

# General Purpose Transistors

## NPN and PNP Silicon

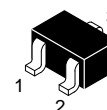
These transistors are designed for general purpose amplifier applications. They are housed in the SOT-323/SC-70 which is designed for low power surface mount applications.

**NPN**  
**MMBT3904WT1**  
**PNP**  
**MMBT3906WT1**

### 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

**GENERAL PURPOSE  
AMPLIFIER TRANSISTORS  
SURFACE MOUNT**



**CASE 419-02, STYLE 3  
SOT-323/SC-70**

### THERMAL CHARACTERISTICS

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

### DEVICE MARKING

MMBT3904WT1 = AM  
MMBT3906WT1 = 2A

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

Characteristic	Symbol	Min	Max	Unit
<b>OFF CHARACTERISTICS</b>				
Collector–Emitter Breakdown Voltage <sup>(2)</sup> ( $I_C = 1.0 \text{ mAdc}, I_B = 0$ ) ( $I_C = -1.0 \text{ mAdc}, I_B = 0$ )	$V_{(BR)CEO}$	40 –40	— —	Vdc
Collector–Base Breakdown Voltage ( $I_C = 10 \mu\text{Adc}, I_E = 0$ ) ( $I_C = -10 \mu\text{Adc}, I_E = 0$ )	$V_{(BR)CBO}$	60 –40	— —	Vdc
Emitter–Base Breakdown Voltage ( $I_E = 10 \mu\text{Adc}, I_C = 0$ ) ( $I_E = -10 \mu\text{Adc}, I_C = 0$ )	$V_{(BR)EBO}$	6.0 –5.0	— —	Vdc
Base Cutoff Current ( $V_{CE} = 30 \text{ Vdc}, V_{EB} = 3.0 \text{ Vdc}$ ) ( $V_{CE} = -30 \text{ Vdc}, V_{EB} = -3.0 \text{ Vdc}$ )	$I_{BL}$	— —	50 –50	nAdc
Collector Cutoff Current ( $V_{CE} = 30 \text{ Vdc}, V_{EB} = 3.0 \text{ Vdc}$ ) ( $V_{CE} = -30 \text{ Vdc}, V_{EB} = -3.0 \text{ Vdc}$ )	$I_{CEX}$	— —	50 –50	nAdc

1. Device mounted on FR4 glass epoxy printed circuit board using the minimum recommended footprint.
2. Pulse Test: Pulse Width  $\leq 300 \mu\text{s}$ ; Duty Cycle  $\leq 2.0\%$ .

Thermal Clad is a trademark of the Berquist Company.

## NPN MMBT3904WT1 PNP MMBT3906WT1

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

Characteristic	Symbol	Min	Max	Unit
<b>ON CHARACTERISTICS(2)</b>				
DC Current Gain ( $I_C = 0.1\text{ mAdc}$ , $V_{CE} = 1.0\text{ Vdc}$ ) ( $I_C = 1.0\text{ mAdc}$ , $V_{CE} = 1.0\text{ Vdc}$ ) ( $I_C = 10\text{ mAdc}$ , $V_{CE} = 1.0\text{ Vdc}$ ) ( $I_C = 50\text{ mAdc}$ , $V_{CE} = 1.0\text{ Vdc}$ ) ( $I_C = 100\text{ mAdc}$ , $V_{CE} = 1.0\text{ Vdc}$ )  ( $I_C = -0.1\text{ mAdc}$ , $V_{CE} = -1.0\text{ Vdc}$ ) ( $I_C = -1.0\text{ mAdc}$ , $V_{CE} = -1.0\text{ Vdc}$ ) ( $I_C = -10\text{ mAdc}$ , $V_{CE} = -1.0\text{ Vdc}$ ) ( $I_C = -50\text{ mAdc}$ , $V_{CE} = -1.0\text{ Vdc}$ ) ( $I_C = -100\text{ mAdc}$ , $V_{CE} = -1.0\text{ Vdc}$ )	MMBT3904WT1      MMBT3906WT1	$h_{FE}$	40 70 100 60 30  60 80 100 60 30	— — 300 — —  — — 300 — —
Collector–Emitter Saturation Voltage ( $I_C = 10\text{ mAdc}$ , $I_B = 1.0\text{ mAdc}$ ) ( $I_C = 50\text{ mAdc}$ , $I_B = 5.0\text{ mAdc}$ )  ( $I_C = -10\text{ mAdc}$ , $I_B = -1.0\text{ mAdc}$ ) ( $I_C = -50\text{ mAdc}$ , $I_B = -5.0\text{ mAdc}$ )	MMBT3904WT1   MMBT3906WT1	$V_{CE(sat)}$	— —  — —	0.2 0.3  -0.25 -0.4
Base–Emitter Saturation Voltage ( $I_C = 10\text{ mAdc}$ , $I_B = 1.0\text{ mAdc}$ ) ( $I_C = 50\text{ mAdc}$ , $I_B = 5.0\text{ mAdc}$ )  ( $I_C = -10\text{ mAdc}$ , $I_B = -1.0\text{ mAdc}$ ) ( $I_C = -50\text{ mAdc}$ , $I_B = -5.0\text{ mAdc}$ )	MMBT3904WT1   MMBT3906WT1	$V_{BE(sat)}$	0.65 —  -0.65 —	0.85 0.95  -0.85 -0.95

