# General Purpose Transistor
## PNP Silicon

COLLECTOR
3

2
BASE

1
EMITTER



| MPS3906 |
| --- |
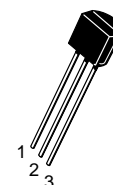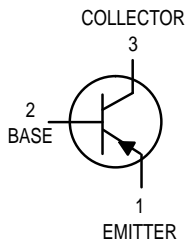
**CASE 29–04, STYLE 1**
**TO–92 (TO–226AA)**

## MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
| --- | --- | --- | --- |
| Collector–Emitter Voltage | $V_{CEO}$ | −40 | Vdc |
| Collector–Base Voltage | $V_{CBO}$ | −40 | Vdc |
| Emitter–Base Voltage | $V_{EBO}$ | −5.0 | Vdc |
| Collector Current — Continuous | $I_C$ | −200 | mAdc |
| Total Device Dissipation @ $T_A$ = 25°C<br>Derate above 25°C | $P_D$ | 625<br>5.0 | mW<br>mW/°C |
| Total Device Dissipation @ $T_C$ = 25°C<br>Derate above 25°C | $P_D$ | 1.5<br>12 | Watts<br>mW/°C |
| Operating and Storage Junction Temperature Range | $T_J$, $T_{stg}$ | −55 to +150 | °C |

## THERMAL CHARACTERISTICS

| Characteristic | Symbol | Max | Unit |
| --- | --- | --- | --- |
| Thermal Resistance, Junction to Ambient | $R_{\theta JA}$ | 200 | °C/W |
| Thermal Resistance, Junction to Case | $R_{\theta JC}$ | 83.3 | °C/W |

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

| Characteristic | Symbol | Min | Max | Unit |
| --- | --- | --- | --- | --- |
| **OFF CHARACTERISTICS** | | | | |
| Collector–Emitter Breakdown Voltage[1]<br>($I_C$ = −1.0 mAdc, $I_B$ = 0) | $V_{(BR)CEO}$ | −40 | — | Vdc |
| Collector–Base Breakdown Voltage<br>($I_C$ = −10 μAdc, $I_E$ = 0) | $V_{(BR)CBO}$ | −40 | — | Vdc |
| Emitter–Base Breakdown Voltage<br>($I_E$ = −10 μAdc, $I_C$ = 0) | $V_{(BR)EBO}$ | −5.0 | — | Vdc |
| Collector Cutoff Current<br>($V_{CE}$ = −30 Vdc, $V_{EB(off)}$ = −3.0 Vdc) | $I_{CEX}$ | — | −50 | nAdc |
| Base Cutoff Current<br>($V_{CE}$ = −30 Vdc, $V_{EB(off)}$ = −3.0 Vdc) | $I_{BL}$ | — | −50 | nAdc |

1. Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2.0%.

