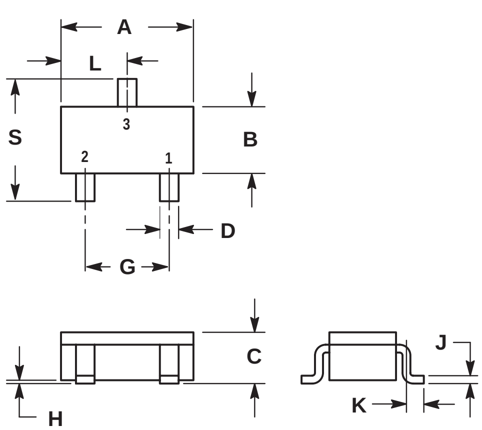
STYLE 12:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 18:
PIN 1. NO CONNECTION
2. CATHODE
3. ANODE

STYLE 19:
PIN 1. CATHODE
2. ANODE
3. CATHODE–ANODE

STYLE 21:
PIN 1. GATE
2. SOURCE
3. DRAIN

CASE 318–08
(TO–236AB) SOT–23
PLASTIC



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.

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	0.09	0.18	0.0034	0.0070
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

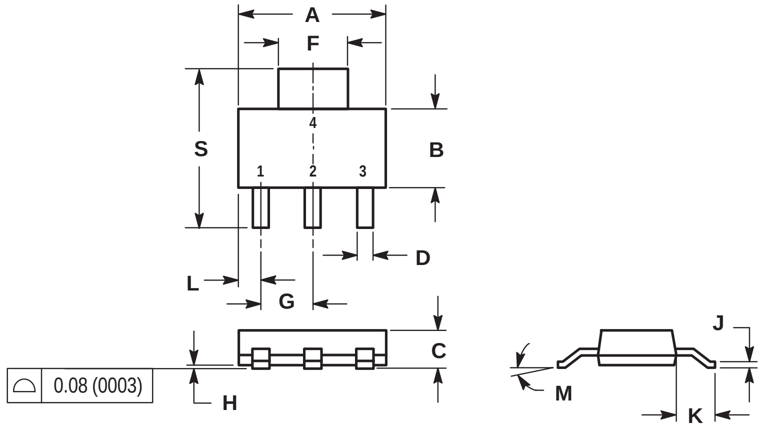
STYLE 3:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 4:
PIN 1. N.C.
2. CATHODE
3. ANODE

STYLE 5:
PIN 1. CATHODE
2. CATHODE
3. ANODE

CASE 318D–04
SC–59

PACKAGE OUTLINE DIMENSIONS (continued)



NOTES:
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
4. CONTROLLING DIMENSION: INCH.

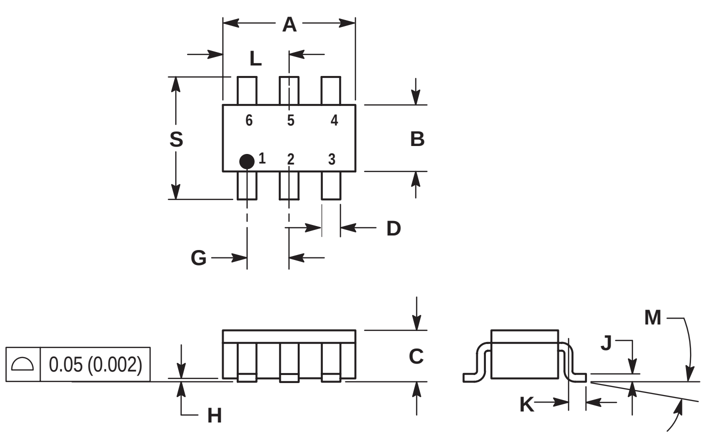
	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.249	0.263	6.30	6.70
B	0.130	0.145	3.30	3.70
C	0.060	0.068	1.50	1.75
D	0.024	0.035	0.60	0.89
F	0.115	0.126	2.90	3.20
G	0.087	0.094	2.20	2.40
H	0.0008	0.0040	0.020	0.100
J	0.009	0.014	0.24	0.35
K	0.060	0.078	1.50	2.00
L	0.033	0.041	0.85	1.05
M	0°	10°	0°	10°
S	0.264	0.287	6.70	7.30