### SMALL–SIGNAL CHARACTERISTICS

Current–Gain — Bandwidth Product ( $I_C = 10\text{ mAdc}$ , $V_{CE} = 20\text{ Vdc}$ , $f = 100\text{ MHz}$ ) ( $I_C = -10\text{ mAdc}$ , $V_{CE} = -20\text{ Vdc}$ , $f = 100\text{ MHz}$ )	MMBT3904WT1 MMBT3906WT1	$f_T$	300 250	— —	MHz
Output Capacitance ( $V_{CB} = 5.0\text{ Vdc}$ , $I_E = 0$ , $f = 1.0\text{ MHz}$ ) ( $V_{CB} = -5.0\text{ Vdc}$ , $I_E = 0$ , $f = 1.0\text{ MHz}$ )	MMBT3904WT1 MMBT3906WT1	$C_{obo}$	— —	4.0 4.5	pF
Input Capacitance ( $V_{EB} = 0.5\text{ Vdc}$ , $I_C = 0$ , $f = 1.0\text{ MHz}$ ) ( $V_{EB} = -0.5\text{ Vdc}$ , $I_C = 0$ , $f = 1.0\text{ MHz}$ )	MMBT3904WT1 MMBT3906WT1	$C_{ibo}$	— —	8.0 10.0	pF
Input Impedance ( $V_{CE} = 10\text{ Vdc}$ , $I_C = 1.0\text{ mAdc}$ , $f = 1.0\text{ kHz}$ ) ( $V_{CE} = -10\text{ Vdc}$ , $I_C = -1.0\text{ mAdc}$ , $f = 1.0\text{ kHz}$ )	MMBT3904WT1 MMBT3906WT1	$h_{ie}$	1.0 2.0	10 12	k $\Omega$
Voltage Feedback Ratio ( $V_{CE} = 10\text{ Vdc}$ , $I_C = 1.0\text{ mAdc}$ , $f = 1.0\text{ kHz}$ ) ( $V_{CE} = -10\text{ Vdc}$ , $I_C = -1.0\text{ mAdc}$ , $f = 1.0\text{ kHz}$ )	MMBT3904WT1 MMBT3906WT1	$h_{re}$	0.5 0.1	8.0 10	$\times 10^{-4}$
Small–Signal Current Gain ( $V_{CE} = 10\text{ Vdc}$ , $I_C = 1.0\text{ mAdc}$ , $f = 1.0\text{ kHz}$ ) ( $V_{CE} = -10\text{ Vdc}$ , $I_C = -1.0\text{ mAdc}$ , $f = 1.0\text{ kHz}$ )	MMBT3904WT1 MMBT3906WT1	$h_{fe}$	100 100	400 400	—
Output Admittance ( $V_{CE} = 10\text{ Vdc}$ , $I_C = 1.0\text{ mAdc}$ , $f = 1.0\text{ kHz}$ ) ( $V_{CE} = -10\text{ Vdc}$ , $I_C = -1.0\text{ mAdc}$ , $f = 1.0\text{ kHz}$ )	MMBT3904WT1 MMBT3906WT1	$h_{oe}$	1.0 3.0	40 60	$\mu\text{hos}$
Noise Figure ( $V_{CE} = 5.0\text{ Vdc}$ , $I_C = 100\text{ }\mu\text{A}$ , $R_S = 1.0\text{ k}\Omega$ , $f = 1.0\text{ kHz}$ ) ( $V_{CE} = -5.0\text{ Vdc}$ , $I_C = -100\text{ }\mu\text{A}$ , $R_S = 1.0\text{ k}\Omega$ , $f = 1.0\text{ kHz}$ )	MMBT3904WT1 MMBT3906WT1	NF	— —	5.0 4.0	dB

### SWITCHING CHARACTERISTICS

Delay Time ( $V_{CC} = 3.0\text{ Vdc}$ , $V_{BE} = -0.5\text{ Vdc}$ ) ( $V_{CC} = -3.0\text{ Vdc}$ , $V_{BE} = 0.5\text{ Vdc}$ )	MMBT3904WT1 MMBT3906WT1	$t_d$	— —	35 35	ns
Rise Time ( $I_C = 10\text{ mAdc}$ , $I_{B1} = 1.0\text{ mAdc}$ ) ( $I_C = -10\text{ mAdc}$ , $I_{B1} = -1.0\text{ mAdc}$ )	MMBT3904WT1 MMBT3906WT1	$t_r$	— —	35 35	
Storage Time ( $V_{CC} = 3.0\text{ Vdc}$ , $I_C = 10\text{ mAdc}$ ) ( $V_{CC} = -3.0\text{ Vdc}$ , $I_C = -10\text{ mAdc}$ )	MMBT3904WT1 MMBT3906WT1	$t_s$	— —	200 225	ns
Fall Time ( $I_{B1} = I_{B2} = 1.0\text{ mAdc}$ ) ( $I_{B1} = I_{B2} = -1.0\text{ mAdc}$ )	MMBT3904WT1 MMBT3906WT1	$t_f$	— —	50 75	

