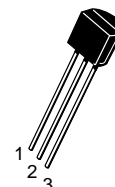
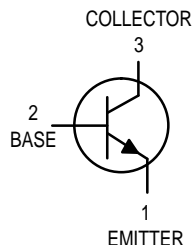


General Purpose Transistors

NPN Silicon

2N4400
2N4401*

*Motorola Preferred Device



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} | 60 | Vdc |
| Emitter–Base Voltage | V_{EBO} | 6.0 | Vdc |
| Collector Current — Continuous | I_C | 600 | mAdc |
| Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C | P_D | 625 5.0 | mW mW/ $^\circ\text{C}$ |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C | P_D | 1.5 12 | Watts mW/ $^\circ\text{C}$ |
| Operating and Storage Junction Temperature Range | T_J, T_{stg} | -55 to +150 | $^\circ\text{C}$ |

THERMAL CHARACTERISTICS

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

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

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

OFF CHARACTERISTICS

| | | | | |
|---|---------------|-----|-----|-----------------|
| Collector–Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 1.0 \text{ mAdc}, I_E = 0$) | $V_{(BR)CEO}$ | 40 | — | Vdc |
| Collector–Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}, I_E = 0$) | $V_{(BR)CBO}$ | 60 | — | Vdc |
| Emitter–Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}, I_C = 0$) | $V_{(BR)EBO}$ | 6.0 | — | Vdc |
| Base Cutoff Current ($V_{CE} = 35 \text{ Vdc}, V_{EB} = 0.4 \text{ Vdc}$) | I_{BEV} | — | 0.1 | μAdc |
| Collector Cutoff Current ($V_{CE} = 35 \text{ Vdc}, V_{EB} = 0.4 \text{ Vdc}$) | I_{CEX} | — | 0.1 | μAdc |

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

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

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

| Characteristic | Symbol | Min | Max | Unit |
|---|------------------|-----------|-------------|------|
| ON CHARACTERISTICS(1) | | | | |
| DC Current Gain ($I_C = 0.1 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) | 2N4401 | 20 | — | — |
| ($I_C = 1.0 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) | 2N4400 2N4401 | 20 40 | — — | — |
| ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) | 2N4400 2N4401 | 40 80 | — — | — |
| ($I_C = 150 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) | 2N4400 2N4401 | 50 100 | 150 300 | — |
| ($I_C = 500 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$) | 2N4400 2N4401 | 20 40 | — — | — |
| Collector–Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) | $V_{CE(sat)}$ | — — | 0.4 0.75 | Vdc |
| Base–Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}, I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc}$) | $V_{BE(sat)}$ | 0.75 — | 0.95 1.2 | Vdc |

SMALL–SIGNAL CHARACTERISTICS

| | | | | | |
|---|------------------|----------|------------|------------|------------------|
| Current–Gain — Bandwidth Product ($I_C = 20 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$) | 2N4400 2N4401 | f_T | 200 250 | — — | MHz |
| Collector–Base Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$) | | C_{cb} | — | 6.5 | pF |
| Emitter–Base Capacitance ($V_{EB} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$) | | C_{eb} | — | 30 | pF |
| Input Impedance ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$) | 2N4400 2N4401 | h_{ie} | 0.5 1.0 | 7.5 15 | k ohms |
| Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$) | | h_{re} | 0.1 | 8.0 | $\times 10^{-4}$ |
| Small–Signal Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$) | 2N4400 2N4401 | h_{fe} | 20 40 | 250 500 | — |
| Output Admittance ($I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$) | | h_{oe} | 1.0 | 30 | μmhos |

SWITCHING CHARACTERISTICS

| | | | | | |
|--------------|---|-------|---|-----|----|
| Delay Time | $(V_{CC} = 30 \text{ Vdc}, V_{BE} = 2.0 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = 15 \text{ mAdc})$ | t_d | — | 15 | ns |
| Rise Time | | t_r | — | 20 | ns |
| Storage Time | $(V_{CC} = 30 \text{ Vdc}, I_C = 150 \text{ mAdc}, I_{B1} = I_{B2} = 15 \text{ mAdc})$ | t_s | — | 225 | ns |
| Fall Time | | t_f | — | 30 | ns |