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

CASE 318E–04
SOT–223



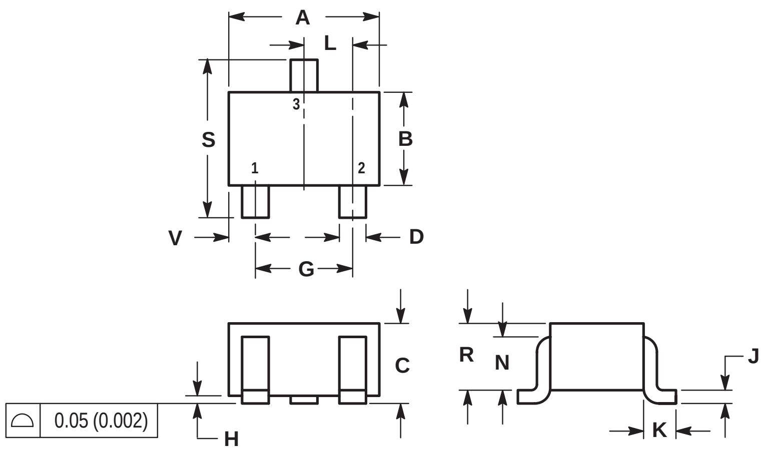
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	2.90	3.10	0.1142	0.1220
B	1.30	1.70	0.0512	0.0669
C	0.90	1.10	0.0354	0.0433
D	0.25	0.50	0.0098	0.0197
G	0.85	1.05	0.0335	0.0413
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	1.55	0.0493	0.0610
M	0°	10°	0°	10°
S	2.50	3.00	0.0985	0.1181

STYLE 1:
PIN 1. DRAIN
2. DRAIN
3. GATE
4. SOURCE
5. DRAIN
6. DRAIN

CASE 318G–02
TSOP–6
PLASTIC

PACKAGE OUTLINE DIMENSIONS (continued)



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	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		0.650 BSC	
N	0.028 REF		0.700 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

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

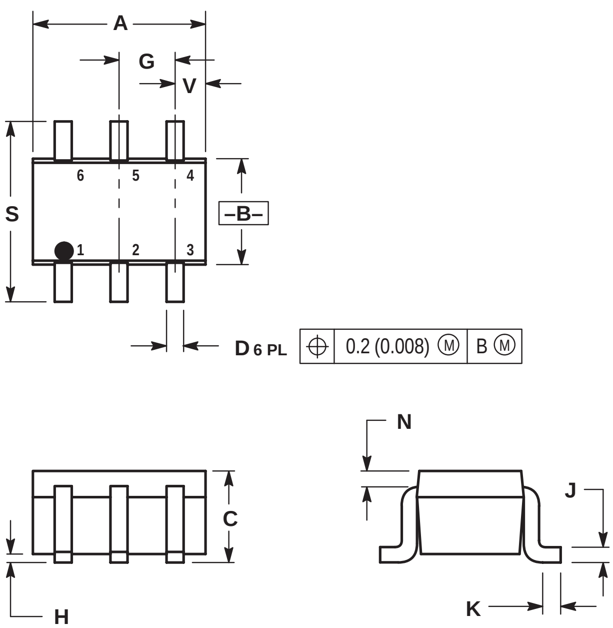
STYLE 5:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 7:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 9:
PIN 1. ANODE
2. CATHODE
3. CATHODE–ANODE

STYLE 10:
PIN 1. CATHODE
2. ANODE
3. ANODE–CATHODE

CASE 419–02
SC–70/SOT–323



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

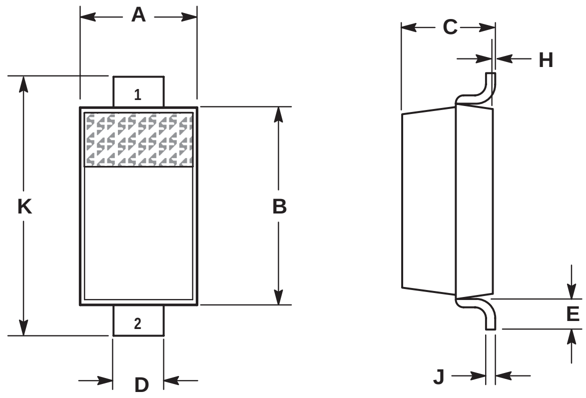
	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.071	0.087	1.80	2.20
B	0.045	0.053	1.15	1.35
C	0.031	0.043	0.80	1.10
D	0.004	0.012	0.10	0.30
G	0.026 BSC		0.65 BSC	
H	—	0.004	—	0.10
J	0.004	0.010	0.10	0.25
K	0.004	0.012	0.10	0.30
N	0.008 REF		0.20 REF	
S	0.079	0.087	2.00	2.20
V	0.012	0.016	0.30	0.40

STYLE 1:
PIN 1. EMITTER 2
2. BASE 2
3. COLLECTOR 1
4. EMITTER 1
5. BASE 1
6. COLLECTOR 2

STYLE 6:
PIN 1. ANODE 2
2. N/C
3. CATHODE 1
4. ANODE 1
5. N/C
6. CATHODE 2

CASE 419B-01
SOT–363

PACKAGE OUTLINE DIMENSIONS (continued)