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

MMBT3904WT1

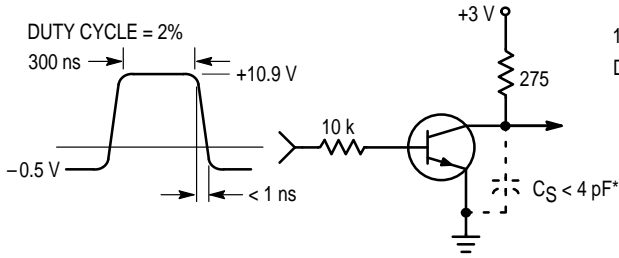


Figure 1. Delay and Rise Time Equivalent Test Circuit

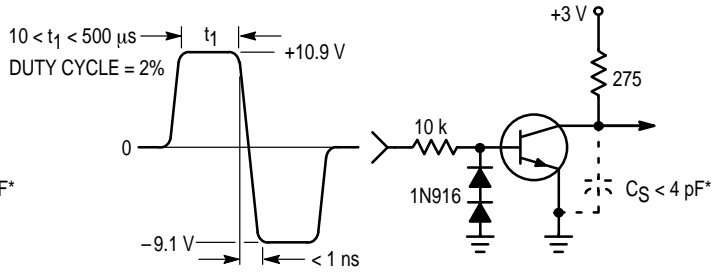


Figure 2. Storage and Fall Time Equivalent Test Circuit

\* Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

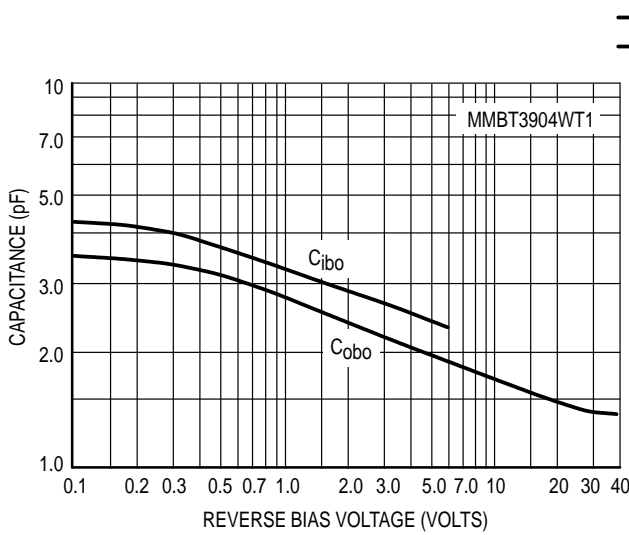


Figure 3. Capacitance

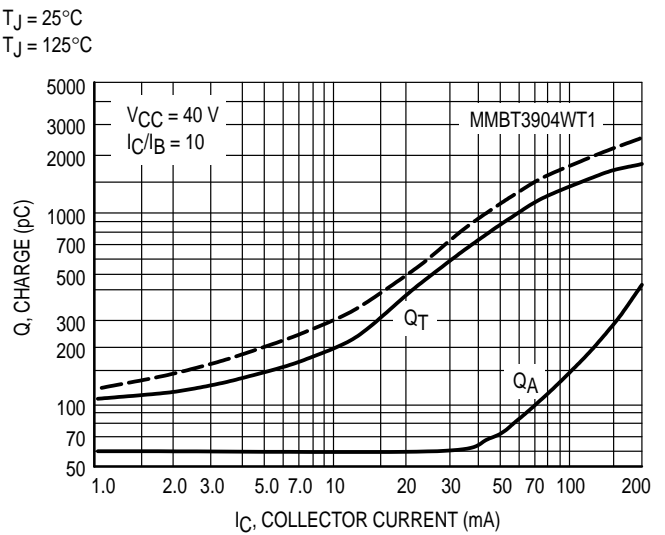


Figure 4. Charge Data

MMBT3904WT1

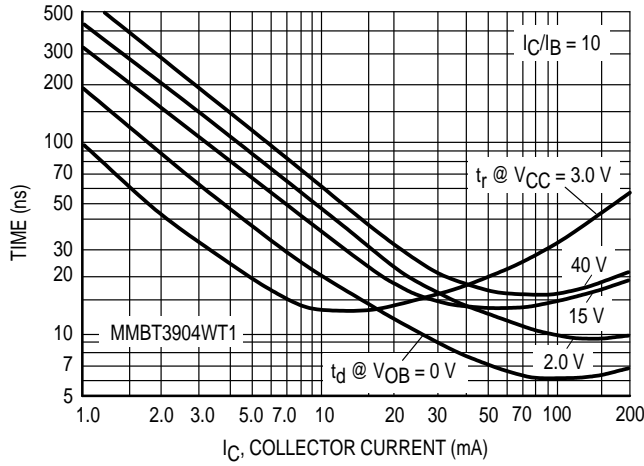


Figure 5. Turn-On Time

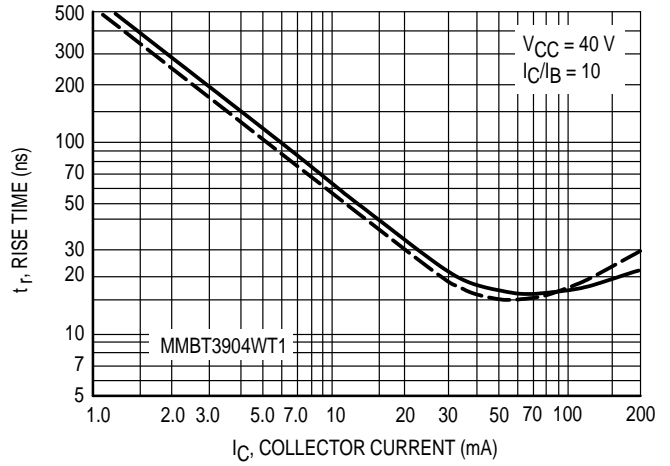


Figure 6. Rise Time

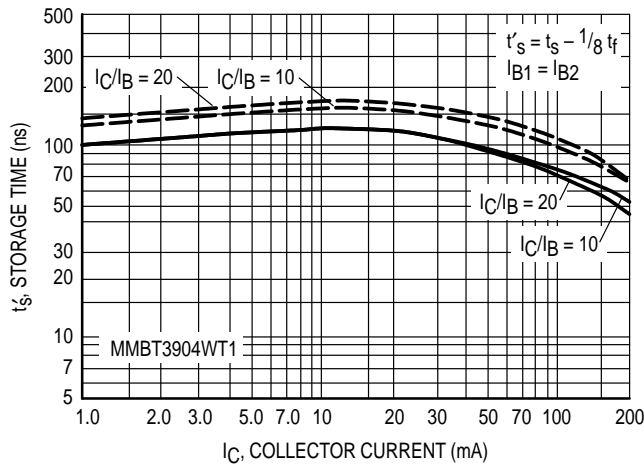


Figure 7. Storage Time

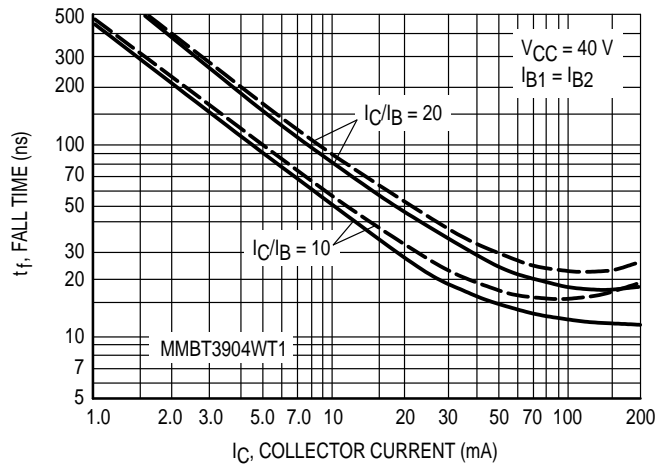


Figure 8. Fall Time

TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS  
NOISE FIGURE VARIATIONS