 **MOTOROLA**

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

| Characteristic | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| **ON CHARACTERISTICS**[1] | | | | |
| DC Current Gain<br>($I_C$ = −0.1 mAdc, $V_{CE}$ = −1.0 Vdc)<br>($I_C$ = −1.0 mAdc, $V_{CE}$ = −1.0 Vdc)<br>($I_C$ = −10 mAdc, $V_{CE}$ = −1.0 Vdc)<br>($I_C$ = −50 mAdc, $V_{CE}$ = −1.0 Vdc)<br>($I_C$ = −100 mAdc, $V_{CE}$ = −1.0 Vdc) | $h_{FE}$ | <br>60<br>80<br>100<br>60<br>30 | <br>—<br>—<br>300<br>—<br>— | — |
| Collector−Emitter Saturation Voltage<br>($I_C$ = −10 mAdc, $I_B$ = −1.0 mAdc)<br>($I_C$ = −50 mAdc, $I_B$ = −5.0 mAdc) | $V_{CE(sat)}$ | <br>—<br>— | <br>−0.25<br>−0.4 | Vdc |
| Base−Emitter Saturation Voltage<br>($I_C$ = −10 mAdc, $I_B$ = −1.0 mAdc)<br>($I_C$ = −50 mAdc, $I_B$ = −5.0 mAdc) | $V_{BE(sat)}$ | <br>−0.65<br>— | <br>−0.85<br>−0.95 | Vdc |
| **SMALL−SIGNAL CHARACTERISTICS** | | | | |
| Current−Gain — Bandwidth Product<br>($I_C$ = −10 mAdc, $V_{CE}$ = −20 V, f = 100 MHz) | $f_T$ | 250 | — | MHz |
| Output Capacitance<br>($V_{CB}$ = −5.0 Vdc, $I_E$ = 0, f = 1.0 MHz) | $C_{obo}$ | — | 4.5 | pF |
| Input Capacitance<br>($V_{EB}$ = −0.5 Vdc, $I_C$ = 0, f = 1.0 MHz) | $C_{ibo}$ | — | 10 | pF |
| Input Impedance<br>($I_C$ = −1.0 mAdc, $V_{CE}$ = −10 Vdc, f = 1.0 kHz) | $h_{ie}$ | 2.0 | 12 | k Ω |
| Voltage Feedback Ratio<br>($I_C$ = −1.0 mAdc, $V_{CE}$ = −10 Vdc, f = 1.0 kHz) | $h_{re}$ | 1.0 | 10 | X $10^{-4}$ |
| Small−Signal Current Gain<br>($I_C$ = −1.0 mAdc, $V_{CE}$ = −10 Vdc, f = 1.0 kHz) | $h_{fe}$ | 100 | 400 | — |
| Output Admittance<br>($I_C$ = −1.0 mAdc, $V_{CE}$ = −10 Vdc, f = 1.0 kHz) | $h_{oe}$ | 3.0 | 60 | μmhos |
| Noise Figure<br>($I_C$ = −100 μAdc, $V_{CE}$ = −5.0 Vdc, $R_S$ = 1.0 k Ω, f = 1.0 kHz) | NF | — | 4.0 | dB |
| **SWITCHING CHARACTERISTICS** | | | | |
| Delay Time | ($V_{CC}$ = −3.0 Vdc, $V_{BE(off)}$ = +0.5 Vdc, | $t_d$ | — | 35 | ns |
| Rise Time | $I_C$ = −10 mAdc, $I_{B1}$ = 1.0 mAdc) | $t_r$ | — | 50 | ns |
| Storage Time | ($V_{CC}$ = −3.0 Vdc, $I_C$ = −10 mAdc, | $t_s$ | — | 600 | ns |
| Fall Time | $I_{B1}$ = $I_{B2}$ = −1.0 mAdc) | $t_f$ | — | 90 | ns |

1. Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2.0%.

