

# MBT3946DW1T1

## Dual General Purpose Transistor

The MBT3946DW1T1 device is a spin-off of our popular SOT-23/SOT-323 three-leaded device. It is designed for general purpose amplifier applications and is housed in the SOT-363 six-leaded surface mount package. By putting two discrete devices in one package, this device is 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
- Device Marking: MBT3946DW1T1 = 46

### MAXIMUM RATINGS

| Rating                                           | Symbol    | Value                 | Unit |
|--------------------------------------------------|-----------|-----------------------|------|
| Collector–Emitter Voltage<br>(NPN)<br>(PNP)      | $V_{CEO}$ | 40<br>–40             | Vdc  |
| Collector–Base Voltage<br>(NPN)<br>(PNP)         | $V_{CBO}$ | 60<br>–40             | Vdc  |
| Emitter–Base Voltage<br>(NPN)<br>(PNP)           | $V_{EBO}$ | 6.0<br>–5.0           | Vdc  |
| Collector Current – Continuous<br>(NPN)<br>(PNP) | $I_C$     | 200<br>–200           | mAdc |
| Electrostatic Discharge                          | ESD       | HBM>16000,<br>MM>2000 | V    |

### THERMAL CHARACTERISTICS

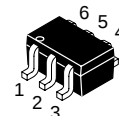
| Characteristic                                                       | Symbol          | Max         | Unit               |
|----------------------------------------------------------------------|-----------------|-------------|--------------------|
| Total Package Dissipation <sup>(1)</sup><br>$T_A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

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

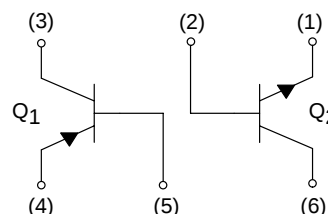


ON Semiconductor™

<http://onsemi.com>



SOT-363/SC-88  
CASE 419B  
STYLE 1



MBT3946DW1T1\*

\*Q1 NPN  
Q2 PNP

### ORDERING INFORMATION

| Device       | Package | Shipping        |
|--------------|---------|-----------------|
| MBT3946DW1T1 | SOT-363 | 3000 Units/Reel |

# MBT3946DW1T1

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

| Characteristic | Symbol | Min | Max | Unit |
|----------------|--------|-----|-----|------|
|----------------|--------|-----|-----|------|

### OFF CHARACTERISTICS

|                                                                                                                                                                   |                      |             |           |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------|-----------|-----|
| Collector–Emitter Breakdown Voltage <sup>(2)</sup><br>(I <sub>C</sub> = 1.0 mA, I <sub>B</sub> = 0) (NPN)<br>(I <sub>C</sub> = –1.0 mA, I <sub>B</sub> = 0) (PNP) | V <sub>(BR)CEO</sub> | 40<br>–40   | –<br>–    | Vdc |
| Collector–Base Breakdown Voltage<br>(I <sub>C</sub> = 10 μA, I <sub>E</sub> = 0) (NPN)<br>(I <sub>C</sub> = –10 μA, I <sub>E</sub> = 0) (PNP)                     | V <sub>(BR)CBO</sub> | 60<br>–40   | –<br>–    | Vdc |
| Emitter–Base Breakdown Voltage<br>(I <sub>E</sub> = 10 μA, I <sub>C</sub> = 0) (NPN)<br>(I <sub>E</sub> = –10 μA, I <sub>C</sub> = 0) (PNP)                       | V <sub>(BR)EBO</sub> | 6.0<br>–5.0 | –<br>–    | Vdc |
| Base Cutoff Current<br>(V <sub>CE</sub> = 30 Vdc, V <sub>EB</sub> = 3.0 Vdc) (NPN)<br>(V <sub>CE</sub> = –30 Vdc, V <sub>EB</sub> = –3.0 Vdc) (PNP)               | I <sub>BL</sub>      | –<br>–      | 50<br>–50 | nA  |
| Collector Cutoff Current<br>(V <sub>CE</sub> = 30 Vdc, V <sub>EB</sub> = 3.0 Vdc) (NPN)<br>(V <sub>CE</sub> = –30 Vdc, V <sub>EB</sub> = –3.0 Vdc) (PNP)          | I <sub>CEX</sub>     | –<br>–      | 50<br>–50 | nA  |

### ON CHARACTERISTICS (2)

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

### SMALL–SIGNAL CHARACTERISTICS

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

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

# MBT3946DW1T1

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

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

## SWITCHING CHARACTERISTICS

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

# MBT3946DW1T1

(NPN)