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

SWITCHING TIME EQUIVALENT TEST CIRCUITS

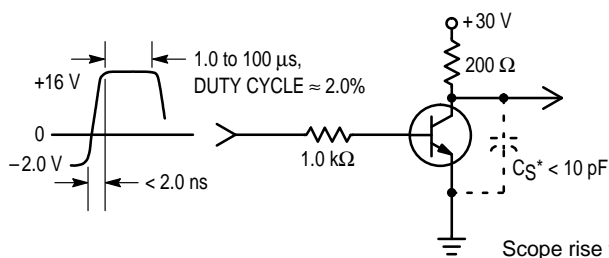


Figure 1. Turn–On Time

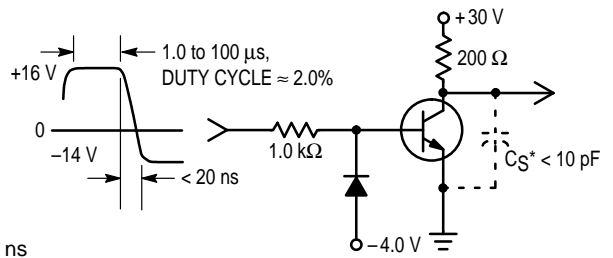


Figure 2. Turn–Off Time

TRANSIENT CHARACTERISTICS

— 25°C - - - 100°C

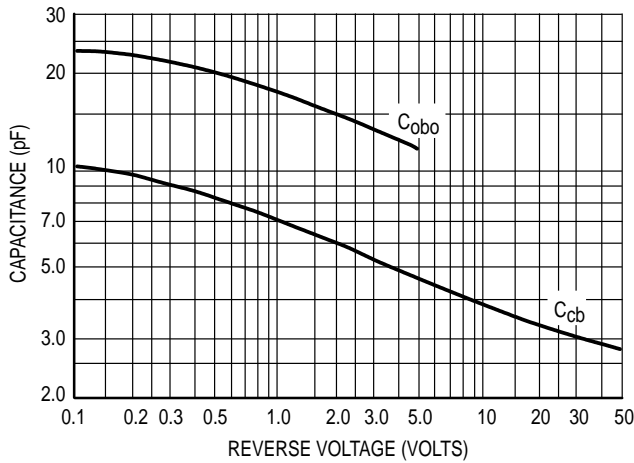


Figure 3. Capacitances

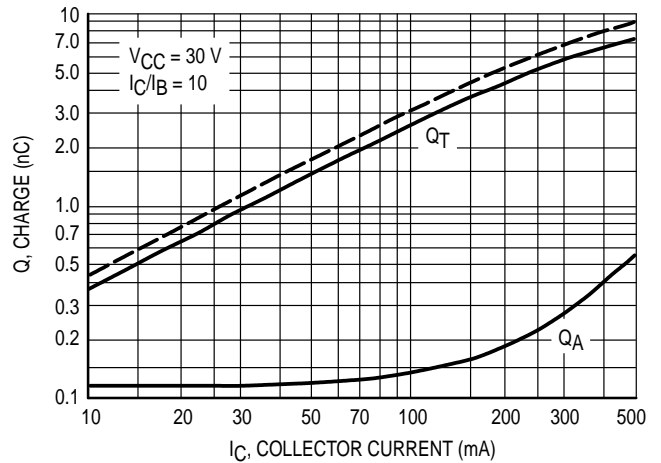


Figure 4. Charge Data

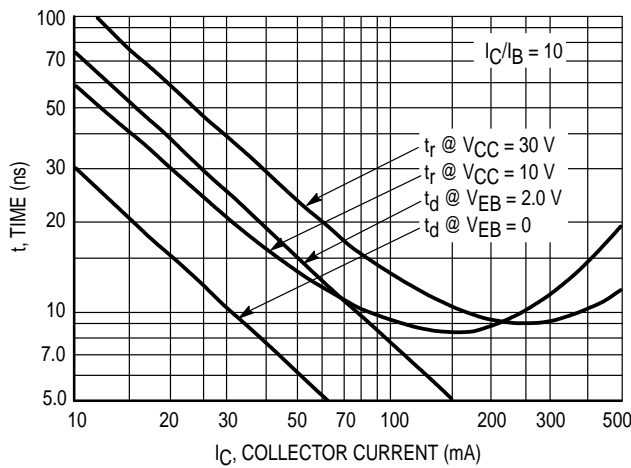


Figure 5. Turn-On Time

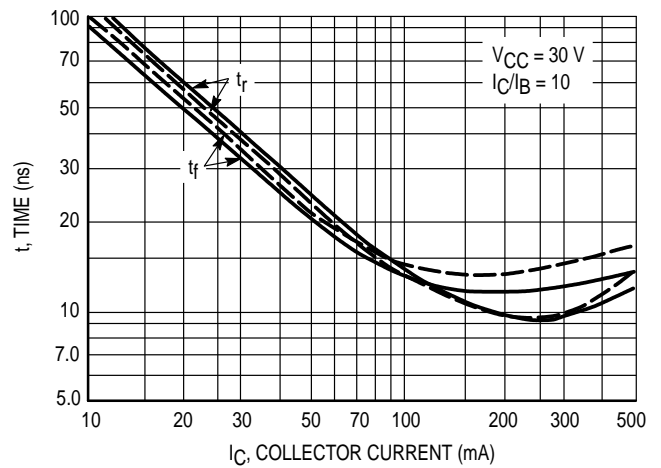


Figure 6. Rise and Fall Times

