MMBT3904WT1, NPN
MMBT3906WT1, PNP

General Purpose Transistors

NPN and PNP Silicon

ON Semiconductor®

http://onsemi.com

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.

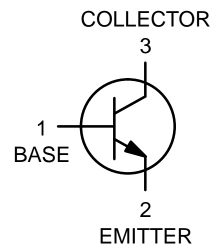
MAXIMUM RATINGS

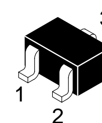
Rating	Symbol	Value	Unit
Collector–Emitter Voltage MMBT3904WT1 MMBT3906WT1	V_{CEO}	 40 –40	Vdc
Collector–Base Voltage MMBT3904WT1 MMBT3906WT1	V_{CBO}	 60 –40	Vdc
Emitter–Base Voltage MMBT3904WT1 MMBT3906WT1	V_{EBO}	 6.0 –5.0	Vdc
Collector Current – Continuous MMBT3904WT1 MMBT3906WT1	I_C	 200 –200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation (Note 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.

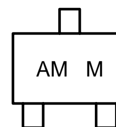




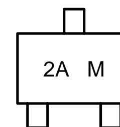
SC–70/SOT–323
CASE 419
STYLE 3

MARKING DIAGRAM

MMBT3904WT1



MMBT3906WT1



AM = Specific Device Code
2A = Specific Device Code
M = Date Code

ORDERING INFORMATION

Device	Package	Shipping
MMBT3904WT1	SC–70	3000/Tape & Reel
MMBT3906WT1	SC–70	3000/Tape & Reel

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (Note 2)		$V_{(BR)CEO}$			Vdc
(I_C = 1.0 mAdc, I_B = 0)	MMBT3904WT1		40	–	
(I_C = –1.0 mAdc, I_B = 0)	MMBT3906WT1		–40	–	
Collector–Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 10 μAdc, I_E = 0)	MMBT3904WT1		60	–	
(I_C = –10 μAdc, I_E = 0)	MMBT3906WT1		–40	–	
Emitter–Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)	MMBT3904WT1		6.0	–	
(I_E = –10 μAdc, I_C = 0)	MMBT3906WT1		–5.0	–	
Base Cutoff Current		I_{BL}			nAdc
(V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)	MMBT3904WT1		–	50	
(V_{CE} = –30 Vdc, V_{EB} = –3.0 Vdc)	MMBT3906WT1		–	–50	
Collector Cutoff Current		I_{CEX}			nAdc
(V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)	MMBT3904WT1		–	50	
(V_{CE} = –30 Vdc, V_{EB} = –3.0 Vdc)	MMBT3906WT1		–	–50	
ON CHARACTERISTICS (Note 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	

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

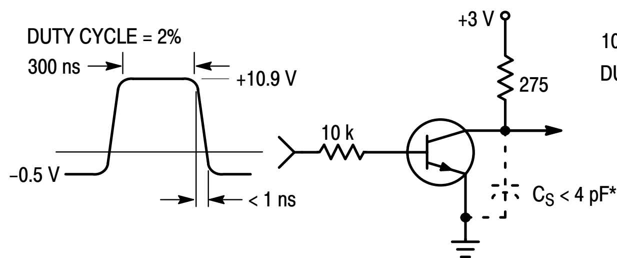
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

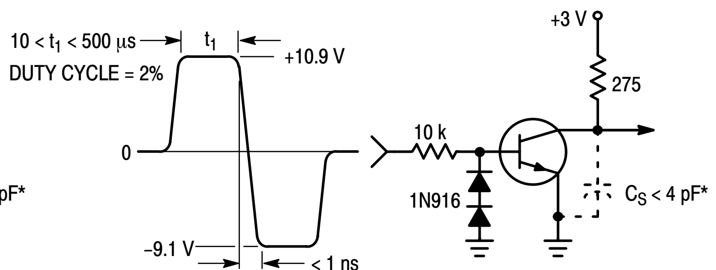
Characteristic		Symbol	Min	Max	Unit
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain – Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMBT3904WT1		300	–	
(I_C = –10 mAdc, V_{CE} = –20 Vdc, f = 100 MHz)	MMBT3906WT1		250	–	
Output Capacitance		C_{obo}			pF
(V_{CB} = 5.0 Vdc, I_E = 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	Condition		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	