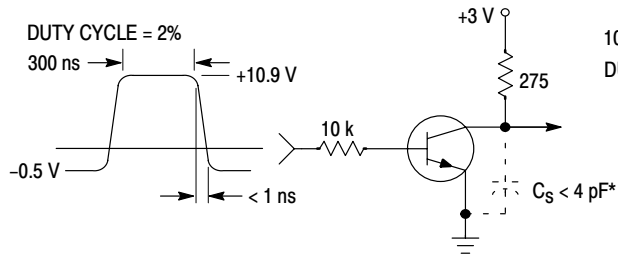


Figure 1. Delay and Rise Time  
Equivalent Test Circuit

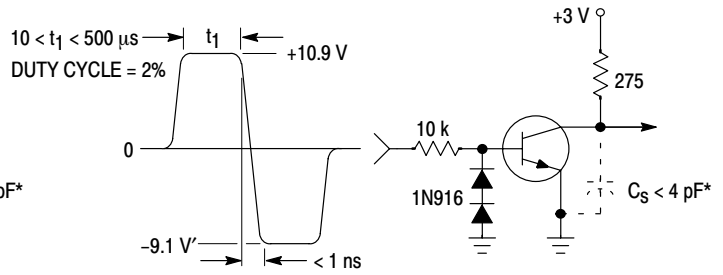


Figure 2. Storage and Fall Time  
Equivalent Test Circuit

\* Total shunt capacitance of test jig and connectors

## TYPICAL TRANSIENT CHARACTERISTICS

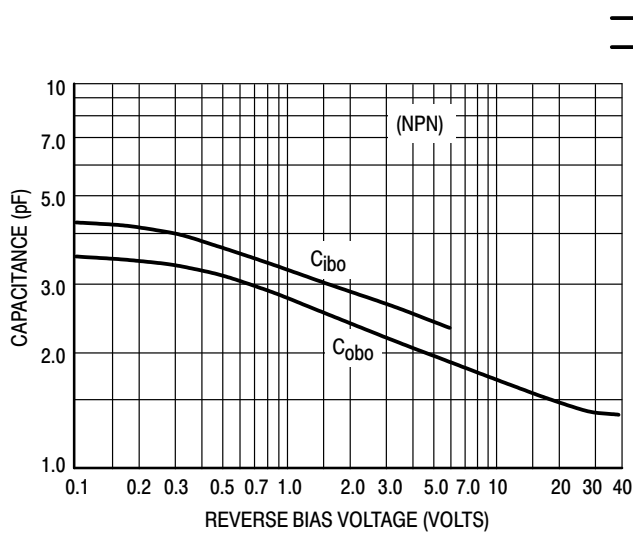


Figure 3. Capacitance

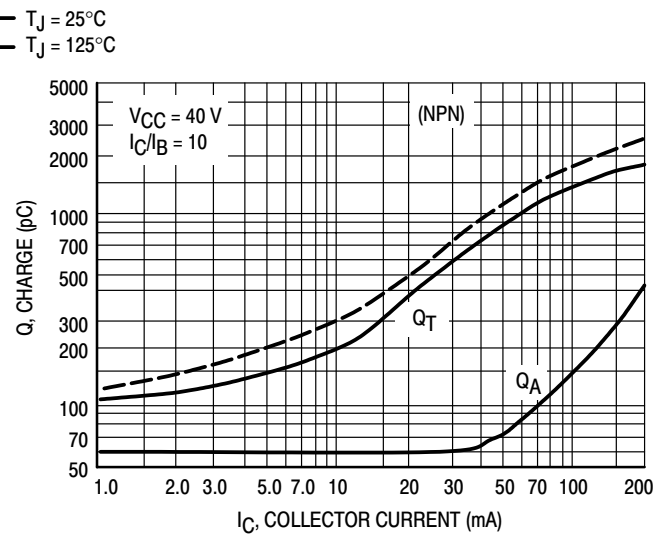


Figure 4. Charge Data

(NPN)