## TYPICAL NOISE CHARACTERISTICS
($V_{CE} = -5.0$ Vdc, $T_A = 25°C$)
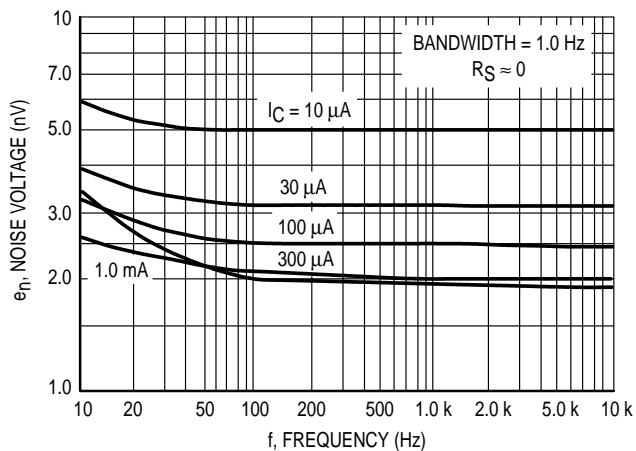


Figure 1. Noise Voltage
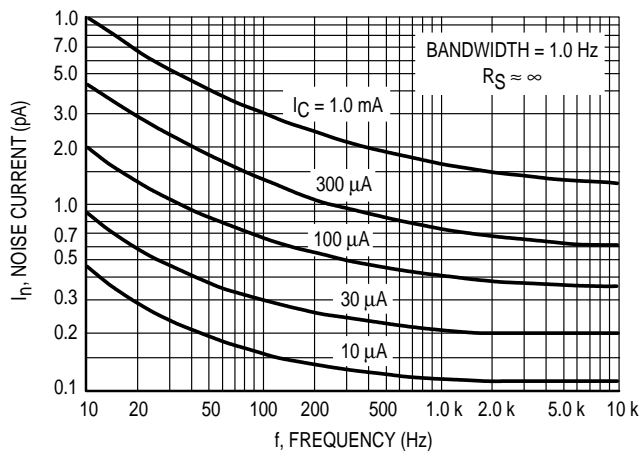


Figure 2. Noise Current

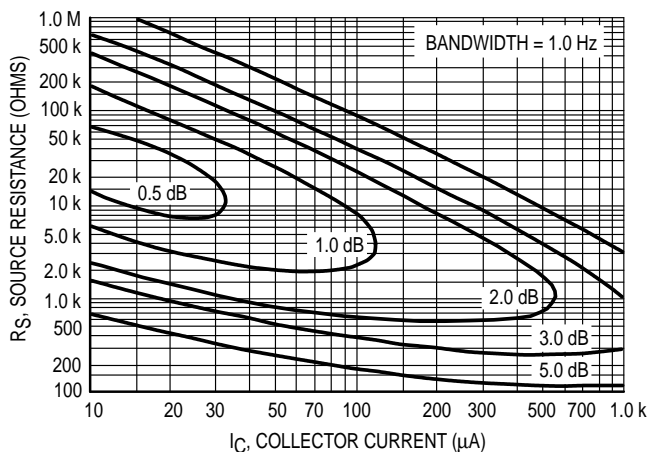## NOISE FIGURE CONTOURS
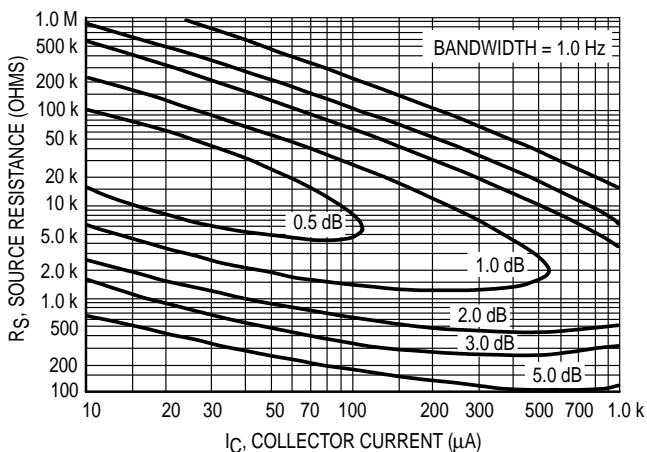($V_{CE} = -5.0$ Vdc, $T_A = 25°C$)



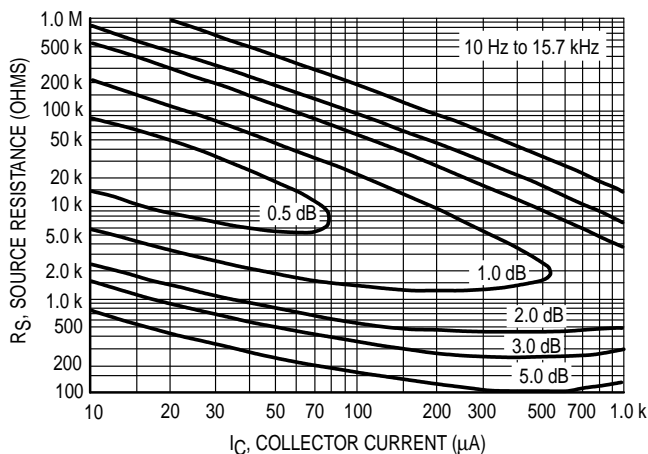Figure 3. Narrow Band, 100 Hz



Figure 4. Narrow Band, 1.0 kHz



Figure 5. Wideband

Noise Figure is Defined as:

$$NF = 20\ \log_{10}\left[\frac{e_n^2 + 4KTR_S + I_n^2 R_S^2}{4KTR_S}\right]^{1/2}$$