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

MMBT3904WT1

TYPICAL TRANSIENT CHARACTERISTICS

$T_J = 25°C$
$T_J = 125°C$

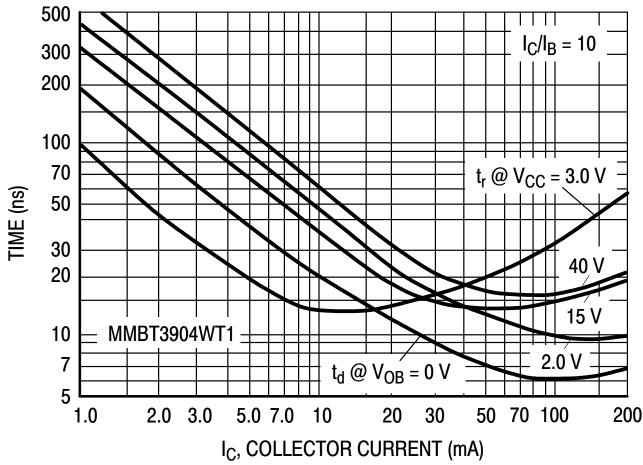


Figure 3. Turn–On Time

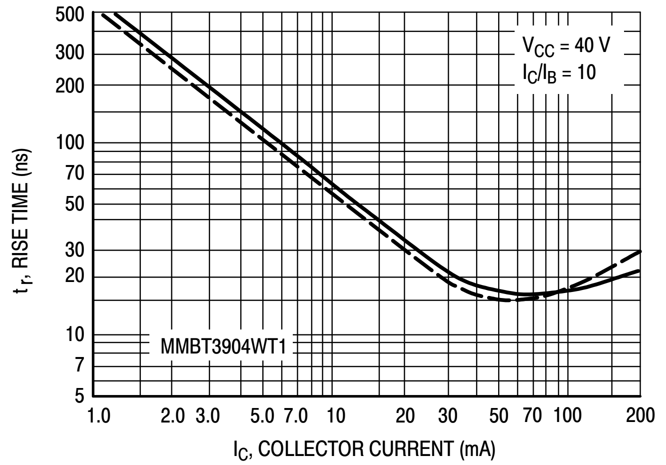


Figure 4. Rise Time

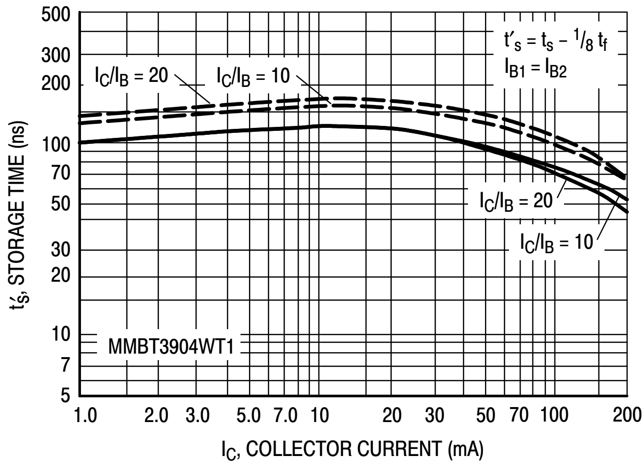


Figure 5. Storage Time

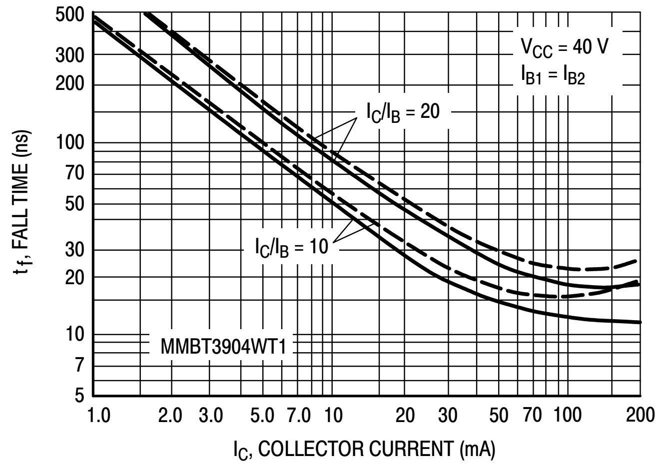


Figure 6. Fall Time

MMBT3904WT1

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS NOISE FIGURE VARIATIONS

