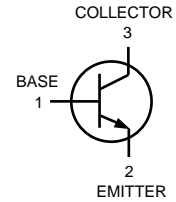
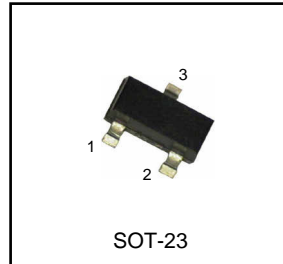


# Switching Transistor

## NPN Silicon

# MMBT4401



### MAXIMUM RATINGS

| Rating                       | Symbol           | Value | Unit              |
|------------------------------|------------------|-------|-------------------|
| Collector-Emitter Voltage    | V <sub>CEO</sub> | 40    | V <sub>d</sub> c  |
| Collector-Base Voltage       | V <sub>CBO</sub> | 60    | V <sub>d</sub> c  |
| Emitter-Base Voltage         | V <sub>EBO</sub> | 6.0   | V <sub>d</sub> c  |
| Collector Current-Continuous | I <sub>C</sub>   | 600   | mA <sub>d</sub> c |

### THERMAL CHARACTERISTICS

| Characteristic   | Symbol                            | Max.        | Unit          |
|--|-----------------------------------|-------------|---------------|
| Total Device Dissipation FR-5 Board <sup>(1)</sup> T <sub>A</sub> =25°C<br>Derate above 25°C         | P <sub>D</sub>                    | 225<br>1.8  | mW<br>mW / °C |
| Thermal Resistance Junction to Ambient   | R <sub>θJA</sub>                  | 556         | °C / W        |
| Total Device Dissipation Alumina Substrate, <sup>(2)</sup> T <sub>A</sub> =25°C<br>Derate above 25°C | P <sub>D</sub>                    | 300<br>2.4  | mW<br>mW / °C |
| Thermal Resistance Junction to Ambient   | R <sub>θJA</sub>                  | 417         | °C / W        |
| Junction and Storage Temperature   | T <sub>J</sub> , T <sub>STG</sub> | -55 to +150 | °C            |

### DEVICE MARKING

**MMBT4401=2X**

### ELECTRICAL CHARACTERISTICS (T<sub>A</sub>=25°C unless otherwise noted)

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

### OFF CHARACTERISTICS

|   |                      |     |     |                   |
|---|----------------------|-----|-----|-------------------|
| Collector-Emitter Breakdown Voltage <sup>(3)</sup><br>( I <sub>C</sub> =1.0mA <sub>d</sub> c, I <sub>B</sub> =0 ) | V <sub>(BR)CEO</sub> | 40  | -   | V <sub>d</sub> c  |
| Collector-Base Breakdown Voltage<br>( I <sub>C</sub> =0.1 mA <sub>d</sub> c, I <sub>E</sub> =0 )                  | V <sub>(BR)CBO</sub> | 60  | -   | V <sub>d</sub> c  |
| Emitter-Base Breakdown Voltage<br>( I <sub>E</sub> =0.1 mA <sub>d</sub> c, I <sub>C</sub> =0 )                    | V <sub>(BR)EBO</sub> | 6.0 | -   | V <sub>d</sub> c  |
| Base Cutoff Current<br>( V <sub>CE</sub> =35 V <sub>d</sub> c, V <sub>EB</sub> =0.4 V <sub>d</sub> c )            | I <sub>BEV</sub>     | -   | 0.1 | nA <sub>d</sub> c |
| Collector Cutoff Current<br>( V <sub>CE</sub> =35 V <sub>d</sub> c, V <sub>EB</sub> =0.4 V <sub>d</sub> c )       | I <sub>C</sub> EX    | -   | 0.1 | nA <sub>d</sub> c |