$e_n$ = Noise Voltage of the Transistor referred to the input. (Figure 3)
$I_n$ = Noise Current of the Transistor referred to the input. (Figure 4)
$K$ = Boltzman's Constant ($1.38 \times 10^{-23}$ j/°K)
$T$ = Temperature of the Source Resistance (°K)
$R_S$ = Source Resistance (Ohms)

## TYPICAL STATIC CHARACTERISTICS
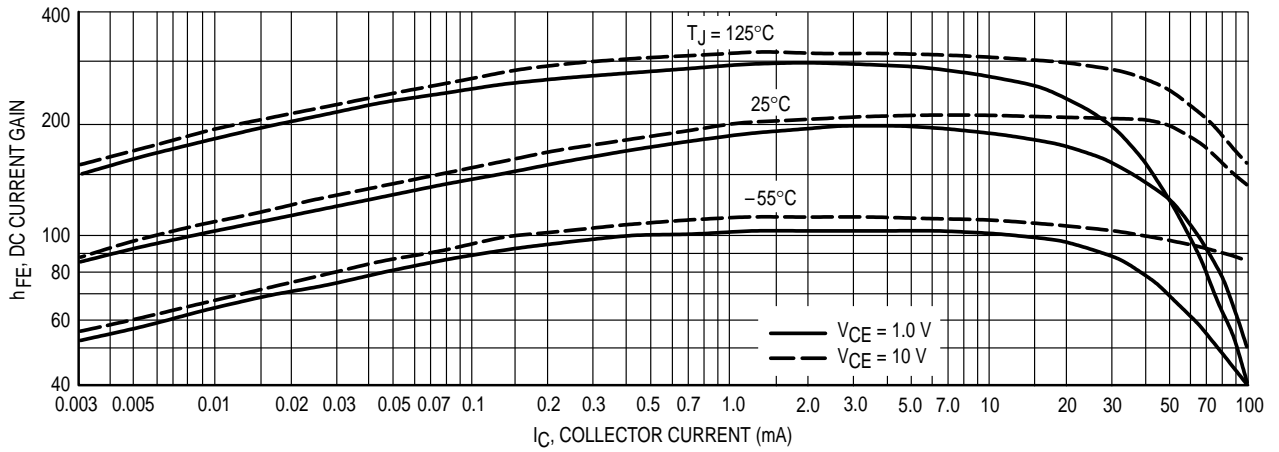


**Figure 6. DC Current Gain**
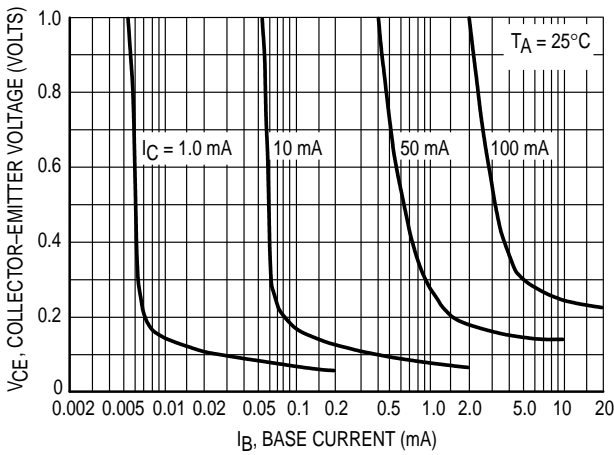


