

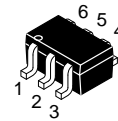
## Dual General Purpose Transistors

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  $V_{CE(sat)}$ ,  $\leq 0.4$  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**

MBT3904DW1T1  
MBT3906DW1T1  
MBT3946DW1T1



CASE 419B-01, STYLE 1

### 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

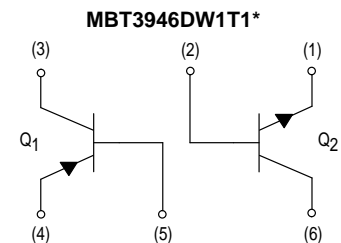
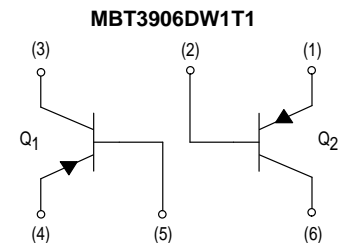
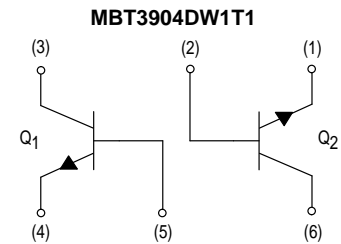
Characteristic	Symbol	Max	Unit
Total Package Dissipation <sup>(1)</sup> $T_A = 25^\circ\text{C}$	$P_D$	150	mW
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	833	$^\circ\text{C/W}$
Junction and Storage Temperature	$T_J, T_{stg}$	–55 to +150	$^\circ\text{C}$

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

### DEVICE MARKING

MBT3904DW1T1 = MA MBT3946DW1T1 = 46  
MBT3906DW1T1 = A2

Thermal Clad is a trademark of the Bergquist Company.



\*Q1 same as MBT3906DW1T1  
Q2 same as MBT3904DW1T1

# MBT3904DW1T1 MBT3906DW1T1 MBT3946DW1T1

## ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit	
<b>OFF CHARACTERISTICS</b>					
Collector–Emitter Breakdown Voltage <sup>(2)</sup> (I <sub>C</sub> = 1.0 mA <sub>dc</sub> , I <sub>B</sub> = 0) (I <sub>C</sub> = -1.0 mA <sub>dc</sub> , I <sub>B</sub> = 0)	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	V <sub>(BR)CEO</sub>	40 -40	— —	V <sub>dc</sub>
Collector–Base Breakdown Voltage (I <sub>C</sub> = 10 μA <sub>dc</sub> , I <sub>E</sub> = 0) (I <sub>C</sub> = -10 μA <sub>dc</sub> , I <sub>E</sub> = 0)	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	V <sub>(BR)CBO</sub>	60 -40	— —	V <sub>dc</sub>
Emitter–Base Breakdown Voltage (I <sub>E</sub> = 10 μA <sub>dc</sub> , I <sub>C</sub> = 0) (I <sub>E</sub> = -10 μA <sub>dc</sub> , I <sub>C</sub> = 0)	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	V <sub>(BR)EBO</sub>	6.0 -5.0	— —	V <sub>dc</sub>
Base Cutoff Current (V <sub>CE</sub> = 30 V <sub>dc</sub> , V <sub>EB</sub> = 3.0 V <sub>dc</sub> ) (V <sub>CE</sub> = -30 V <sub>dc</sub> , V <sub>EB</sub> = -3.0 V <sub>dc</sub> )	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	I <sub>BL</sub>	— —	50 -50	nA <sub>dc</sub>
Collector Cutoff Current (V <sub>CE</sub> = 30 V <sub>dc</sub> , V <sub>EB</sub> = 3.0 V <sub>dc</sub> ) (V <sub>CE</sub> = -30 V <sub>dc</sub> , V <sub>EB</sub> = -3.0 V <sub>dc</sub> )	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	I <sub>CEX</sub>	— —	50 -50	nA <sub>dc</sub>

## ON CHARACTERISTICS (2)

DC Current Gain (I <sub>C</sub> = 0.1 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> ) (I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> ) (I <sub>C</sub> = 10 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> ) (I <sub>C</sub> = 50 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> ) (I <sub>C</sub> = 100 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )  (I <sub>C</sub> = -0.1 mA <sub>dc</sub> , V <sub>CE</sub> = -1.0 V <sub>dc</sub> ) (I <sub>C</sub> = -1.0 mA <sub>dc</sub> , V <sub>CE</sub> = -1.0 V <sub>dc</sub> ) (I <sub>C</sub> = -10 mA <sub>dc</sub> , V <sub>CE</sub> = -1.0 V <sub>dc</sub> ) (I <sub>C</sub> = -50 mA <sub>dc</sub> , V <sub>CE</sub> = -1.0 V <sub>dc</sub> ) (I <sub>C</sub> = -100 mA <sub>dc</sub> , V <sub>CE</sub> = -1.0 V <sub>dc</sub> )	MBT3904DW1T1 (NPN)     MBT3906DW1T1 (PNP)	h <sub>FE</sub>	40 70 100 60 30  60 80 100 60 30	— — 300 — —  — — 300 — —	—
Collector–Emitter Saturation Voltage (I <sub>C</sub> = 10 mA <sub>dc</sub> , I <sub>B</sub> = 1.0 mA <sub>dc</sub> ) (I <sub>C</sub> = 50 mA <sub>dc</sub> , I <sub>B</sub> = 5.0 mA <sub>dc</sub> )  (I <sub>C</sub> = -10 mA <sub>dc</sub> , I <sub>B</sub> = -1.0 mA <sub>dc</sub> ) (I <sub>C</sub> = -50 mA <sub>dc</sub> , I <sub>B</sub> = -5.0 mA <sub>dc</sub> )	MBT3904DW1T1 (NPN)  MBT3906DW1T1 (PNP)	V <sub>CE(sat)</sub>	— —  — —	0.2 0.3  -0.25 -0.4	V <sub>dc</sub>
Base–Emitter Saturation Voltage (I <sub>C</sub> = 10 mA <sub>dc</sub> , I <sub>B</sub> = 1.0 mA <sub>dc</sub> ) (I <sub>C</sub> = 50 mA <sub>dc</sub> , I <sub>B</sub> = 5.0 mA <sub>dc</sub> )  (I <sub>C</sub> = -10 mA <sub>dc</sub> , I <sub>B</sub> = -1.0 mA <sub>dc</sub> ) (I <sub>C</sub> = -50 mA <sub>dc</sub> , I <sub>B</sub> = -5.0 mA <sub>dc</sub> )	MBT3904DW1T1 (NPN)  MBT3906DW1T1 (PNP)	V <sub>BE(sat)</sub>	0.65 —  -0.65 —	0.85 0.95  -0.85 -0.95	V <sub>dc</sub>