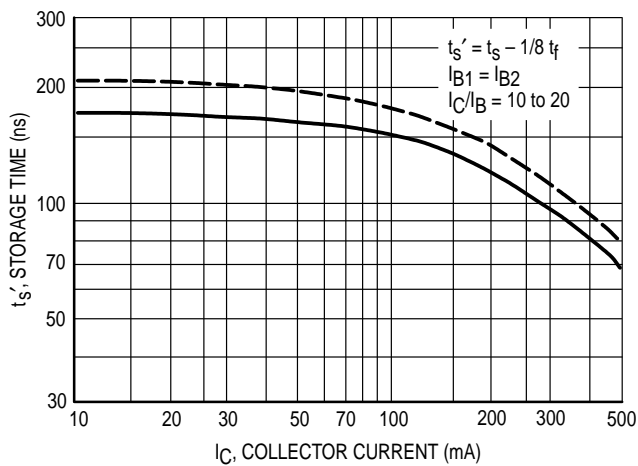


Figure 7. Storage Time

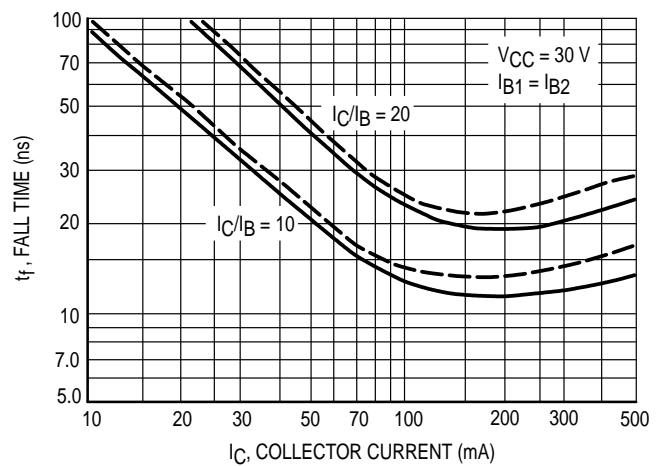


Figure 8. Fall Time

SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$
Bandwidth = 1.0 Hz

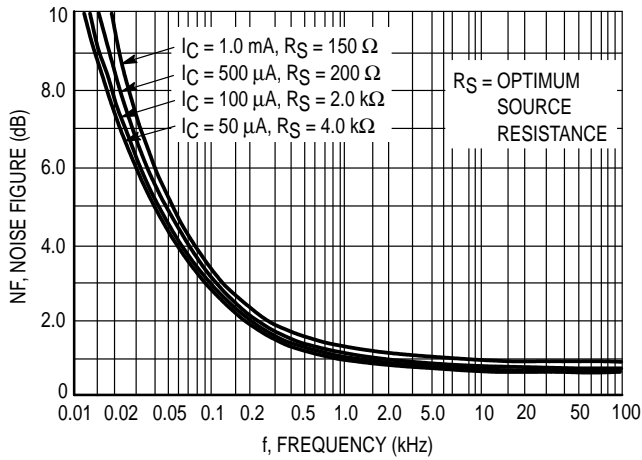


Figure 9. Frequency Effects

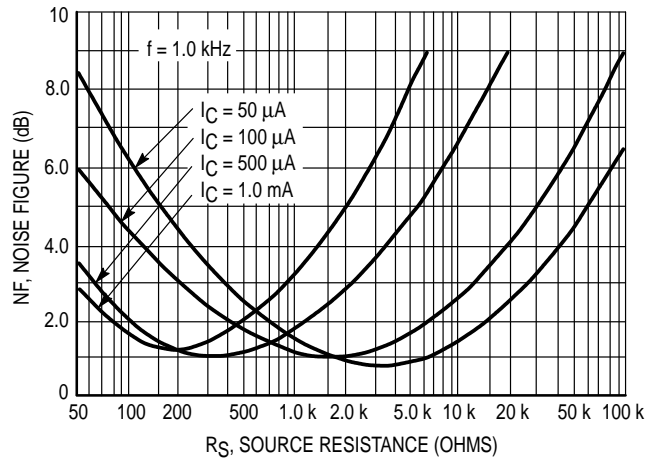


Figure 10. Source Resistance Effects

h PARAMETERS

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

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were

selected from both the 2N4400 and 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

