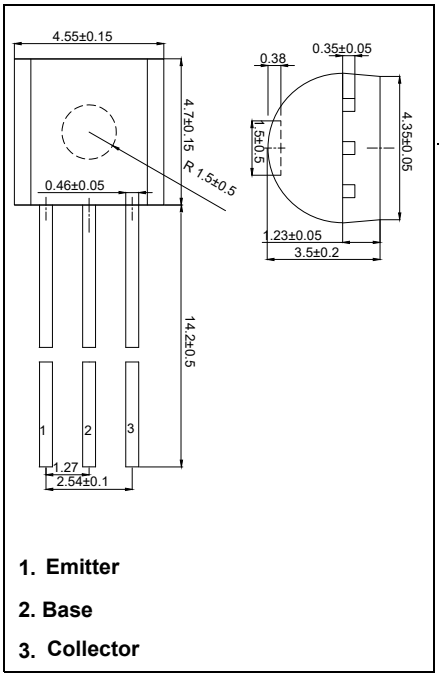
SHENZHEN LONG JING MICRO-ELECTRONICS CO., LTD.

# TO-92 Plastic-Encapsulate Transistors

## 2N4401052

NPN Silicon




1. Emitter
2. Base
3. Collector

### Features

- Pb−Free Packages are Available

### MAXIMUM RATINGS

| Symbol | Rating | Value | Unit |
|---|---|---|---|
| $V_{CEO}$ | Collector − Emitter Voltage | 40 | Vdc |
| $V_{CBO}$ | Collector − Base Voltage | 60 | Vdc |
| $V_{EBO}$ | Emitter − Base Voltage | 6.0 | Vdc |
| $I_C$ | Collector Current − Continuous | 600 | mAdc |
| $P_D$ | Total Device Dissipation<br>@ $T_A$ = 25°C<br>Derate above 25°C | <br>625<br>5.0 | <br>mW<br>mW/°C |
| $P_D$ | Total Device Dissipation<br>@ $T_C$ = 25°C<br>Derate above 25°C | <br>1.5<br>12 | <br>W<br>mW/°C |
| $T_J$, $T_{stg}$ | Operating and Storage Junction Temperature Range | −55 to +150 | °C |

### THERMAL CHARACTERISTICS

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

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

| Symbol | Characteristic | | Min | Max | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| $V_{(BR)CEO}$ | Collector−Emitter Breakdown Voltage (Note 1) | ($I_C$ = 1.0 mAdc, $I_B$ = 0) | 40 | − | Vdc |
| $V_{(BR)CBO}$ | Collector−Base Breakdown Voltage | ($I_C$ = 0.1 mAdc, $I_E$ = 0) | 60 | − | Vdc |
| $V_{(BR)EBO}$ | Emitter−Base Breakdown Voltage | ($I_E$ = 0.1 mAdc, $I_C$ = 0) | 6.0 | − | Vdc |
| $I_{BEV}$ | Base Cutoff Current | ($V_{CE}$ = 35 Vdc, $V_{EB}$ = 0.4 Vdc) | − | 0.1 | μAdc |
| $I_{CEX}$ | Collector Cutoff Current | ($V_{CE}$ = 35 Vdc, $V_{EB}$ = 0.4 Vdc) | − | 0.1 | μAdc |
| **ON CHARACTERISTICS** (Note 1) | | | | | |
| $h_{FE}$ | 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>($I_C$ = 150 mAdc, $V_{CE}$ = 1.0 Vdc)<br>($I_C$ = 500 mAdc, $V_{CE}$ = 2.0 Vdc) | <br>20<br>40<br>80<br>100<br>40 | <br>−<br>−<br>−<br>300<br>− | − |
| $V_{CE(sat)}$ | Collector−Emitter Saturation Voltage | ($I_C$ = 150 mAdc, $I_B$ = 15 mAdc)<br>($I_C$ = 500 mAdc, $I_B$ = 50 mAdc) | −<br>− | 0.4<br>0.75 | Vdc |
| $V_{BE(sat)}$ | Base−Emitter Saturation Voltage | ($I_C$ = 150 mAdc, $I_B$ = 15 mAdc)<br>($I_C$ = 500 mAdc, $I_B$ = 50 mAdc) | 0.75<br>− | 0.95<br>1.2 | Vdc |