## SMALL–SIGNAL CHARACTERISTICS

Current–Gain — Bandwidth Product (I <sub>C</sub> = 10 mA <sub>dc</sub> , V <sub>CE</sub> = 20 V <sub>dc</sub> , f = 100 MHz) (I <sub>C</sub> = -10 mA <sub>dc</sub> , V <sub>CE</sub> = -20 V <sub>dc</sub> , f = 100 MHz)	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	f <sub>T</sub>	300 250	— —	MHz
Output Capacitance (V <sub>CB</sub> = 5.0 V <sub>dc</sub> , I <sub>E</sub> = 0, f = 1.0 MHz) (V <sub>CB</sub> = -5.0 V <sub>dc</sub> , I <sub>E</sub> = 0, f = 1.0 MHz)	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	C <sub>obo</sub>	— —	4.0 4.5	pF
Input Capacitance (V <sub>EB</sub> = 0.5 V <sub>dc</sub> , I <sub>C</sub> = 0, f = 1.0 MHz) (V <sub>EB</sub> = -0.5 V <sub>dc</sub> , I <sub>C</sub> = 0, f = 1.0 MHz)	MBT3904DW1T1 (NPN) MBT3906DW1T1 (PNP)	C <sub>ibo</sub>	— —	8.0 10.0	pF

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

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

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

**SWITCHING CHARACTERISTICS**

Delay Time	( $V_{CC} = 3.0\text{ Vdc}$ , $V_{BE} = -0.5\text{ Vdc}$ )	MBT3904DW1T1 (NPN)	$t_d$	—	35	ns
	( $V_{CC} = -3.0\text{ Vdc}$ , $V_{BE} = 0.5\text{ Vdc}$ )	MBT3906DW1T1 (PNP)		—	35	
Rise Time	( $I_C = 10\text{ mAdc}$ , $I_{B1} = 1.0\text{ mAdc}$ )	MBT3904DW1T1 (NPN)	$t_r$	—	35	ns
	( $I_C = -10\text{ mAdc}$ , $I_{B1} = -1.0\text{ mAdc}$ )	MBT3906DW1T1 (PNP)		—	35	
Storage Time	( $V_{CC} = 3.0\text{ Vdc}$ , $I_C = 10\text{ mAdc}$ )	MBT3904DW1T1 (NPN)	$t_s$	—	200	ns
	( $V_{CC} = -3.0\text{ Vdc}$ , $I_C = -10\text{ mAdc}$ )	MBT3906DW1T1 (PNP)		—	225	
Fall Time	( $I_{B1} = I_{B2} = 1.0\text{ mAdc}$ )	MBT3904DW1T1 (NPN)	$t_f$	—	50	ns
	( $I_{B1} = I_{B2} = -1.0\text{ mAdc}$ )	MBT3906DW1T1 (PNP)		—	75	

MBT3904DW1T1 (NPN)

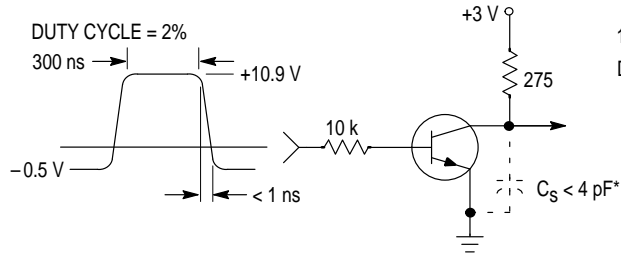


Figure 1. Delay and Rise Time Equivalent Test Circuit

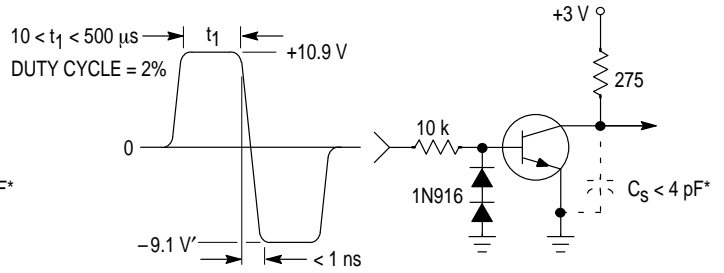


Figure 2. Storage and Fall Time Equivalent Test Circuit

\* Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

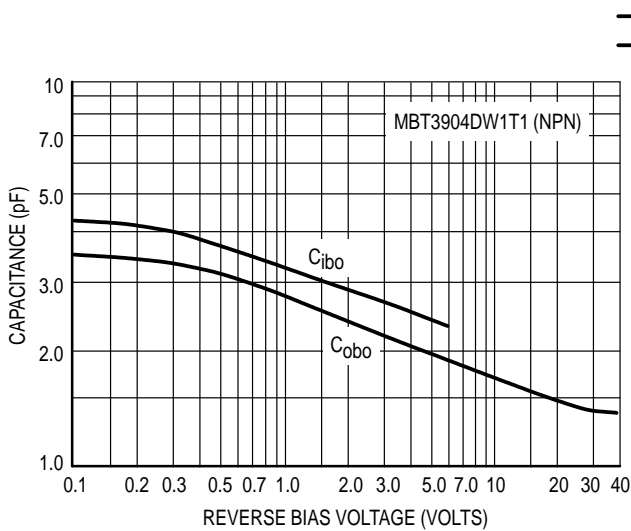


Figure 3. Capacitance

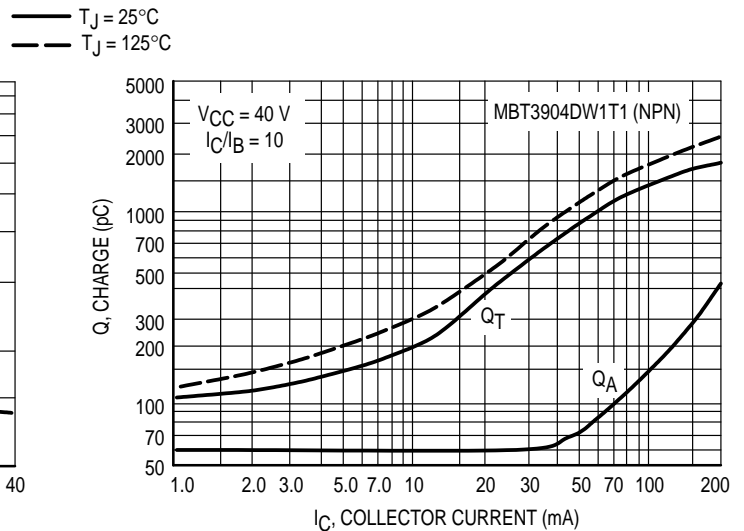


Figure 4. Charge Data

MBT3904DW1T1 (NPN)