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

| Characteristic   | Symbol               | Min.                        | Max.                    | Unit            |
|--|----------------------|-----------------------------|-------------------------|-----------------|
| <b>ON CHARACTERISTICS<sup>(3)</sup></b>  |                      |                             |                         |                 |
| DC Current Gain<br>( IC=0.1 mA <sub>dc</sub> , V <sub>CE</sub> =1.0 V <sub>dc</sub> )<br>( IC=1.0 mA <sub>dc</sub> , V <sub>CE</sub> =1.0 V <sub>dc</sub> )<br>( IC=10 mA <sub>dc</sub> , V <sub>CE</sub> =1.0 V <sub>dc</sub> )<br>( IC=150 mA <sub>dc</sub> , V <sub>CE</sub> =1.0 V <sub>dc</sub> )<br>( IC=500 mA <sub>dc</sub> , V <sub>CE</sub> =2.0 V <sub>dc</sub> ) | HFE                  | 20<br>40<br>80<br>100<br>40 | -<br>-<br>-<br>300<br>- | -               |
| Collector-Emitter Saturation Voltage <sup>(3)</sup><br>( IC=150 mA <sub>dc</sub> , I <sub>B</sub> =15 mA <sub>dc</sub> )<br>( IC=500 mA <sub>dc</sub> , I <sub>B</sub> =50 mA <sub>dc</sub> )  | V <sub>CE(sat)</sub> | -<br>-                      | 0.4<br>0.75             | V <sub>dc</sub> |
| Base-Emitter Saturation Voltage <sup>(3)</sup><br>( IC=150 mA <sub>dc</sub> , I <sub>B</sub> =15 mA <sub>dc</sub> )<br>( IC=500 mA <sub>dc</sub> , I <sub>B</sub> =50 mA <sub>dc</sub> )   | V <sub>BE(sat)</sub> | 0.75<br>-                   | 0.95<br>1.2             | V <sub>dc</sub> |

**SMALL-SIGNAL CHARACTERISTIC**

|   |                 |     |     |                    |
|---|-----------------|-----|-----|--------------------|
| Current-Gain-Bandwidth Product<br>( IC=20 mA <sub>dc</sub> , V <sub>CE</sub> =10 V <sub>dc</sub> , f=100 MHz )          | f <sub>T</sub>  | 250 | -   | MHz                |
| Collector-Base Capacitance<br>( V <sub>CB</sub> =5.0 V <sub>dc</sub> , I <sub>E</sub> =0, f=1.0 MHz )                   | C <sub>cb</sub> | -   | 6.5 | pF                 |
| Emitter-Base Capacitance<br>( V <sub>EB</sub> =0.5 V <sub>dc</sub> , I <sub>C</sub> =0, f=1.0 MHz )                     | C <sub>eb</sub> | -   | 30  | pF                 |
| Input Impedance<br>( V <sub>CE</sub> =10 V <sub>dc</sub> , I <sub>C</sub> =1.0 mA <sub>dc</sub> , f=1.0 kHz )           | h <sub>ie</sub> | 1.0 | 15  | k ohms             |
| Voltage Feedback Ratio<br>( V <sub>CE</sub> =10 V <sub>dc</sub> , I <sub>C</sub> =1.0 mA <sub>dc</sub> , f=1.0 kHz )    | h <sub>re</sub> | 0.1 | 8.0 | X 10 <sup>-4</sup> |
| Small-Signal Current Gain<br>( V <sub>CE</sub> =10 V <sub>dc</sub> , I <sub>C</sub> =1.0 mA <sub>dc</sub> , f=1.0 kHz ) | h <sub>fe</sub> | 40  | 500 | -                  |
| Output Admittance<br>( V <sub>CE</sub> =10 V <sub>dc</sub> , I <sub>C</sub> =1.0 mA <sub>dc</sub> , f=1.0 kHz )         | h <sub>oe</sub> | 1.0 | 30  | u mhos             |

**SWITCHING CHARACTERISTICS**

|              |   |                |   |     |    |
|--------------|---|----------------|---|-----|----|
| Delay Time   | ( V <sub>CC</sub> =30 V <sub>dc</sub> , V <sub>BE</sub> =2.0 V <sub>dc</sub> ,<br>I <sub>C</sub> =150 mA <sub>dc</sub> , I <sub>B1</sub> =15 mA <sub>dc</sub> ) | t <sub>d</sub> | - | 15  | nS |
| Rise Time    |   | t <sub>r</sub> | - | 20  |    |
| Storage Time | ( V <sub>CC</sub> =30 V <sub>dc</sub> ,<br>I <sub>C</sub> =150 mA <sub>dc</sub> , I <sub>B1</sub> =I <sub>B2</sub> =15 mA <sub>dc</sub> )                       | t <sub>s</sub> | - | 225 | nS |
| Fall Time    |   | t <sub>f</sub> | - | 30  |    |

(1) FR-5=1.0 x 0.75 x 0.062in.