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

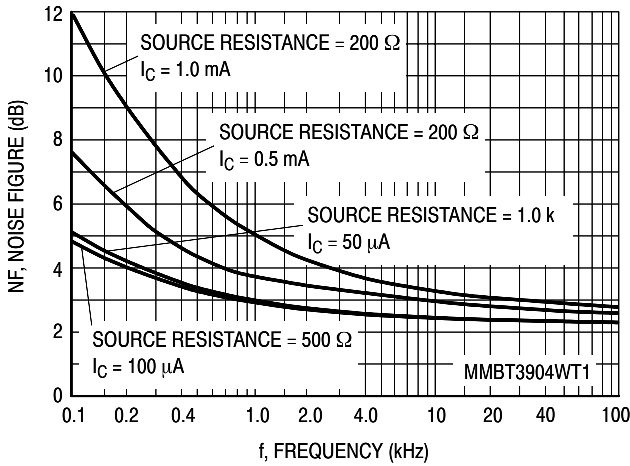


Figure 7. Noise Figure

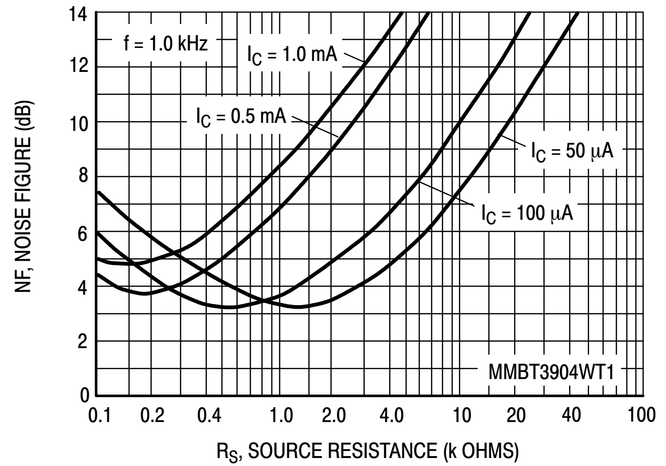


Figure 8. Noise Figure

h PARAMETERS

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

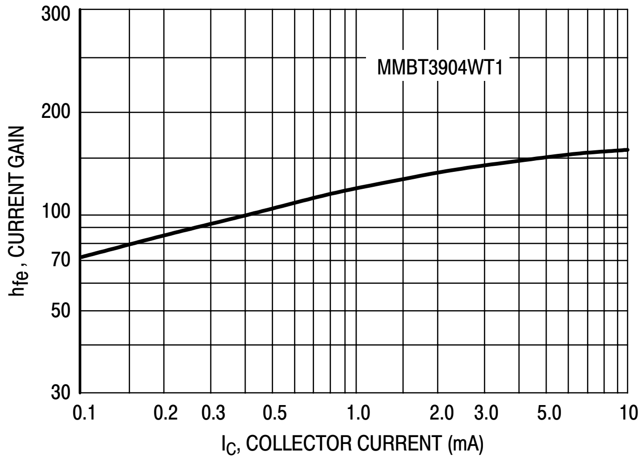


Figure 9. Current Gain

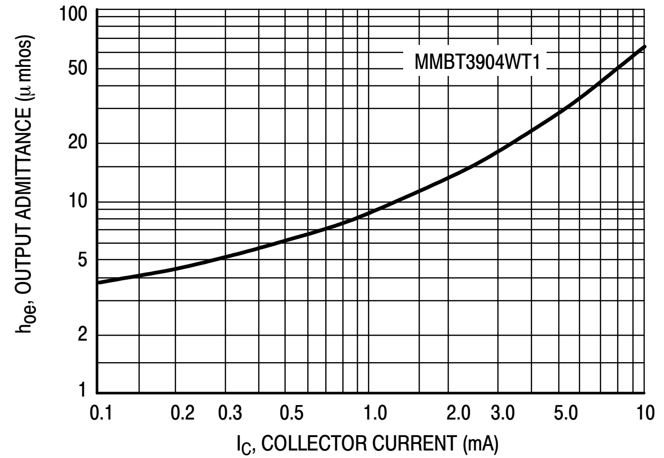


Figure 10. Output Admittance

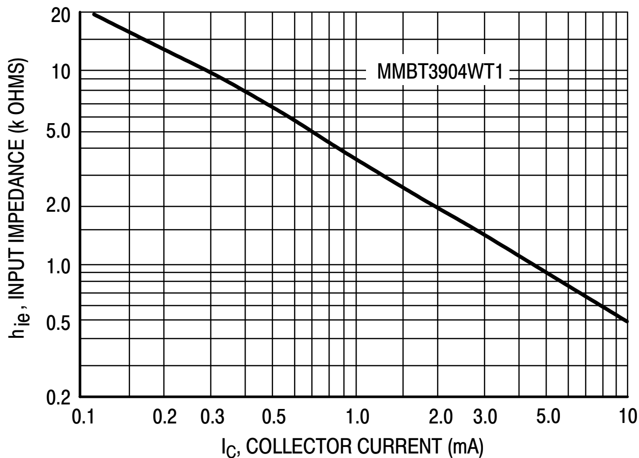


Figure 11. Input Impedance

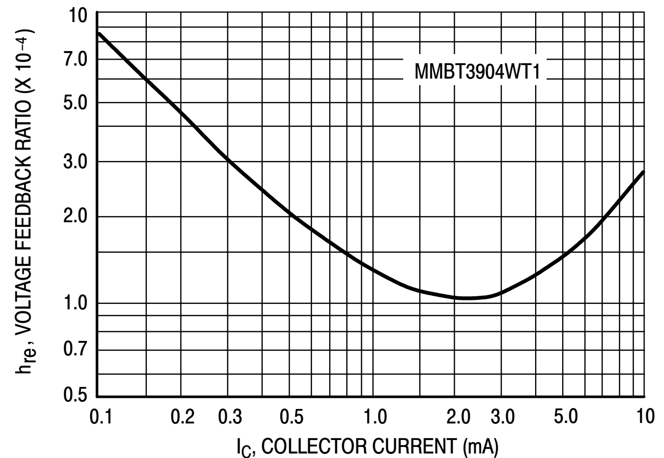