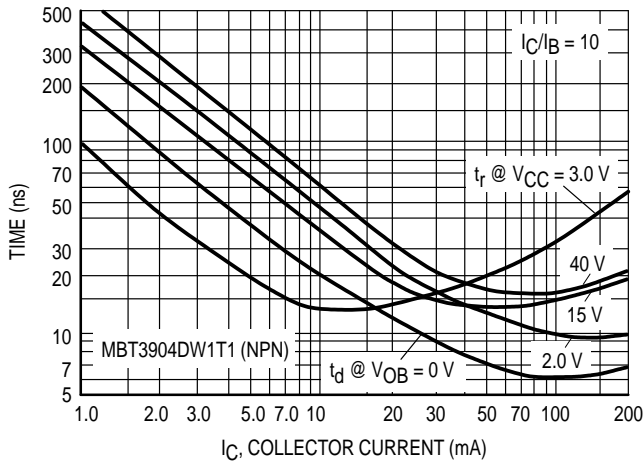


Figure 5. Turn-On Time

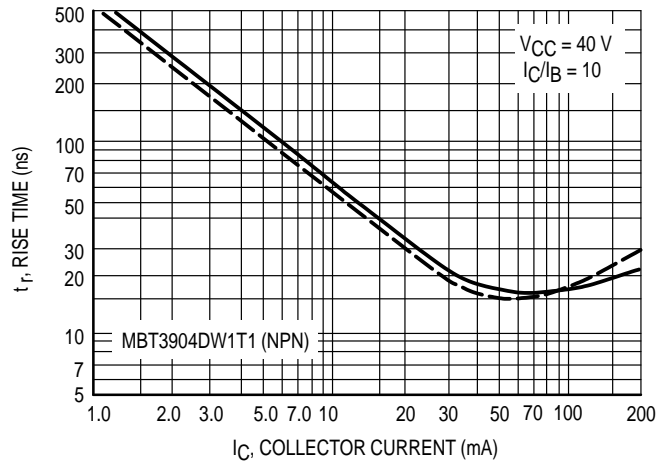


Figure 6. Rise Time

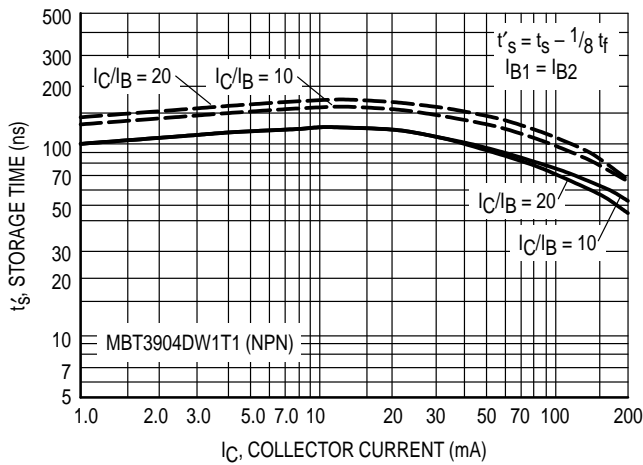


Figure 7. Storage Time

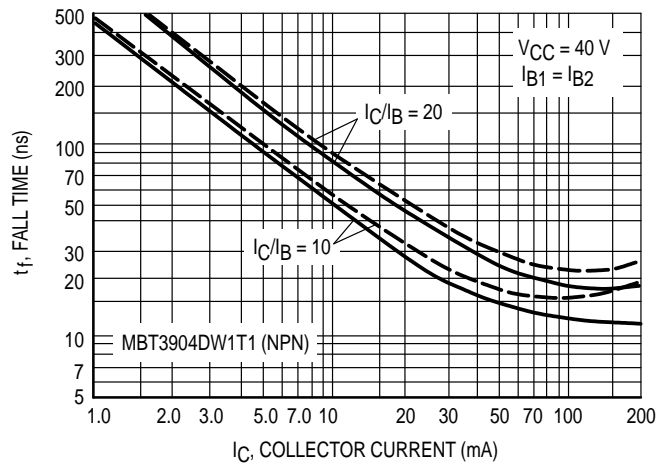


Figure 8. Fall Time

TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS  
NOISE FIGURE VARIATIONS

(VCE = 5.0 Vdc, TA = 25°C, Bandwidth = 1.0 Hz)

