

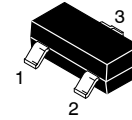
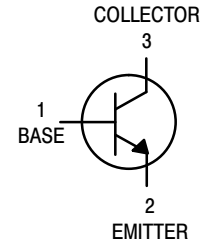
# Switching Transistor

## NPN Silicon

### MMBT4401L, SMMBT4401L

#### Features

- S Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant



SOT-23 (TO-236)  
CASE 318  
STYLE 6

#### 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 |
| Collector Current - Peak       | $I_{CM}$  | 900   | mAdc |

#### THERMAL CHARACTERISTICS

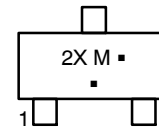
| Characteristic   | Symbol          | Max         | Unit                       |
|--|-----------------|-------------|----------------------------|
| Total Device Dissipation FR-5 Board<br>(Note 1) @ $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$        | $P_D$           | 225<br>1.8  | mW<br>mW/ $^\circ\text{C}$ |
| Thermal Resistance, Junction-to-Ambient  | $R_{\theta JA}$ | 556         | $^\circ\text{C}/\text{W}$  |
| Total Device Dissipation Alumina<br>Substrate (Note 2) @ $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$           | 300<br>2.4  | mW<br>mW/ $^\circ\text{C}$ |
| Thermal Resistance, Junction-to-Ambient  | $R_{\theta JA}$ | 417         | $^\circ\text{C}/\text{W}$  |
| Junction and Storage Temperature   | $T_J, T_{stg}$  | -55 to +150 | $^\circ\text{C}$           |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

\*Transient pulses must not cause the junction temperature to be exceeded.

1. FR-5 =  $1.0 \times 0.75 \times 0.062$  in.
2. Alumina =  $0.4 \times 0.3 \times 0.024$  in. 99.5% alumina.

#### MARKING DIAGRAM



- 2X = Specific Device Code
- M = Date Code\*
- = Pb-Free Package

(Note: Microdot may be in either location)

\*Date Code orientation and/or overbar may vary depending upon manufacturing location.

#### ORDERING INFORMATION

| Device                        | Package             | Shipping <sup>†</sup> |
|-------------------------------|---------------------|-----------------------|
| MMBT4401LT1G<br>SMMBT4401LT1G | SOT-23<br>(Pb-Free) | 3000 / Tape & Reel    |
| MMBT4401LT3G                  | SOT-23<br>(Pb-Free) | 10,000 / Tape & Reel  |

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# MMBT4401L, SMMBT4401L

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

| Characteristic   | Symbol               | Min | Max | Unit             |
|--|----------------------|-----|-----|------------------|
| <b>OFF CHARACTERISTICS</b>   |                      |     |     |                  |
| Collector - Emitter Breakdown Voltage (Note 3)<br>(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , I <sub>B</sub> = 0) | V <sub>(BR)CEO</sub> | 40  | -   | V <sub>dc</sub>  |
| Collector - Base Breakdown Voltage<br>(I <sub>C</sub> = 0.1 mA <sub>dc</sub> , I <sub>E</sub> = 0)             | V <sub>(BR)CBO</sub> | 60  | -   | V <sub>dc</sub>  |
| Emitter - Base Breakdown Voltage<br>(I <sub>E</sub> = 0.1 mA <sub>dc</sub> , I <sub>C</sub> = 0)               | V <sub>(BR)EBO</sub> | 6.0 | -   | V <sub>dc</sub>  |
| Base Cutoff Current<br>(V <sub>CE</sub> = 35 V <sub>dc</sub> , V <sub>EB</sub> = 0.4 V <sub>dc</sub> )         | I <sub>BEV</sub>     | -   | 0.1 | μA <sub>dc</sub> |
| Collector Cutoff Current<br>(V <sub>CE</sub> = 35 V <sub>dc</sub> , V <sub>EB</sub> = 0.4 V <sub>dc</sub> )    | I <sub>CEX</sub>     | -   | 0.1 | μA <sub>dc</sub> |