Figure 12. Voltage Feedback Ratio

MMBT3904WT1

TYPICAL STATIC CHARACTERISTICS

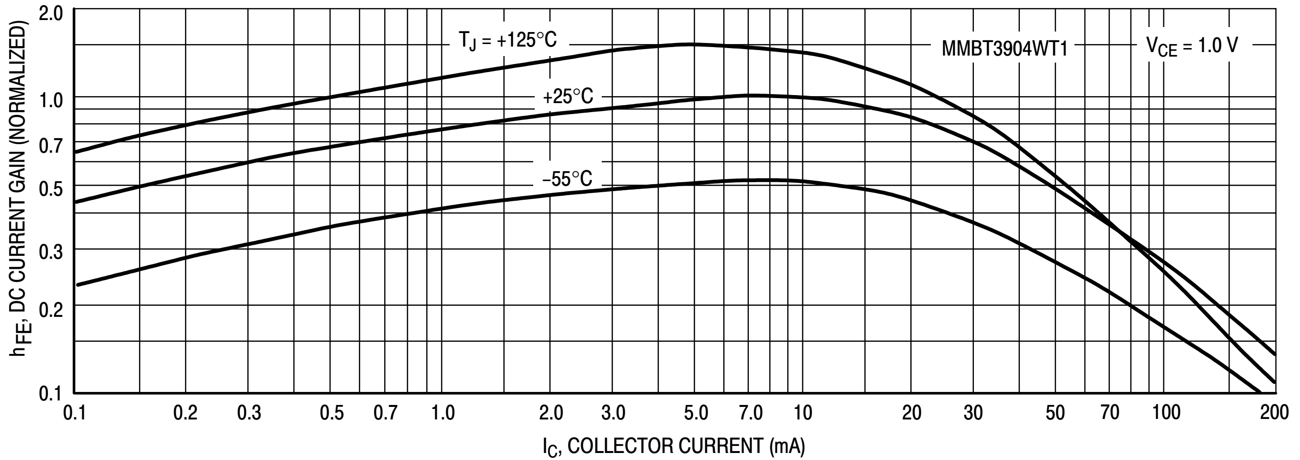


Figure 13. DC Current Gain

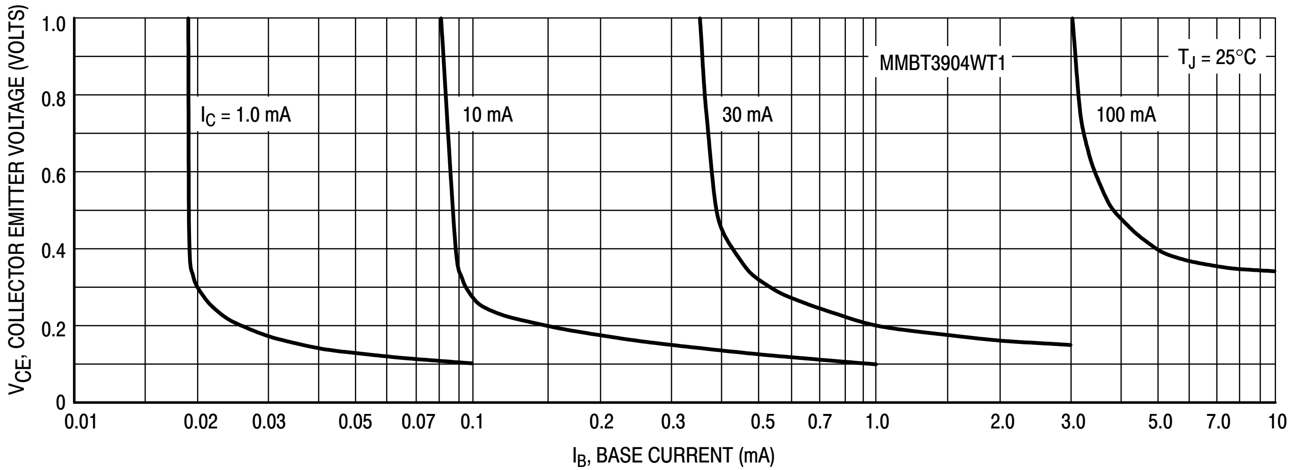


Figure 14. Collector Saturation Region

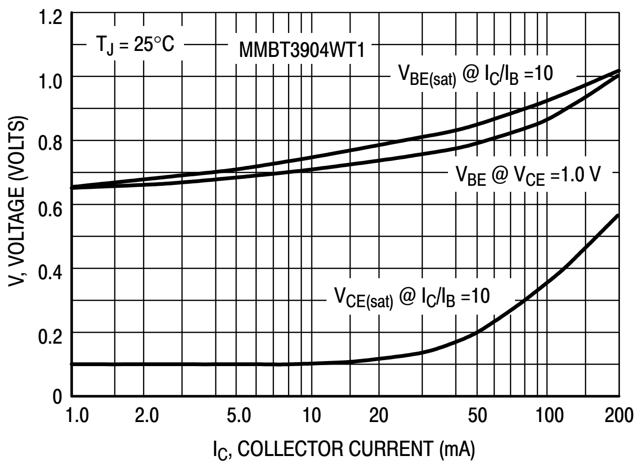


Figure 15. "ON" Voltages

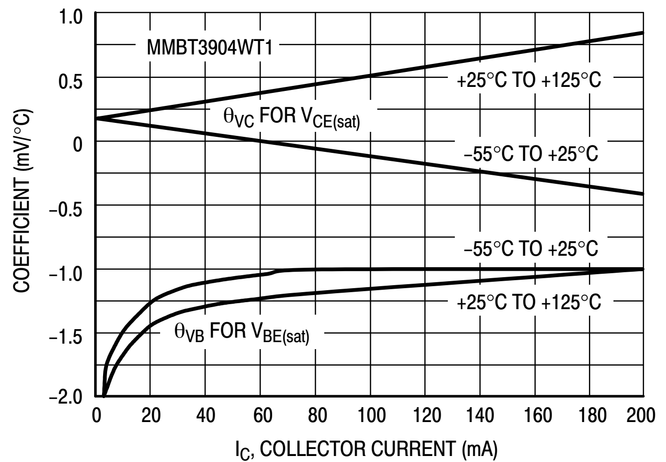


Figure 16. Temperature Coefficients

MMBT3904WT1

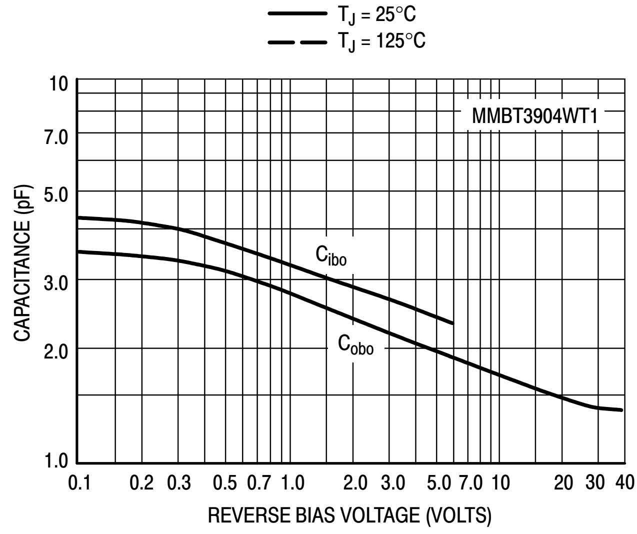
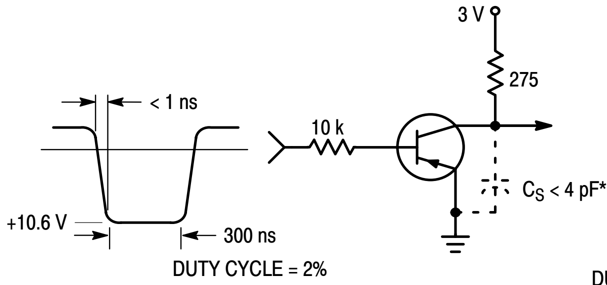
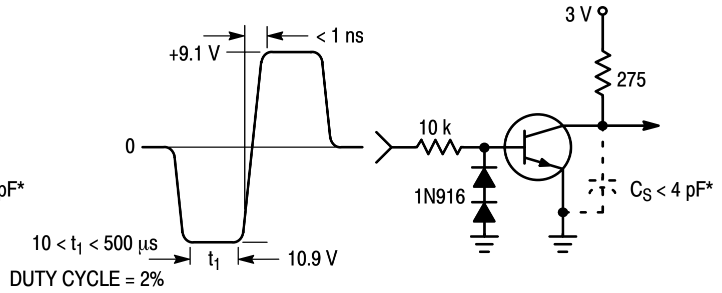