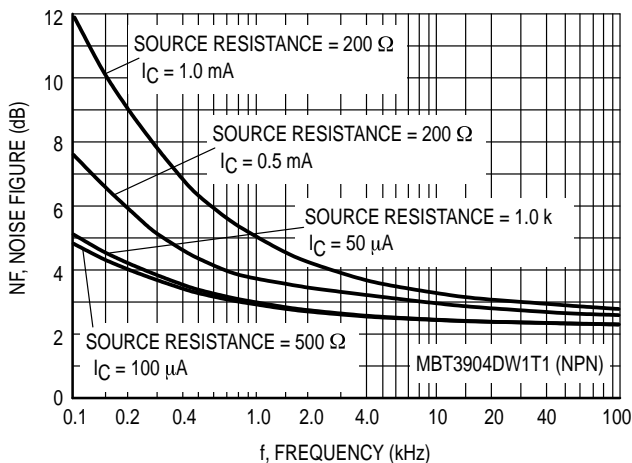


Figure 9. Noise Figure

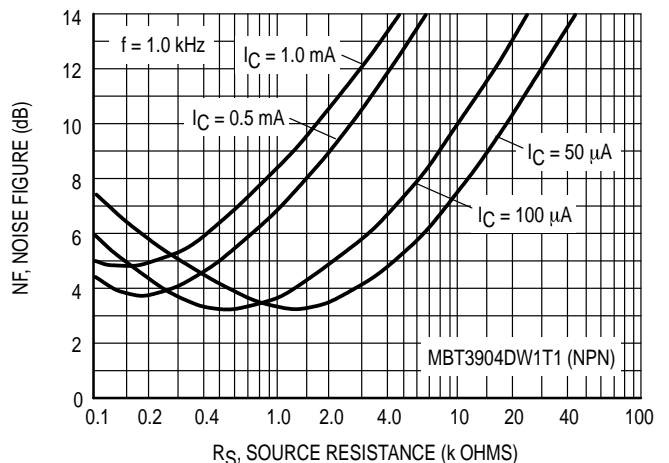


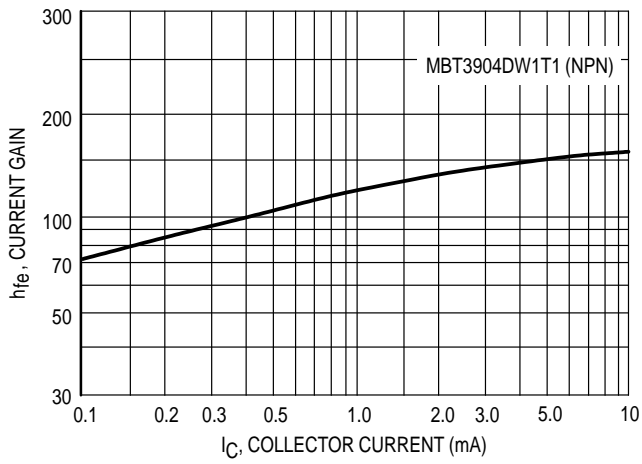
Figure 10. Noise Figure

**MBT3904DW1T1 MBT3906DW1T1 MBT3946DW1T1**

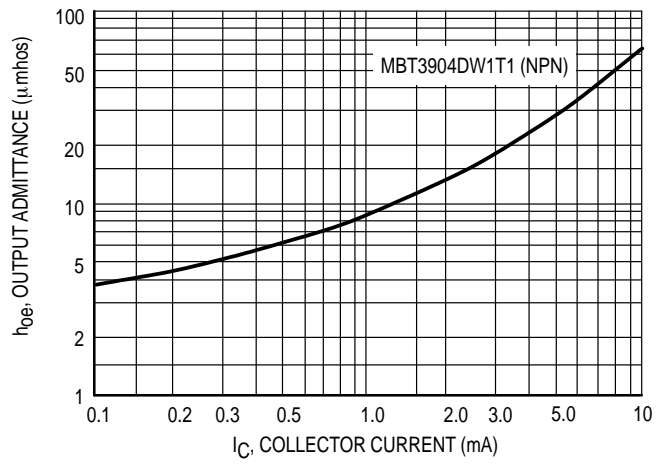
**MBT3904DW1T1 (NPN)**

**h PARAMETERS**

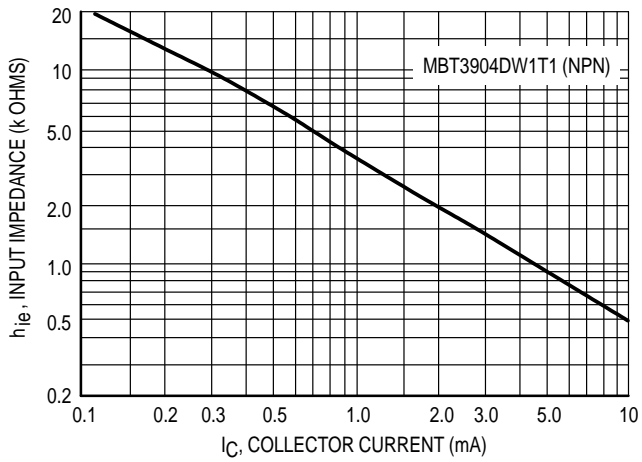
( $V_{CE} = 10 \text{ Vdc}$ ,  $f = 1.0 \text{ kHz}$ ,  $T_A = 25^\circ\text{C}$ )



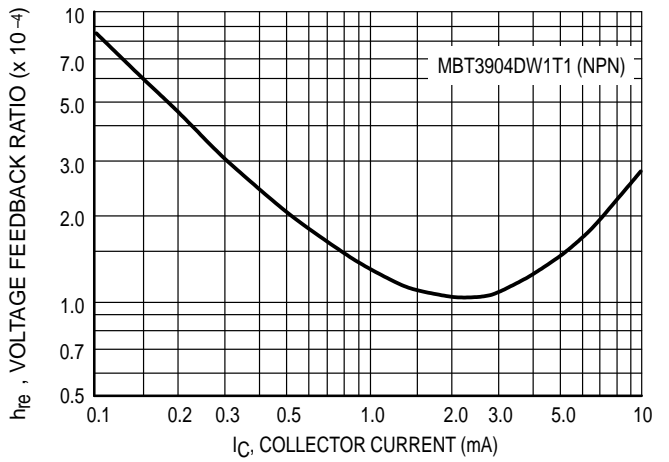
**Figure 11. Current Gain**



**Figure 12. Output Admittance**



**Figure 13. Input Impedance**



**Figure 14. Voltage Feedback Ratio**

MBT3904DW1T1 (NPN)