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

| Symbol | Characteristic | | Min | Max | Unit |
|---|---|---|---|---|---|
| **SMALL−SIGNAL CHARACTERISTICS** | | | | | |
| $f_T$ | Current−Gain − Bandwidth Product | ($I_C$ = 20 mAdc, $V_{CE}$ = 10 Vdc, f = 100 MHz) | 250 | − | MHz |
| $C_{cb}$ | Collector−Base Capacitance | ($V_{CB}$ = 5.0 Vdc, $I_E$ = 0, f = 1.0 MHz) | − | 6.5 | pF |
| $C_{eb}$ | Emitter−Base Capacitance | ($V_{EB}$ = 0.5 Vdc, $I_C$ = 0, f = 1.0 MHz) | − | 30 | pF |
| $h_{ie}$ | Input Impedance | ($I_C$ = 1.0 mAdc, $V_{CE}$ = 10 Vdc, f = 1.0 kHz) | 1.0 | 15 | k Ω |
| $h_{re}$ | Voltage Feedback Ratio | ($I_C$ = 1.0 mAdc, $V_{CE}$ = 10 Vdc, f = 1.0 kHz) | 0.1 | 8.0 | X $10^{-4}$ |
| $h_{fe}$ | Small−Signal Current Gain | ($I_C$ = 1.0 mAdc, $V_{CE}$ = 10 Vdc, f = 1.0 kHz) | 40 | 500 | − |
| $h_{oe}$ | Output Admittance | ($I_C$ = 1.0 mAdc, $V_{CE}$ = 10 Vdc, f = 1.0 kHz) | 1.0 | 30 | μmhos |
| **SWITCHING CHARACTERISTICS** | | | | | |
| $t_d$ | Delay Time | ($V_{CC}$ = 30 Vdc, $V_{BE}$ = 2.0 Vdc, $I_C$ = 150 mAdc, $I_{B1}$ = 15 mAdc) | − | 15 | ns |
| $t_r$ | Rise Time | | − | 20 | ns |
| $t_s$ | Storage Time | ($V_{CC}$ = 30 Vdc, $I_C$ = 150 mAdc, $I_{B1}$ = $I_{B2}$ = 15 mAdc) | − | 225 | ns |
| $t_f$ | Fall Time | | − | 30 | ns |

1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

## SWITCHING TIME EQUIVALENT TEST CIRCUITS

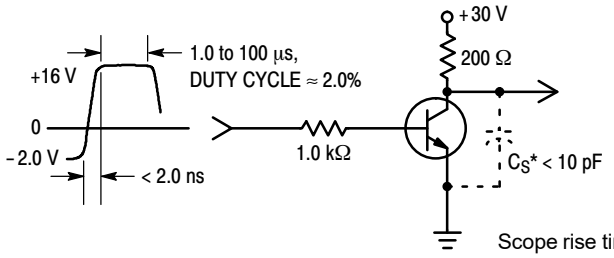



**Figure 1. Turn−On Time**

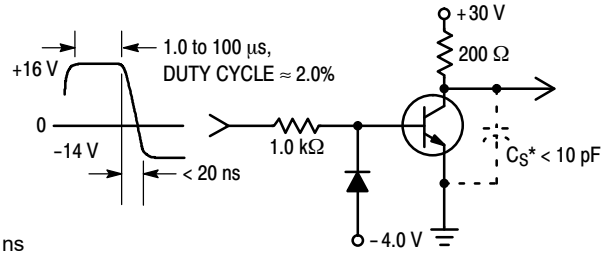



**Figure 2. Turn−Off Time**

Scope rise time < 4.0 ns
*Total shunt capacitance of test jig connectors, and oscilloscope