Figure 17. Capacitance

MMBT3906WT1





* Total shunt capacitance of test jig and connectors

Figure 18. Delay and Rise Time Equivalent Test Circuit

Figure 19. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

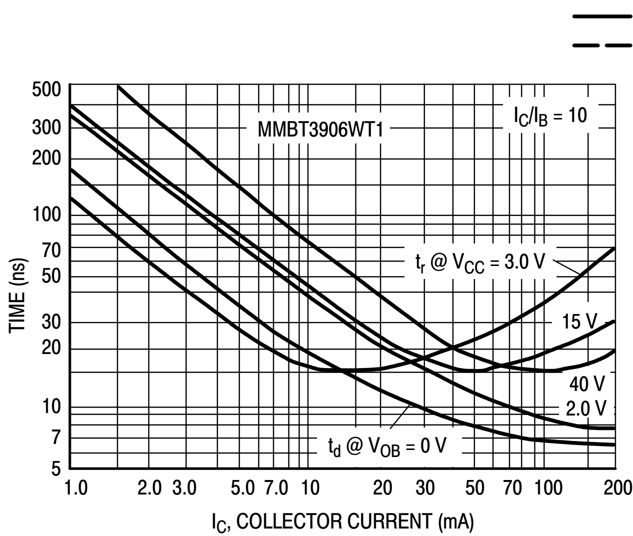


Figure 20. Turn–On Time

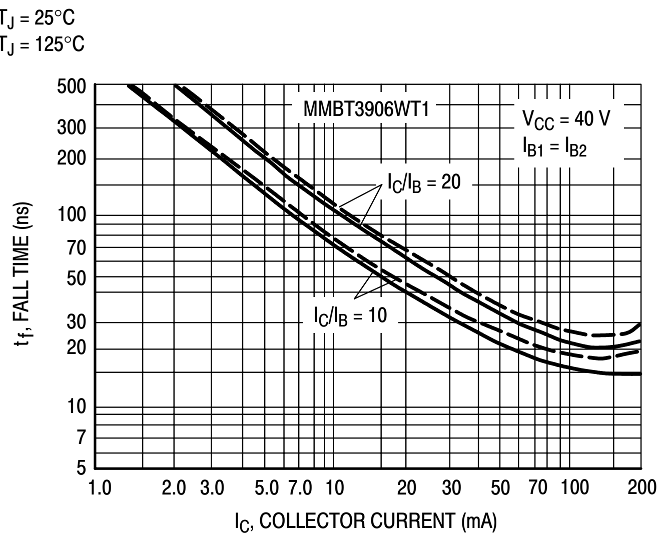


Figure 21. Fall Time

MMBT3906WT1

TYPICAL AUDIO SMALL–SIGNAL CHARACTERISTICS NOISE FIGURE VARIATIONS

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

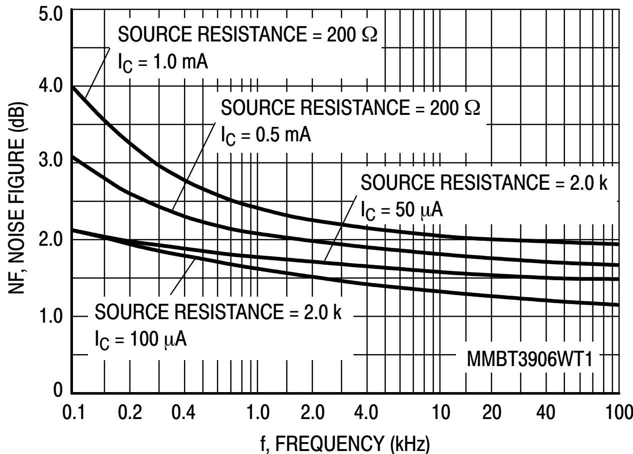


Figure 22.

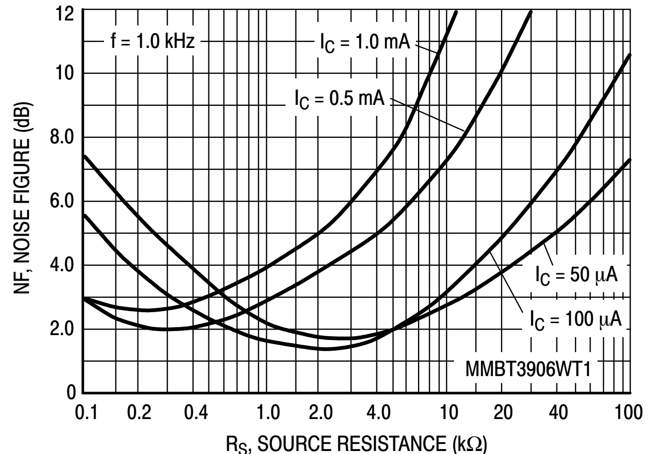


Figure 23.