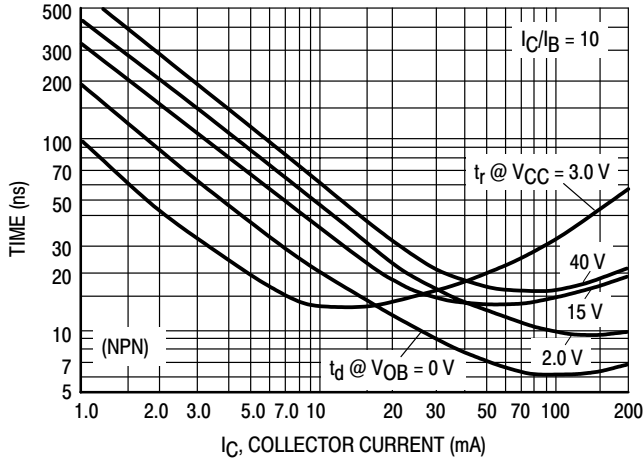


Figure 5. Turn-On Time

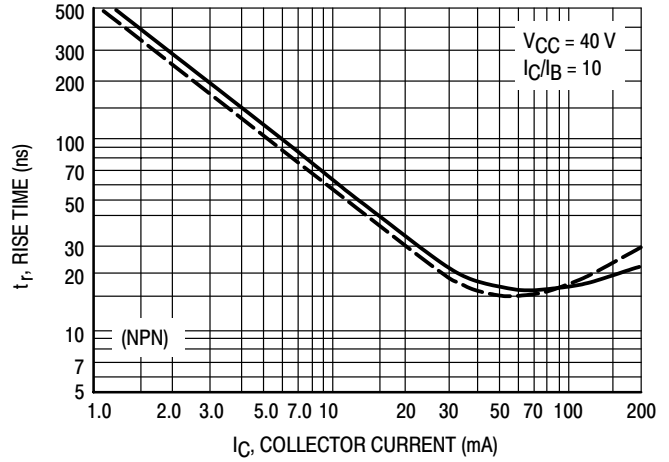


Figure 6. Rise Time

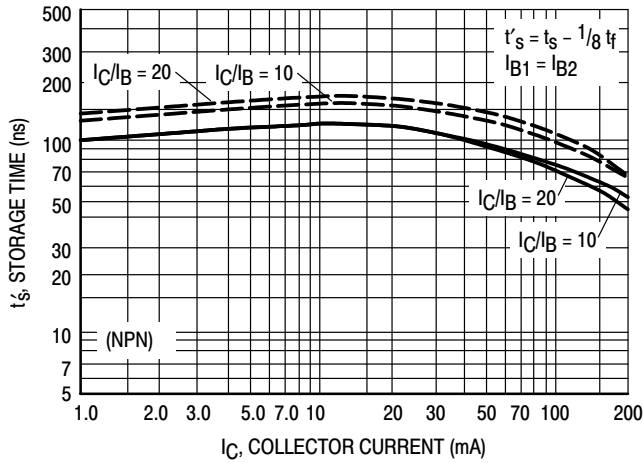


Figure 7. Storage Time

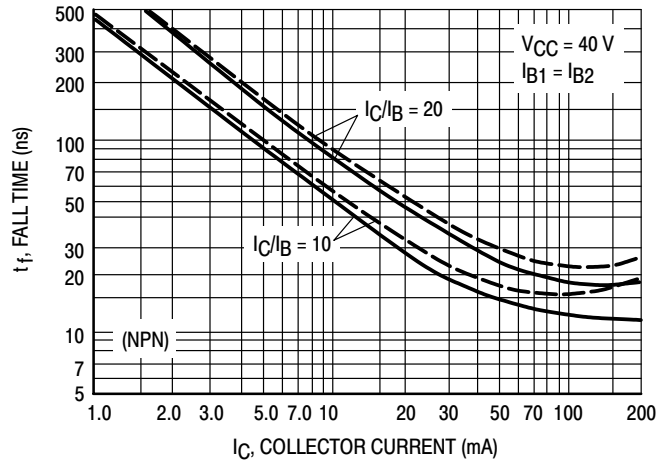


Figure 8. Fall Time

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

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

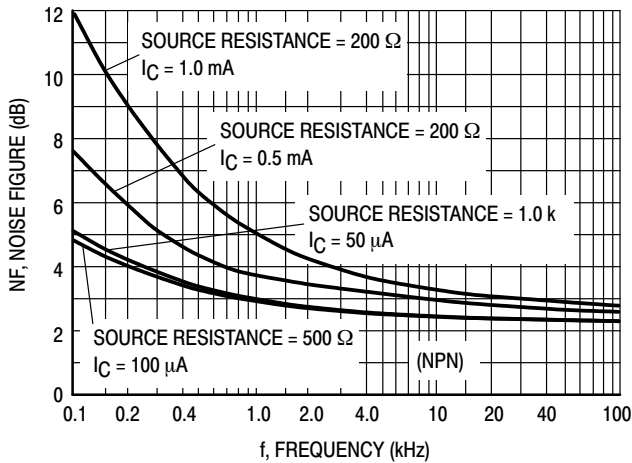


Figure 9. Noise Figure

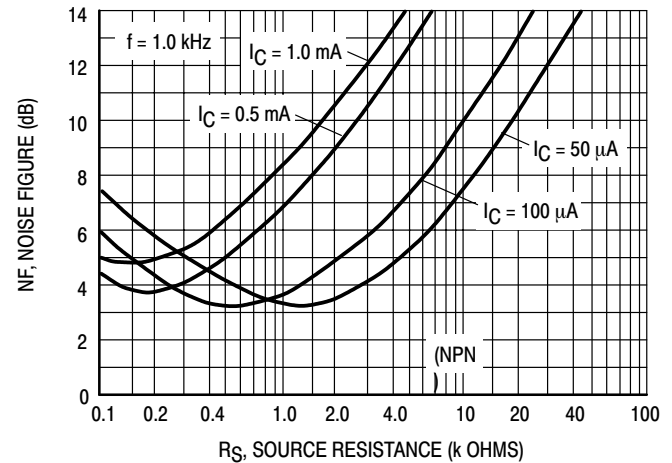


Figure 10. Noise Figure

# MBT3946DW1T1

(NPN)

