

# General Purpose Transistor

## NPN Silicon

### MMBT3904L, SMMBT3904L

#### Features

- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant
- S Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable

#### MAXIMUM RATINGS

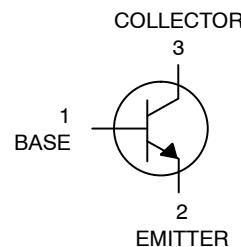
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	$V_{CEO}$	40	Vdc
Collector-Base Voltage	$V_{CBO}$	60	Vdc
Emitter-Base Voltage	$V_{EBO}$	6.0	Vdc
Collector Current - Continuous	$I_C$	200	mAdc
Collector Current - Peak (Note 3)	$I_{CM}$	900	mAdc

#### THERMAL CHARACTERISTICS

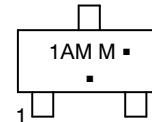
Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board (Note 1) @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	225 1.8	mW mW/ $^\circ\text{C}$
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	556	$^\circ\text{C}/\text{W}$
Total Device Dissipation Alumina Substrate, (Note 2) @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	300 2.4	mW mW/ $^\circ\text{C}$
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	417	$^\circ\text{C}/\text{W}$
Junction and Storage Temperature	$T_J, T_{stg}$	-55 to +150	$^\circ\text{C}$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. FR-5 =  $1.0 \times 0.75 \times 0.062$  in.
2. Alumina =  $0.4 \times 0.3 \times 0.024$  in. 99.5% alumina.
3. Reference SOA curve.



#### MARKING DIAGRAM



1AM = Specific Device Code

M = Date Code\*

■ = Pb-Free Package

(Note: Microdot may be in either location)

\*Date Code orientation and/or overbar may vary depending upon manufacturing location.

#### ORDERING INFORMATION

Device	Package	Shipping <sup>†</sup>
MMBT3904LT1G SMMBT3904LT1G	SOT-23 (Pb-Free)	3000 / Tape & Reel
MMBT3904LT3G SMMBT3904LT3G	SOT-23 (Pb-Free)	10,000 / Tape & Reel

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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

Characteristic	Symbol	Min	Max	Unit
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## OFF CHARACTERISTICS

Collector – Emitter Breakdown Voltage ( $I_C = 1.0 \text{ mA}_\text{dc}$ , $I_B = 0$ )	$V_{(\text{BR})\text{CEO}}$	40	–	Vdc
Collector – Base Breakdown Voltage ( $I_C = 10 \mu\text{A}_\text{dc}$ , $I_E = 0$ )	$V_{(\text{BR})\text{CBO}}$	60	–	Vdc
Emitter – Base Breakdown Voltage ( $I_E = 10 \mu\text{A}_\text{dc}$ , $I_C = 0$ )	$V_{(\text{BR})\text{EBO}}$	6.0	–	Vdc
Base Cutoff Current ( $V_{CE} = 30 \text{ Vdc}$ , $V_{EB} = 3.0 \text{ Vdc}$ )	$I_{BL}$	–	50	nAdc
Collector Cutoff Current ( $V_{CE} = 30 \text{ Vdc}$ , $V_{EB} = 3.0 \text{ Vdc}$ )	$I_{CEX}$	–	50	nAdc

## ON CHARACTERISTICS (Note 4)

DC Current Gain ( $I_C = 0.1 \text{ mA}_\text{dc}$ , $V_{CE} = 1.0 \text{ Vdc}$ ) ( $I_C = 1.0 \text{ mA}_\text{dc}$ , $V_{CE} = 1.0 \text{ Vdc}$ ) ( $I_C = 10 \text{ mA}_\text{dc}$ , $V_{CE} = 1.0 \text{ Vdc}$ ) ( $I_C = 50 \text{ mA}_\text{dc}$ , $V_{CE} = 1.0 \text{ Vdc}$ ) ( $I_C = 100 \text{ mA}_\text{dc}$ , $V_{CE} = 1.0 \text{ Vdc}$ )	$H_{FE}$	40 70 100 60 30	– – 300 – –	–
Collector – Emitter Saturation Voltage ( $I_C = 10 \text{ mA}_\text{dc}$ , $I_B = 1.0 \text{ mA}_\text{dc}$ ) ( $I_C = 50 \text{ mA}_\text{dc}$ , $I_B = 5.0 \text{ mA}_\text{dc}$ )	$V_{CE(\text{sat})}$	– –	0.2 0.3	Vdc
Base – Emitter Saturation Voltage ( $I_C = 10 \text{ mA}_\text{dc}$ , $I_B = 1.0 \text{ mA}_\text{dc}$ ) ( $I_C = 50 \text{ mA}_\text{dc}$ , $I_B = 5.0 \text{ mA}_\text{dc}$ )	$V_{BE(\text{sat})}$	0.65 –	0.85 0.95	Vdc