(2) Alumina=0.4 x 0.3 x 0.024in. 99.5% alumina.

(3) Pulse Test : Pulse Width ≤ 300uS, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

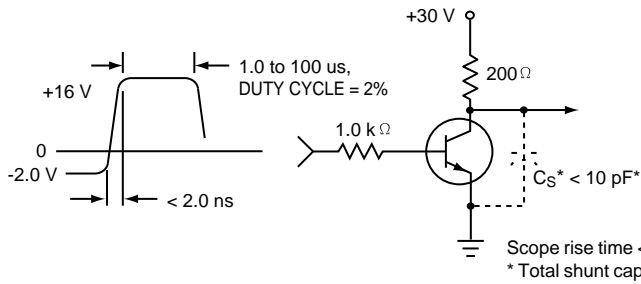


Figure 1. Turn-On Time

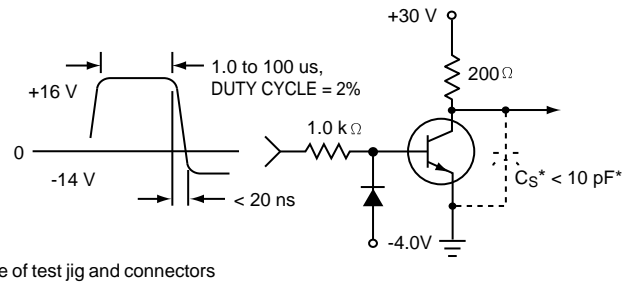


Figure 2. Turn-Off Time

TRANSIENT CHARACTERISTICS

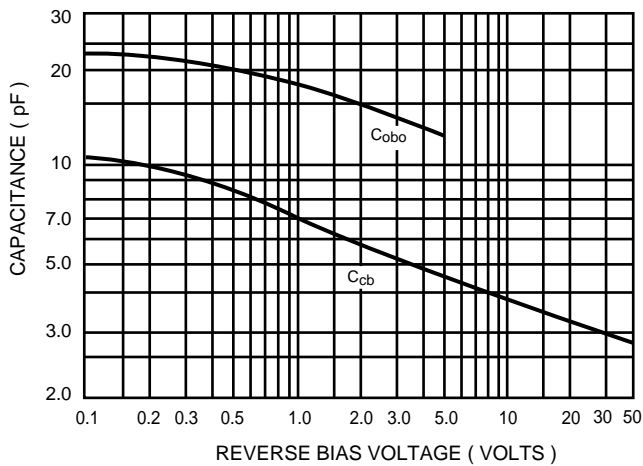


Figure 3. Capacitance

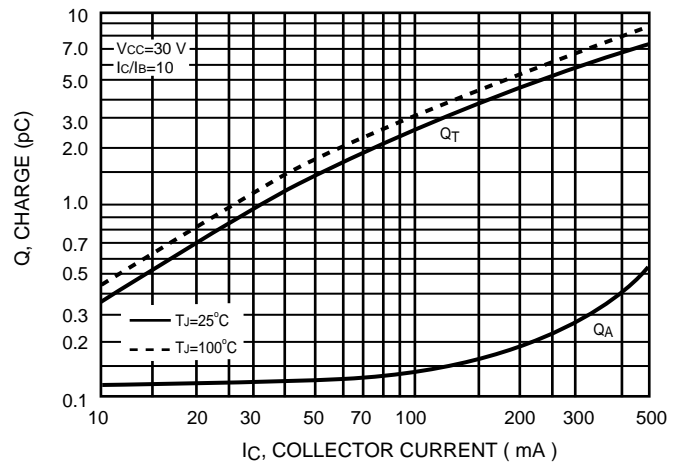


Figure 4. Charge Data

TRANSIENT CHARACTERISTICS