## h PARAMETERS

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

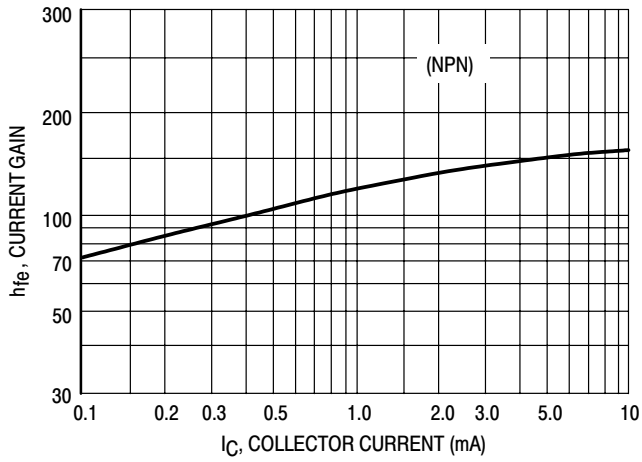


Figure 11. Current Gain

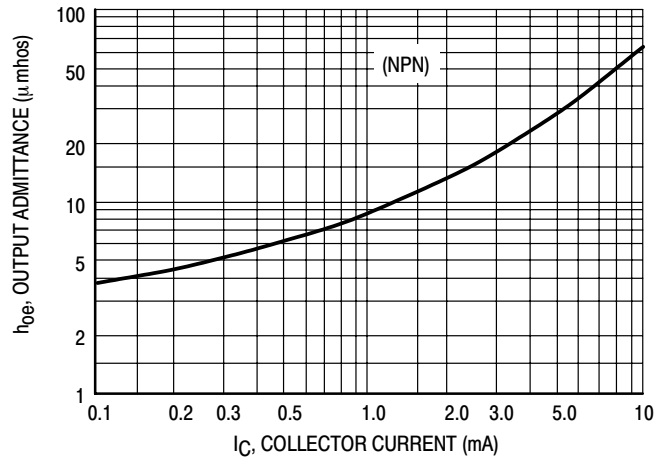


Figure 12. Output Admittance

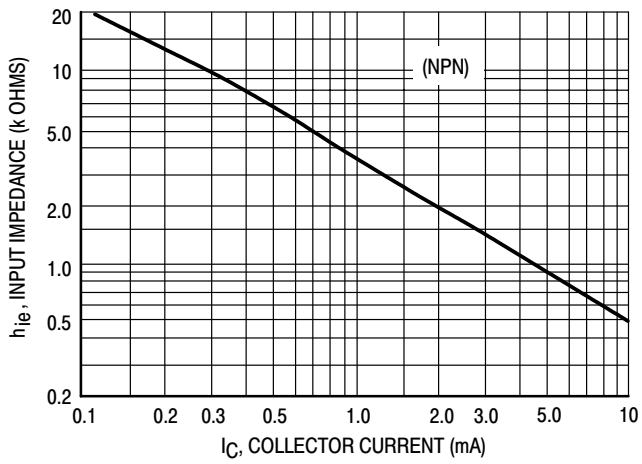


Figure 13. Input Impedance

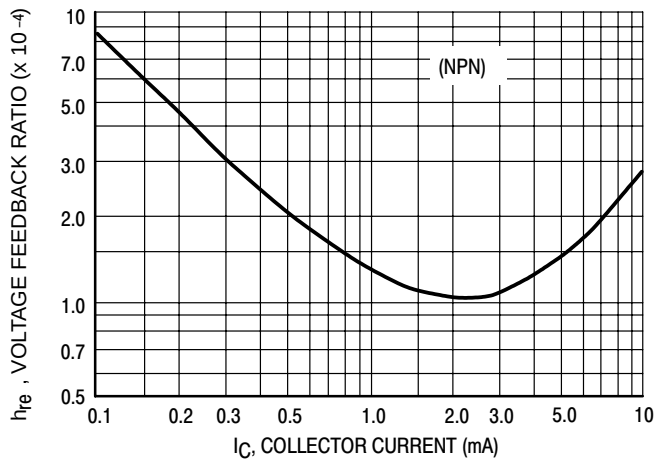


Figure 14. Voltage Feedback Ratio

# MBT3946DW1T1

(NPN)