MMBT3906WT1

h PARAMETERS

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

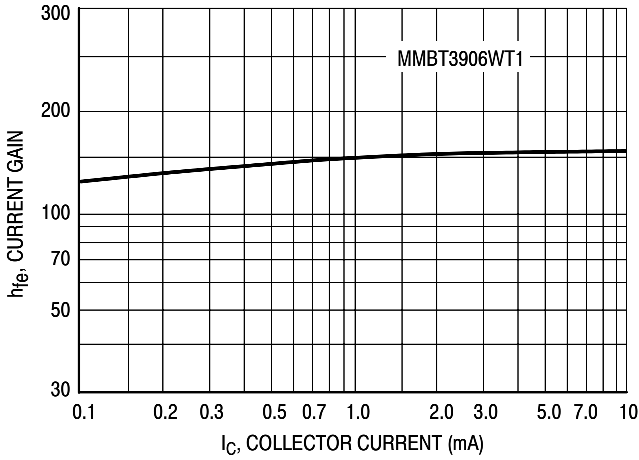


Figure 24. Current Gain

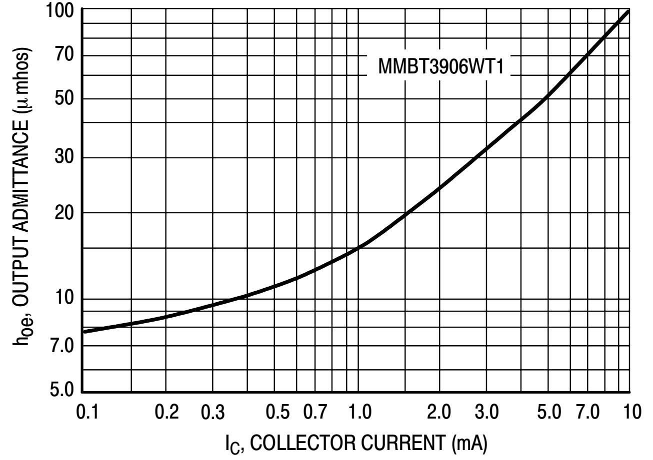


Figure 25. Output Admittance

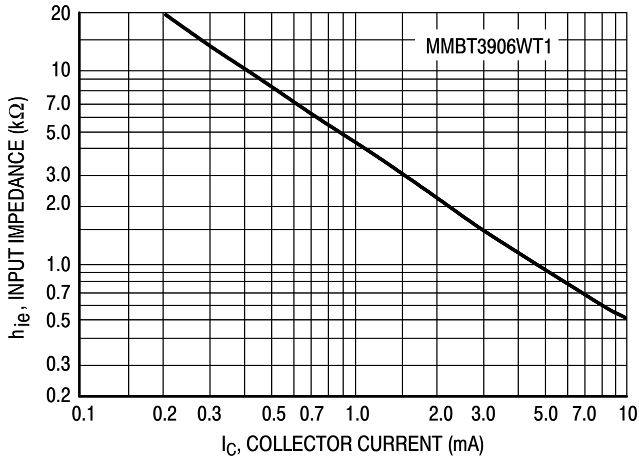


Figure 26. Input Impedance

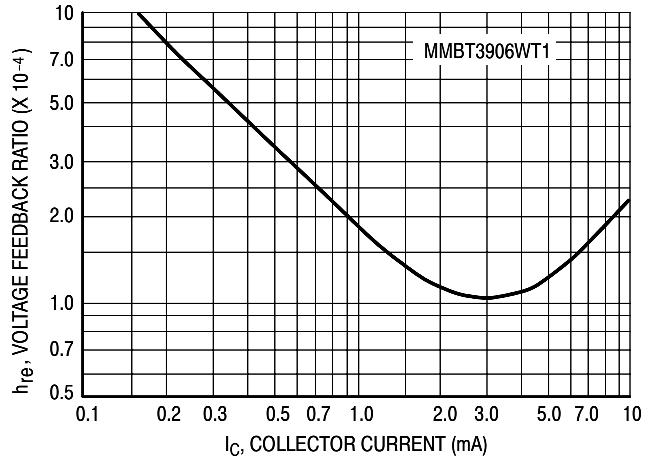


Figure 27. Voltage Feedback Ratio

MMBT3906WT1

STATIC CHARACTERISTICS

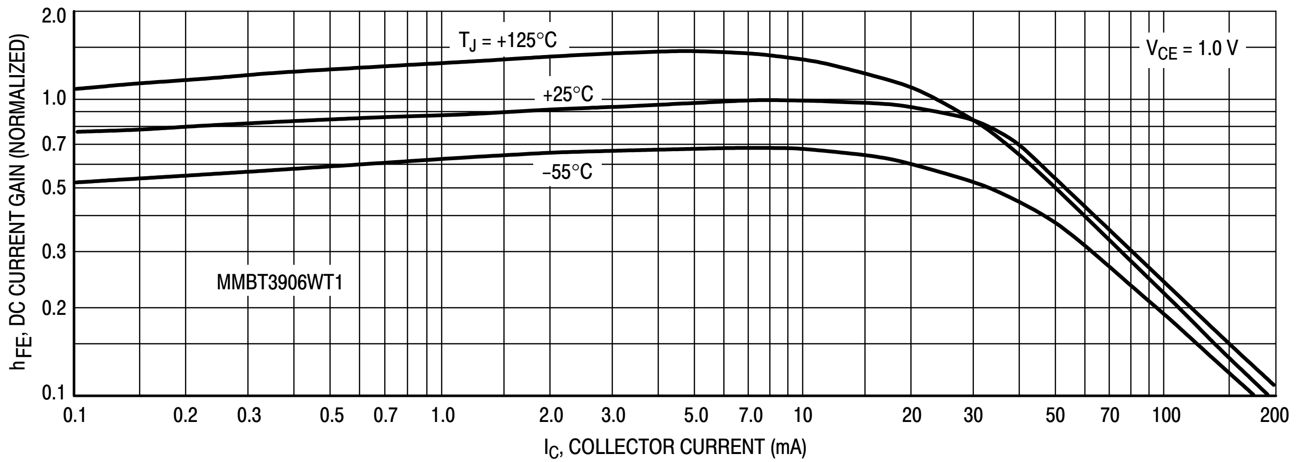


