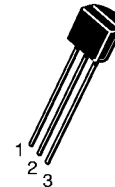
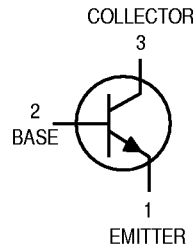


# General Purpose Transistors

## 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 $25^\circ\text{C}$	$P_D$	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	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
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### OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage <sup>(1)</sup> ( $I_C = 1.0 \text{ mAdc}, I_B = 0$ )	$V_{(BR)CEO}$	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	$\mu\text{Adc}$
Collector Cutoff Current ( $V_{CE} = 35 \text{ Vdc}, V_{EB} = 0.4 \text{ Vdc}$ )	$I_{CEX}$	—	0.1	$\mu\text{Adc}$

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

## 2N4400 2N4401

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

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

### SMALL–SIGNAL CHARACTERISTICS

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

### SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30 \text{ V dc}$ , $V_{BE} = 2.0 \text{ V dc}$ , $I_C = 150 \text{ mA dc}$ , $I_{B1} = 15 \text{ mA dc}$ )	$t_d$	—	15	ns
Rise Time		$t_r$	—	20	ns
Storage Time		$t_s$	—	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

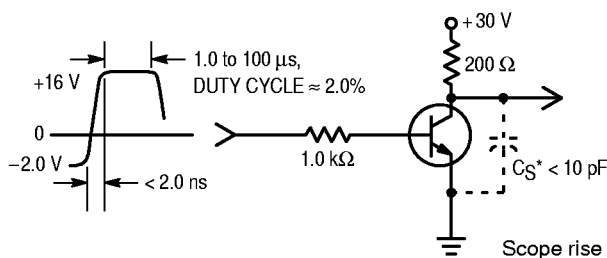


Figure 1. Turn–On Time

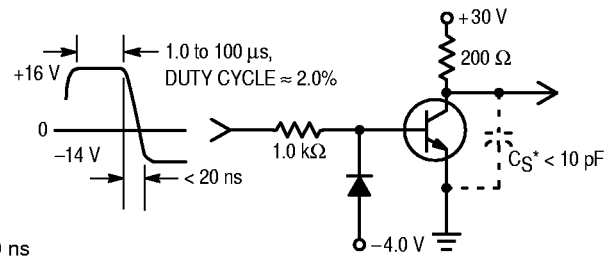


Figure 2. Turn–Off Time

TRANSIENT CHARACTERISTICS

— 25°C    - - - 100°C

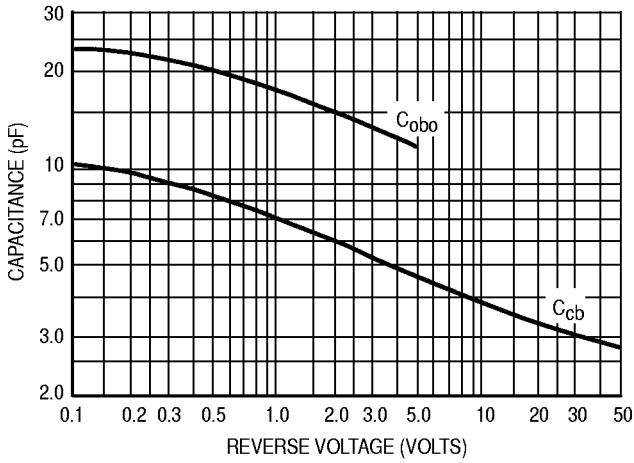


Figure 3. Capacitances

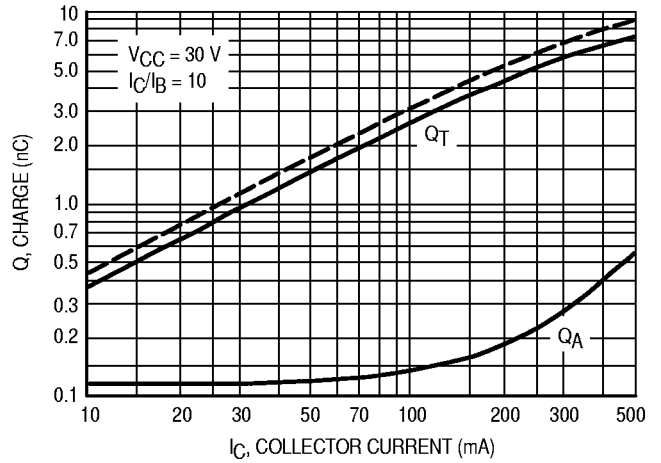


Figure 4. Charge Data

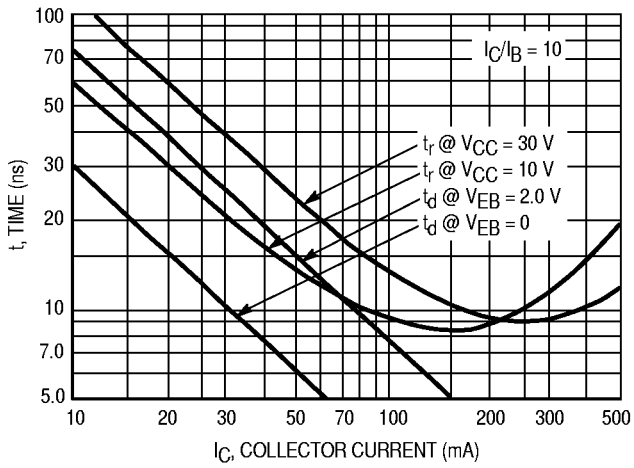


Figure 5. Turn-On Time

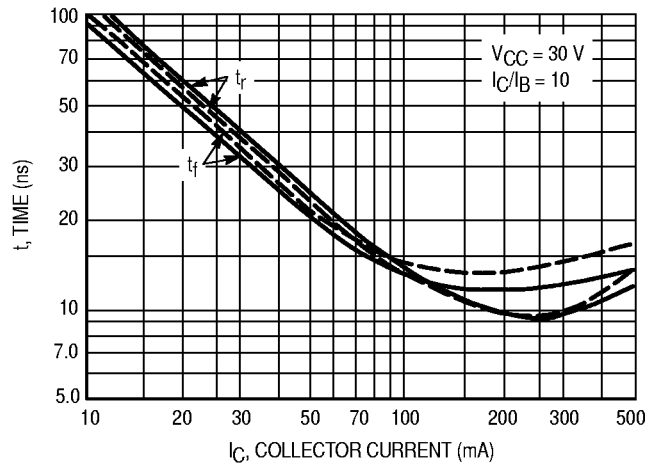


Figure 6. Rise and Fall Times

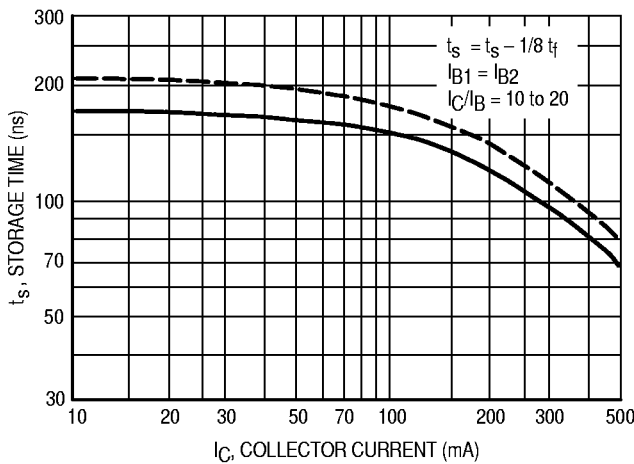


Figure 7. Storage Time

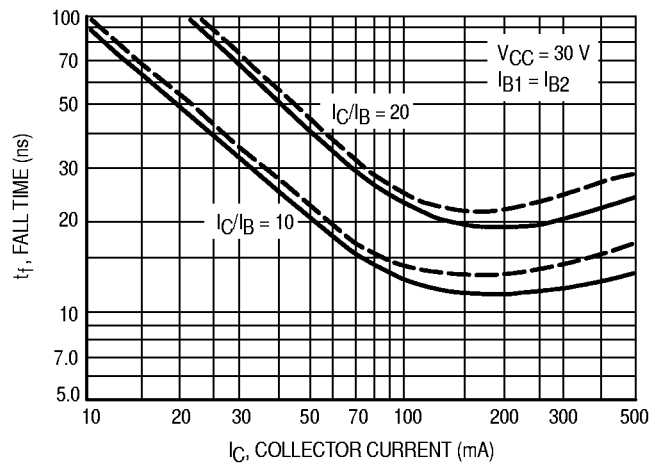


Figure 8. Fall Time

SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

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

Bandwidth = 1.0 Hz

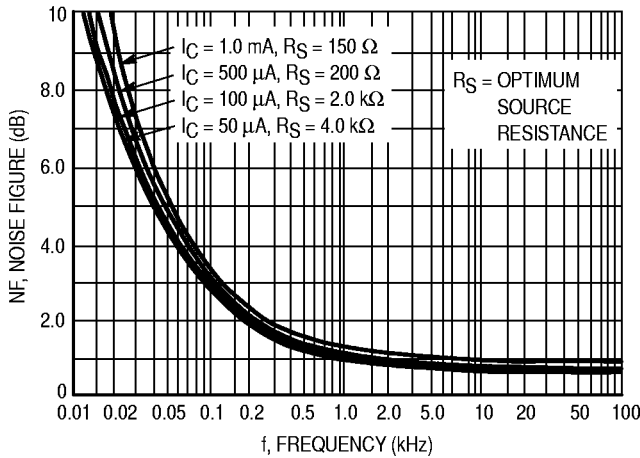


Figure 9. Frequency Effects

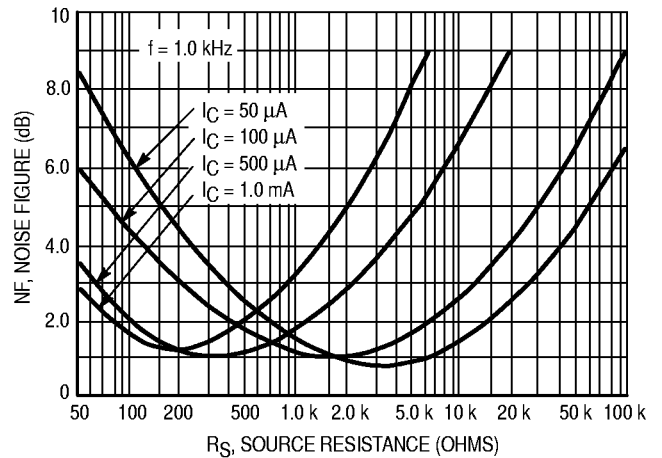


Figure 10. Source Resistance Effects

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.