## TYPICAL STATIC CHARACTERISTICS

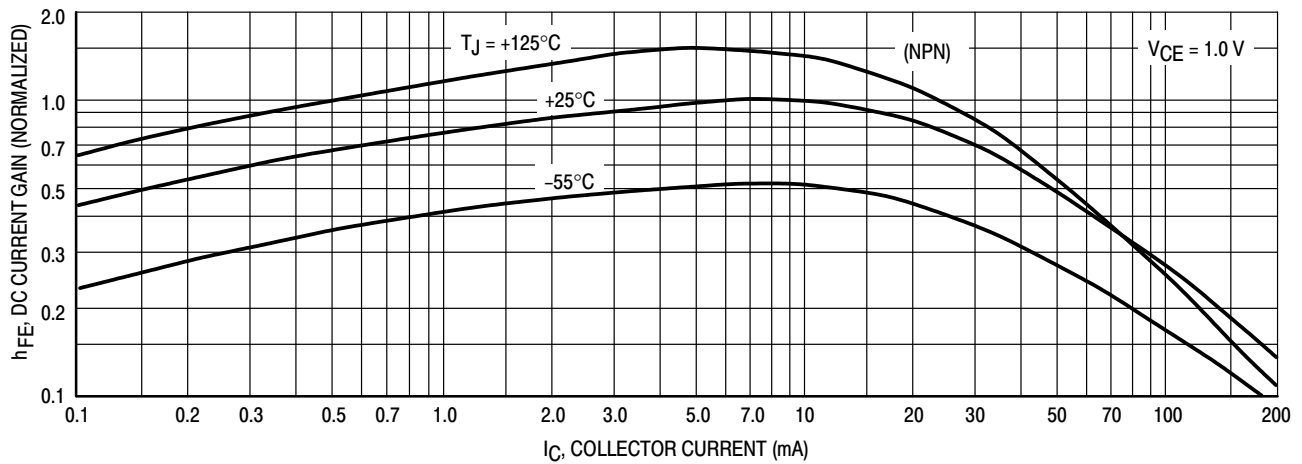


Figure 15. DC Current Gain

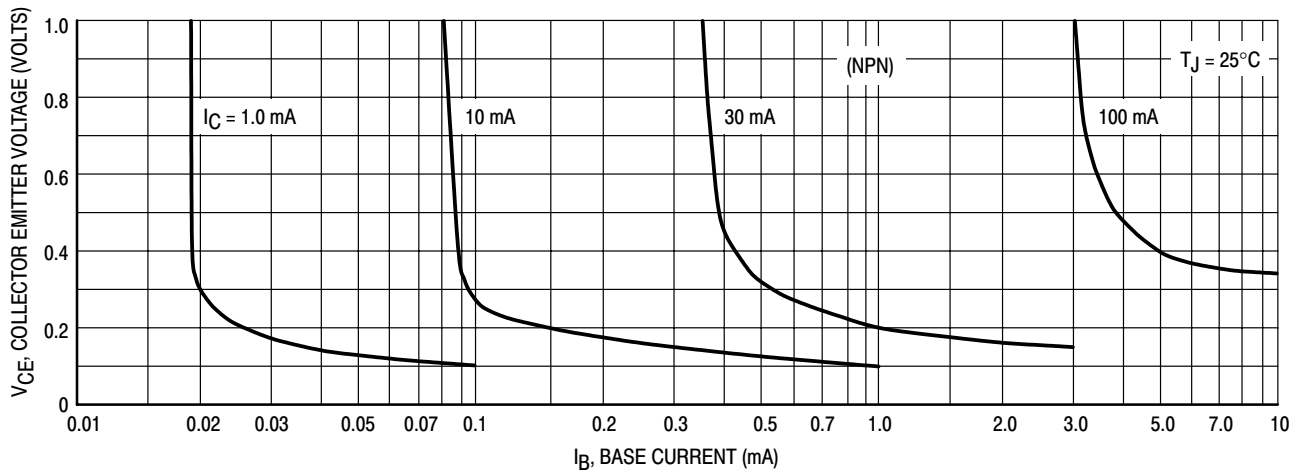


Figure 16. Collector Saturation Region

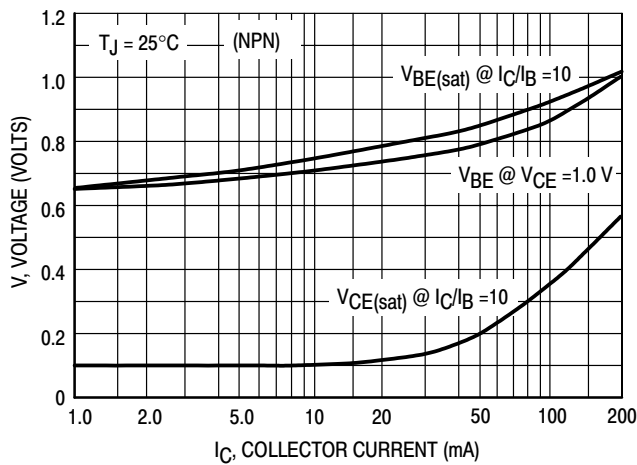


Figure 17. "ON" Voltages

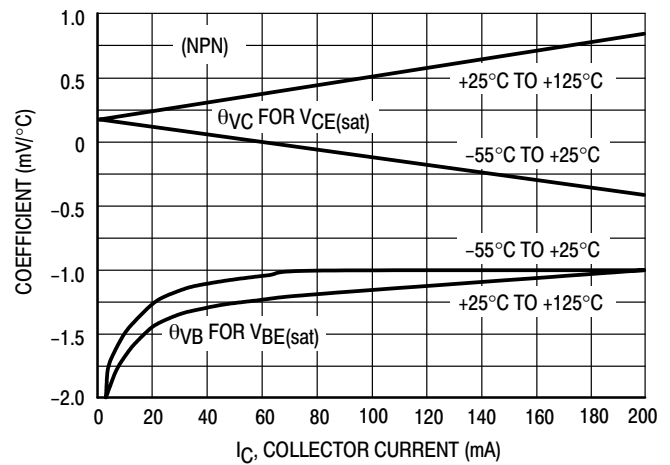


Figure 18. Temperature Coefficients

# MBT3946DW1T1

(PNP)