Figure 28. DC Current Gain

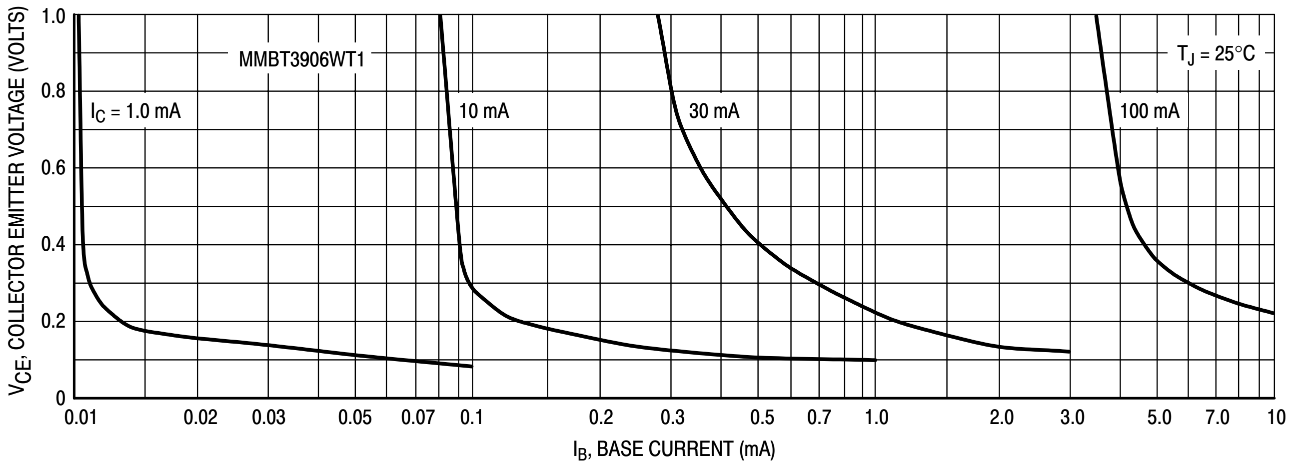


Figure 29. Collector Saturation Region

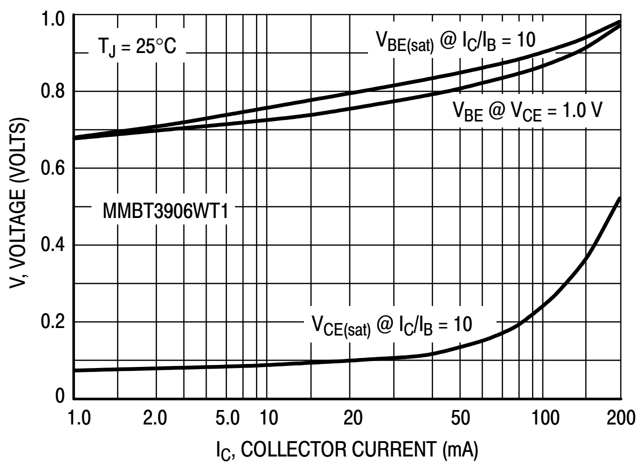


Figure 30. “ON” Voltages

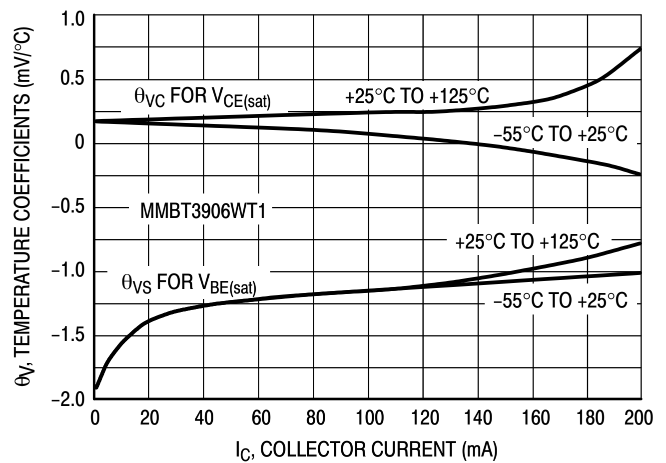


Figure 31. Temperature Coefficients

MMBT3906WT1

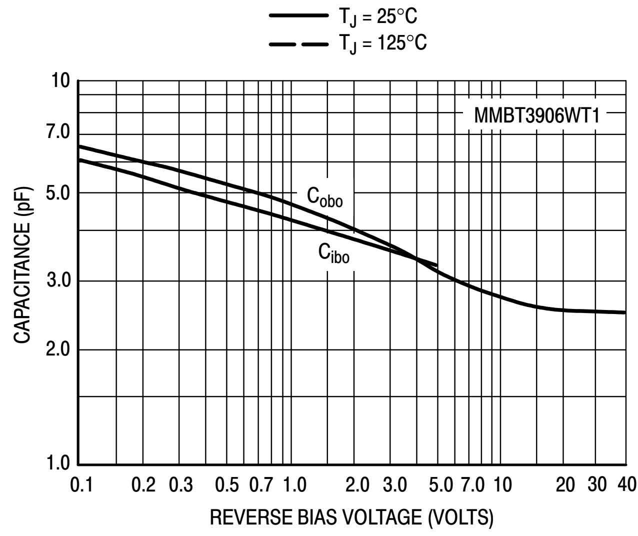
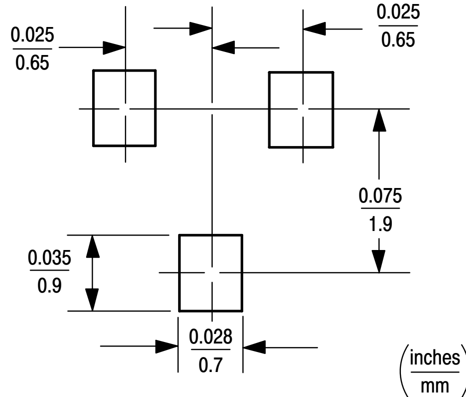


Figure 32. Capacitance

INFORMATION FOR USING THE SC–70/SOT–323 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.