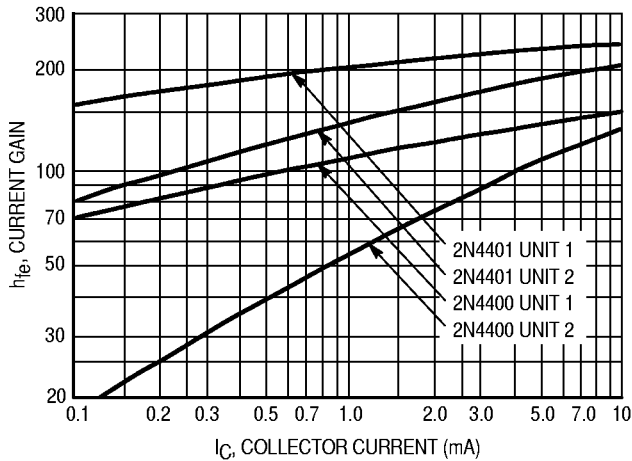


Figure 11. Current Gain

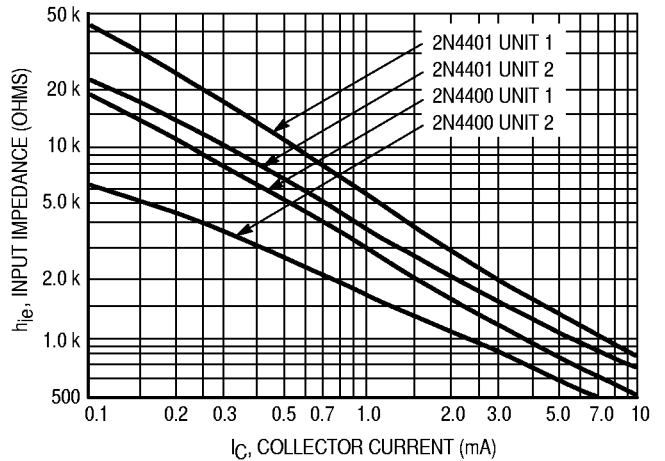


Figure 12. Input Impedance

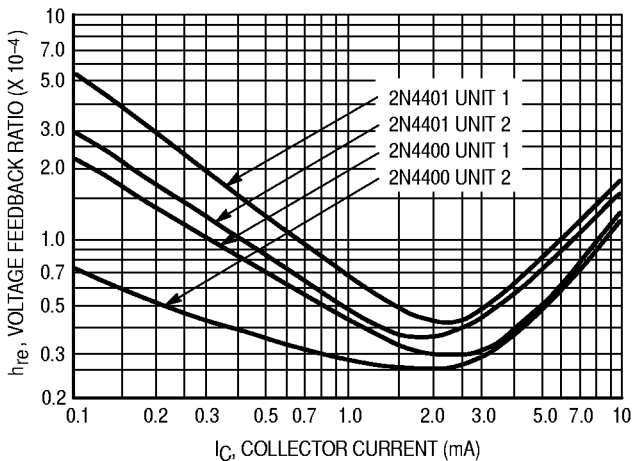


Figure 13. Voltage Feedback Ratio

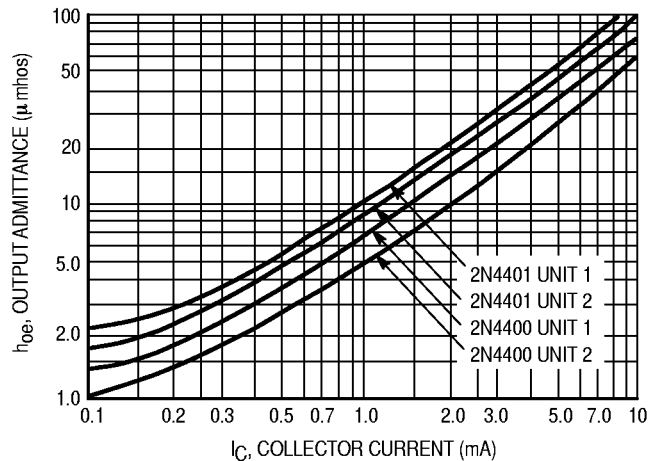