## SMALL-SIGNAL CHARACTERISTICS

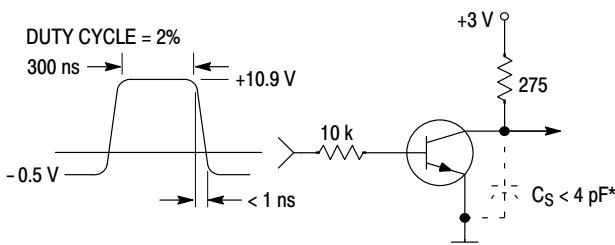
Current – Gain – Bandwidth Product ( $I_C = 10 \text{ mA}_\text{dc}$ , $V_{CE} = 20 \text{ Vdc}$ , $f = 100 \text{ MHz}$ )	$f_T$	300	–	MHz
Output Capacitance ( $V_{CB} = 5.0 \text{ Vdc}$ , $I_E = 0$ , $f = 1.0 \text{ MHz}$ )	$C_{obo}$	–	4.0	pF
Input Capacitance ( $V_{EB} = 0.5 \text{ Vdc}$ , $I_C = 0$ , $f = 1.0 \text{ MHz}$ )	$C_{ibo}$	–	8.0	pF
Input Impedance ( $V_{CE} = 10 \text{ Vdc}$ , $I_C = 1.0 \text{ mA}_\text{dc}$ , $f = 1.0 \text{ kHz}$ )	$h_{ie}$	1.0	10	kΩ
Voltage Feedback Ratio ( $V_{CE} = 10 \text{ Vdc}$ , $I_C = 1.0 \text{ mA}_\text{dc}$ , $f = 1.0 \text{ kHz}$ )	$h_{re}$	0.5	8.0	$\times 10^{-4}$
Small-Signal Current Gain ( $V_{CE} = 10 \text{ Vdc}$ , $I_C = 1.0 \text{ mA}_\text{dc}$ , $f = 1.0 \text{ kHz}$ )	$h_{fe}$	100	400	–
Output Admittance ( $V_{CE} = 10 \text{ Vdc}$ , $I_C = 1.0 \text{ mA}_\text{dc}$ , $f = 1.0 \text{ kHz}$ )	$h_{oe}$	1.0	40	μmhos
Noise Figure ( $V_{CE} = 5.0 \text{ Vdc}$ , $I_C = 100 \mu\text{A}_\text{dc}$ , $R_S = 1.0 \text{ k ohms}$ , $f = 1.0 \text{ kHz}$ )	NF	–	5.0	dB

## SWITCHING CHARACTERISTICS

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

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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



\* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time  
Equivalent Test Circuit

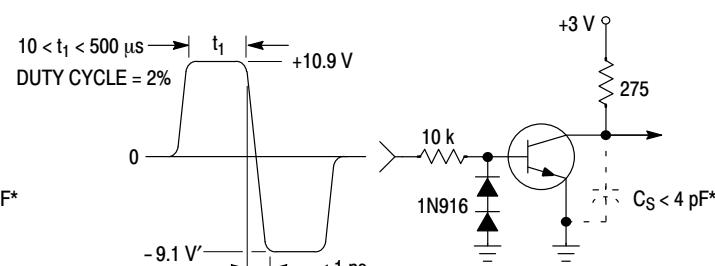
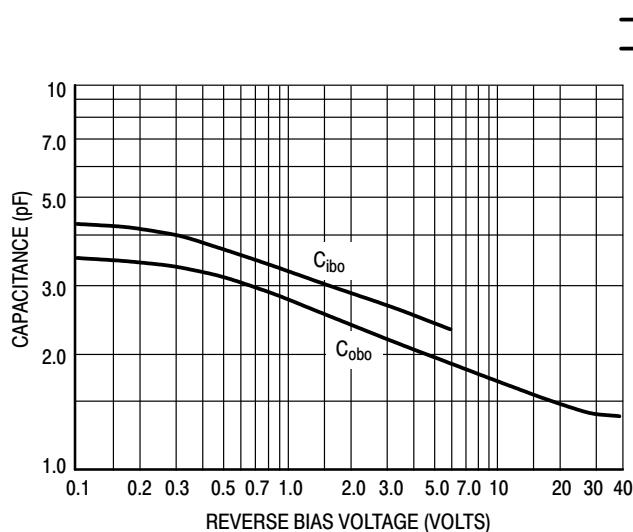