## ON CHARACTERISTICS (Note 3)

|  |                      |                             |                         |                 |
|--|----------------------|-----------------------------|-------------------------|-----------------|
| DC Current Gain<br>(I <sub>C</sub> = 0.1 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )<br>(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )<br>(I <sub>C</sub> = 10 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )<br>(I <sub>C</sub> = 150 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )<br>(I <sub>C</sub> = 500 mA <sub>dc</sub> , V <sub>CE</sub> = 2.0 V <sub>dc</sub> ) | h <sub>FE</sub>      | 20<br>40<br>80<br>100<br>40 | -<br>-<br>-<br>300<br>- | -               |
| Collector - Emitter Saturation Voltage<br>(I <sub>C</sub> = 150 mA <sub>dc</sub> , I <sub>B</sub> = 15 mA <sub>dc</sub> )<br>(I <sub>C</sub> = 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<br>(I <sub>C</sub> = 150 mA <sub>dc</sub> , I <sub>B</sub> = 15 mA <sub>dc</sub> )<br>(I <sub>C</sub> = 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 CHARACTERISTICS

|   |                 |     |     |                    |
|---|-----------------|-----|-----|--------------------|
| Current - Gain - Bandwidth Product<br>(I <sub>C</sub> = 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>(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 V <sub>dc</sub> , f = 1.0 kHz)                   | h <sub>ie</sub> | 1.0 | 15  | kΩ                 |
| Voltage Feedback Ratio<br>(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 V <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>(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 V <sub>dc</sub> , f = 1.0 kHz)       | h <sub>fe</sub> | 40  | 500 | -                  |
| Output Admittance<br>(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 V <sub>dc</sub> , f = 1.0 kHz)                 | h <sub>oe</sub> | 1.0 | 30  | μmhos              |

## SWITCHING CHARACTERISTICS

|              |  |                |   |     |    |
|--------------|--|----------------|---|-----|----|
| Delay Time   | (V <sub>CC</sub> = 30 V <sub>dc</sub> , V <sub>EB</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> , I <sub>C</sub> = 150 mA <sub>dc</sub> ,<br>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  |    |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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