SC–70/SOT–323 POWER DISSIPATION

The power dissipation of the SC–70/SOT–323 is a function of the pad size. This can vary from the minimum pad size for soldering to the 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 which in this case is 200 milliwatts.

$$P_D = \frac{150°C - 25°C}{0.625°C/W} = 200 \text{ milliwatts}$$

The 0.625°C/W assumes the use of the recommended footprint on a glass epoxy printed circuit board to achieve a power dissipation of 200 milliwatts. 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, a higher power dissipation of 300 milliwatts can be achieved 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 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 should 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.

SOLDER STENCIL GUIDELINES

Prior to placing surface mount components onto a printed circuit board, solder paste must be applied to the pads. A solder stencil is required to screen the optimum amount of solder paste onto the footprint. The stencil is made of brass or stainless steel with a typical thickness of 0.008 inches. The stencil opening size for the surface mounted package should be the same as the pad size on the printed circuit board, i.e., a 1:1 registration.

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 33 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.

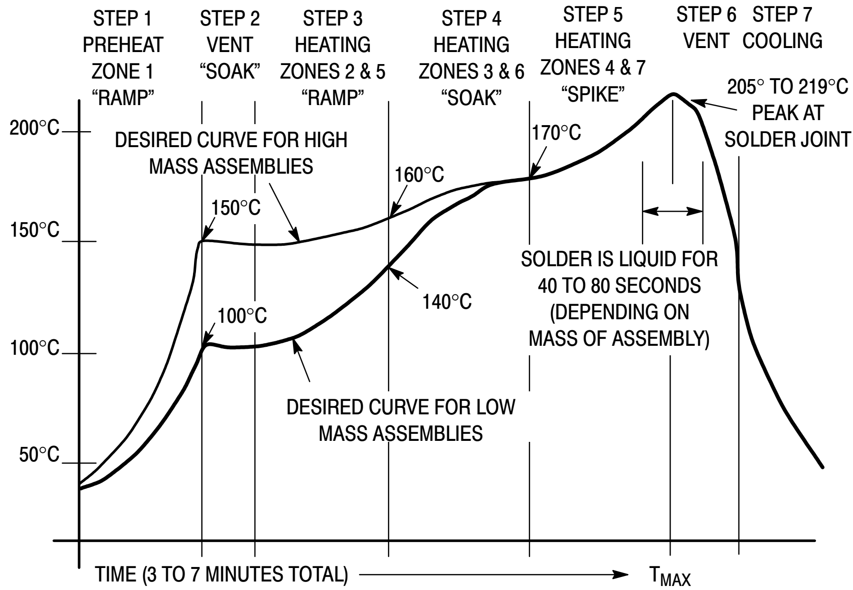
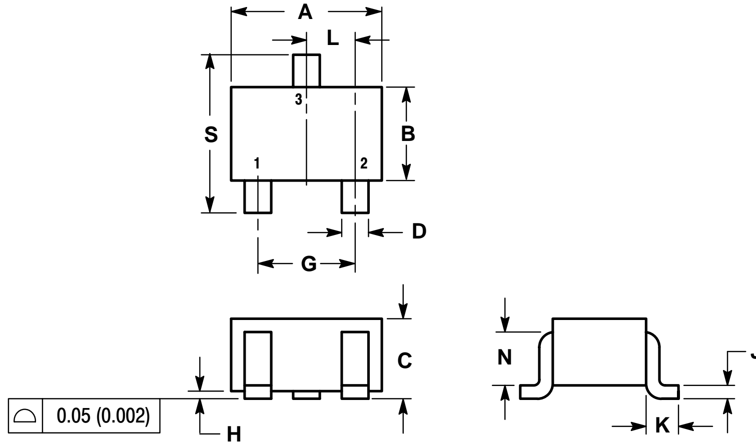


Figure 33. Typical Solder Heating Profile

PACKAGE DIMENSIONS

SC–70/SOT–323
CASE 419–04
ISSUE L



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	0.032	0.040	0.80	1.00
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	
S	0.079	0.095	2.00	2.40

STYLE 3:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

Notes

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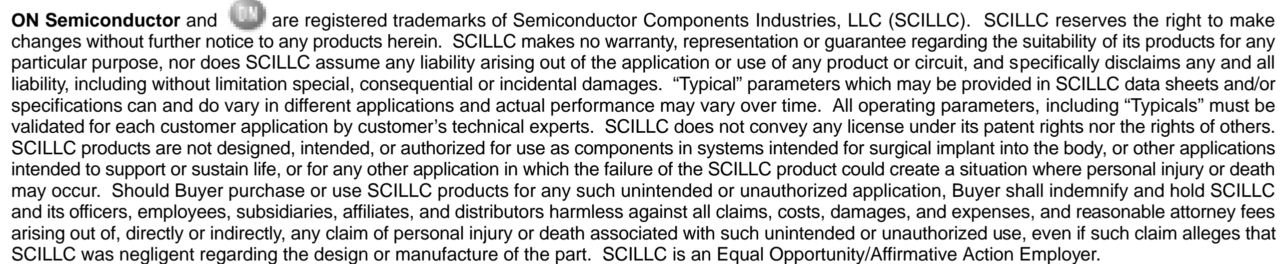

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