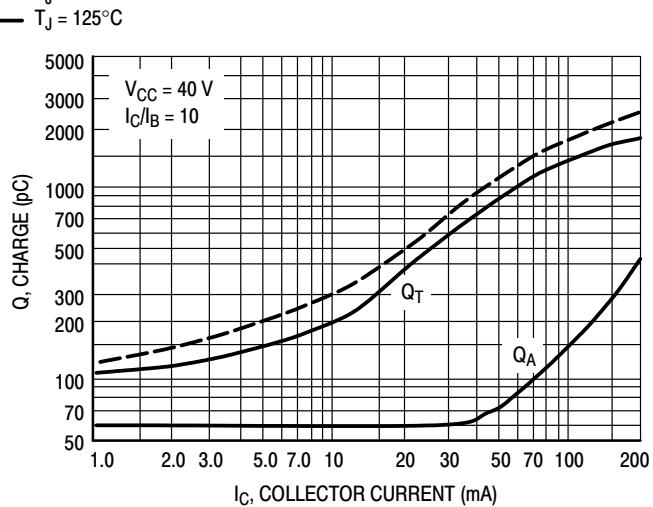
Figure 2. Storage and Fall Time  
Equivalent Test Circuit

# MMBT3904L, SMMBT3904L

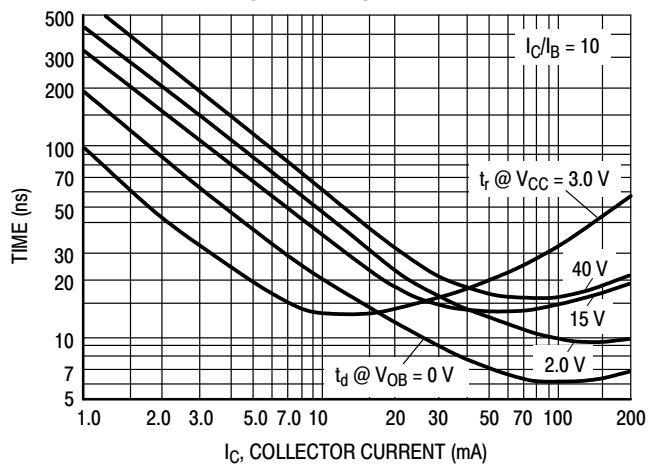
## TYPICAL TRANSIENT CHARACTERISTICS



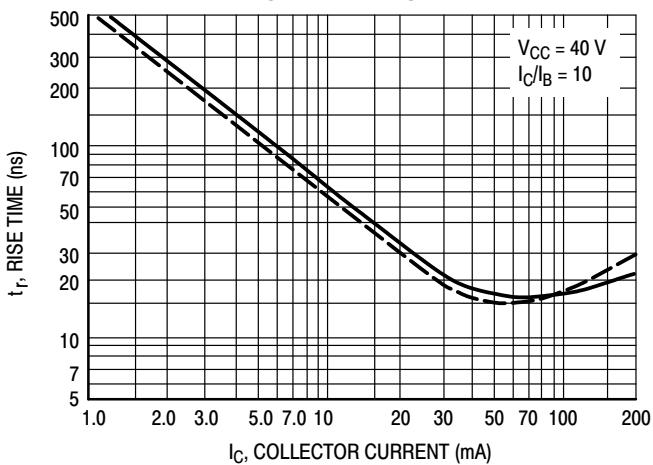
**Figure 3. Capacitance**



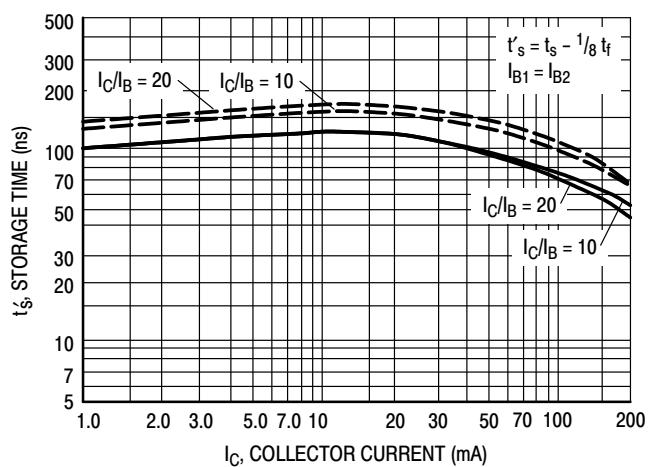
**Figure 4. Charge Data**



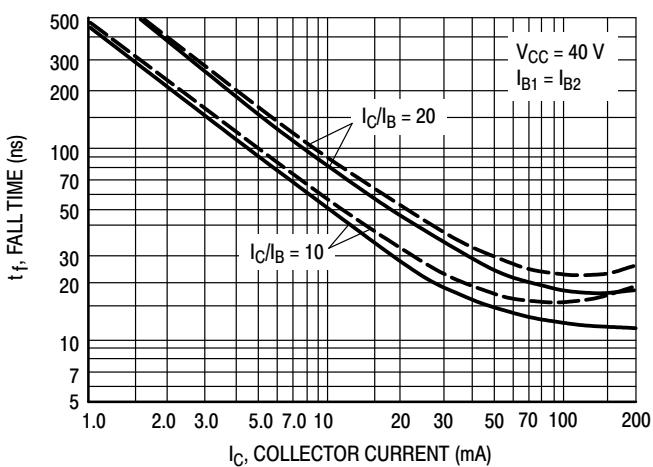