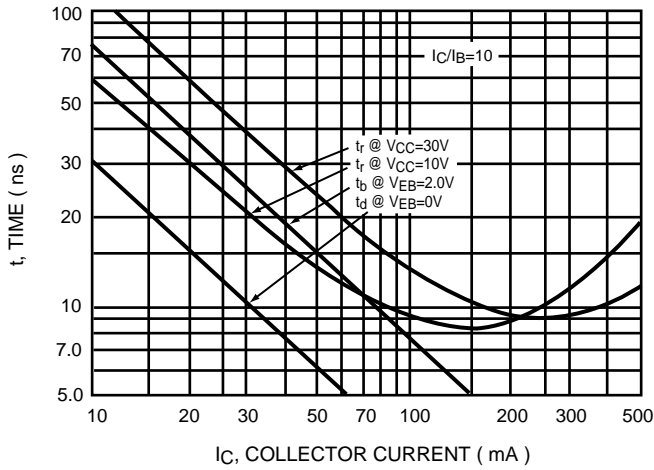


Figure 5. Turn-On Time

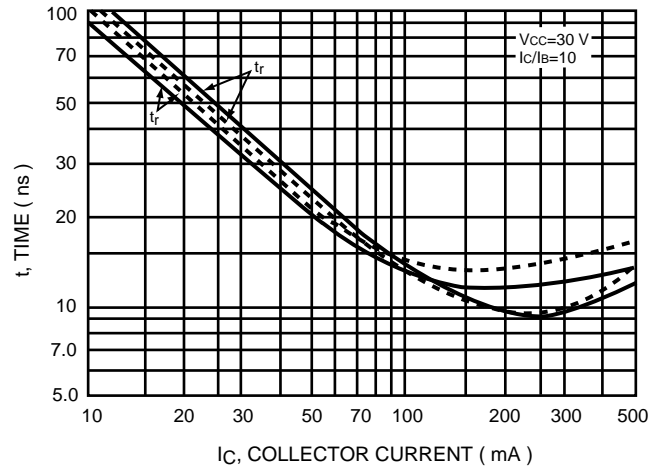


Figure 6. Rise and Fall Times

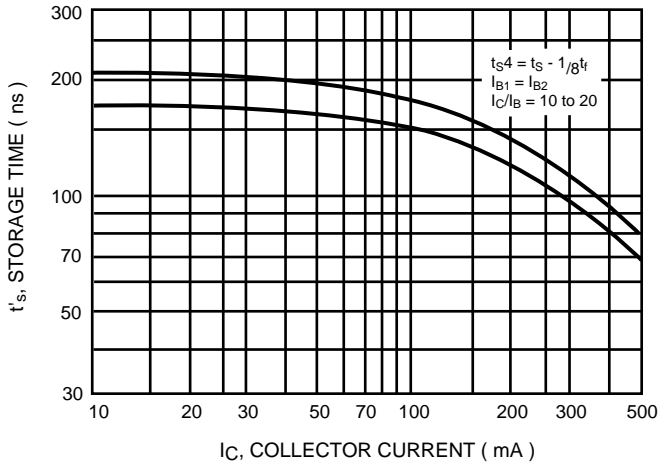


Figure 7. Storage Time

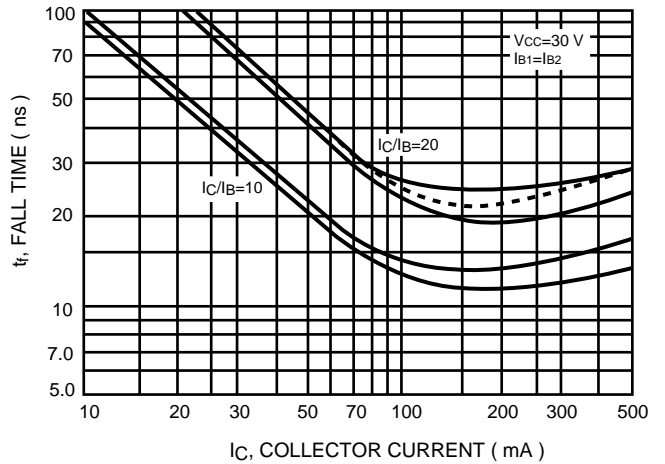


Figure 8. Fall Time

SMALL-SIGNAL CHARACTERISTICS  
NOISE FIGURE

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

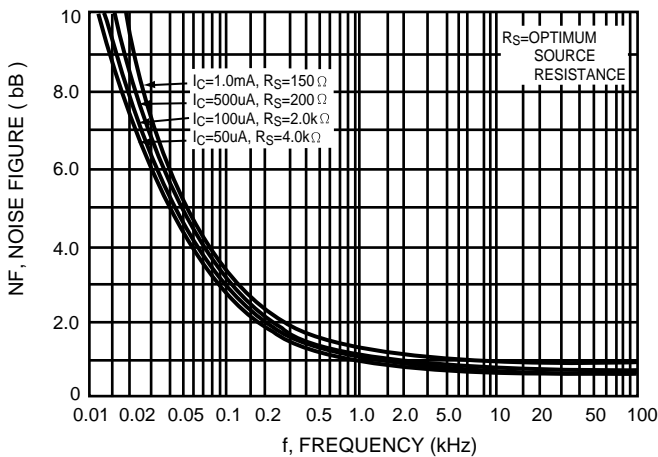


Figure 9. Frequency Effects

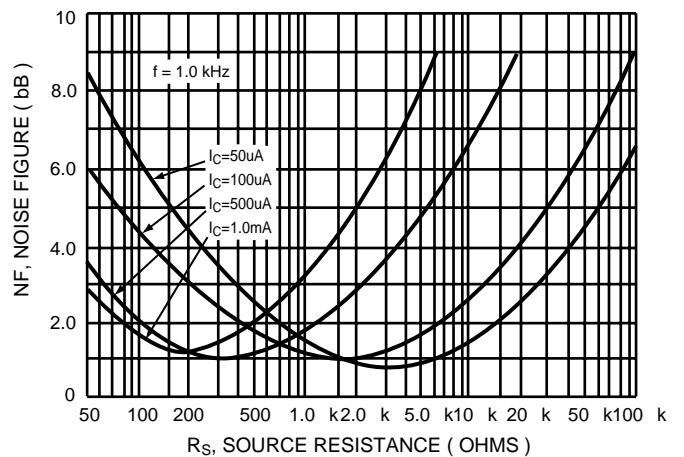


