MOTOROLA

2N4400 (SILICON)
2N4401

CASE 29(1)
(TO-92)

NPN silicon annular transistors designed for general purpose switching and amplifier applications and for complementary circuitry with PNP types 2N4402 and 2N4403. Features one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current - Continuous	I_C	600	mAdc
Total Device Dissipation T_A = 25°C	P_D	310	mW
Derate above 25°C		2.81	mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.137	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

2N4400, 2N4401 (continued)

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

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1 mAdc, I_B = 0)			BV_{CEO}*	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)			BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)			BV_{EBO}	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 35 Vdc, $V_{EB(off)}$ = 0.4 Vdc)			I_{CEX}	—	0.1	μAdc
Base Cutoff Current (V_{CE} = 35 Vdc, $V_{EB(off)}$ = 0.4 Vdc)			I_{BL}	—	0.1	μAdc
ON CHARACTERISTICS						
DC Current Gain		15	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N4401			20	—	
(I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N4400			20	—	
	2N4401			40	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N4400			40	—	
	2N4401			80	—	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)*	2N4400			50	150	
	2N4401			100	300	
(I_C = 500 mAdc, V_{CE} = 2 Vdc)*	2N4400			20	—	
	2N4401			40	—	
Collector-Emitter Saturation Voltage*		16, 17, 18	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)				—	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)				—	0.75	
Base-Emitter Saturation Voltage*		17, 18	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)				0.75	0.95	
(I_C = 500 mAdc, I_B = 50 mAdc)				—	1.2	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product			f_T			MHz
(I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N4400			200	—	
	2N4401			250	—	
Collector-Base Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz, emitter guarded)		3	C_{cb}	—	6.5	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)		3	C_{eb}	—	30	pF
Input Impedance		12	h_{ie}			k ohms
(I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4400			0.5	7.5	
	2N4401			1.0	15	
Voltage Feedback Ratio (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		13	h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain		11	h_{fe}			—
(I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4400			20	250	
	2N4401			40	500	
Output Admittance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		14	h_{oe}	1.0	30	μmhos
SWITCHING CHARACTERISTICS						
Delay Time	V_{CC} = 30 Vdc, $V_{EB(off)}$ = 2 Vdc,	1, 5	t_d	—	15	ns
Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc	1, 5, 6	t_r	—	20	ns
Storage Time	V_{CC} = 30 Vdc, I_C = 150 mAdc,	2, 7	t_s	—	225	ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc	2, 8	t_f	—	30	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

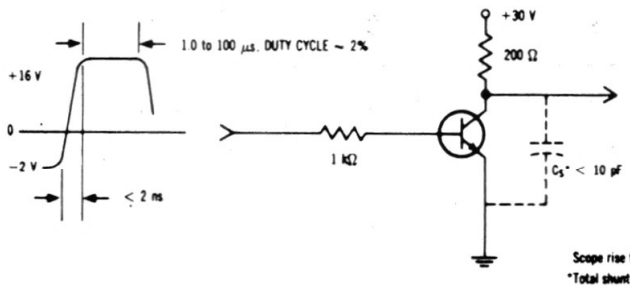
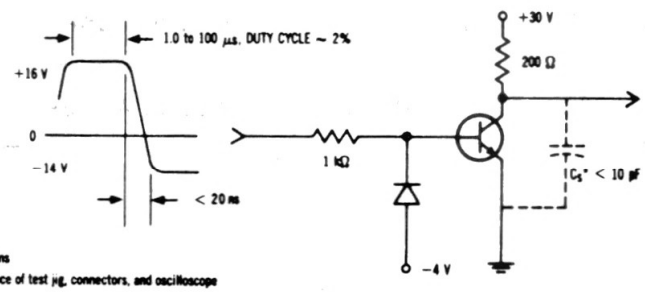


FIGURE 2 — TURN-OFF TIME



Scope rise time < 4 ns

*Total shunt capacitance of test jig, connectors, and oscilloscope

2N4400, 2N4401 (continued)