**Figure 5. Turn-On Time**



**Figure 6. Rise Time**



**Figure 7. Storage Time**



**Figure 8. Fall Time**

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## TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS NOISE FIGURE VARIATIONS

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

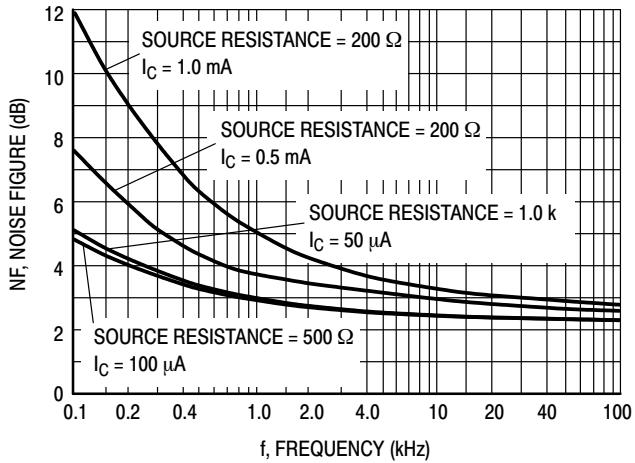


Figure 9.

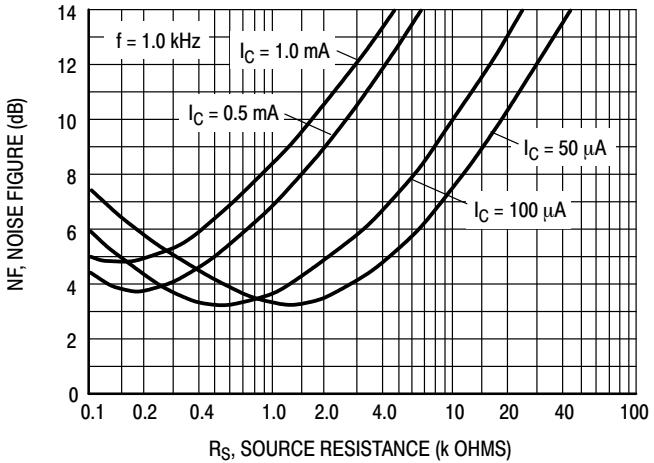


Figure 10.