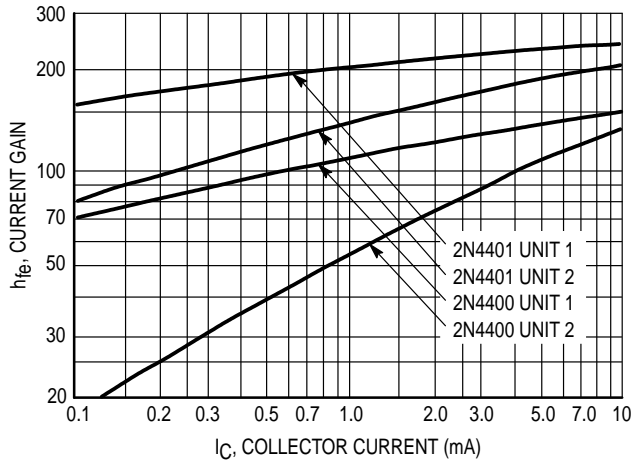


Figure 11. Current Gain

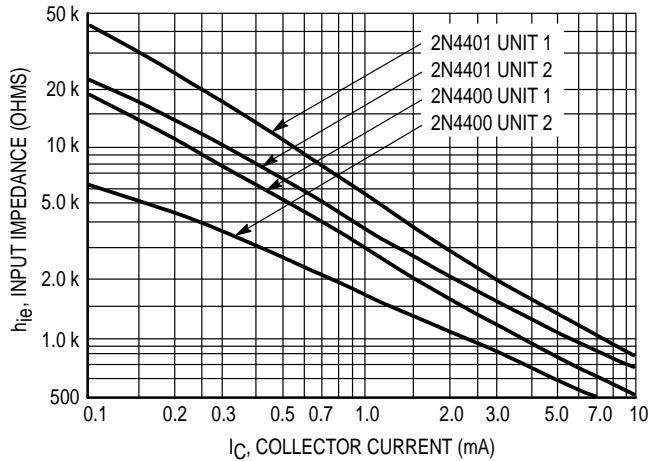


Figure 12. Input Impedance

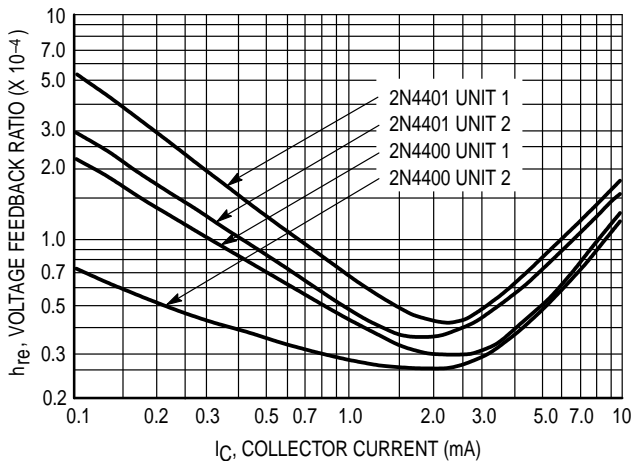


Figure 13. Voltage Feedback Ratio

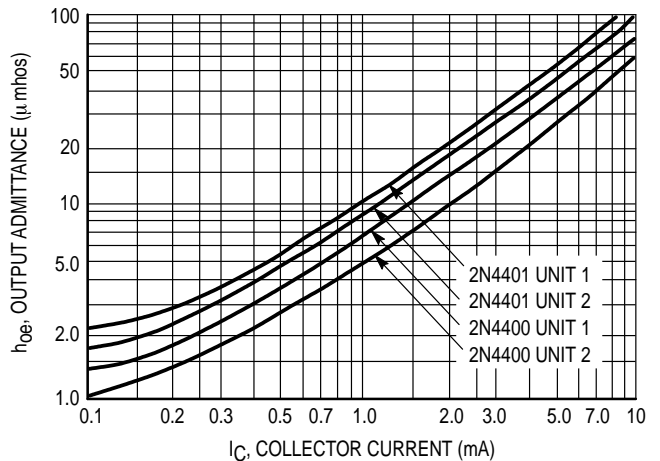


Figure 14. Output Admittance

STATIC CHARACTERISTICS

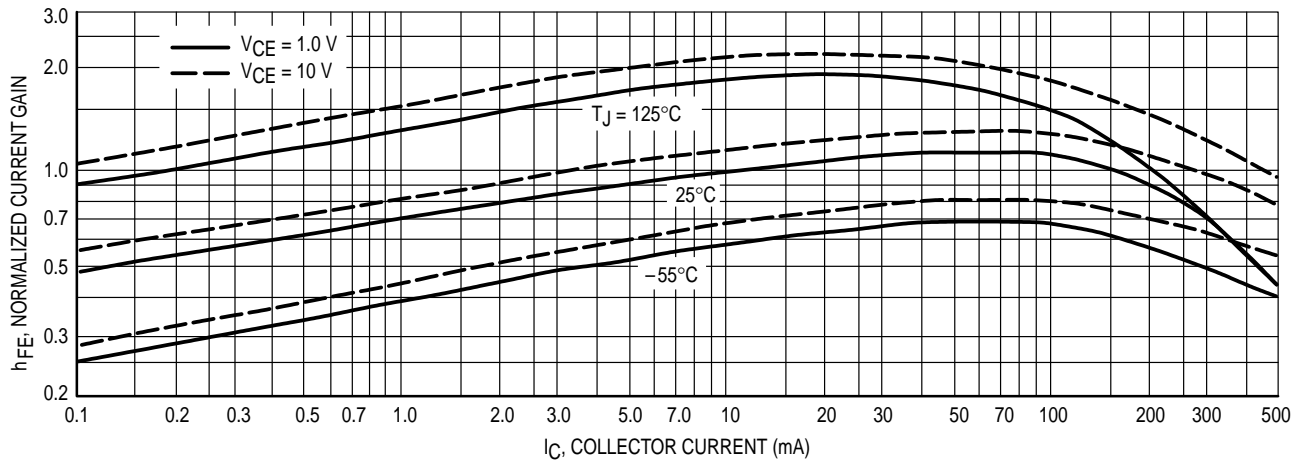


Figure 15. DC Current Gain

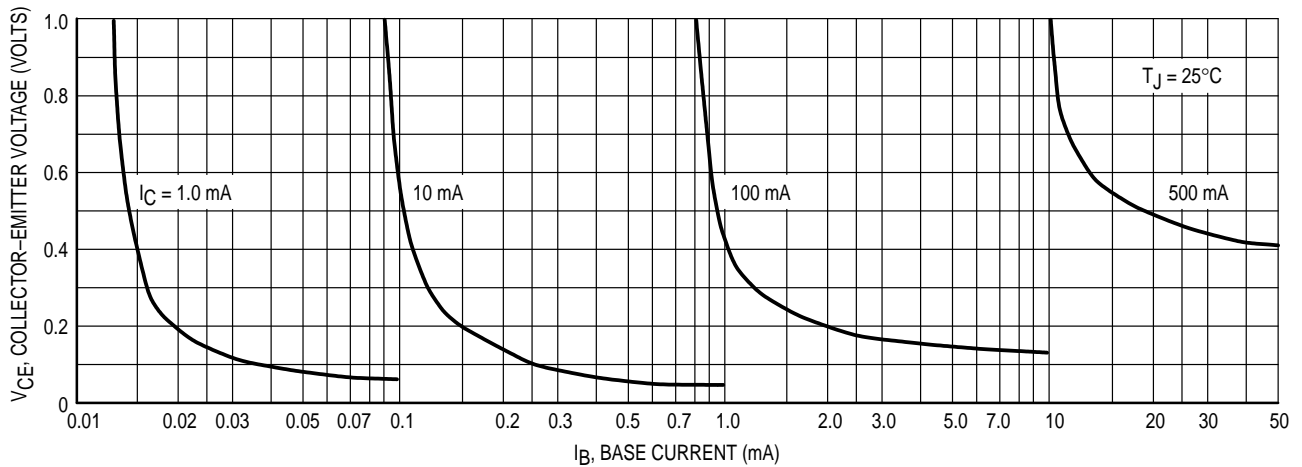


Figure 16. Collector Saturation Region