TRANSIENT CHARACTERISTICS

——— 25°C — — — 100°C

FIGURE 3 — CAPACITANCES

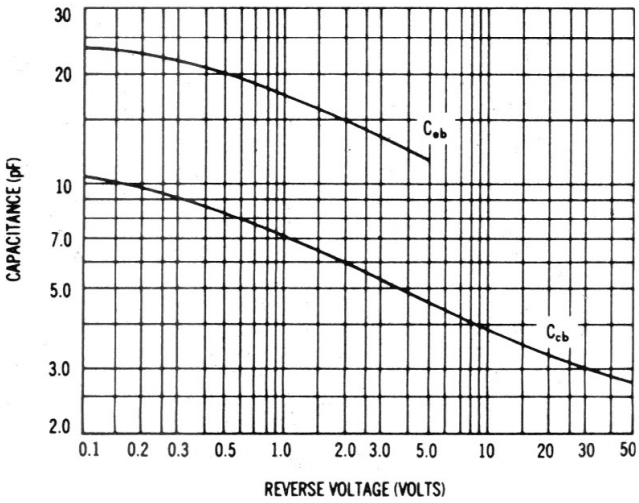


FIGURE 4 — CHARGE DATA

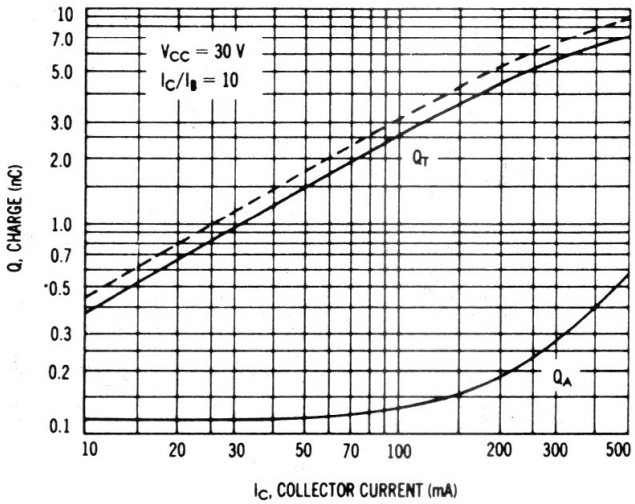


FIGURE 5 — TURN-ON TIME

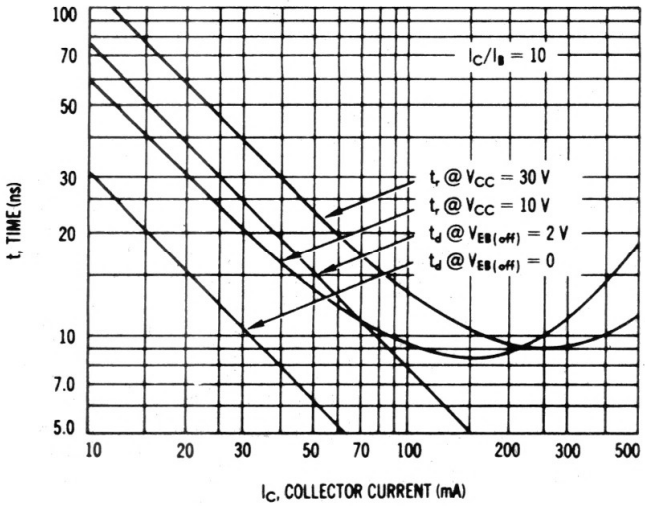


FIGURE 6 — RISE AND FALL TIMES

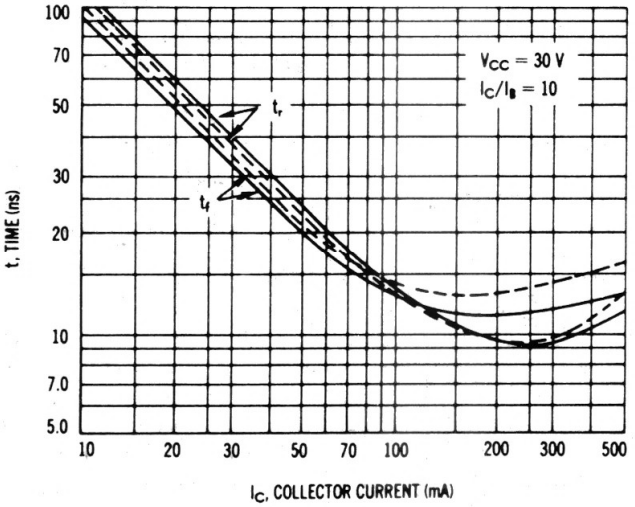


FIGURE 7 — STORAGE TIME

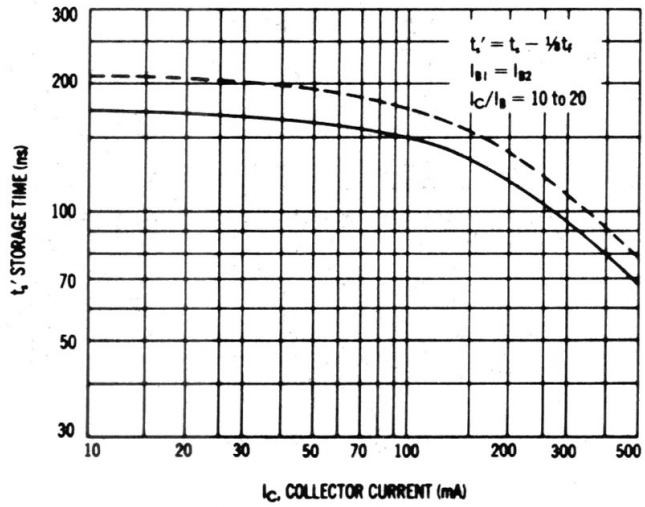