## **h** PARAMETERS

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

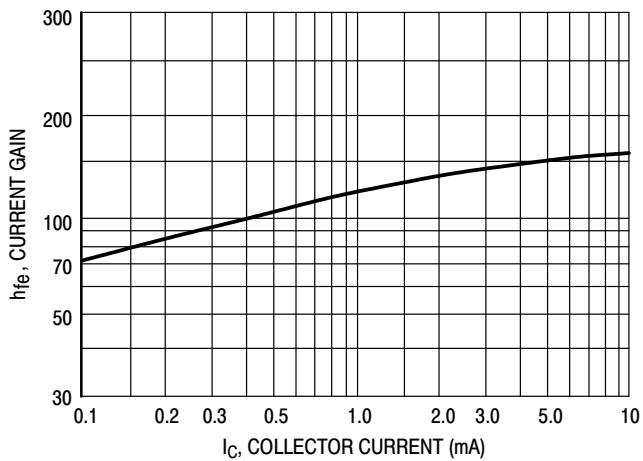


Figure 11. Current Gain

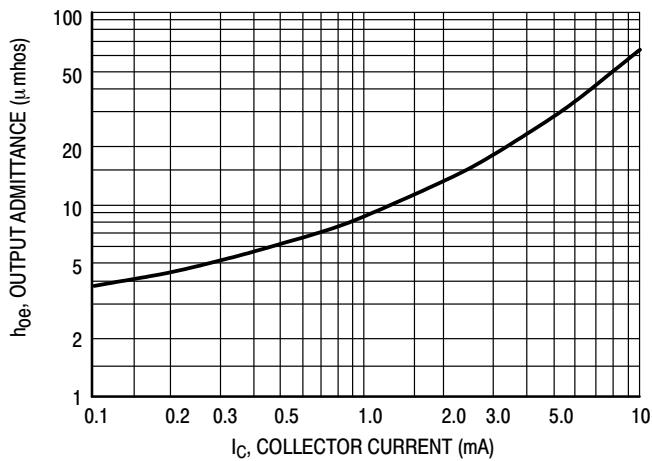


Figure 12. Output Admittance

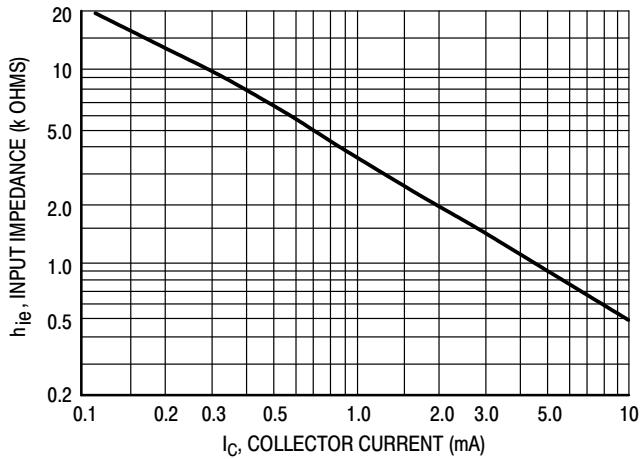


Figure 13. Input Impedance

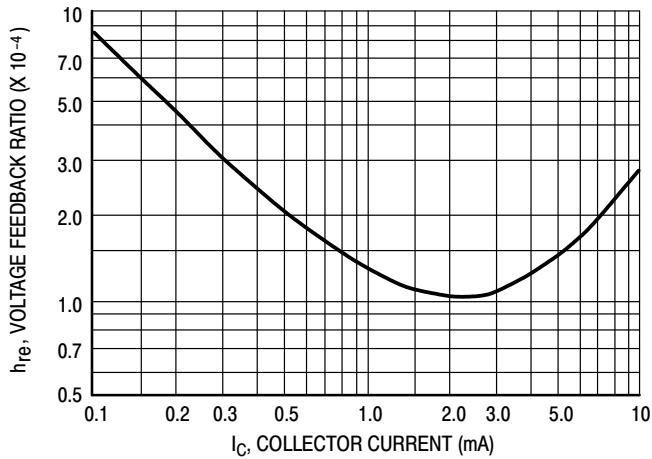


Figure 14. Voltage Feedback Ratio

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## TYPICAL STATIC CHARACTERISTICS