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

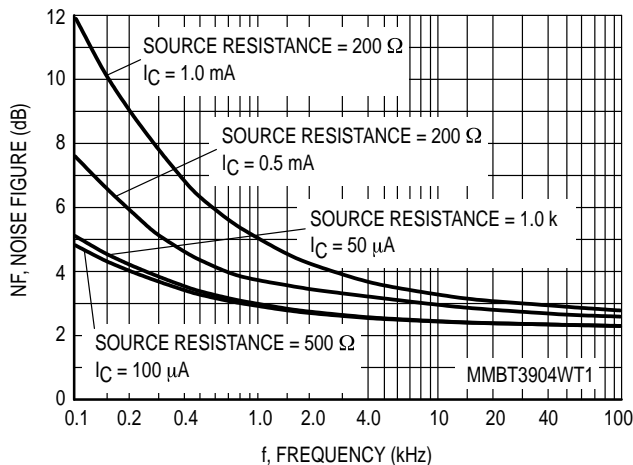


Figure 9. Noise Figure

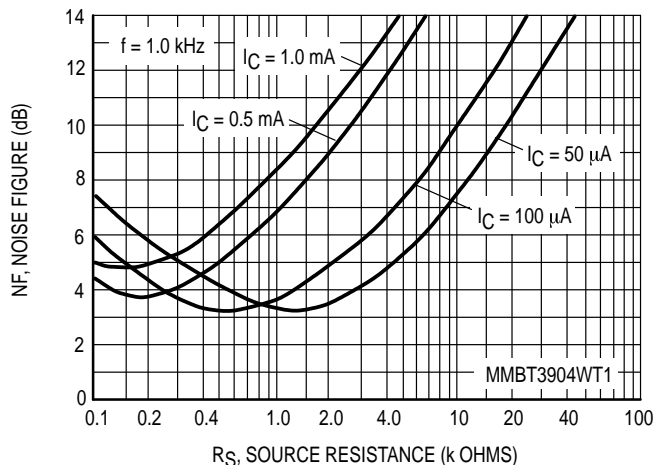


Figure 10. Noise Figure

MMBT3904WT1

**h PARAMETERS**

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

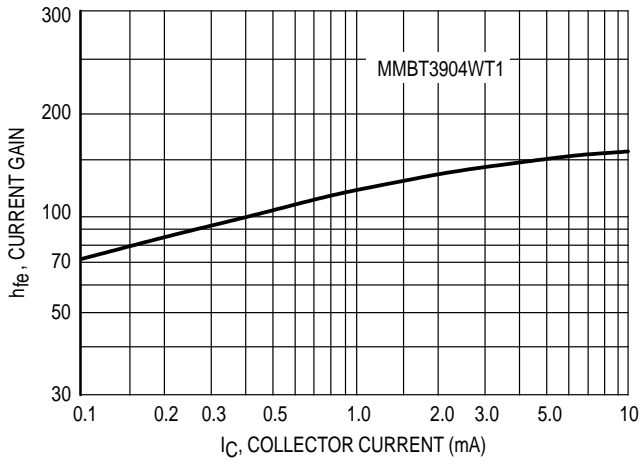


Figure 11. Current Gain

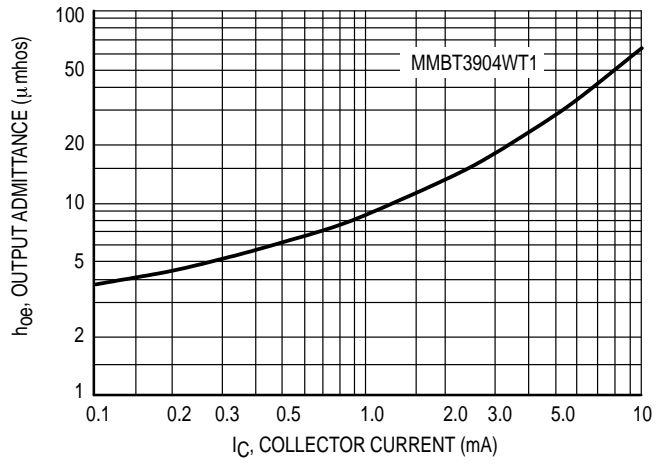


Figure 12. Output Admittance

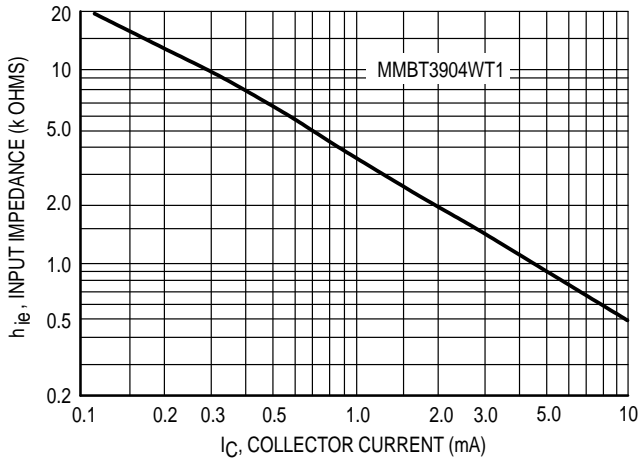


Figure 13. Input Impedance