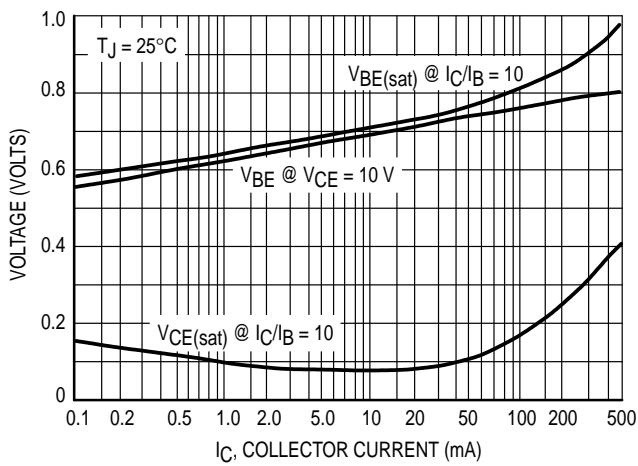


Figure 17. "On" Voltages

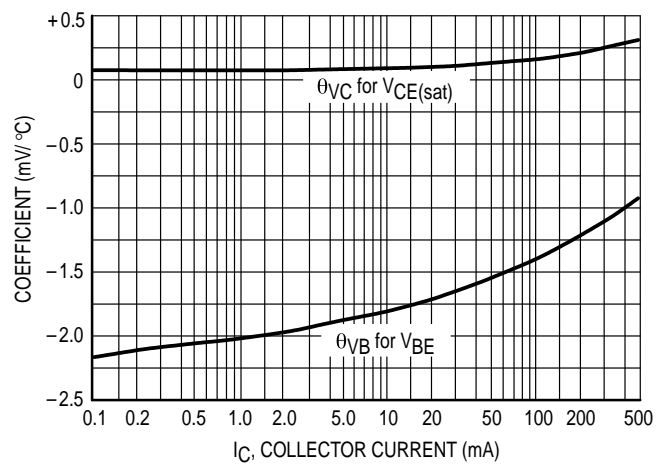


Figure 18. Temperature Coefficients

PACKAGE DIMENSIONS



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 | | MILLIMETERS | |
|-----|--------|-------|-------------|------|
| | MIN | MAX | MIN | 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:

1. EMITTER
2. BASE
3. COLLECTOR

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How to reach us:

USA/EUROPE: Motorola Literature Distribution;
P.O. Box 20912; Phoenix, Arizona 85036. 1-800-441-2447

JAPAN: Nippon Motorola Ltd.; Tatsumi-SPD-JLDC, Toshikatsu Otsuki,
6F Seibu-Butsuryu-Center, 3-14-2 Tatsumi Koto-Ku, Tokyo 135, Japan. 03-3521-8315

MFAX: RMFAX0@email.sps.mot.com - TOUCHTONE (602) 244-6609
INTERNET: http://Design-NET.com

HONG KONG: Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park,
51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852-26629298