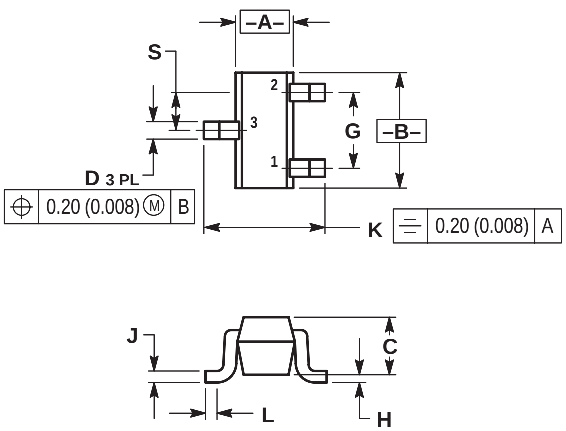


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.055	0.071	1.40	1.80
B	0.100	0.112	2.55	2.85
C	0.037	0.053	0.95	1.35
D	0.020	0.028	0.50	0.70
E	0.004	—	0.25	—
H	0.000	0.004	0.00	0.10
J	—	0.006	—	0.15
K	0.140	0.152	3.55	3.85

STYLE 1:
PIN 1. CATHODE
2. ANODE

CASE 425–04
SOD–123



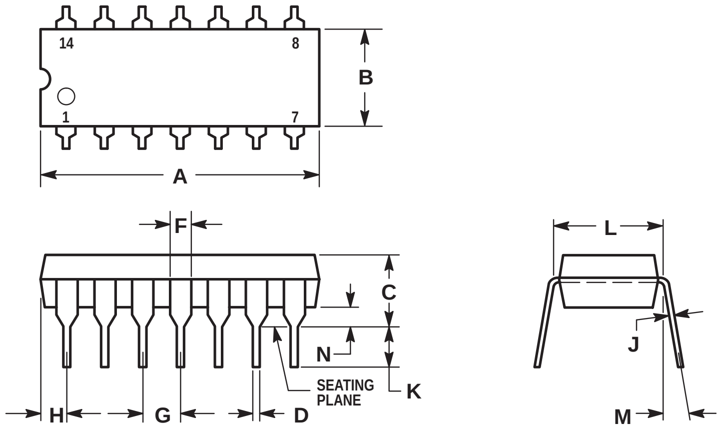
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	0.70	0.80	0.028	0.031
B	1.40	1.80	0.055	0.071
C	0.60	0.90	0.024	0.035
D	0.15	0.30	0.006	0.012
G	1.00 BSC		0.039 BSC	
H	—	0.10	—	0.004
J	0.10	0.25	0.004	0.010
K	1.45	1.75	0.057	0.069
L	0.10	0.20	0.004	0.008
S	0.50 BSC		0.020 BSC	

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 4:
PIN 1. CATHODE
2. CATHODE
3. ANODE

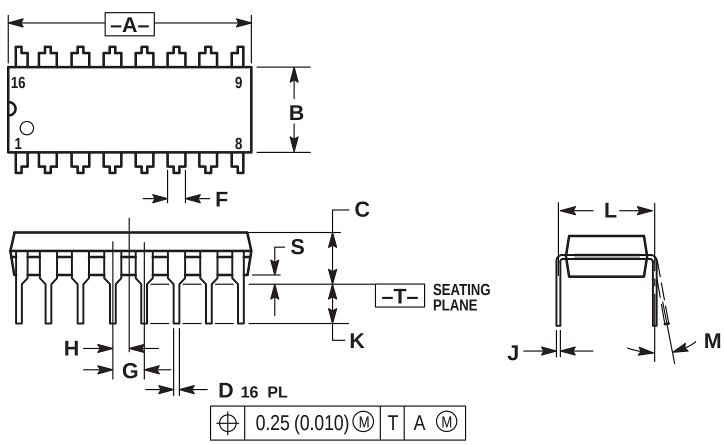
CASE 463–01
SOT–416/SC–90



NOTES:
1. LEADS WITHIN 0.13 (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	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.715	0.770	18.16	19.56
B	0.240	0.260	6.10	6.60
C	0.145	0.185	3.69	4.69
D	0.015	0.021	0.38	0.53
F	0.040	0.070	1.02	1.78
G	0.100 BSC		2.54 BSC	
H	0.052	0.095	1.32	2.41
J	0.008	0.015	0.20	0.38
K	0.115	0.135	2.92	3.43
L	0.300 BSC		7.62 BSC	
M	0°	10°	0°	10°
N	0.015	0.039	0.39	1.01