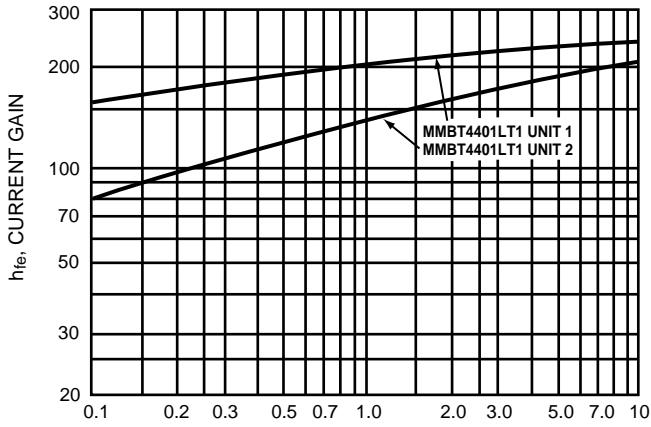
Figure 10. Source Resistance Effects

**h PARAMETERS**

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

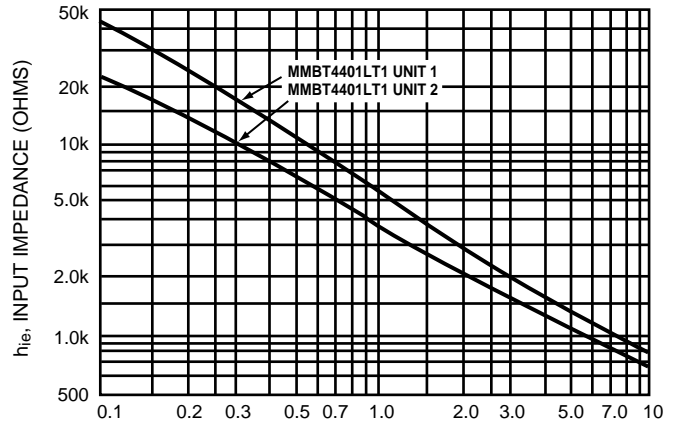
This group of graphs illustrates the relationship between  $h_{fe}$  and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were

selected from the MMBT4401LT1 lines, and the same units were used to develop the correspondingly numbered curves on each graph.