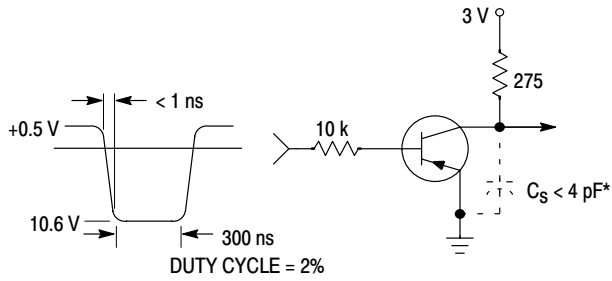


Figure 19. Delay and Rise Time  
Equivalent Test Circuit

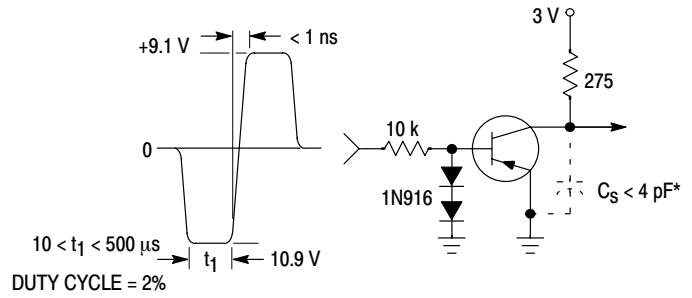


Figure 20. Storage and Fall Time  
Equivalent Test Circuit

## TYPICAL TRANSIENT CHARACTERISTICS

—  $T_J = 25^\circ\text{C}$   
- -  $T_J = 125^\circ\text{C}$

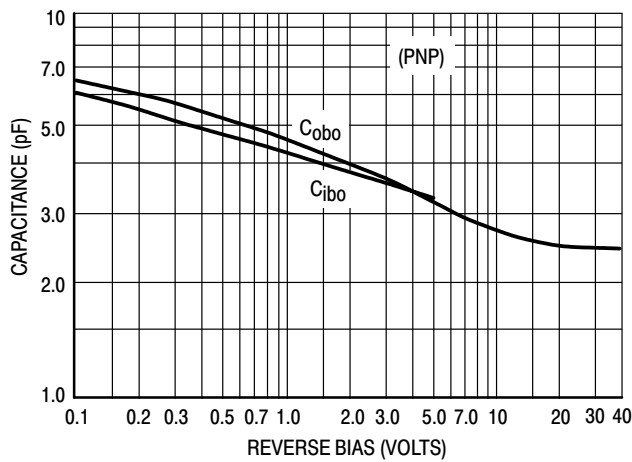


Figure 21. Capacitance

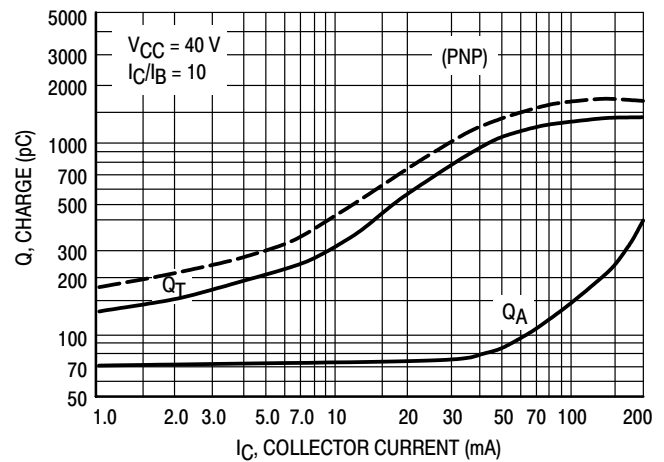


Figure 22. Charge Data

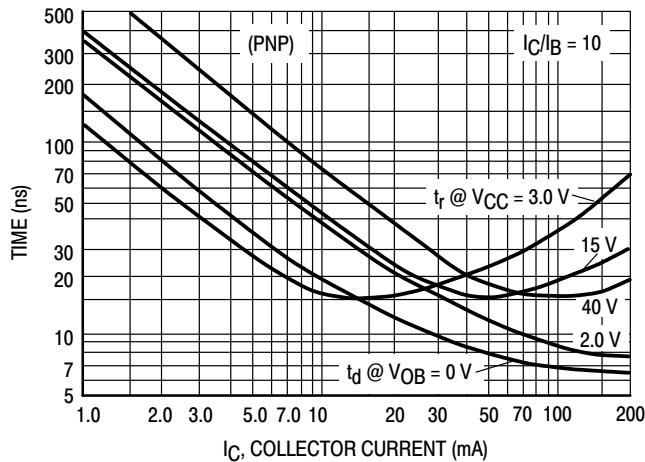


Figure 23. Turn-On Time

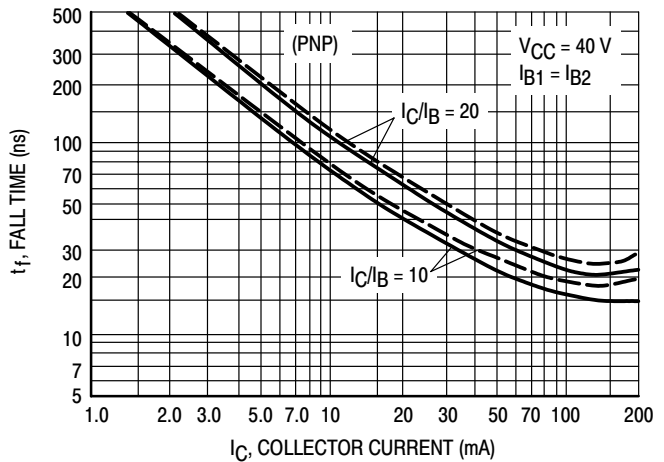


Figure 24. Fall Time

(PNP)

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

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

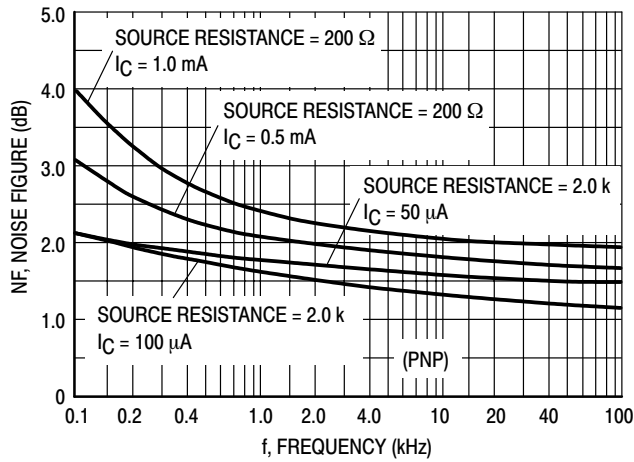


Figure 25.

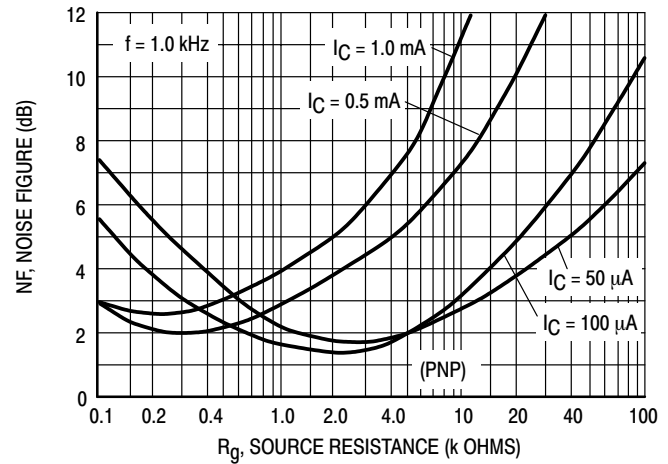


Figure 26.