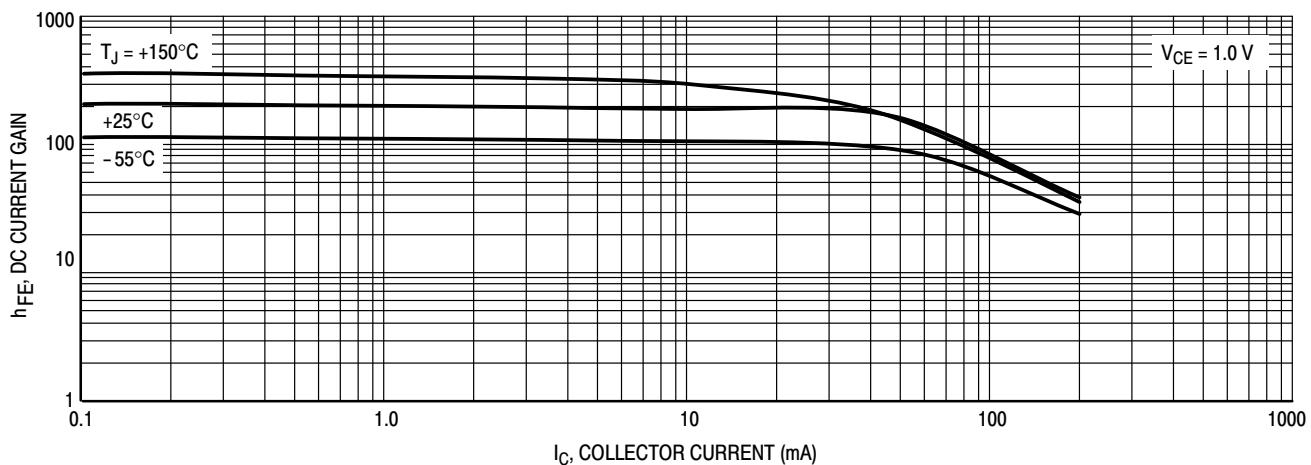


Figure 15. DC Current Gain

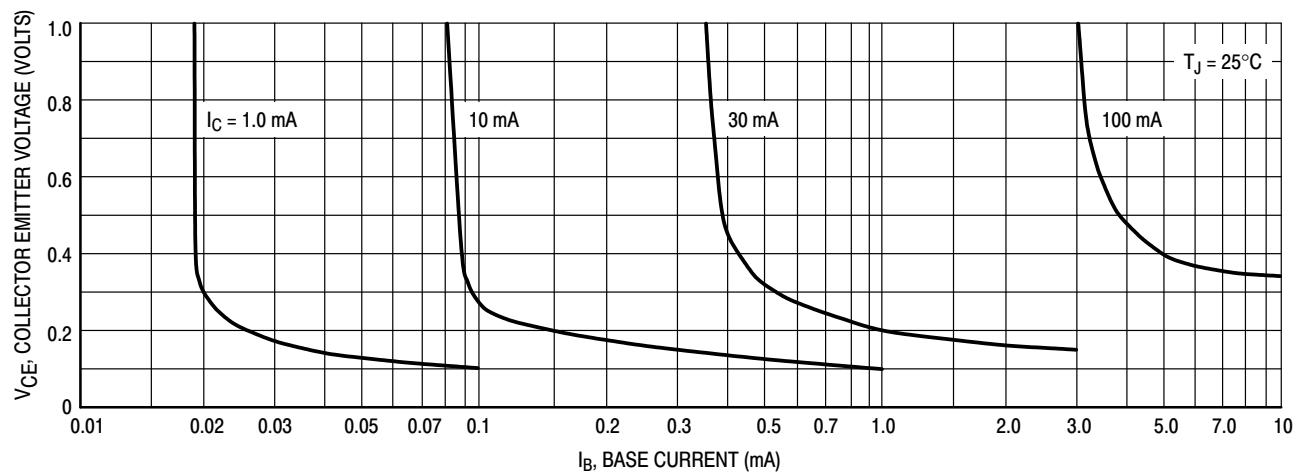
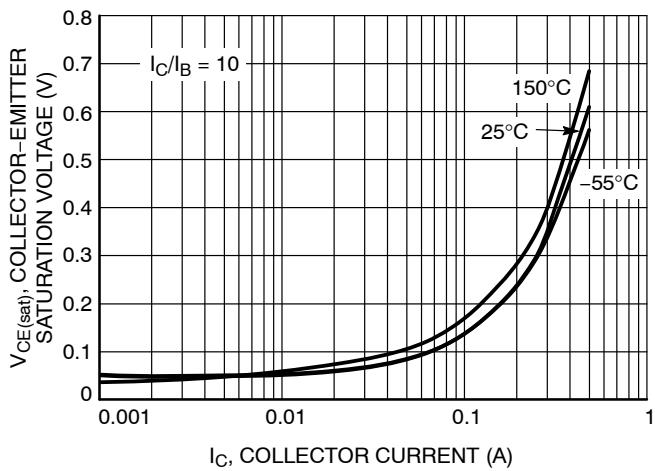
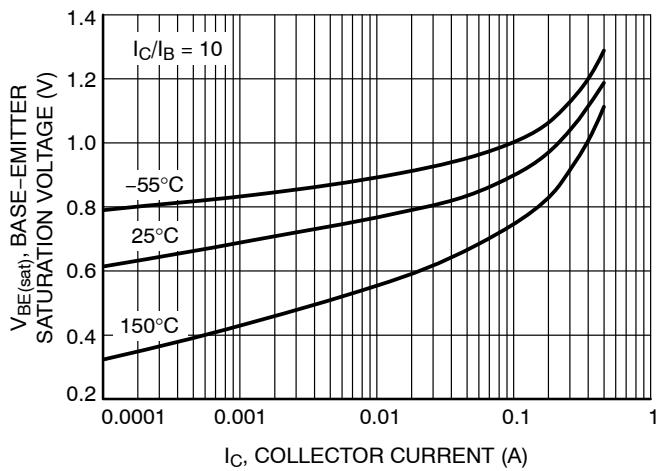