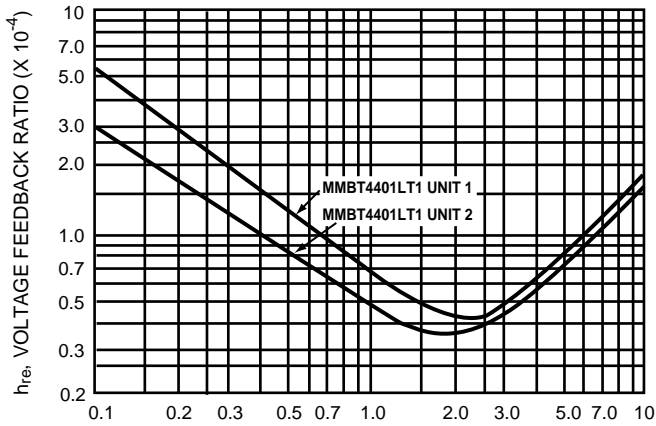
$I_C$ , COLLECTOR CURRENT ( mA )

**Figure 11. Current Gain**



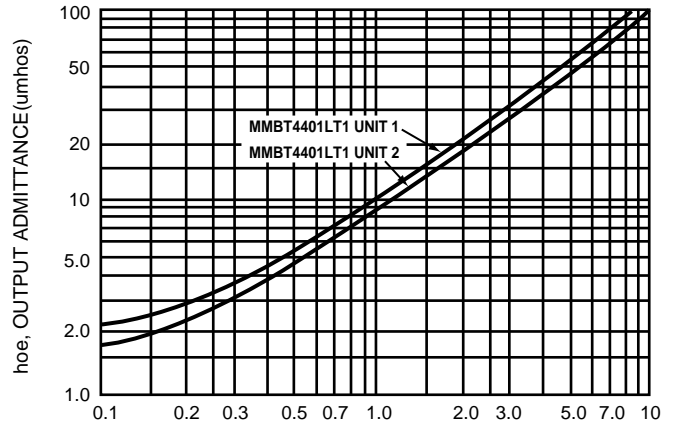
$I_C$ , COLLECTOR CURRENT ( mA )

**Figure 12. Input Impedance**



$I_C$ , COLLECTOR CURRENT ( mA )

**Figure 13. Voltage Feedback Ratio**



$I_C$ , COLLECTOR CURRENT ( mA )