## TRANSIENT CHARACTERISTICS

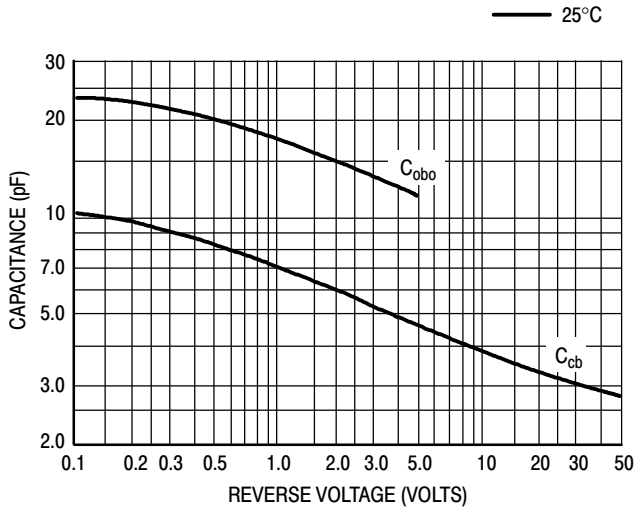



**Figure 3. Capacitances**

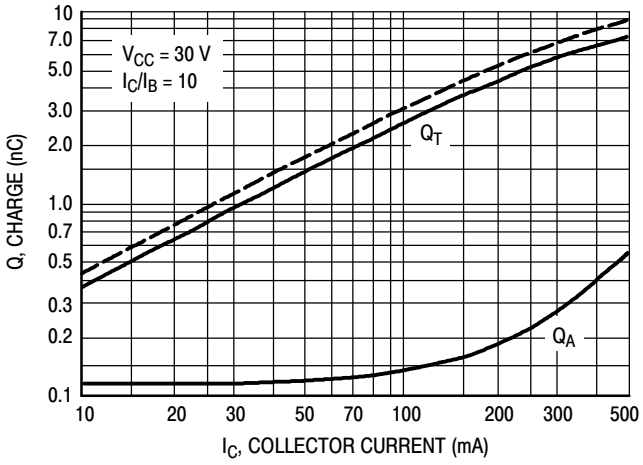



**Figure 4. Charge Data**

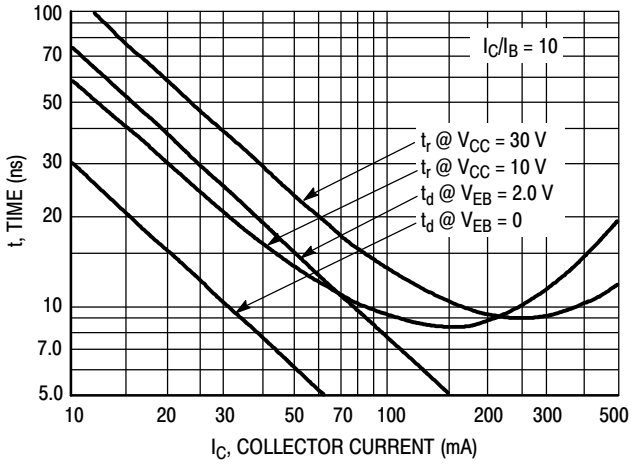



**Figure 5. Turn−On Time**

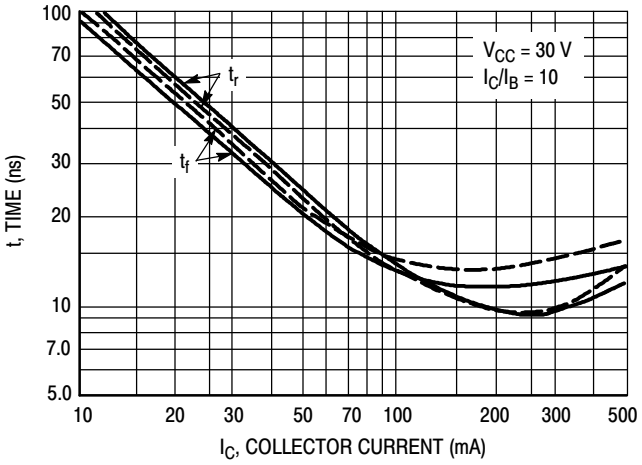



**Figure 6. Rise and Fall Times**

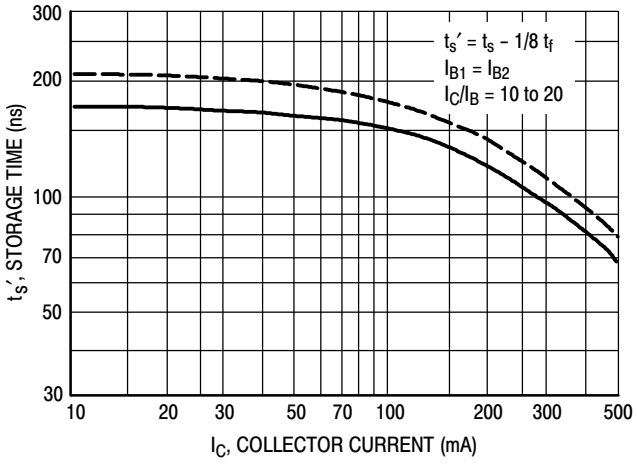



**Figure 7. Storage Time**

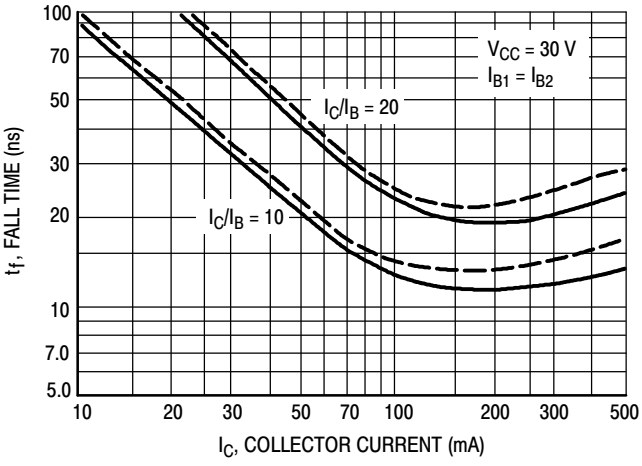