**Figure 7. Collector Saturation Region**
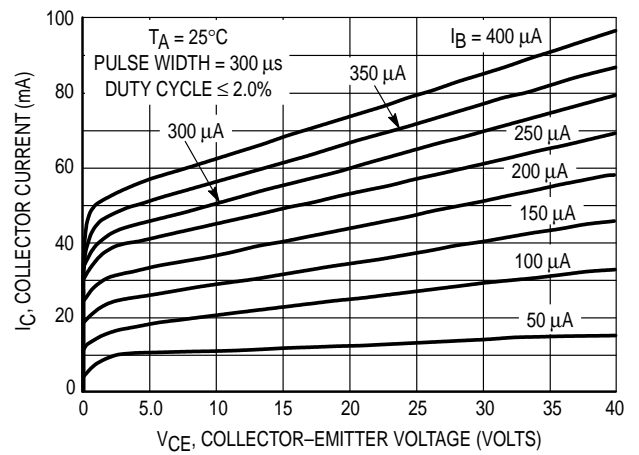


**Figure 8. Collector Characteristics**
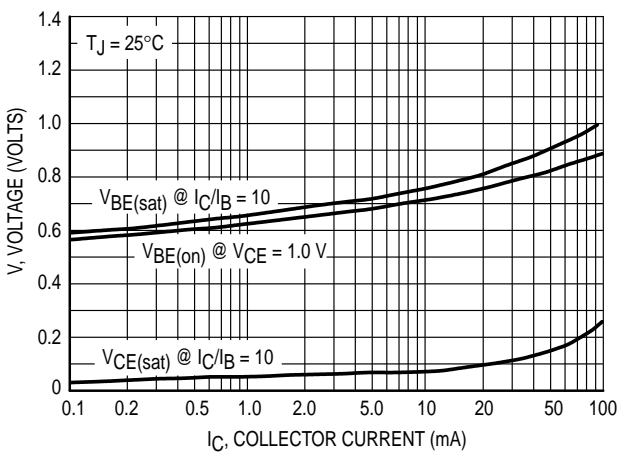


**Figure 9. "On" Voltages**
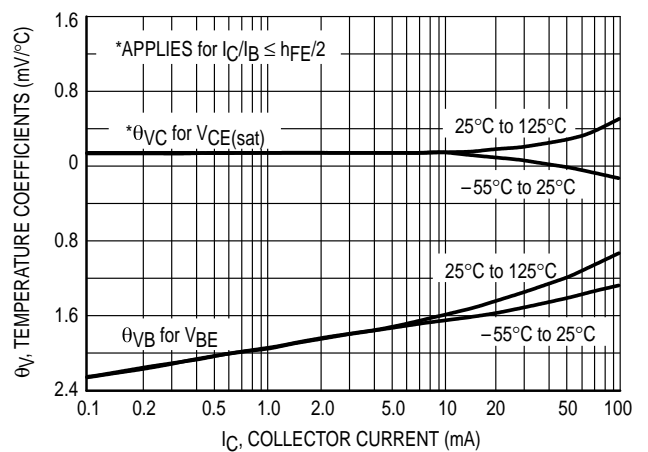


**Figure 10. Temperature Coefficients**

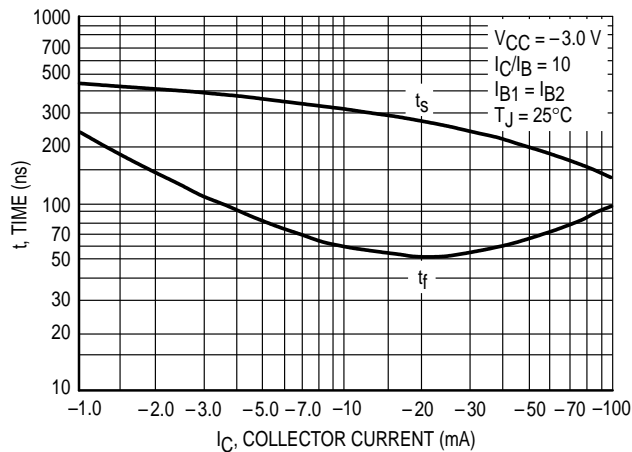## TYPICAL DYNAMIC CHARACTERISTICS
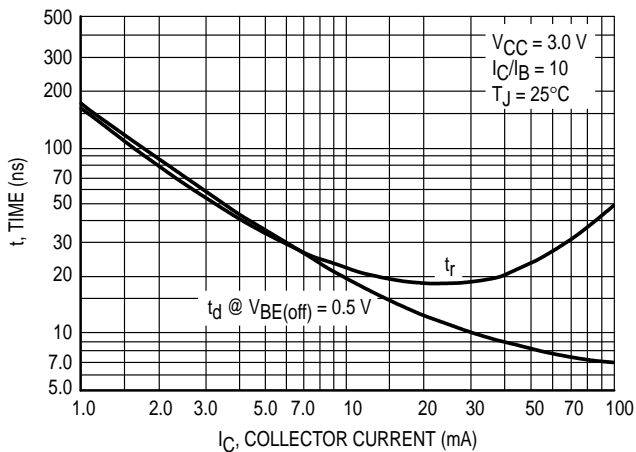
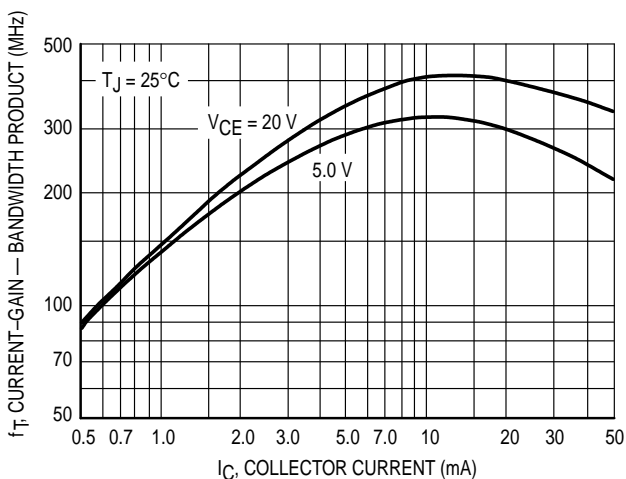**Figure 11. Turn–On Time**