TYPICAL STATIC CHARACTERISTICS

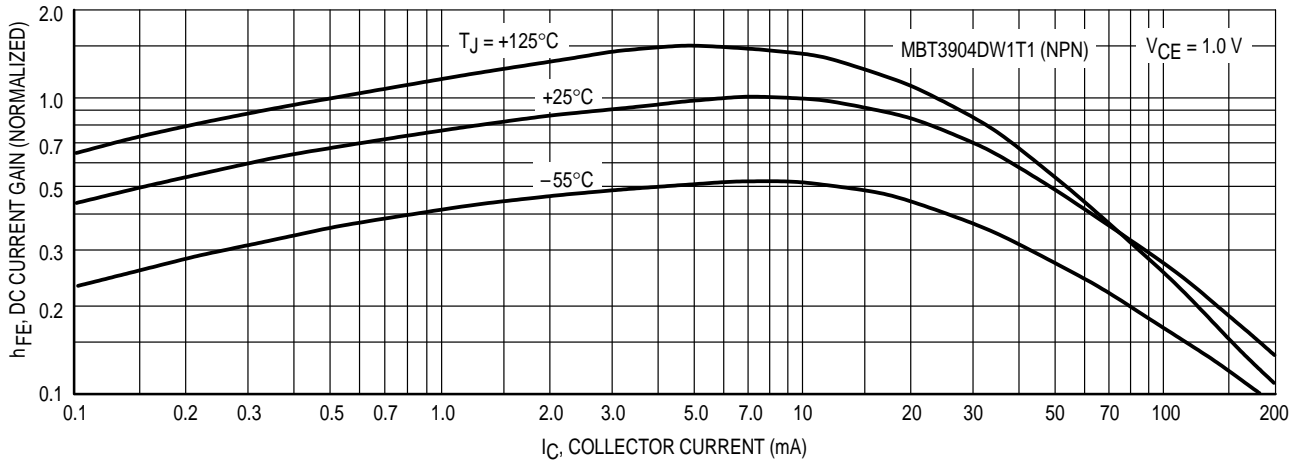


Figure 15. DC Current Gain

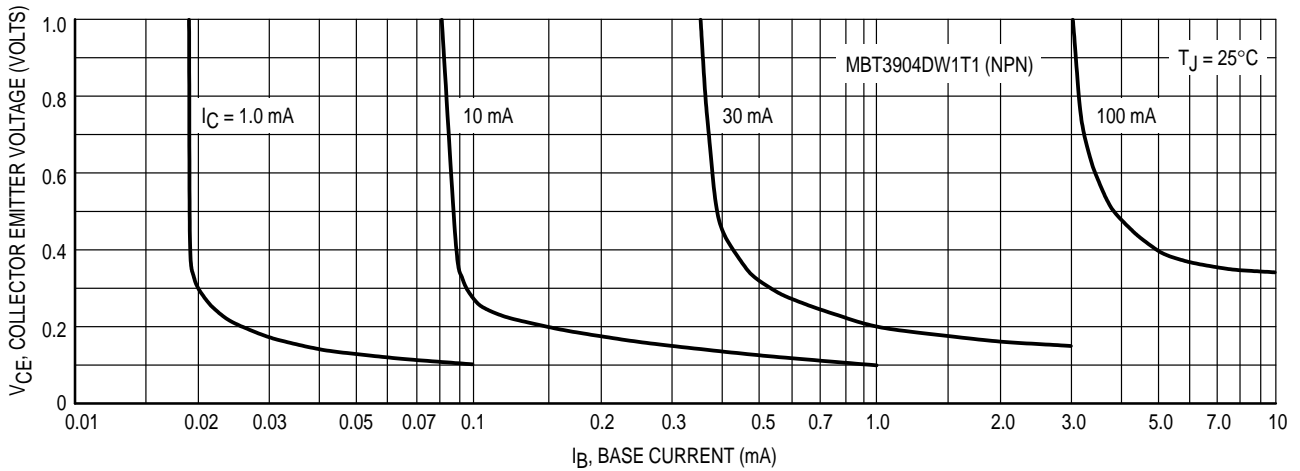


Figure 16. Collector Saturation Region

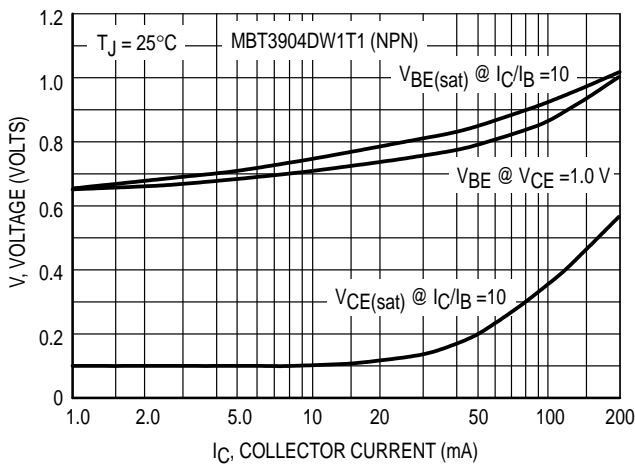


Figure 17. "ON" Voltages

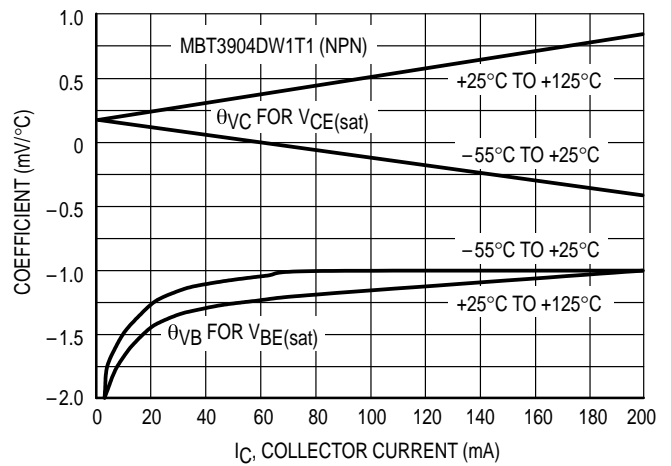


Figure 18. Temperature Coefficients

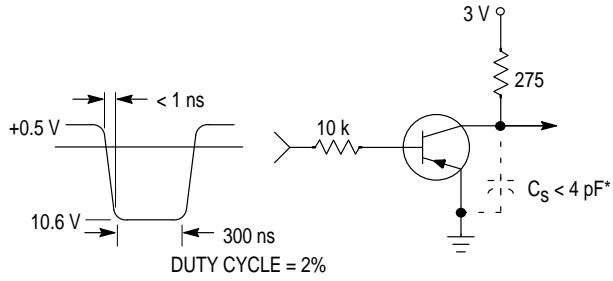


Figure 19. Delay and Rise Time Equivalent Test Circuit

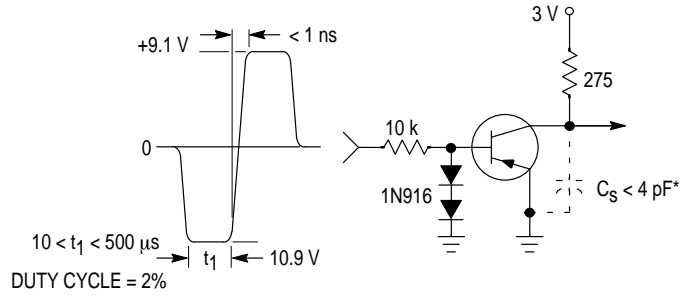


Figure 20. Storage and Fall Time Equivalent Test Circuit

\* Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

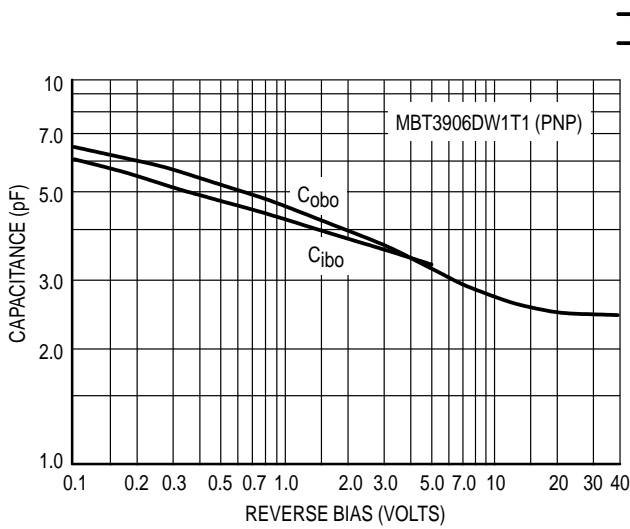


Figure 21. Capacitance

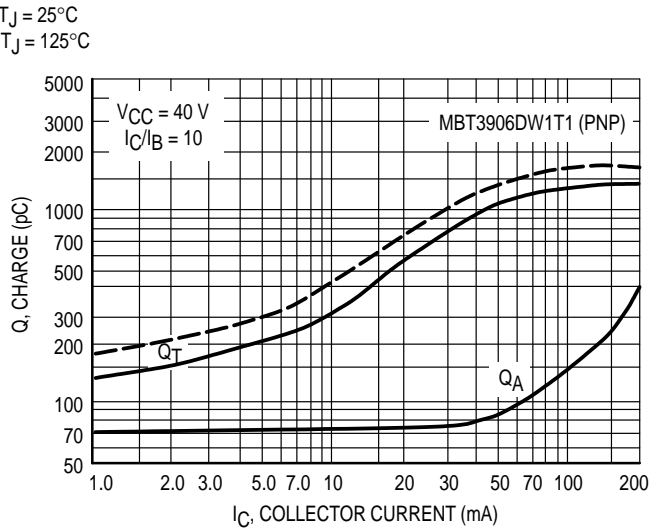


Figure 22. Charge Data

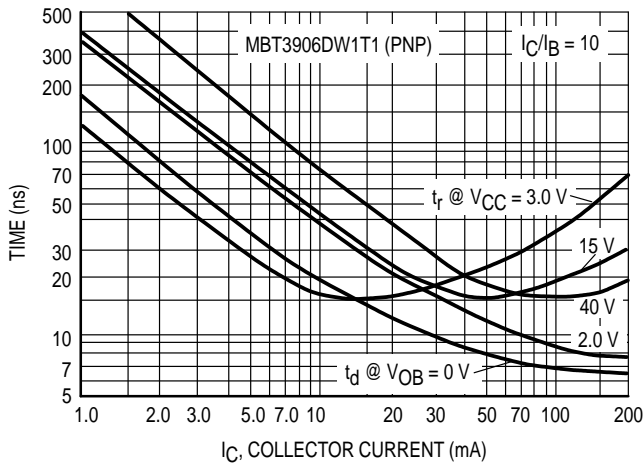


Figure 23. Turn-On Time

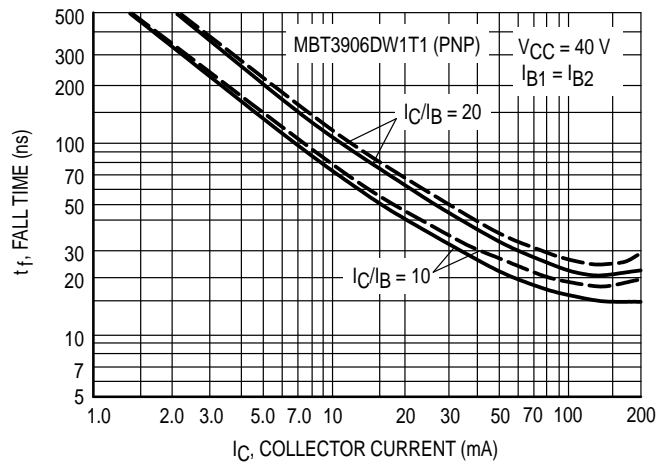


Figure 24. Fall Time



MBT3906DW1T1 (PNP)

TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS  
NOISE FIGURE VARIATIONS

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

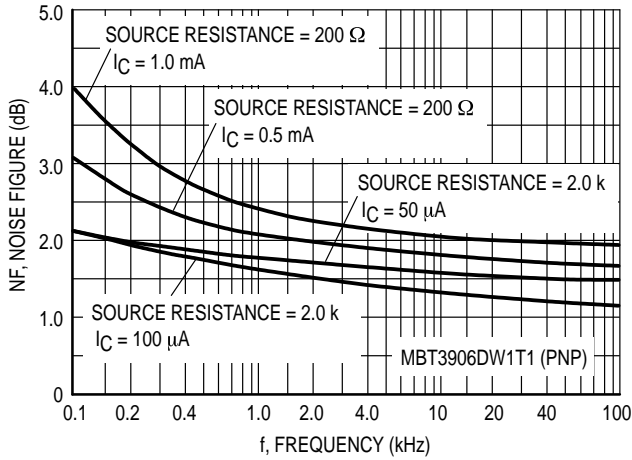


Figure 25.