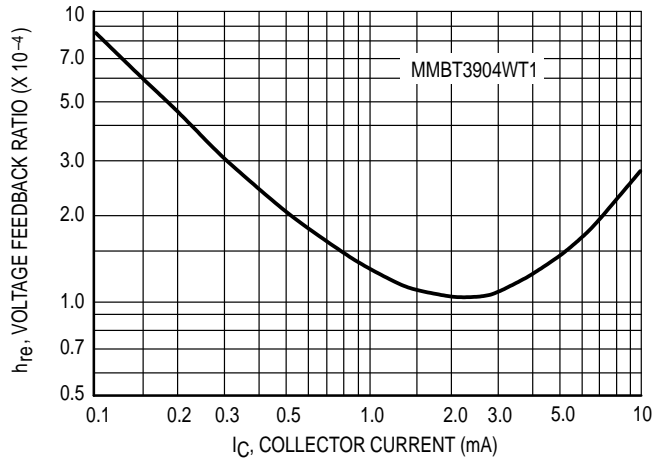


Figure 14. Voltage Feedback Ratio

MMBT3904WT1

TYPICAL STATIC CHARACTERISTICS

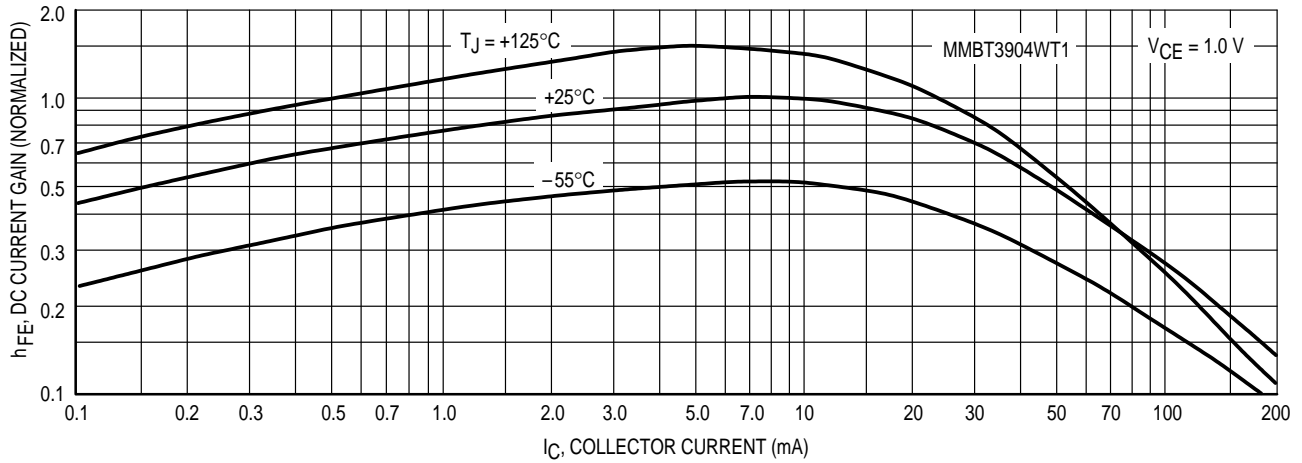


Figure 15. DC Current Gain

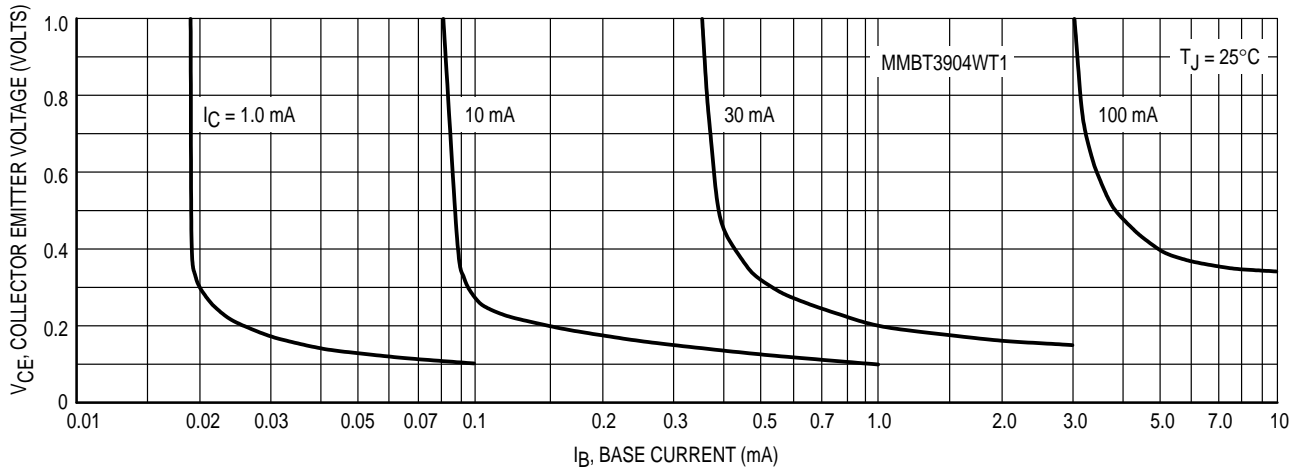


Figure 16. Collector Saturation Region

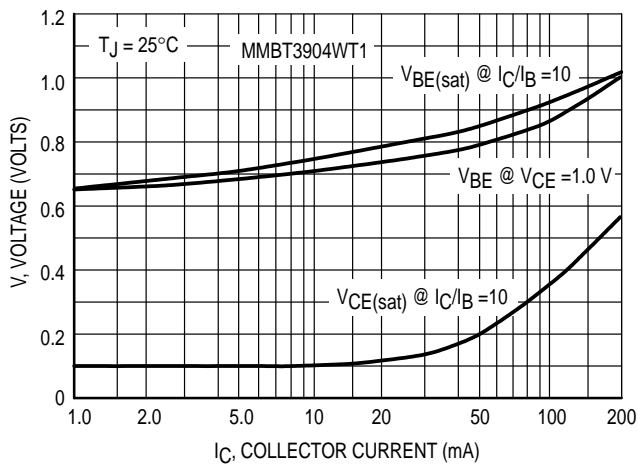


Figure 17. "ON" Voltages

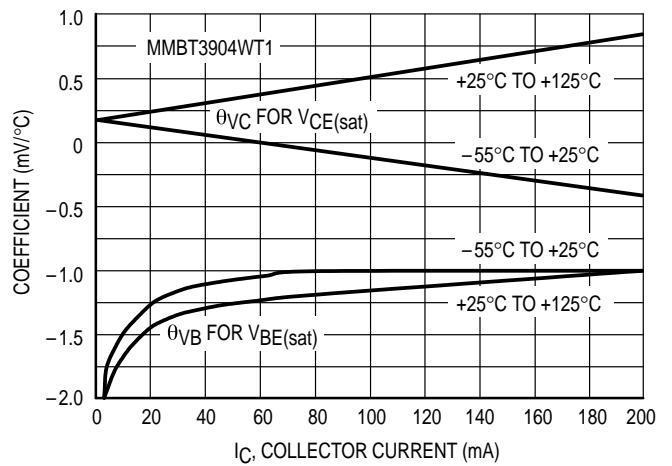


Figure 18. Temperature Coefficients

MMBT3906WT1

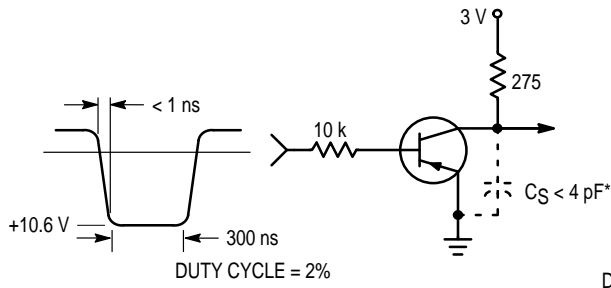