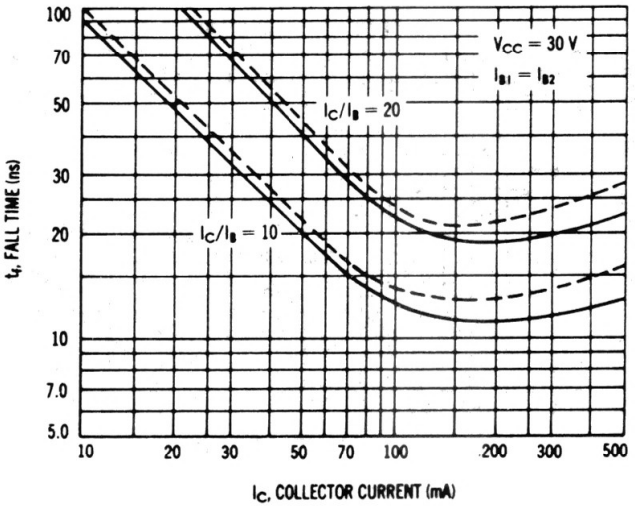


FIGURE 8 — FALL TIME



2N4400, 2N4401 (continued)

SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 9 — FREQUENCY EFFECTS

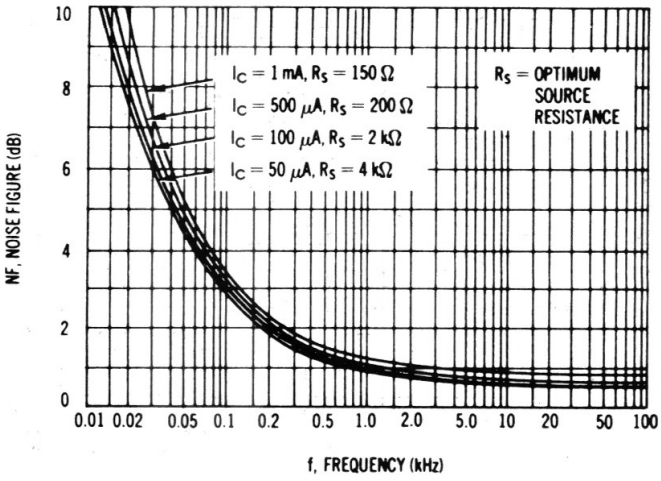
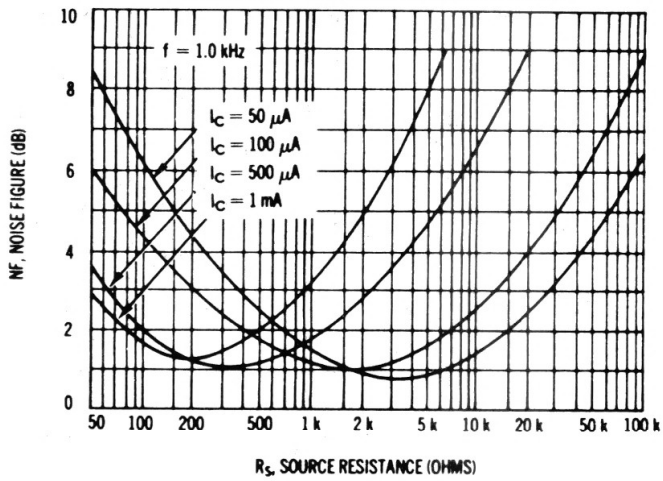


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1 kHz, T_A = 25°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