CASE 646–06
14–PIN DIP
PLASTIC

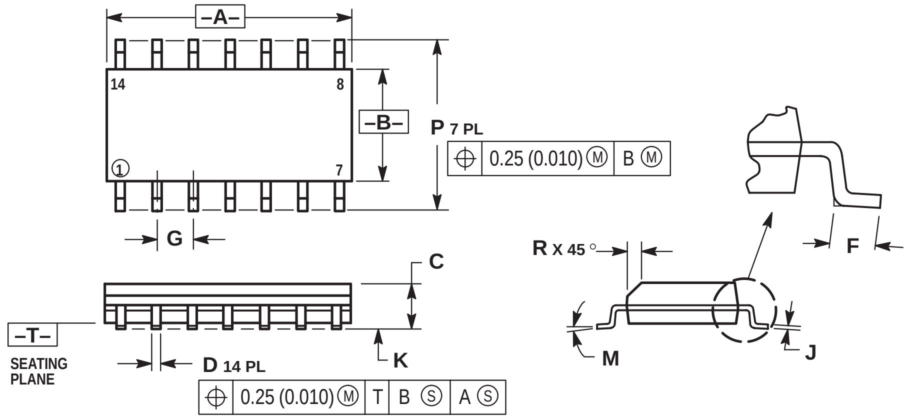


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	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	0.70	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

CASE 648–08
16–PIN DIP
PLASTIC

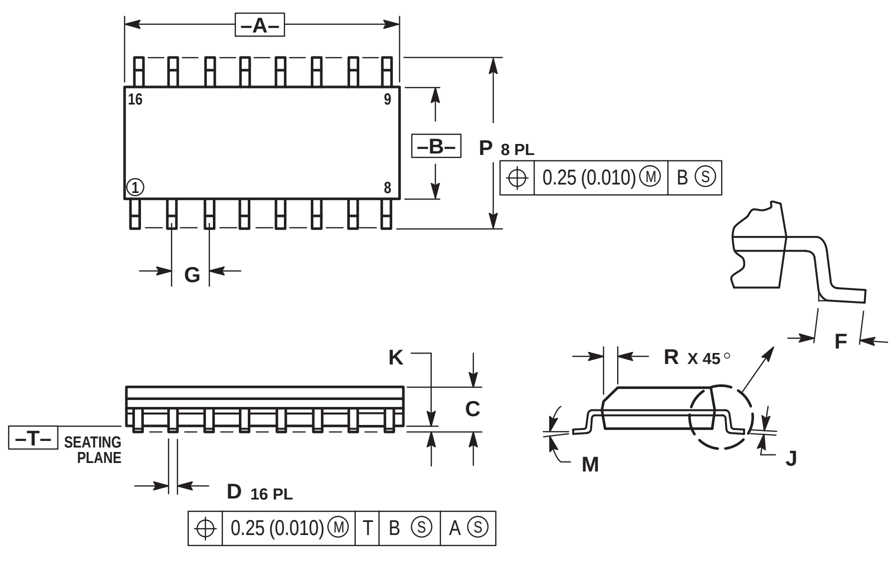
PACKAGE OUTLINE DIMENSIONS (continued)



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. 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	0.228	0.244
R	0.25	0.50	0.010	0.019

CASE 751A–03
SO–14
PLASTIC



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. 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	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

Section 9

Reliability and Quality Assurance

In Brief . . .

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.

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 its 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

$$AOQ = (\text{Process Average}) \bullet (\text{Probability of Acceptance}) \bullet (10^6)\ (\text{PPM})$$

- Process Average = $\dfrac{\text{Total Projected Reject Devices}}{\text{Total Number of Devices}}$
- 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
- Probability of Acceptance = $1 \pm \dfrac{\text{Number of Lots Rejected}}{\text{Number of Lots Tested}}$
- 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.

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:

$$\lambda = \frac{\chi 2\ (\alpha,\ d.\ f.)}{2t}$$

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 in Table 1–1.

Table 1–1 – 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.

The table on the following page shows observed activation energies with references.

Table 1–2 – 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 Water 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 reliabiity 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:

$$T_J = T_A + P_D(\bar{\theta}_{JC} + \bar{\theta}_{CA}) \qquad (1)$$

or

$$T_J = T_A + P_D(\bar{\theta}_{JA}) \qquad (2)$$

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, θ_{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 θ_{CA} thermal resistance term. θ_{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:

$$T_J = T_C + P_D(\theta_{JC}) \qquad (3)$$

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 $\bar{\theta}_{JC}$) 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 effect 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/cycles, 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 the 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, nonwetting
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 critierion 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 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

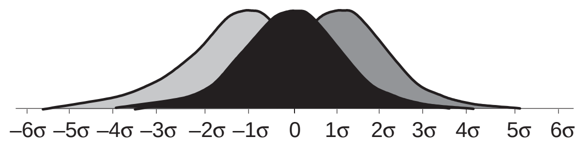
Communication Power & Signal Technologies Group (CPSTG) is continually pursuing new ways to improve product quality. Initial design improvement is one method that can be used to produce a superior product. Equally important to outgoing product quality is the ability to produce product that consistently 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 ensures that 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, 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 ± 3σ	2700 ppm defective 99.73% yield	66810 ppm defective 93.32% yield
At ± 4σ	63 ppm defective 99.9937% yield	6210 ppm defective 99.379% yield
At ± 5σ	0.57 ppm defective 99.999943% yield	233 ppm defective 99.9767% yield
At ± 6σ	0.002 ppm defective 99.9999998% yield	3.4 ppm defective 99.99966% yield

Figure 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, the random variability is due to 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 2 shows the impact on predictability that assignable cause can have. Figure 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 the 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 = $|\text{closest specification} - \bar{X}|/3\sigma$.