**Figure 14. Output Admittance**

STATIC CHARACTERISTICS

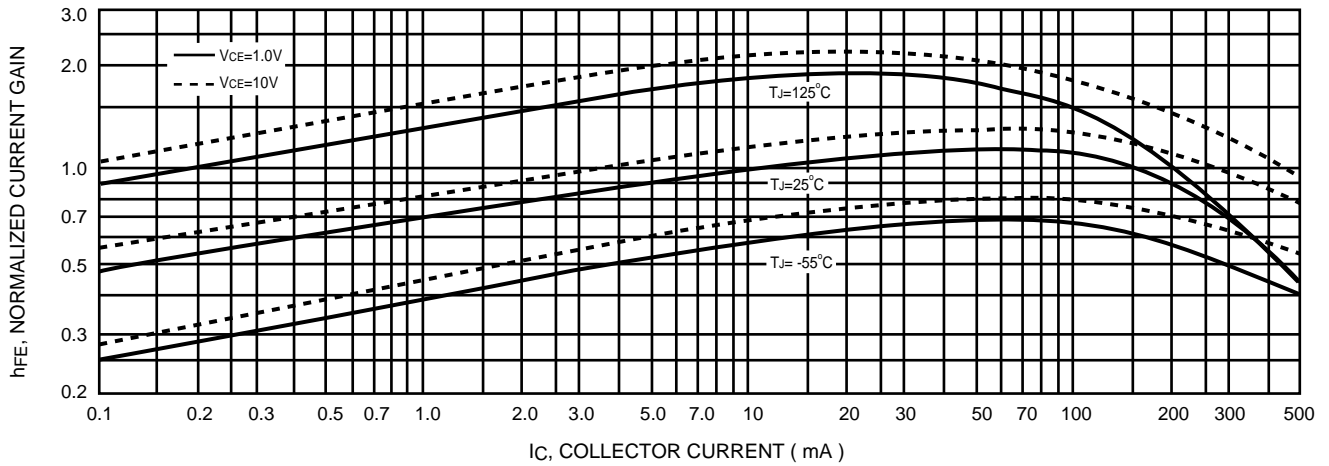


Figure 15. DC Current Gain

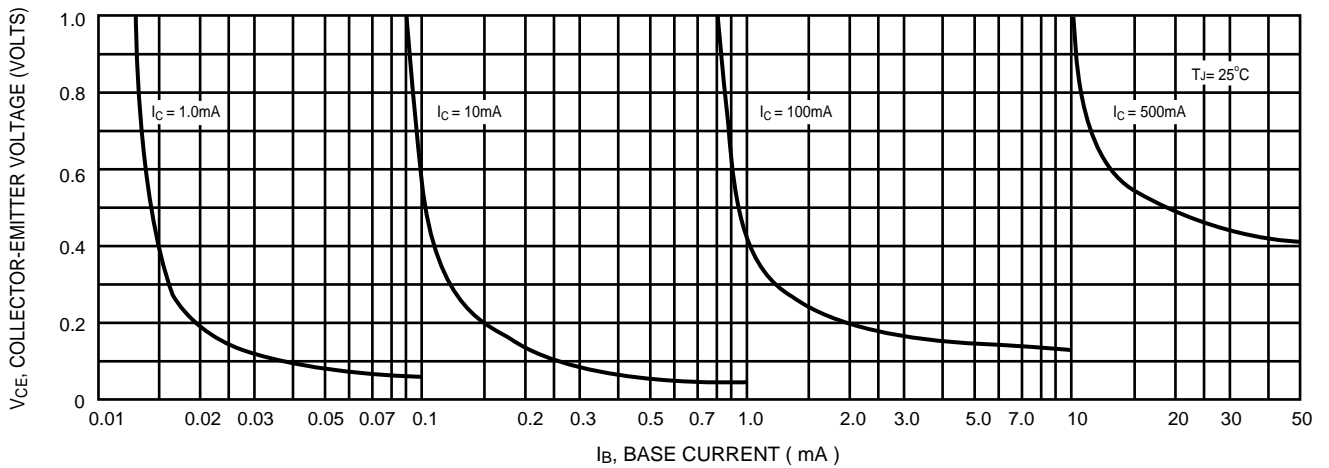


Figure 16. Collector Saturation Region

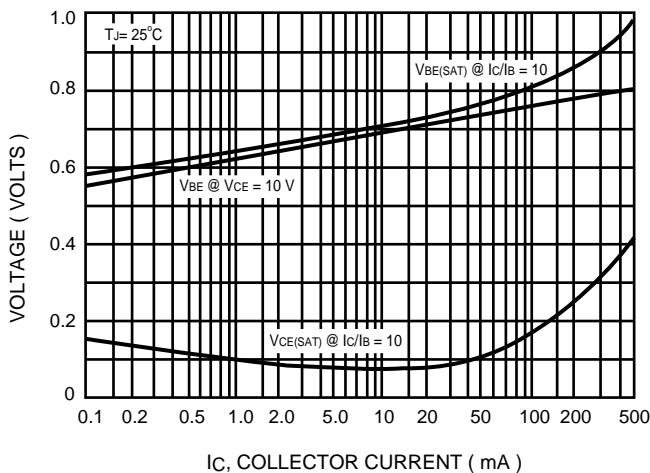


Figure 17. " ON " Voltage

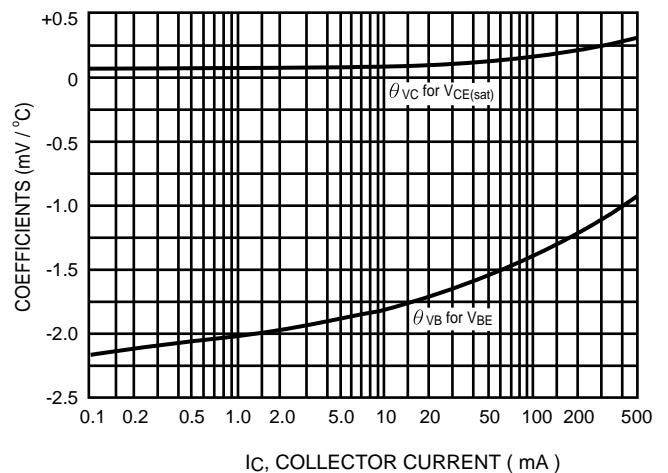


Figure 18. Temperature Coefficients