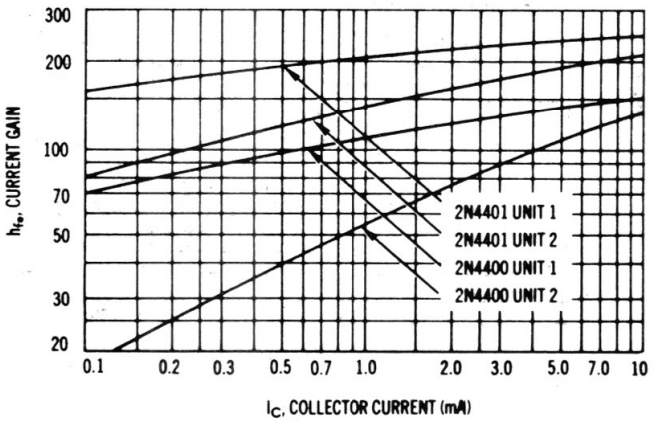


FIGURE 12 — INPUT IMPEDANCE

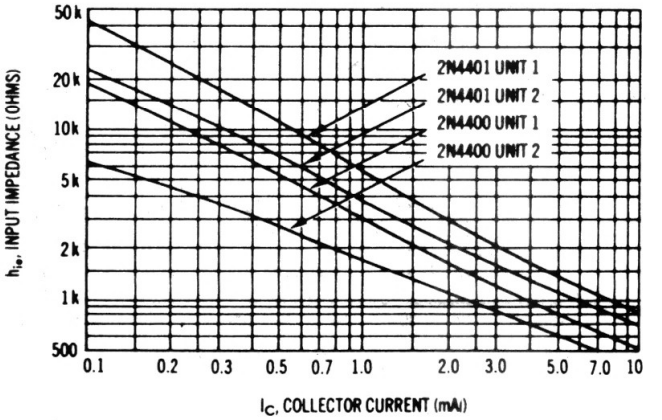


FIGURE 13 — VOLTAGE FEEDBACK RATIO

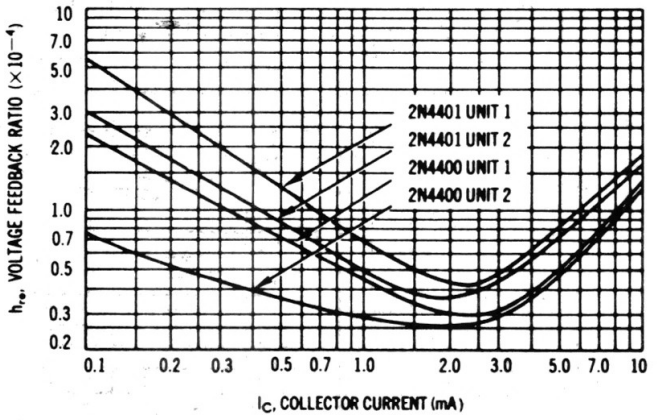
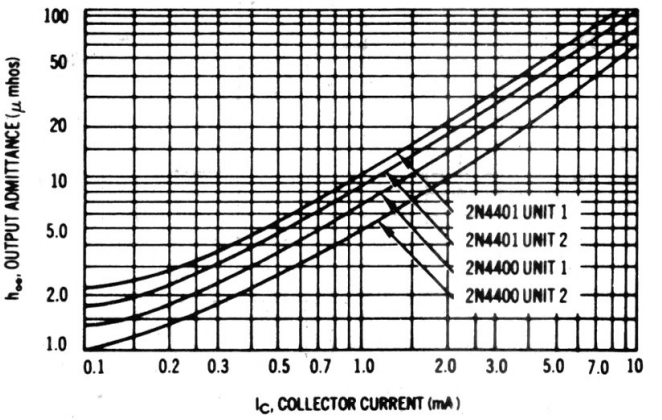


FIGURE 14 — OUTPUT ADMITTANCE



2N4400, 2N4401 (continued)

STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

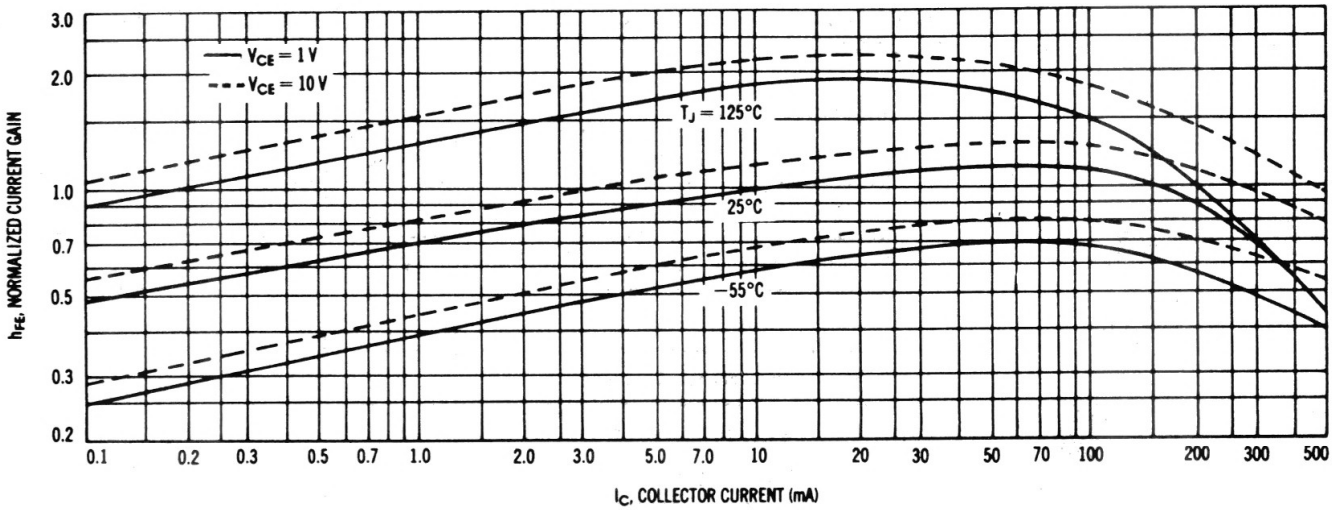


FIGURE 16 — COLLECTOR SATURATION REGION

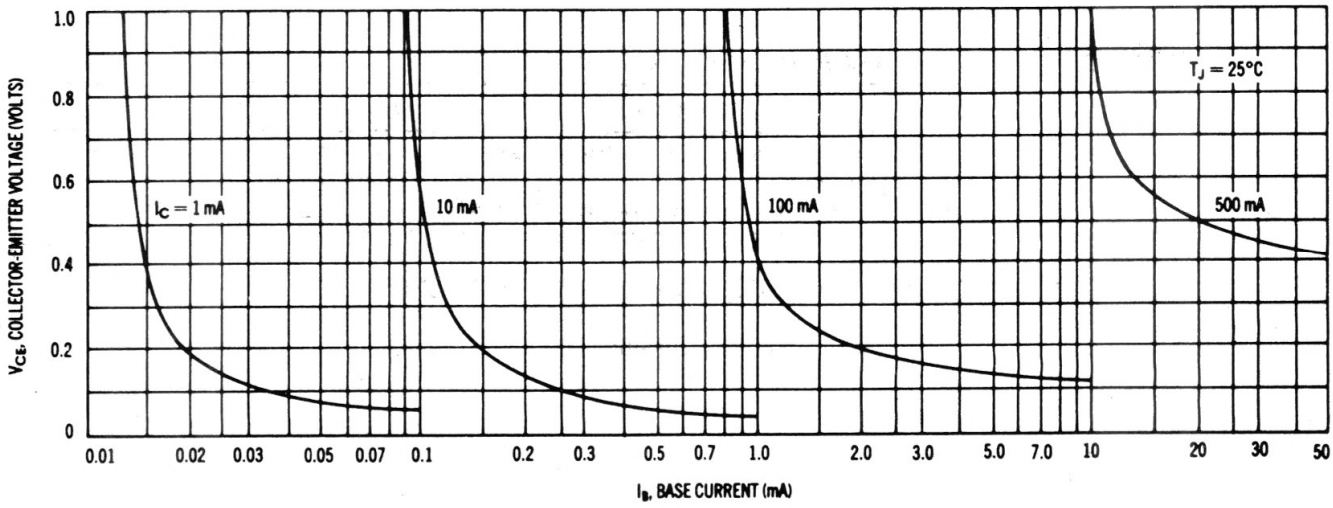


FIGURE 17 — "ON" VOLTAGES

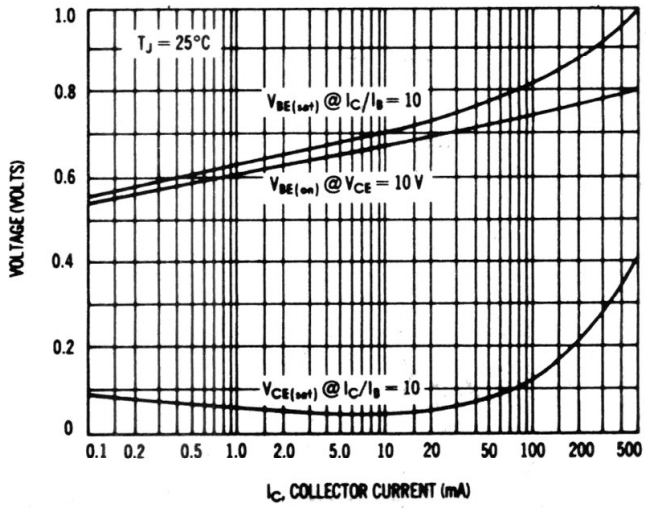


FIGURE 18 — TEMPERATURE COEFFICIENTS