Figure 19. Delay and Rise Time Equivalent Test Circuit

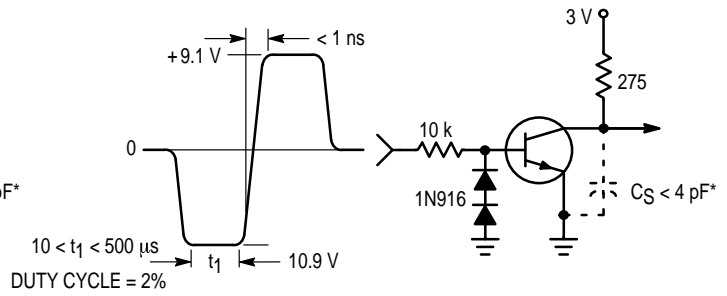


Figure 20. Storage and Fall Time Equivalent Test Circuit

\* Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

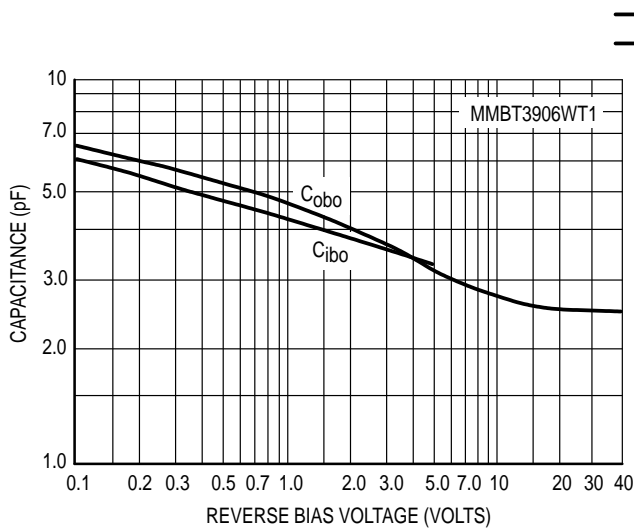


Figure 21. Capacitance

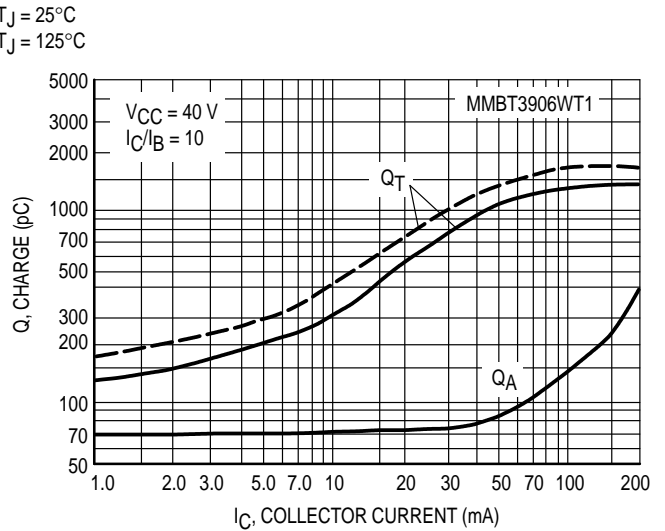


Figure 22. Charge Data

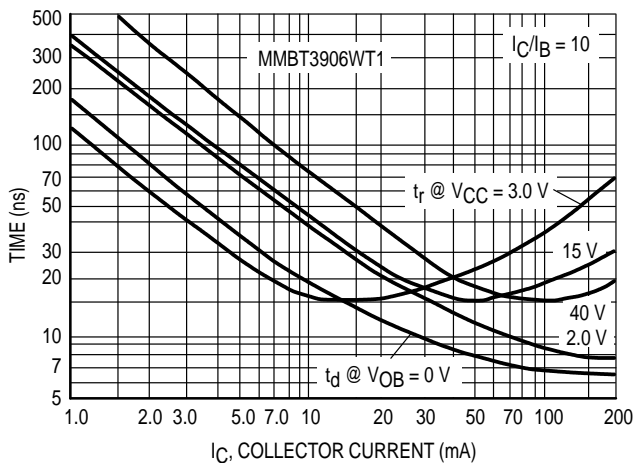


Figure 23. Turn-On Time

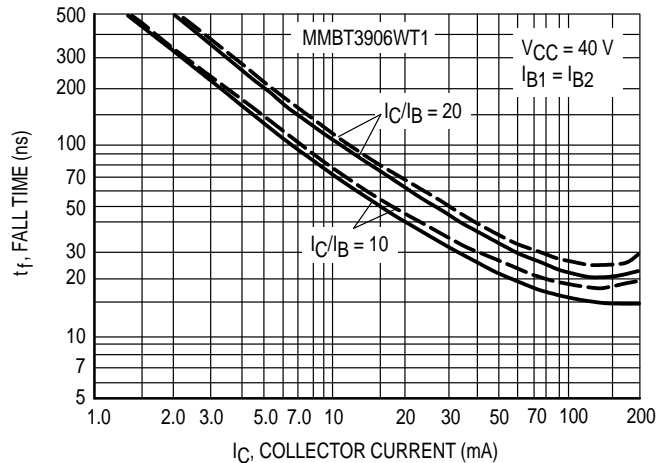
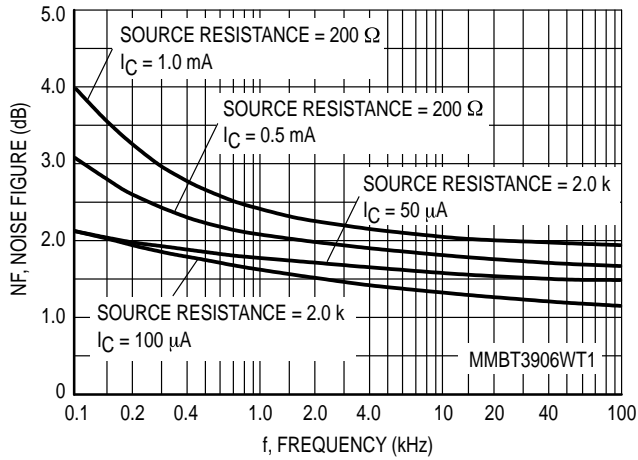