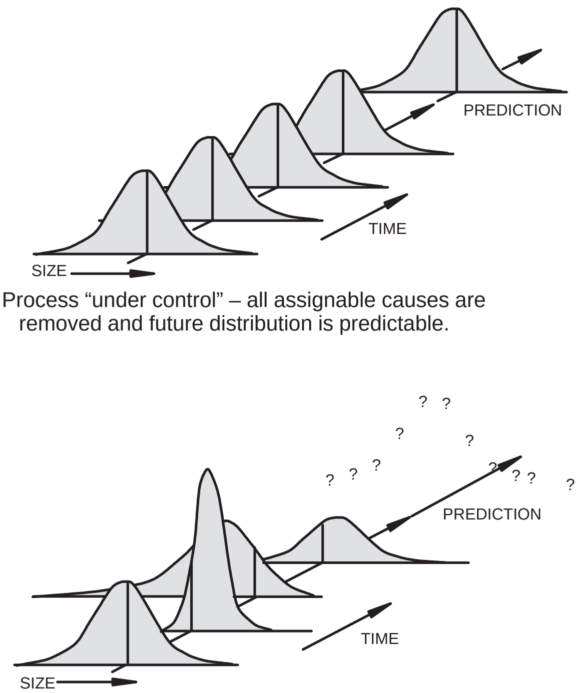


Figure 2. Impact of Assignable Causes on Process Predictable

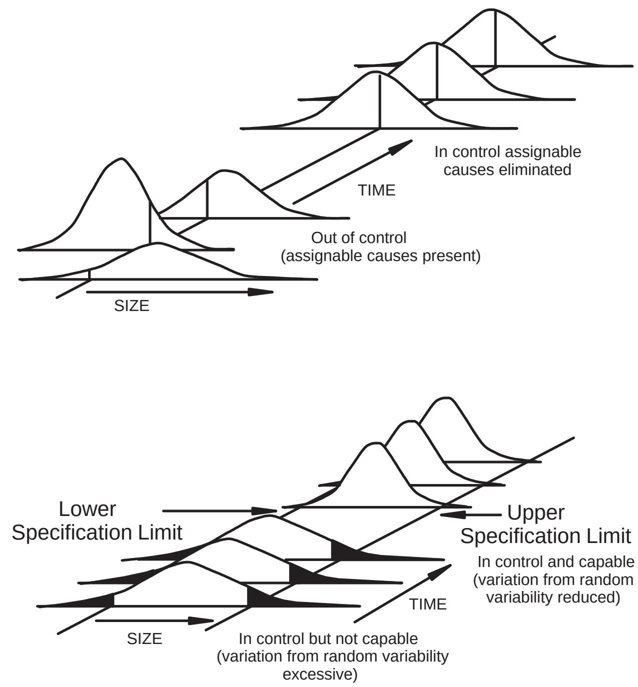


Figure 3. Difference Between Process Control and Process Capability

At Motorola, for critical parameters, the process capability is acceptable with a Cpk = 1.50 with continual improvement our goal. 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

CPSTG 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 as well. It is equally important to find a measurement in these process steps that correlates with product performance. This measurement 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 two to five 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 are operator, machine, time, settings, product type, etc.

Once the plan is established, data collection may begin. The data collected with 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:

$$\bar{\bar{X}} = (\bar{X} + \bar{X}2 + \bar{X}3 + \ldots)/K$$
$$\bar{R} = (R1 + R2 + R2 + \ldots)/K$$

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 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 = $UCL_X = \bar{\bar{X}} + A2\ \bar{R}$
X lower control limit = $LCL_X = \bar{\bar{X}} - A2\ \bar{R}$