Figure 14. Output Admittance

STATIC CHARACTERISTICS

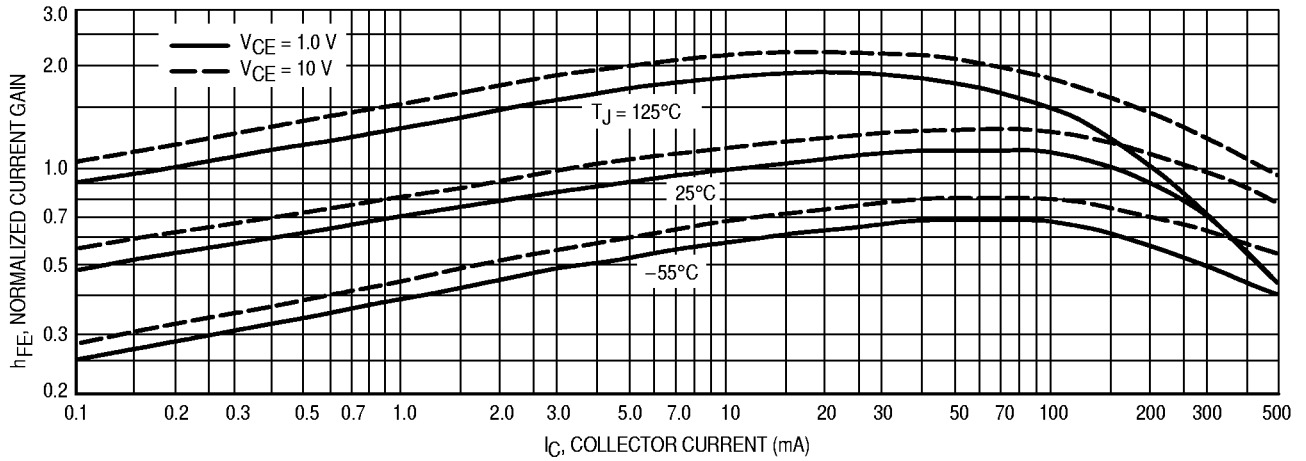


Figure 15. DC Current Gain

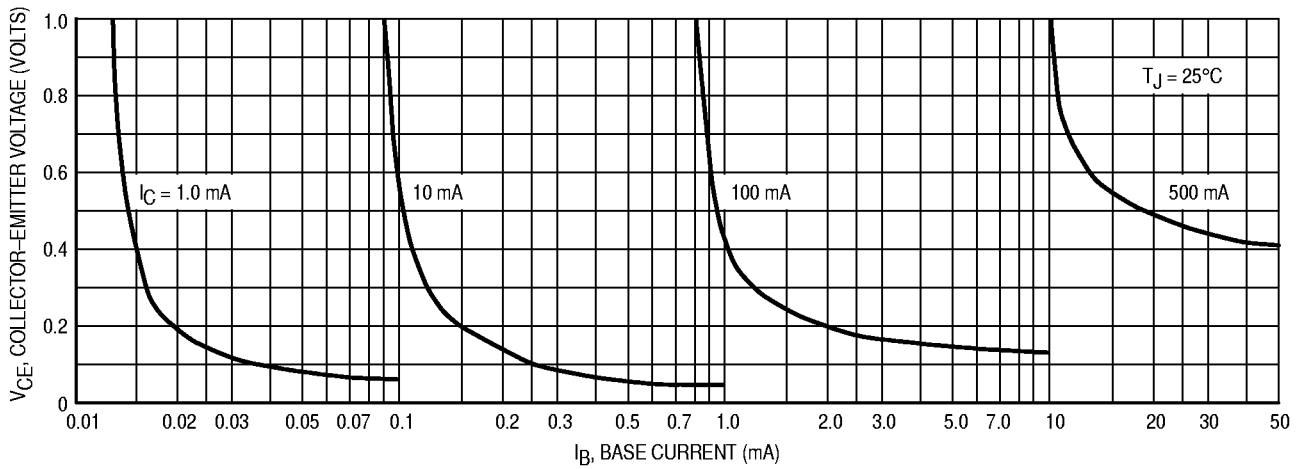


Figure 16. Collector Saturation Region

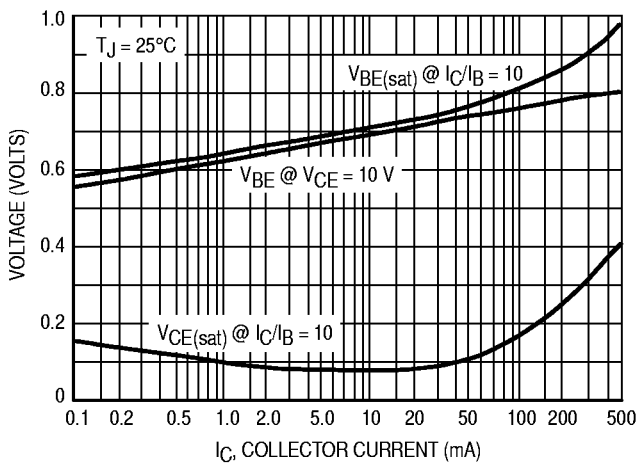


Figure 17. "On" Voltages