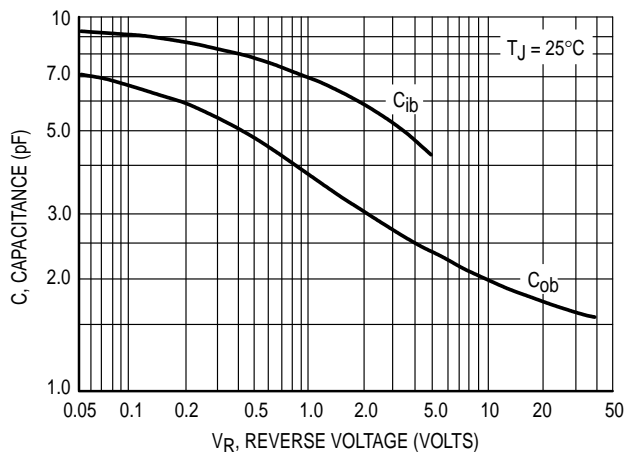**Figure 12. Turn–Off Time**

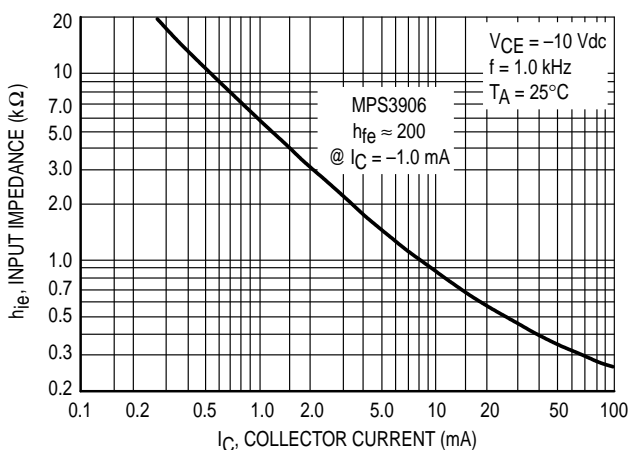**Figure 13. Current–Gain — Bandwidth Product**
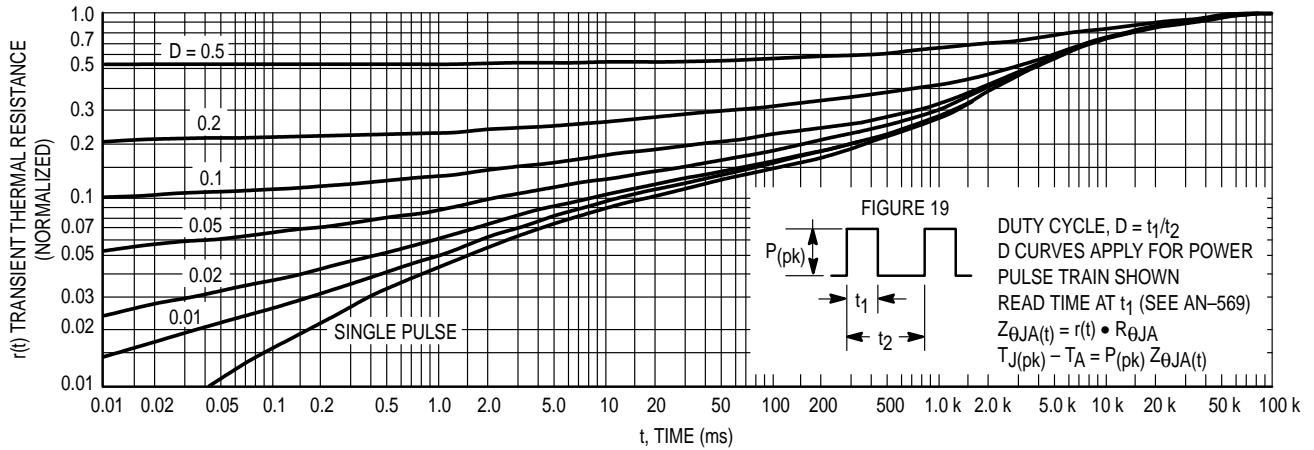