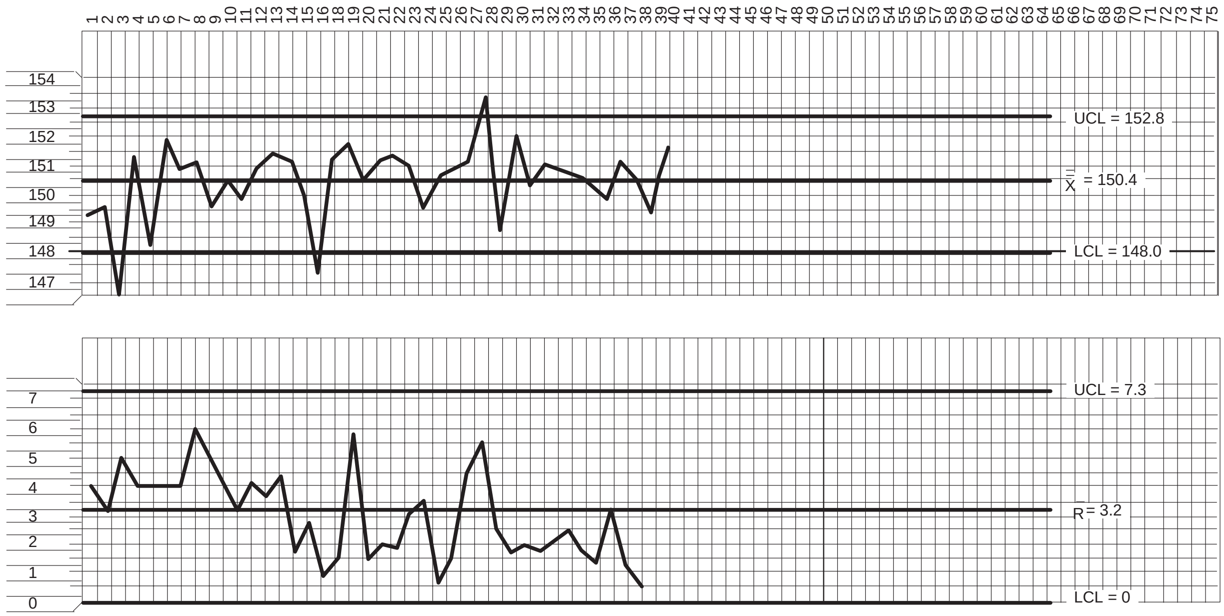


Figure 4. Example of Process Control Chart Showing Oven Temperature Data

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 5 shows a control chart subdivided into zones A, B, and C corresponding to 3 sigma, 2 sigma, and 1 sigma limits respectively. In Figures 6 through 9 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:

$$\sigma \text{ tot} = \sqrt{\sigma A^2 + \sigma B^2 + \sigma C^2 + \sigma D^2 + \sigma E^2}$$

$$\sigma \text{ tot} = \sqrt{5^2 + 3^2 + 2^2 + 1^2 + (0.4)^2} = 6.3$$

If only D is identified and eliminated, then:

$$\sigma \text{ tot} = \sqrt{5^2 + 3^2 + 2^2 + (0.4)^2} = 6.2$$

This results in less than 2% total variability improvement. If B, C, and D were eliminated, then:

$$\sigma \text{ tot} = \sqrt{5^2 + (0.4)^2} = 5.02$$

This gives a considerably better improvement of 23%. If only A is identified and reduced from 5 to 2, then:

$$\sigma \text{ tot} = \sqrt{2^2 + 3^2 + 2^2 + 1^2 + (0.4)^2} = 4.3$$

Identifying and improving the variability from 5 to 2 yields 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 variablility 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 in a state of control.

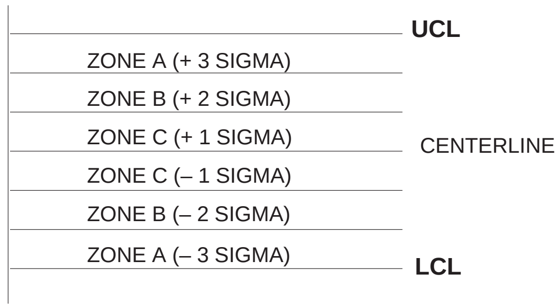


Figure 5. Control Chart Zones

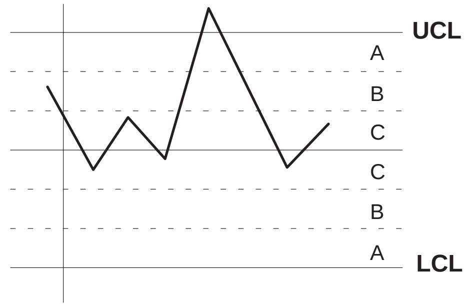


Figure 6. One Point Outside Control Limit Indicating Excessive Variability

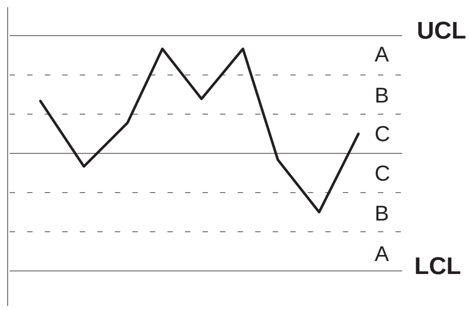


Figure 7. Two Out of Three Points in Zone A or Beyond Indicating Excessive Variability