Figure 24. Fall Time

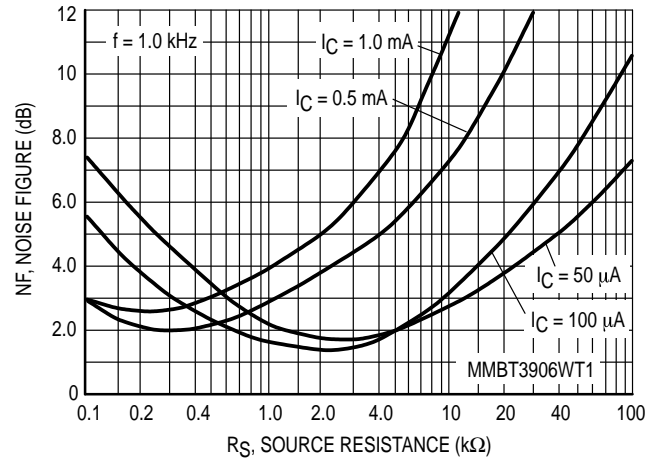
**MMBT3906WT1**

**TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS  
NOISE FIGURE VARIATIONS**

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



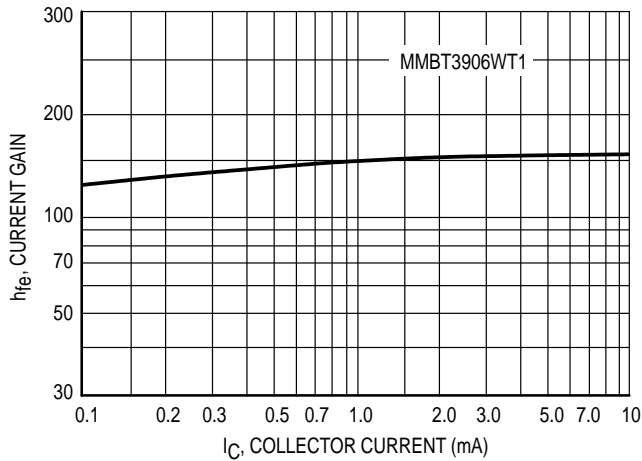
**Figure 25.**



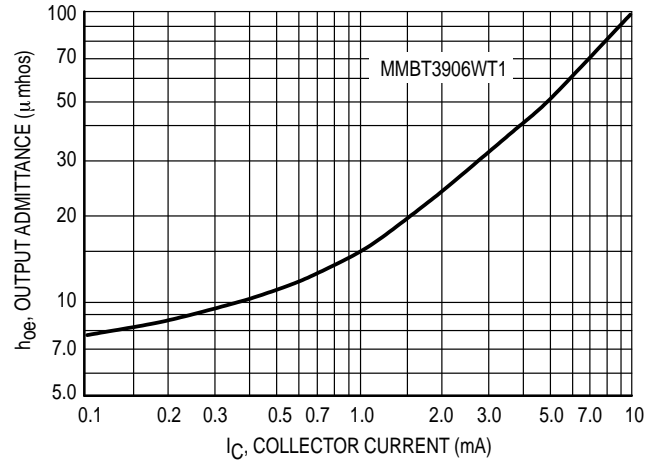
**Figure 26.**

**h PARAMETERS**

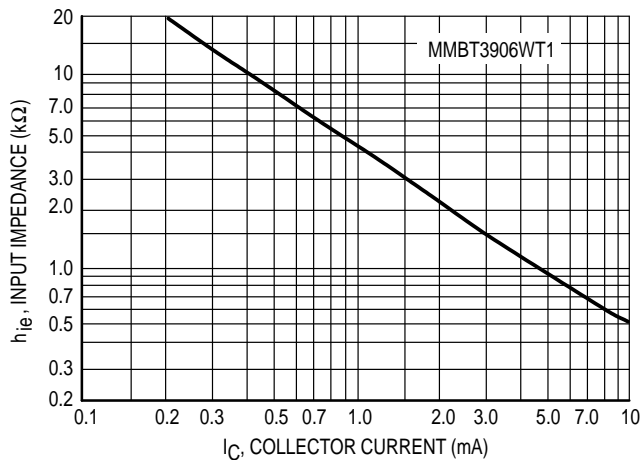
( $V_{CE} = -10$  Vdc,  $f = 1.0$  kHz,  $T_A = 25^\circ\text{C}$ )