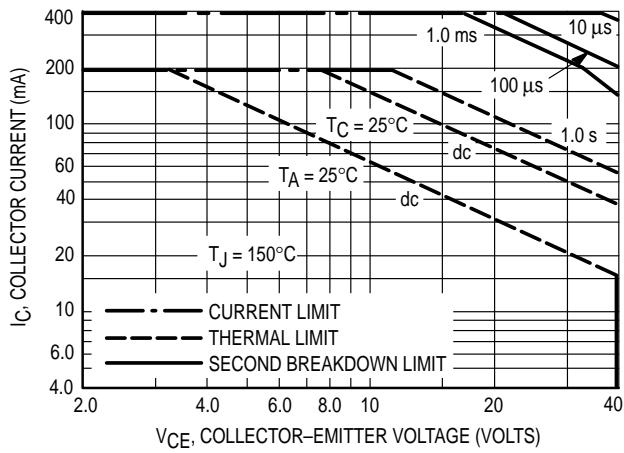
**Figure 14. Capacitance**
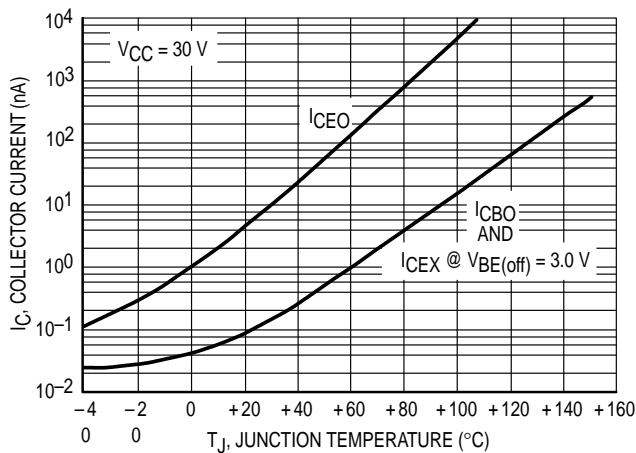
**Figure 15. Input Impedance**
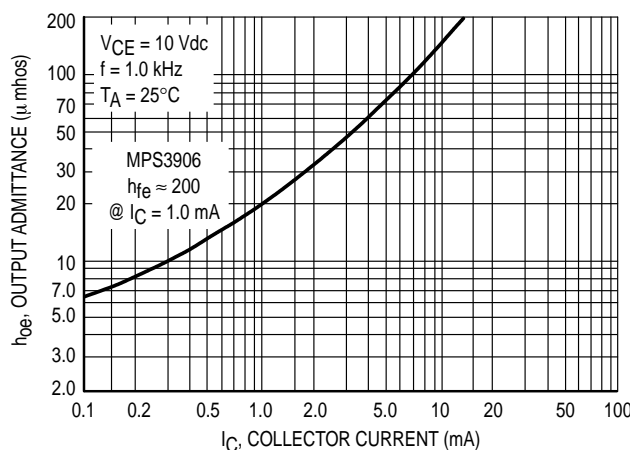
**Figure 16. Output Admittance**