**Figure 8. Fall Time**

## SMALL−SIGNAL CHARACTERISTICS

### NOISE FIGURE

$V_{CE}$ = 10 Vdc, $T_A$ = 25°C; Bandwidth = 1.0 Hz

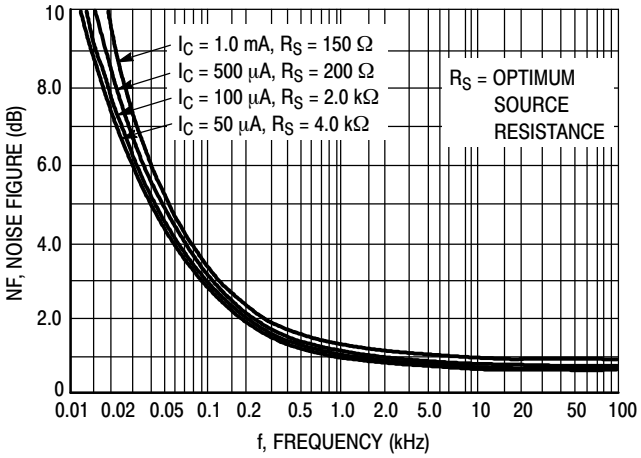



**Figure 9. Frequency Effects**

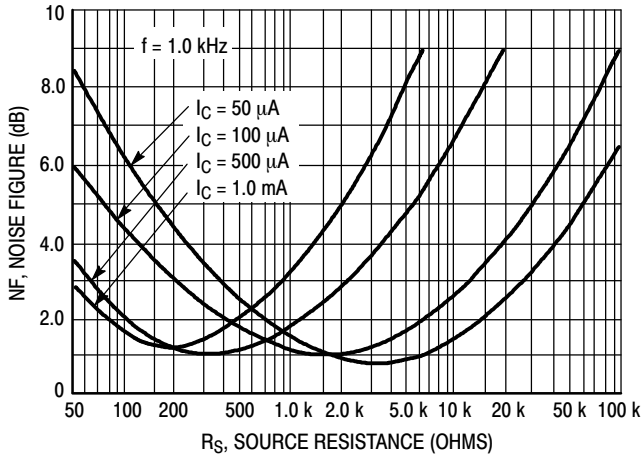



**Figure 10. Source Resistance Effects**

## h PARAMETERS

$V_{CE}$ = 10 Vdc, f = 1.0 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 the 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