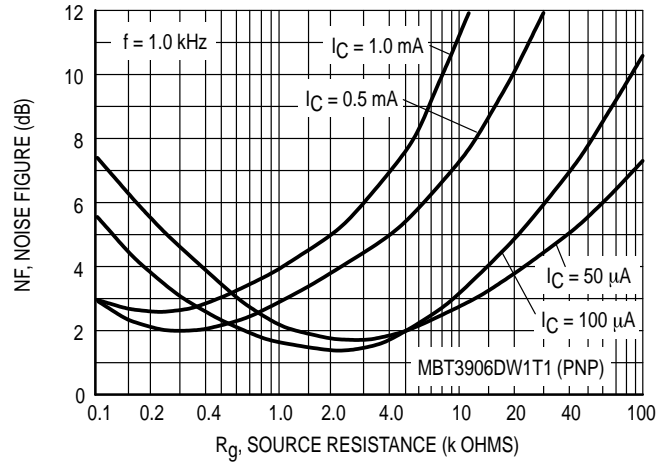


Figure 26.

h PARAMETERS

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

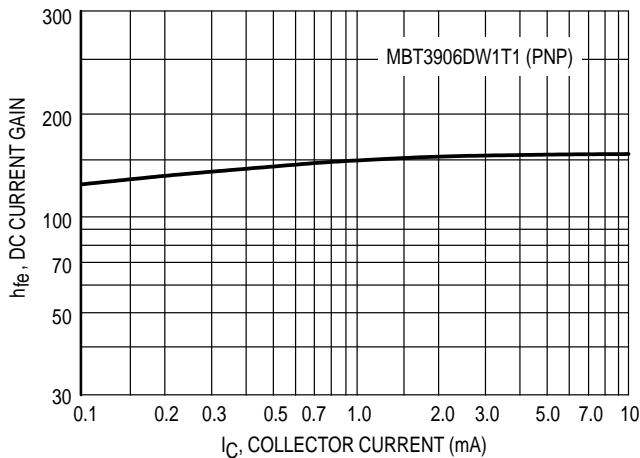


Figure 27. Current Gain

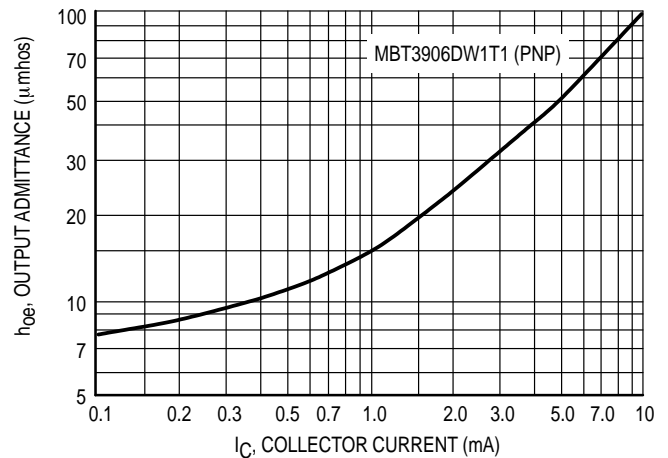


Figure 28. Output Admittance

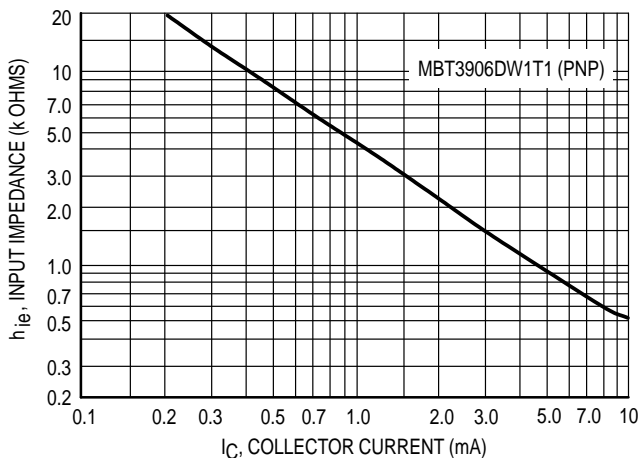


Figure 29. Input Impedance

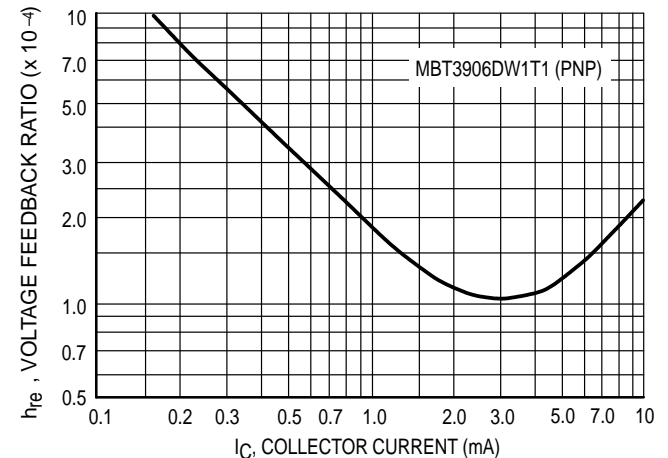


Figure 30. Voltage Feedback Ratio

TYPICAL STATIC CHARACTERISTICS

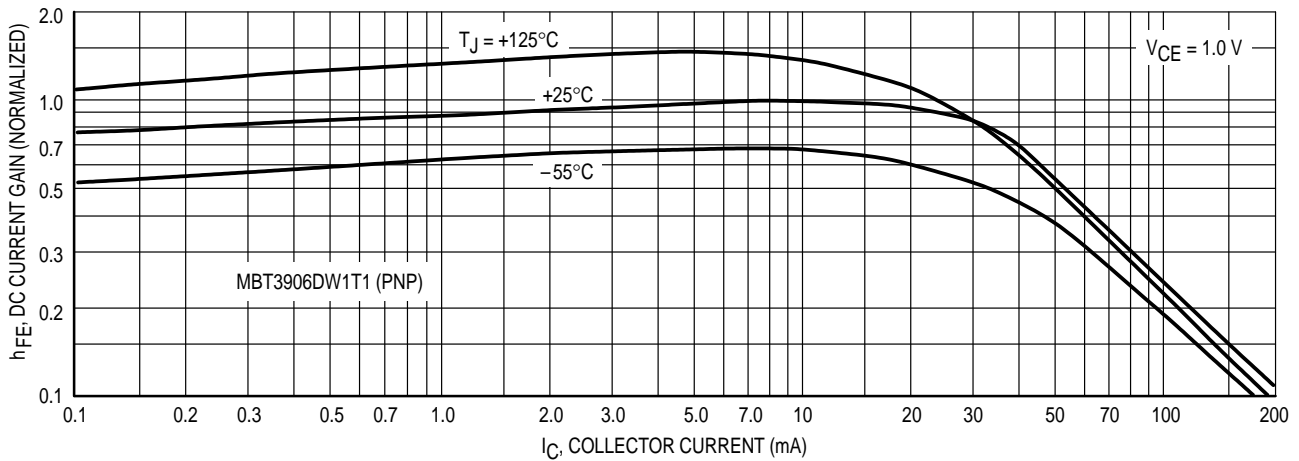


Figure 31. DC Current Gain

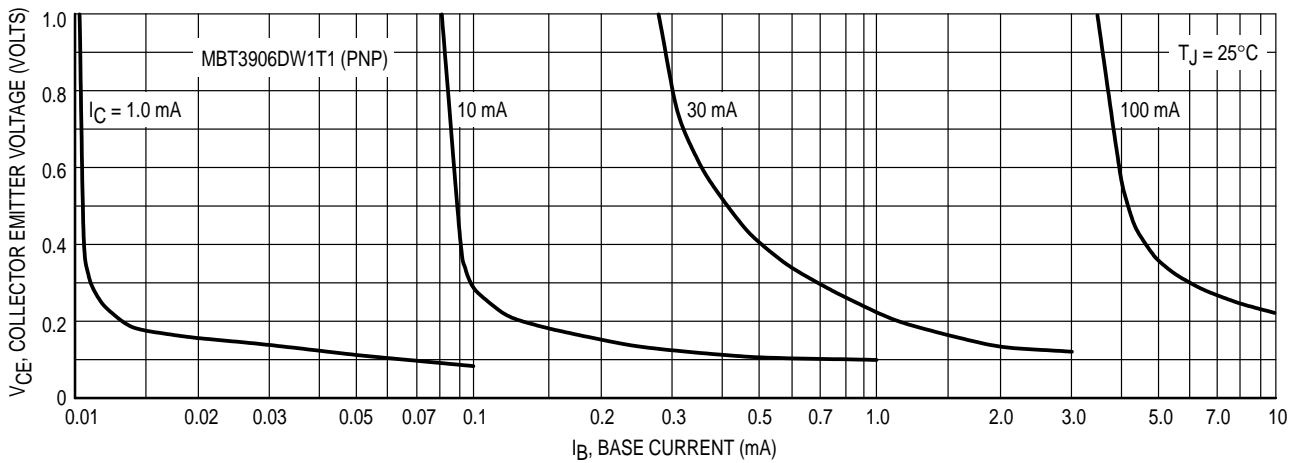


Figure 32. Collector Saturation Region

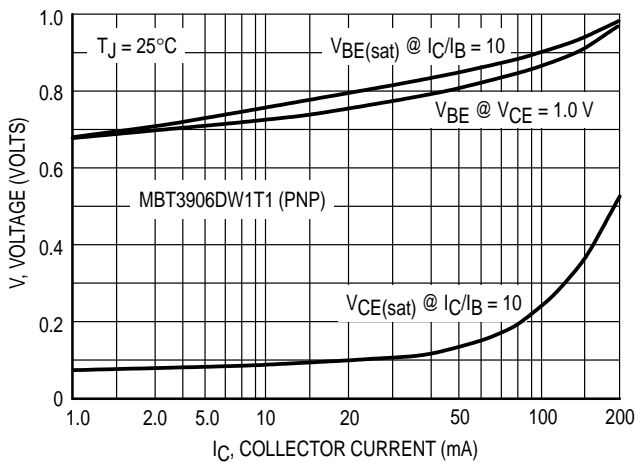


Figure 33. "ON" Voltages

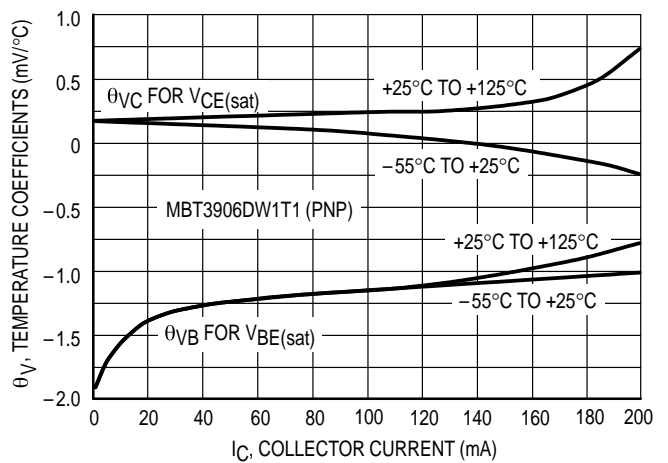


Figure 34. Temperature Coefficients

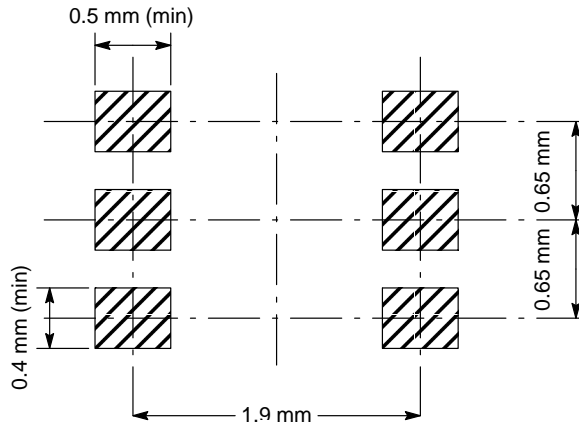
INFORMATION FOR USING THE SOT-363 SURFACE MOUNT PACKAGE