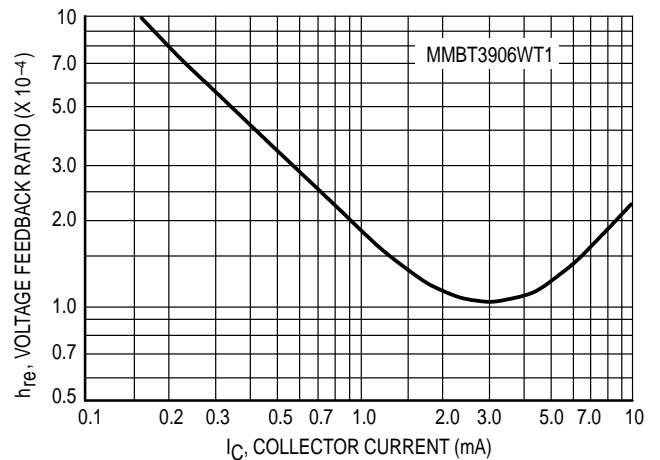
**Figure 27. Current Gain**



**Figure 28. Output Admittance**



**Figure 29. Input Impedance**



**Figure 30. Voltage Feedback Ratio**



MMBT3906WT1

STATIC CHARACTERISTICS

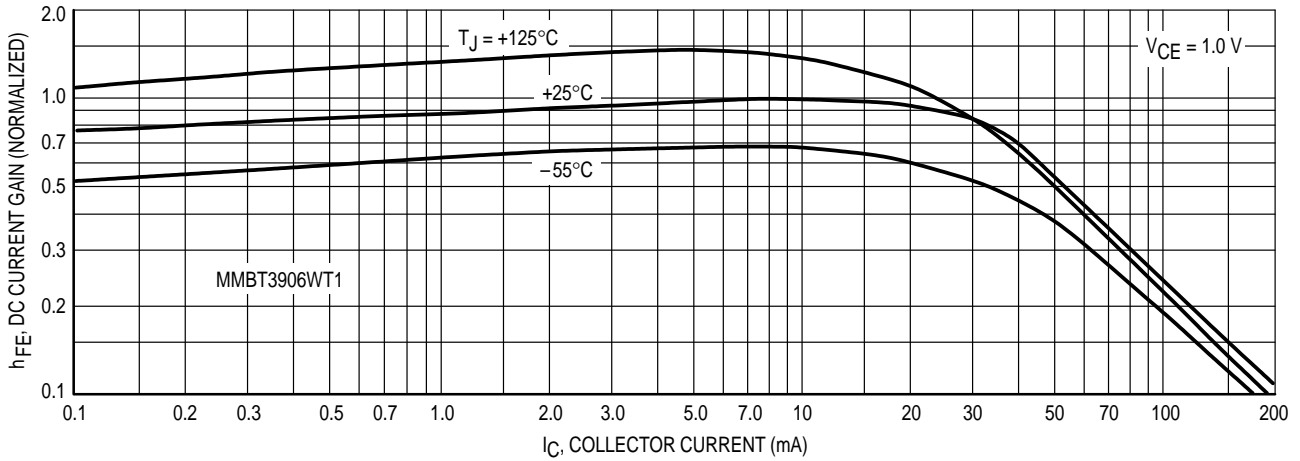


Figure 31. DC Current Gain

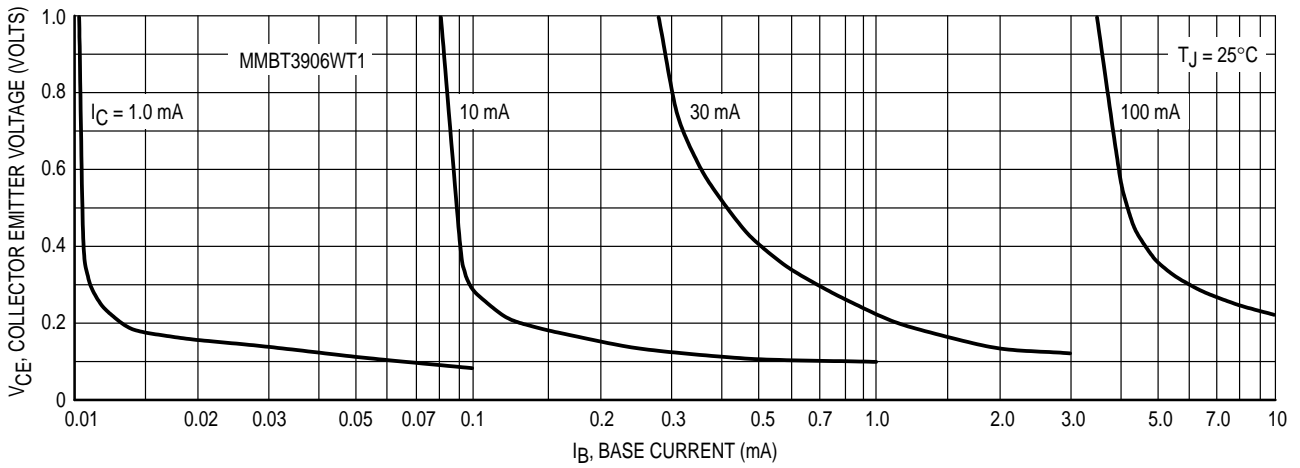


Figure 32. Collector Saturation Region

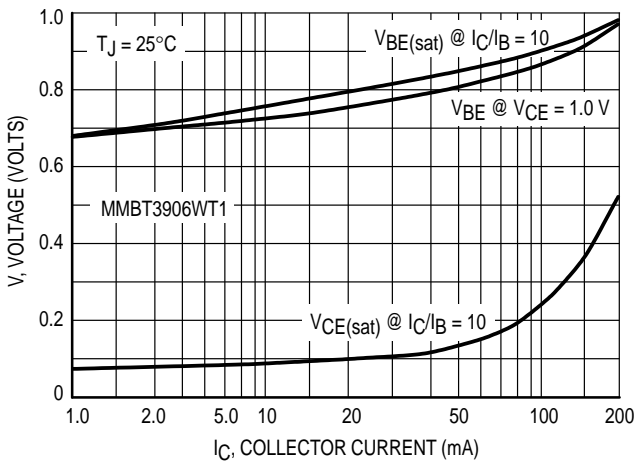


Figure 33. "ON" Voltages

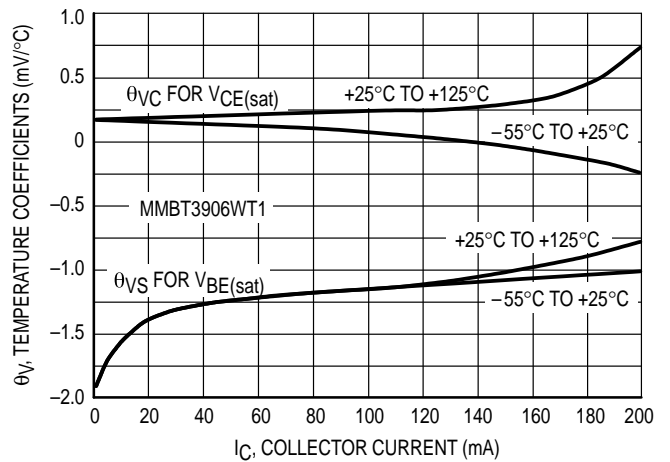


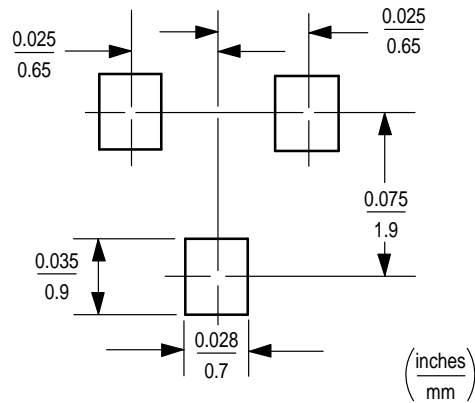
Figure 34. Temperature Coefficients

**INFORMATION FOR USING THE SOT-323/SC-70 SURFACE MOUNT PACKAGE**

**MINIMUM RECOMMENDED FOOTPRINT FOR SURFACE MOUNTED APPLICATIONS**

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to insure proper solder connection

interface between the board and the package. With the correct pad geometry, the packages will self align when subjected to a solder reflow process.



**SOT-323/SC-70**

**SOT-323/SC-70 POWER DISSIPATION**

The power dissipation of the SOT-323/SC-70 is a function of the pad size. This 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 for the SOT-323/SC-70 package,  $P_D$  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 which in this case is 150 milliwatts.

$$P_D = \frac{150^\circ\text{C} - 25^\circ\text{C}}{833^\circ\text{C/W}} = 150 \text{ milliwatts}$$

The 833°C/W for the SOT-323/SC-70 package assumes the use of the recommended footprint on a glass epoxy printed circuit board to achieve a power dissipation of 150 milliwatts. There are other alternatives to achieving higher power dissipation from the SOT-323/SC-70 package. 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.

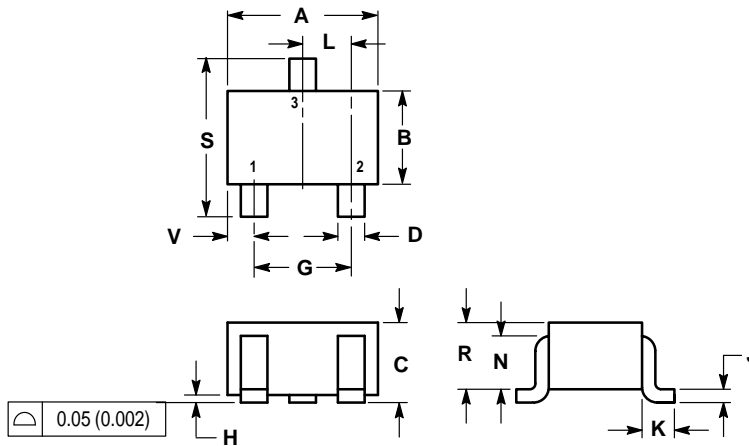
**SOLDERING PRECAUTIONS**

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
- The delta temperature between the preheat and soldering should be 100°C or less.\*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference shall be a maximum of 10°C.
- The soldering temperature and time shall not exceed 260°C for more than 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 as the use of forced cooling will increase the temperature gradient and result in latent failure due to mechanical stress.
- Mechanical stress or shock should not be applied during cooling.

\* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

PACKAGE DIMENSIONS




- NOTES:  
 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
 2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	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 3:  
 PIN 1. BASE  
 2. EMITTER  
 3. COLLECTOR

**CASE 419-02  
 ISSUE G  
 SOT-323/SC-70**

# NPN MMBT3904WT1 PNP MMBT3906WT1

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