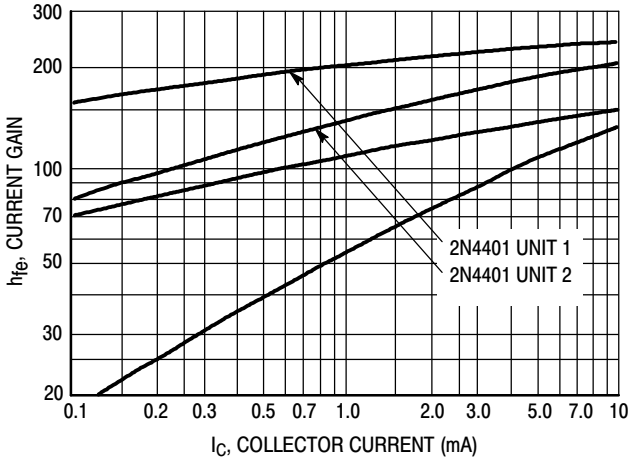



**Figure 11. Current Gain**

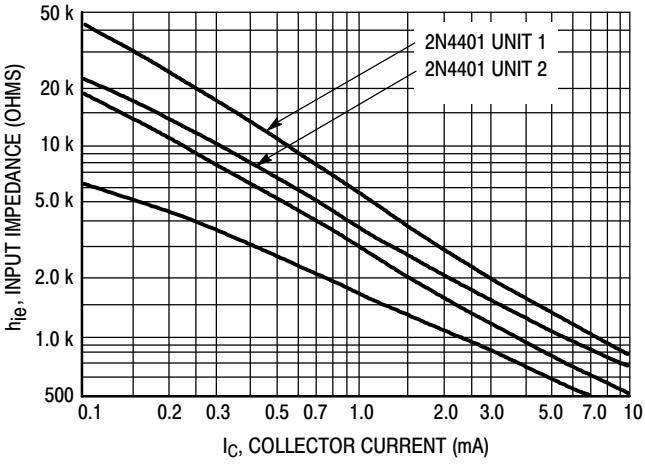



**Figure 12. Input Impedance**

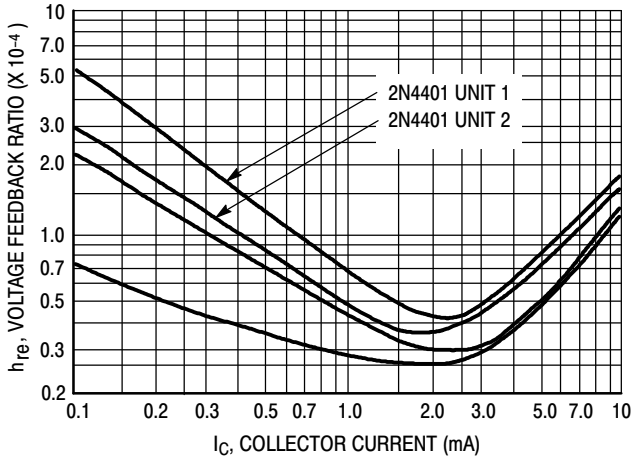



**Figure 13. Voltage Feedback Ratio**