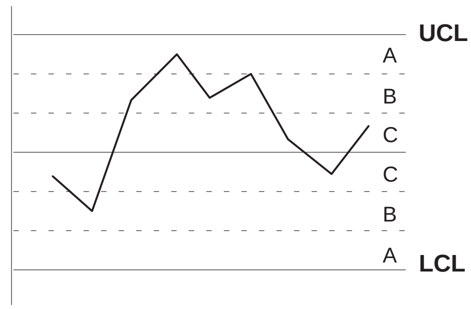


Figure 8. Four Out of Five Points in Zone B or Beyond Indicating Excessive Variability

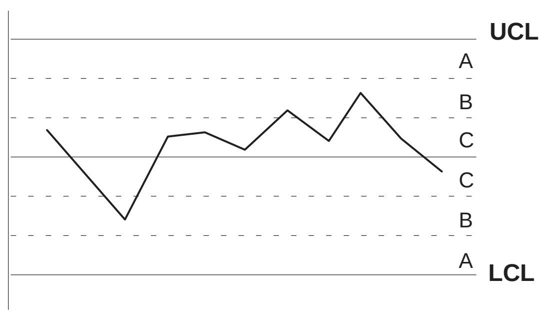


Figure 9. Seven Out of Eight Points in Zone C or Beyond Indicating Excessive Variability

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**.

Section 10

Replacement Devices

In Brief . . .

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 5) 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

DEVICE	REPLACEMENT	DEVICE	REPLACEMENT	DEVICE	REPLACEMENT
1N5139	MV2101	2N3053A	MPSA05	BC560B	BC560C
1N5139A	MV2101	2N3244	2N4403	BC849ALT1	BC848ALT1
1N5140	MMBV2103LT1	2N3250	2N4403	BC850ALT1	BC848ALT1
1N5140A	MMBV2103LT1	2N3251	MPS2907A	BC857CLT1	BC857ALT1
1N5141	MMBV2104LT1	2N3251A	MPS2907A	BCY70	MPS2222A
1N5141A	MMBV2104LT1	2N3467	MPSA56	BCY71	MPS2222A
1N5142	MMBV2105LT1	2N3468	MPSA56	BCY72	MPS2222A
1N5142A	MMBV2105LT1	2N3497	2N5401	BDB01D	BDB01C
1N5143	MMBV2105LT1	2N3500	2N5551	BDB02D	BDB02C
1N5143A	MMBV2105LT1	2N3501	2N5551	BDC02D	BDC01D
1N5144	MMBV2107LT1	2N3546	MPSH17	BDC05	MPSW42
1N5144A	MMBV2107LT1	2N3634	2N5401	BF244A	2N3819
1N5145	MMBV2108LT1	2N3635	2N5401	BF244B	2N3819
1N5145A	MMBV2108LT1	2N3636	MPSA92	BF245	BF245A
1N5146	MMBV2109LT1	2N3637	MPSA92	BF245A	BF245A
1N5146A	MV2109	2N3700	MPSA06	BF245B	BF245A
1N5147	MV2111	2N3799	MPSA18	BF245C	BF245A
1N5147A	MV2111	2N3947	MPS2222A	BF246A	BF245A
1N5441A	MV2101	2N3963	MPSA18	BF246B	BF245A
1N5443A	MV2103	2N3964	MPSA18	BF247B	BF245A
1N5444A	MV2104	2N4014	MPS2222A	BF256B	BF256A
1N5445A	MV2105	2N4032	MPS2907A	BF256C	BF256A
1N5449A	MV2108	2N4033	MPSA56	BF258	BF422
1N5450A	MV2109	2N4036	MPSA56	BF374	BC338
1N5451A	MV2111	2N4037	MPSA56	BF391	MPSA42
1N5452A	MV2111	2N4126	MPS4126	BF392	MPSA42
1N5453A	MV2111	2N4265	2N4264	BF492	MPSA92
1N5455A	MV2115	2N4405	MPS8599	BF493	MPSA92
2N697	MPSA20	2N4407	MPS8599	BFW43	2N5401
2N718A	MPSA05	2N4931	MPSA92	BSP20AT1	BF720T1
2N720A	MPSA06	2N5086	2N5087	BSS71	MPSA42
2N930	MPSA18	2N5668	2N3819	BSS72	MPSA42
2N930A	MPSA18	2N5669	2N3819	BSS73	MPSA42
2N956	MPSA05	2N5670	2N3819	BSS74	MPSA92
2N1613	2N4410	2N6431	MPSA42	BSS75	MPSA92
2N1711	MPSA05	2N6433	MPSA92	BSS76	MPSA92
2N1893	MPSA06	2N6516	2N6517	BSS89	BS107
2N2102	2N4410	BA582T1	MMBV3401LT1	BSV16–10	MPS2907A
2N2218A	MPS2222A	BC107	BC237	BSX20	MPS2369A
2N2219	MPS2222A	BC107A	BC237	CV12253	MPSA06
2N2219A	MPS2222A	BC107B	BC237	IRFD110	BSS123LT1
2N2222	MPS2222	BC108		IRFD113	MMBF170LT1
2N2222A	MPS2222A	BC109C	BC3338	IRFD120	BSS123LT1
2N2270	MPSA05	BC140–10	MPSW06	IRFD123	MMBF170LT1
2N2369	MPS2369	BC140–16	MPSW06	IRFD210	MMFT107T1
2N2369A	MPS2369A	BC141–10	MPSW06	IRFD213	MMFT107T1
2N2484	2N5087	BC141–16	MPSW06	IRFD220	MMFT107T1
2N2895	MPSA06	BC160–16	MPSW56	IRFD223	MMFT107T1
2N2896	2N5551	BC161–16	MPSW56	IRFD9120	BSS123LT1
2N2904	MPS2907	BC177	BC547	IRFD9123	2N7002LT1
2N2904A	MPS2907A	BC177A	BC547A	J111	J111RLRA
2N2905	MPS2907	BC177B	BC547B	J113	J113RL1
2N2905A	MPS2907A	BC238	BC238B	J203	2N5458
2N2906	MPS2907	BC309B	BC308C	J300	2N5486
2N2906A	MPS2907A	BC393	MPSA92	J305	MMBF5484LT1
2N2907	MPS2907	BC394	MPSA42	MAD130P	BAS16LT1
2N2907A	MPS2907A	BC450	MPSA92	MAD1103P	BAS16LT1
2N3019	MPSA06	BC450A	MPSA92	MAD1107P	BAS16LT1
2N3020	MPSA06	BC546A	BC546B	MAD1108P	BAS16LT1
2N3053	MPSA20	BC559	BC559B	MAD1109P	BAS16LT1