**h PARAMETERS**

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

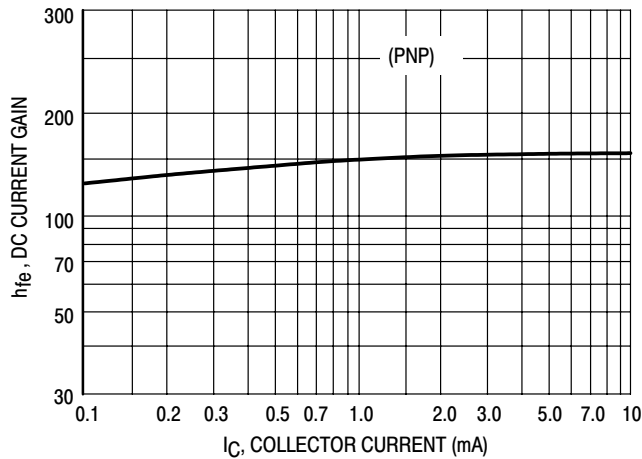


Figure 27. Current Gain

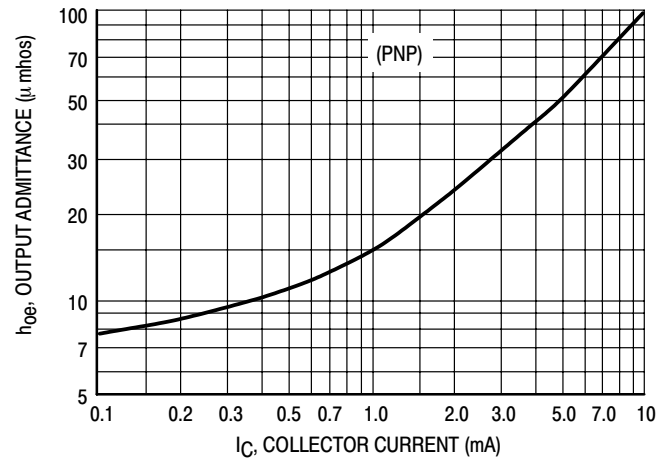


Figure 28. Output Admittance

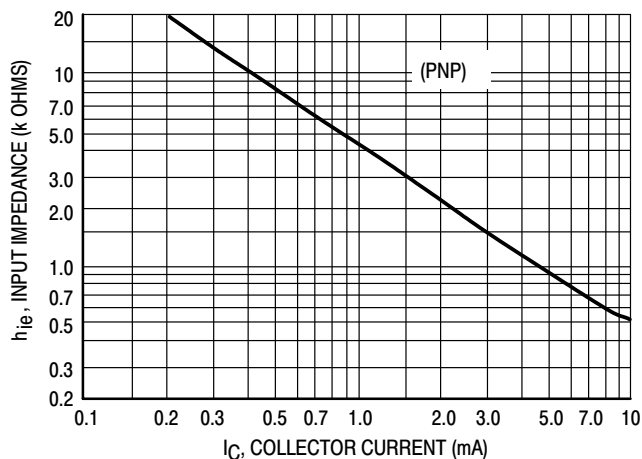


Figure 29. Input Impedance

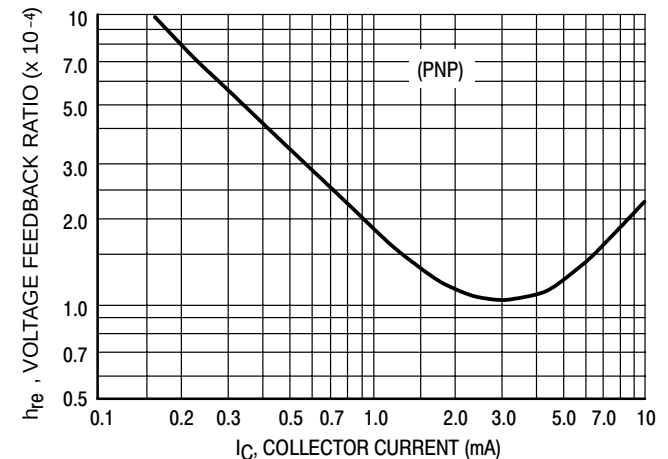


Figure 30. Voltage Feedback Ratio

# MBT3946DW1T1

(PNP)