Figure 16. Collector Saturation Region

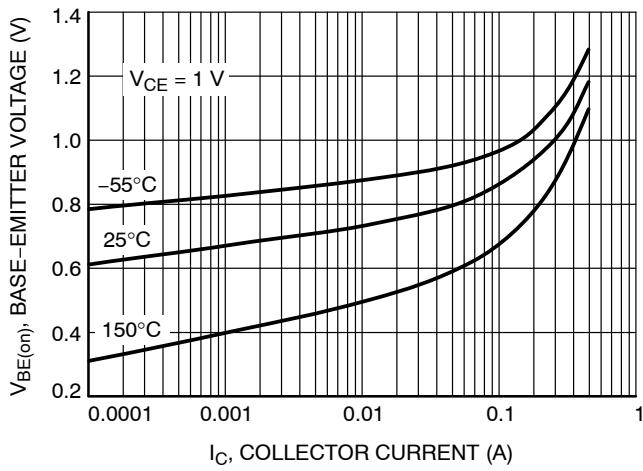
# MMBT3904L, SMMBT3904L



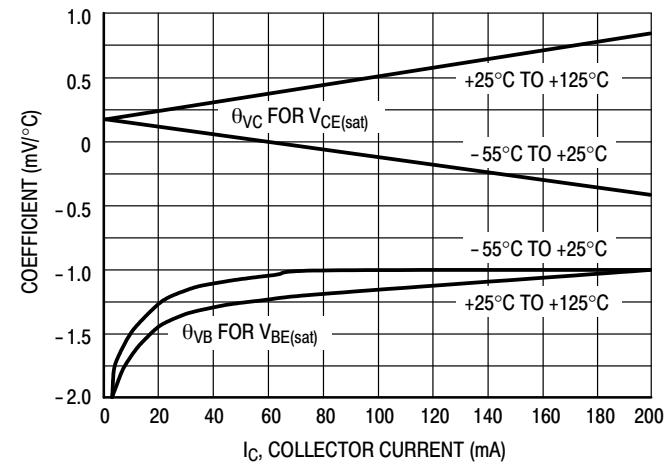
**Figure 17. Collector Emitter Saturation Voltage vs. Collector Current**



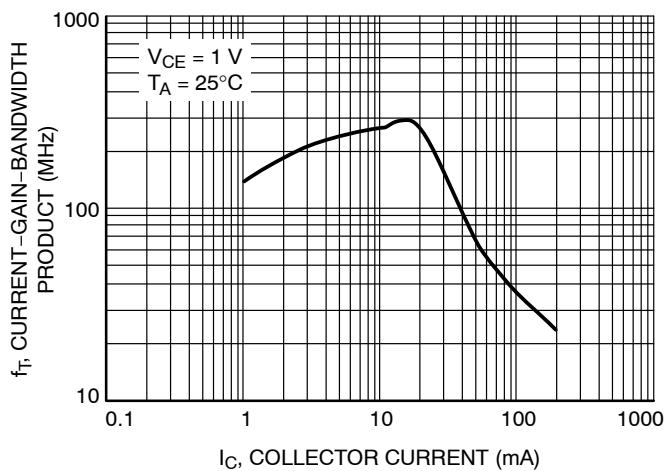
**Figure 18. Base Emitter Saturation Voltage vs. Collector Current**



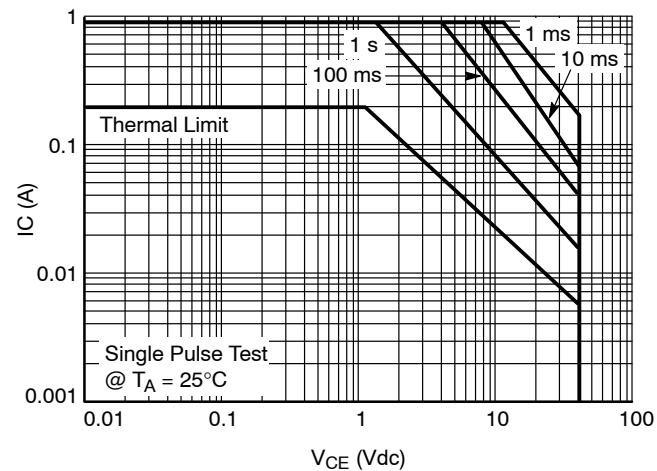
**Figure 19. Base Emitter Voltage vs. Collector Current**