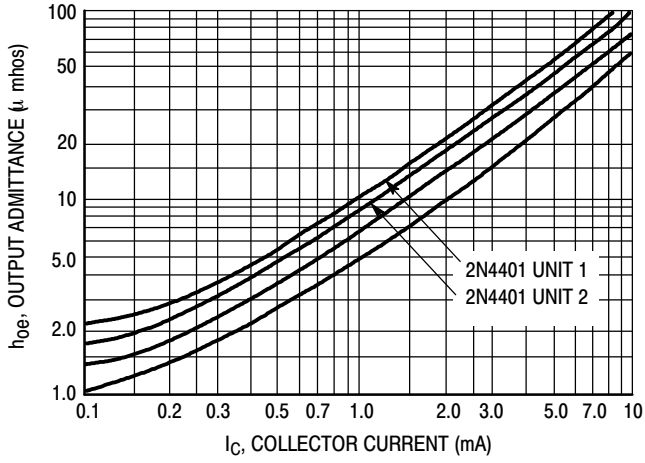



**Figure 14. Output Admittance**

## STATIC CHARACTERISTICS

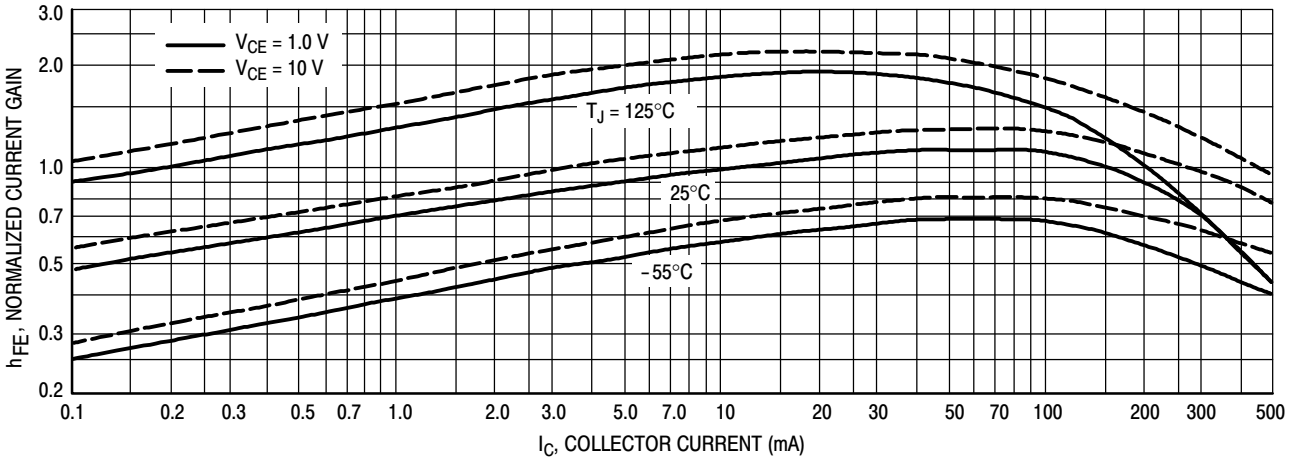



**Figure 15. DC Current Gain**

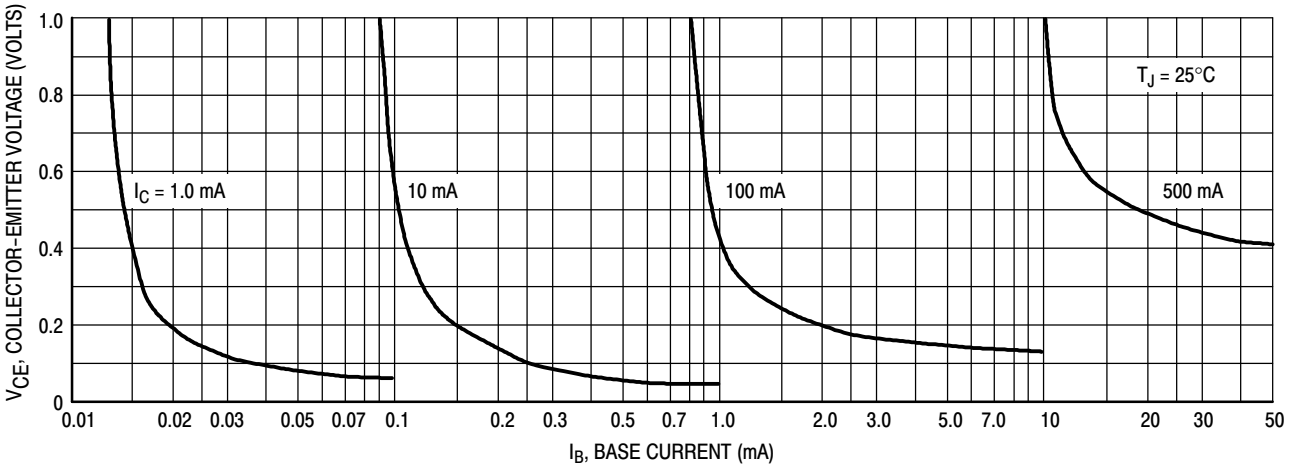