## TYPICAL STATIC CHARACTERISTICS

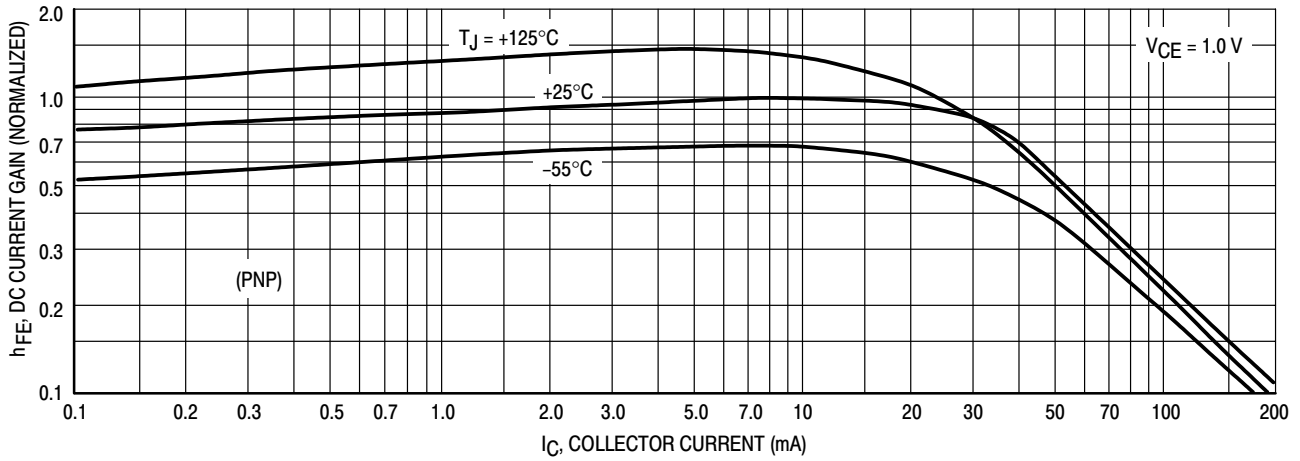


Figure 31. DC Current Gain

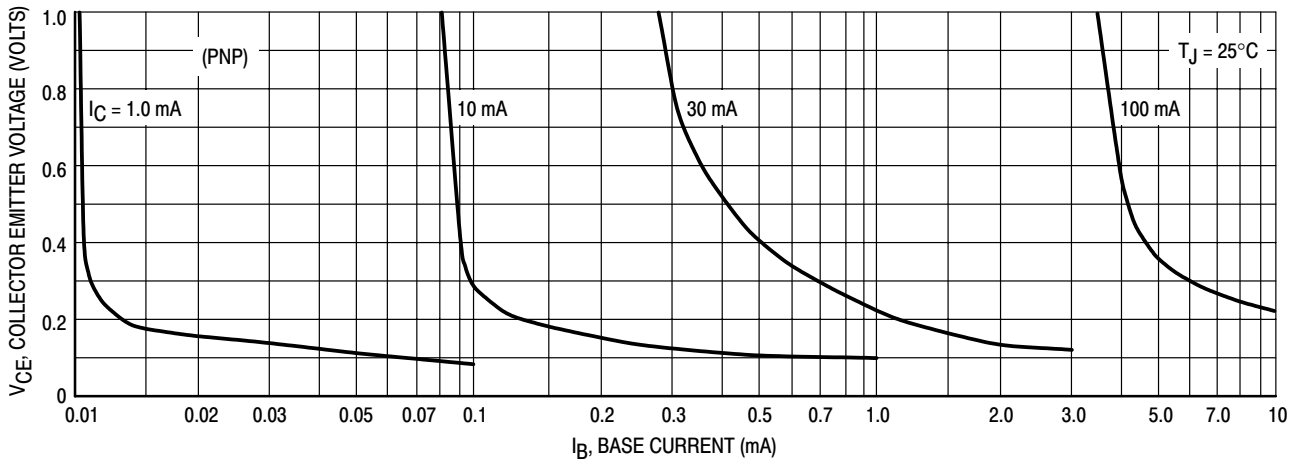


Figure 32. Collector Saturation Region

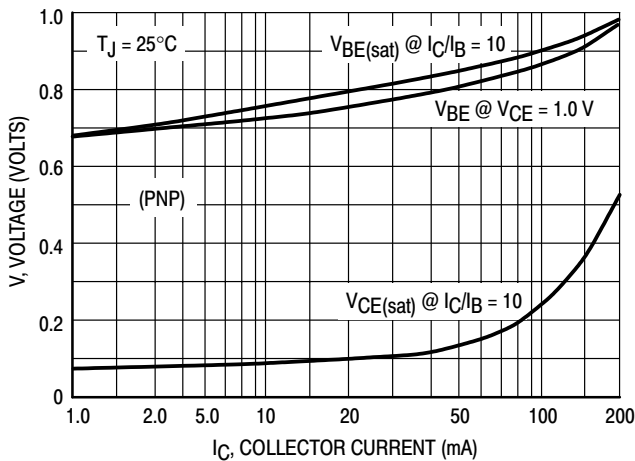


Figure 33. "ON" Voltages

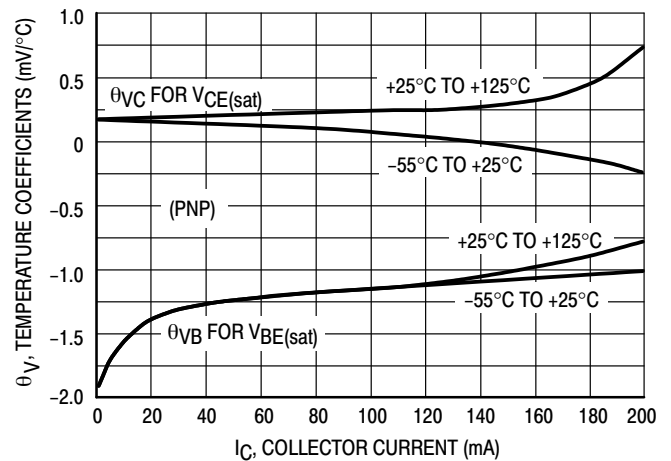


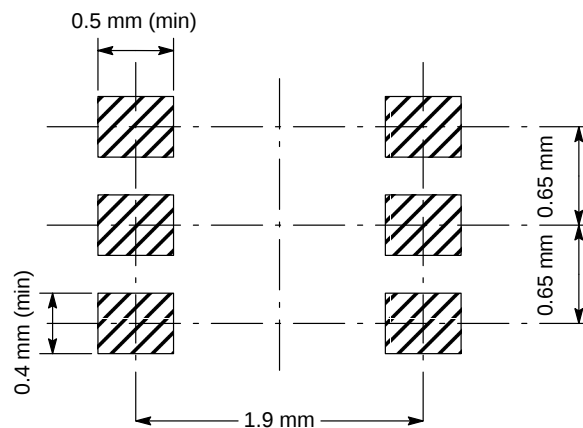
Figure 34. Temperature Coefficients

## 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.

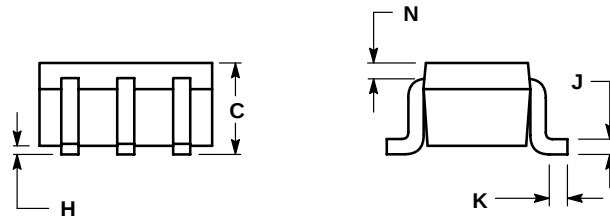
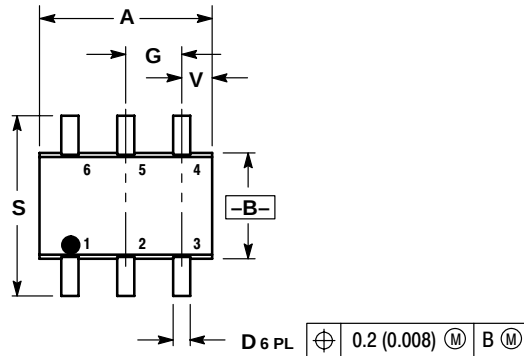
# MBT3946DW1T1

## PACKAGE DIMENSIONS

SOT-363/SC-88

CASE 419B-01

ISSUE G



### 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

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