**Figure 20. Temperature Coefficients**



**Figure 21. Current Gain Bandwidth vs. Collector Current**

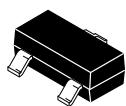


**Figure 22. Safe Operating Area**

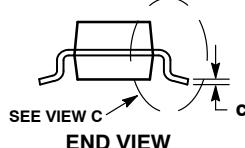
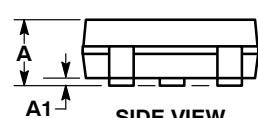
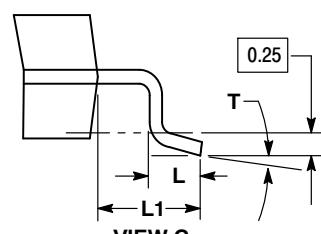
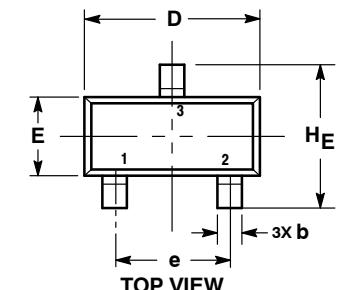
# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

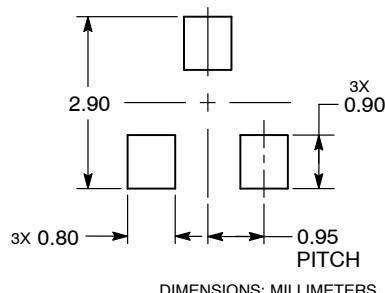
ON Semiconductor®



SCALE 4:1



### RECOMMENDED SOLDERING FOOTPRINT



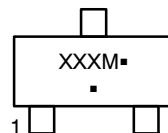
DIMENSIONS: MILLIMETERS

### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH.  
MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

DIM	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.89	1.00	1.11	0.035	0.039	0.044
A1	0.01	0.06	0.10	0.000	0.002	0.004
b	0.37	0.44	0.50	0.015	0.017	0.020
c	0.08	0.14	0.20	0.003	0.006	0.008
D	2.80	2.90	3.04	0.110	0.114	0.120
E	1.20	1.30	1.40	0.047	0.051	0.055
e	1.78	1.90	2.04	0.070	0.075	0.080
L	0.30	0.43	0.55	0.012	0.017	0.022
L1	0.35	0.54	0.69	0.014	0.021	0.027
H <sub>E</sub>	2.10	2.40	2.64	0.083	0.094	0.104
T	0°	---	10°	0°	---	10°

### GENERIC MARKING DIAGRAM\*



XXX = Specific Device Code

M = Date Code

■ = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "■", may or may not be present.

STYLE 1 THRU 5:  
CANCELLED

STYLE 6:  
PIN 1. BASE  
2. Emitter  
3. Collector

STYLE 7:  
PIN 1. Emitter  
2. Base  
3. Collector

STYLE 8:  
PIN 1. ANODE  
2. NO CONNECTION  
3. CATHODE

STYLE 9:  
PIN 1. ANODE  
2. ANODE  
3. CATHODE

STYLE 10:  
PIN 1. DRAIN  
2. SOURCE  
3. GATE

STYLE 11:  
PIN 1. ANODE  
2. CATHODE  
3. CATHODE-ANODE

STYLE 12:  
PIN 1. CATHODE  
2. CATHODE  
3. ANODE

STYLE 13:  
PIN 1. SOURCE  
2. DRAIN  
3. GATE

STYLE 14:  
PIN 1. CATHODE  
2. GATE  
3. ANODE

STYLE 15:  
PIN 1. GATE  
2. CATHODE  
3. ANODE

STYLE 16:  
PIN 1. ANODE  
2. CATHODE  
3. CATHODE

STYLE 17:  
PIN 1. NO CONNECTION  
2. ANODE  
3. CATHODE

STYLE 18:  
PIN 1. NO CONNECTION  
2. CATHODE  
3. ANODE

STYLE 19:  
PIN 1. CATHODE  
2. ANODE  
3. CATHODE-ANODE

STYLE 20:  
PIN 1. CATHODE  
2. ANODE  
3. GATE

STYLE 21:  
PIN 1. GATE  
2. SOURCE  
3. DRAIN

STYLE 22:  
PIN 1. RETURN  
2. OUTPUT  
3. INPUT

STYLE 23:  
PIN 1. ANODE  
2. ANODE  
3. CATHODE

STYLE 24:  
PIN 1. GATE  
2. DRAIN  
3. SOURCE

STYLE 25:  
PIN 1. ANODE  
2. CATHODE  
3. GATE

STYLE 26:  
PIN 1. CATHODE  
2. ANODE  
3. NO CONNECTION

STYLE 27:  
PIN 1. CATHODE  
2. CATHODE  
3. CATHODE

STYLE 28:  
PIN 1. ANODE  
2. ANODE  
3. ANODE

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