**Figure 17. Thermal Response**



**Figure 18. Active–Region Safe Operating Area**

The safe operating area curves indicate $I_C$–$V_{CE}$ limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 18 is based upon $T_{J(pk)}$ = 150°C; $T_C$ or $T_A$ is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 150°C. $T_{J(pk)}$ may be calculated from the data in Figure 17. At high case or ambient temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown.



**Figure 19. Typical Collector Leakage Current**

**DESIGN NOTE: USE OF THERMAL RESPONSE DATA**

A train of periodical power pulses can be represented by the model as shown in Figure 19. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 17 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 17 by the steady state value $R_{\theta JA}$.

Example:
Dissipating 2.0 watts peak under the following conditions:
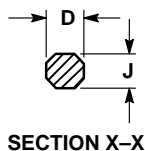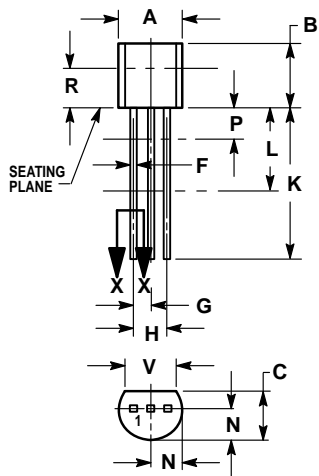$$t_1 = 1.0 \text{ ms}, t_2 = 5.0 \text{ ms} (D = 0.2)$$
Using Figure 17 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

The peak rise in junction temperature is therefore
$$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C.$$

For more information, see AN–569.

## PACKAGE DIMENSIONS



**SEATING PLANE**

**SECTION X–X**

**CASE 029–04**
**(TO–226AA)**
**ISSUE AD**

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. DIMENSION F APPLIES BETWEEN P AND L. DIMENSION D AND J APPLY BETWEEN L AND K MINIMUM. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

| DIM | INCHES MIN | INCHES MAX | MILLIMETERS MIN | MILLIMETERS MAX |
|-----|-----|-----|-----|-----|
| A | 0.175 | 0.205 | 4.45 | 5.20 |
| B | 0.170 | 0.210 | 4.32 | 5.33 |
| C | 0.125 | 0.165 | 3.18 | 4.19 |
| D | 0.016 | 0.022 | 0.41 | 0.55 |
| F | 0.016 | 0.019 | 0.41 | 0.48 |
| G | 0.045 | 0.055 | 1.15 | 1.39 |
| H | 0.095 | 0.105 | 2.42 | 2.66 |
| J | 0.015 | 0.020 | 0.39 | 0.50 |
| K | 0.500 | — | 12.70 | — |
| L | 0.250 | — | 6.35 | — |
| N | 0.080 | 0.105 | 2.04 | 2.66 |
| P | — | 0.100 | — | 2.54 |
| R | 0.115 | — | 2.93 | — |
| V | 0.135 | — | 3.43 | — |

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

---

Motorola Small–Signal Transistors, FETs and Diodes Device Data

**MPS3906**

**MOTOROLA**

◊

**MPS3906/D**