REPLACEMENT DEVICES

DEVICE	REPLACEMENT
MM3001	2N5551
MM3725	MPS2222A
MM4001	2N5401
MMAD1106	BAS16LT1
MMBF4856LT1	MMBF4391LT1
MMBF4860LT1	MMBF5457LT1
MMBF5459LT1	MMBF5457LT1
MMBF5486LT1	2N5486
MMBT8599LT1	MMBT5551LT1
MMBV2104LT1	MMBV2103LT1
MMPQ3799	MMPQ3725
MMSV3401T1	MMBV3401LT1
MPF970	MMBFJ175LT1
MPF971	MMBFJ175LT1
MPF3821	MMBF5457LT1
MPF3822	MMBF5457LT1
MPF4856	MPF4391RLRA
MPF4857	2N5639
MPF4858	J112
MPF4859	2N5638RLRA
MPF4860	2N5638RLRA
MPF4861	J112
MPQ6501	MPQ6502
MPS3638	MPS3638A
MPS3866	BF224
MPS4123	MPS4124
MPS4125	MPS4126
MPS4258	MPS3640
MPS5771	MPS3640
MPS6520	MPS6521

DEVICE	REPLACEMENT
MPS6530	MPS6530RLRM
MPS6531	MPS6530RLRM
MPS6562	MPS6651
MPS6568A	MPS918
MPS6571	MPSA18
MPS6595	MPS3563
MPS8093	2N4402
MPSA16	MPSA17
MPSH04	MPSH17
MPSH07A	MPSH17
MPSH20	MPSH17
MPSH24	MPSH17
MPSH34	MPSH17
MPSH69	MPSH81
MSA1022–BT1	MSA1022–CT1
MSB709–ST1	MSB709–RT1
MSB710–QT1	MSB710–RT1
MSB1218A–ST1	MSB1218A–RT1
MSC1621T1	MSD602–RT1
MSC2404–CT1	MSC2295–CT1
MSD1819A–ST1	MSD1819A–RT1
MV1620	MV2101
MV1624	MMBV2103LT1
MV1636	MV2108
MV1640	MV2109
MV1642	MV2111
MV1644	MV2111
MV2103	MMBV2103LT1
MV2107	MV2108
MV2113	MV2111

DEVICE	REPLACEMENT
MV2114	MV2115
MVAM108	MMBV2109LT1
MVAM109	MMBV2109LT1
MVAM115	MMBV2109LT1
MVAM125	MMBV2109LT1
PBF259	MMBT6517LT1
PBF259S	MMBT6517LT1
PBF259RS	MMBT6517LT1
PBF493	MMBTA92LT1
PBF493R	MMBTA92LT1
PBF493RS	MMBTA92LT1
PBF493S	MMBTA92LT1
VN1706L	MMFT107T1

Section 11

Alphanumeric Index

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