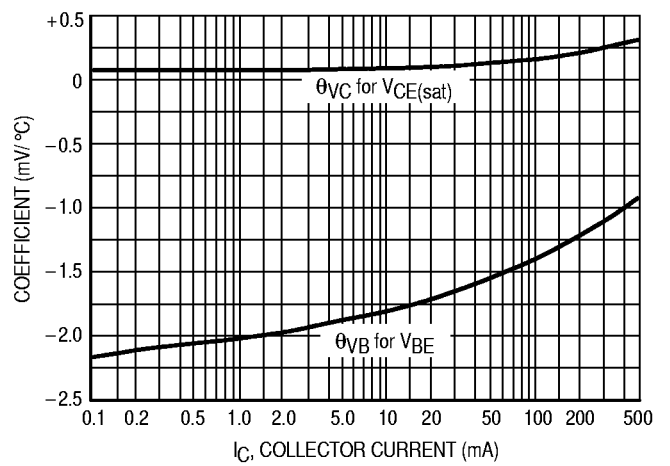
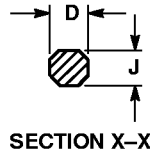
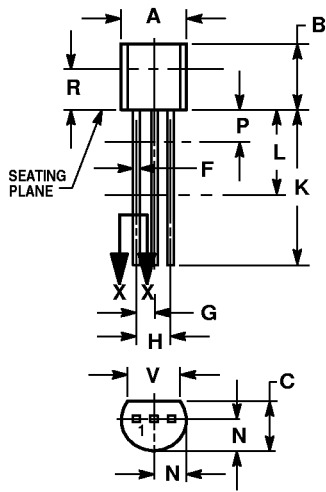


Figure 18. Temperature Coefficients

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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