**Figure 16. Collector Saturation Region**

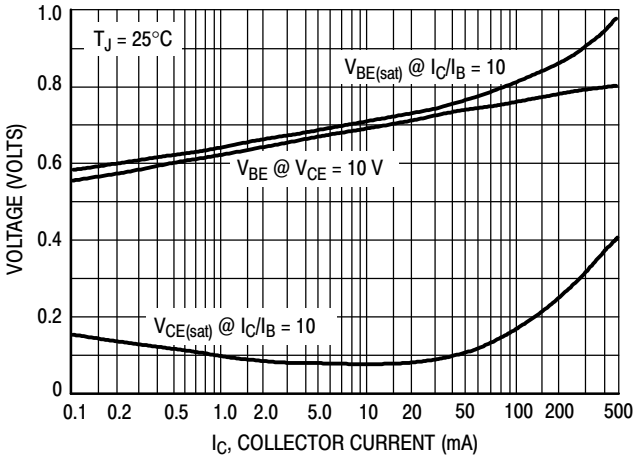



**Figure 17. "On" Voltages**

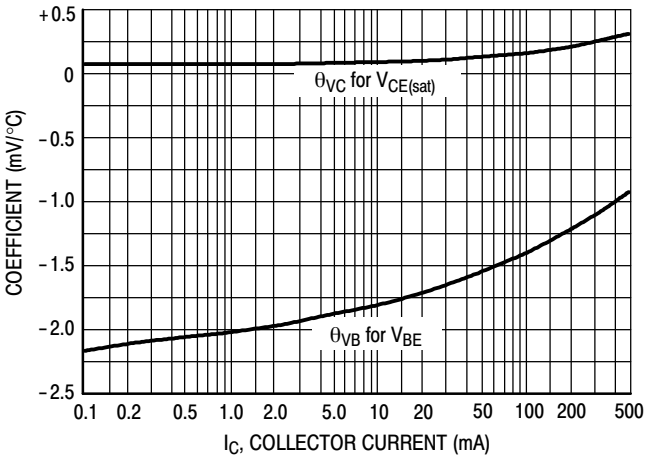



**Figure 18. Temperature Coefficients**

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