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-363



SOT-363 POWER DISSIPATION

The power dissipation of the SOT-363 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-363 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-363 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-363 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

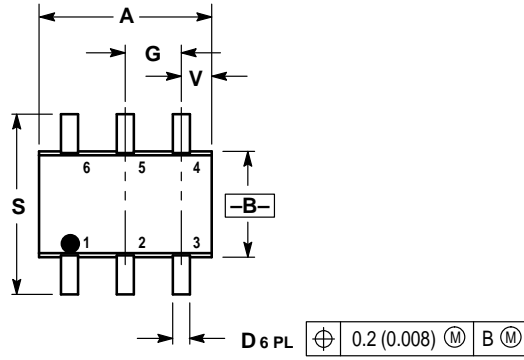
The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize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

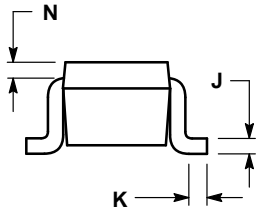
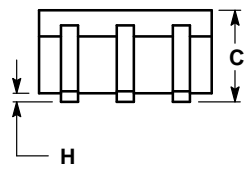
**MBT3904DW1T1 MBT3906DW1T1 MBT3946DW1T1**

**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	0.031	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

**CASE 419B-01  
 ISSUE C**

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