## SWITCHING TIME EQUIVALENT TEST CIRCUITS

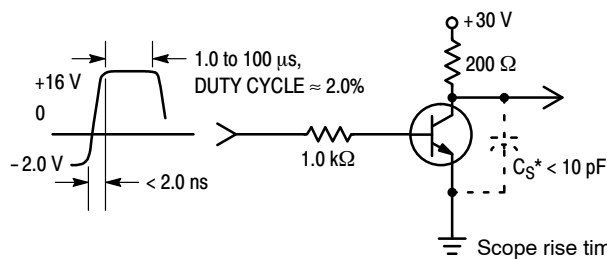


Figure 1. Turn-On Time

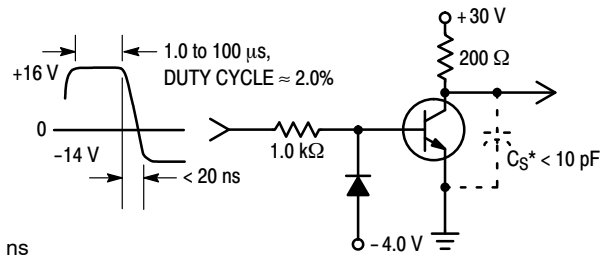


Figure 2. Turn-Off Time

# MMBT4401L, SMMBT4401L

## TRANSIENT CHARACTERISTICS

— 25°C    - - - 100°C

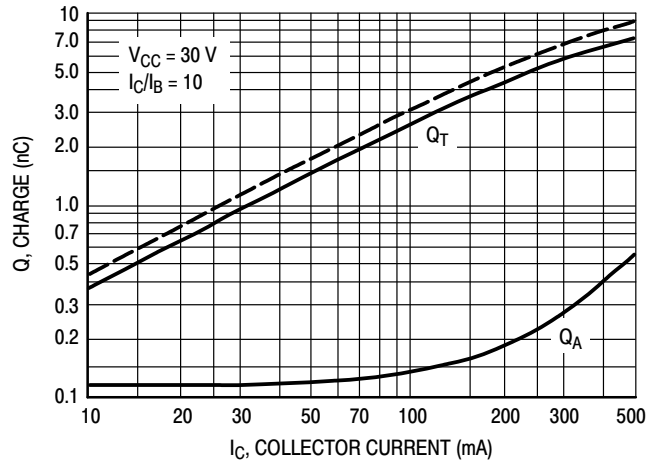


Figure 3. Charge Data

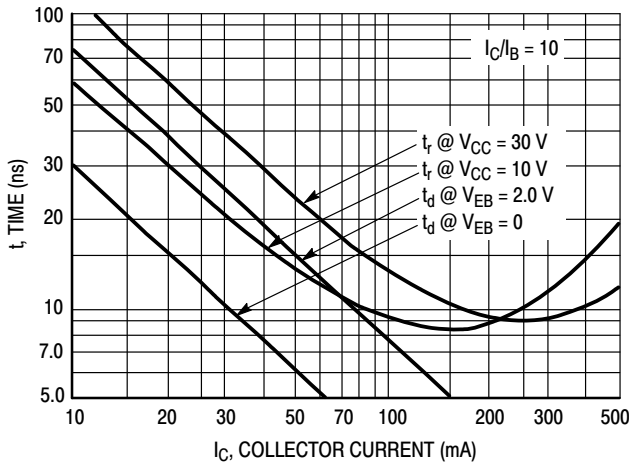


Figure 4. Turn-On Time

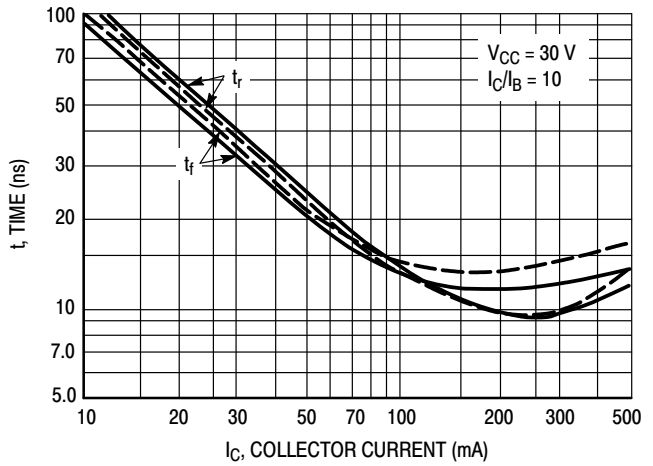


Figure 5. Rise and Fall Times

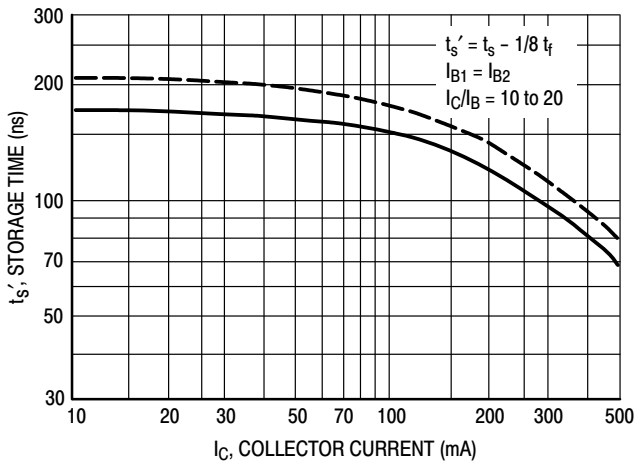


Figure 6. Storage Time

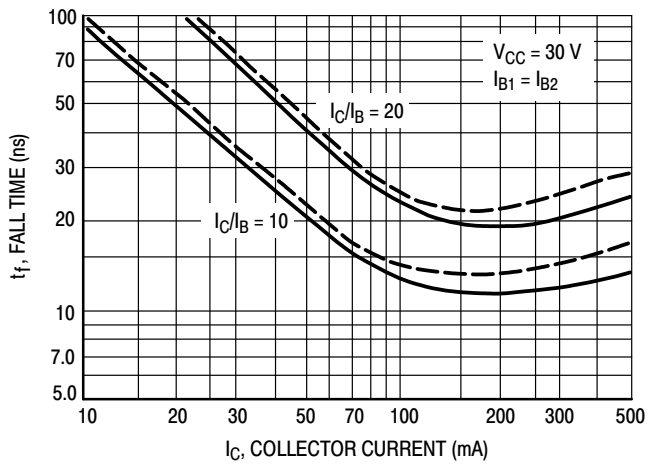


Figure 7. Fall Time

# MMBT4401L, SMMBT4401L

## SMALL-SIGNAL CHARACTERISTICS NOISE FIGURE

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

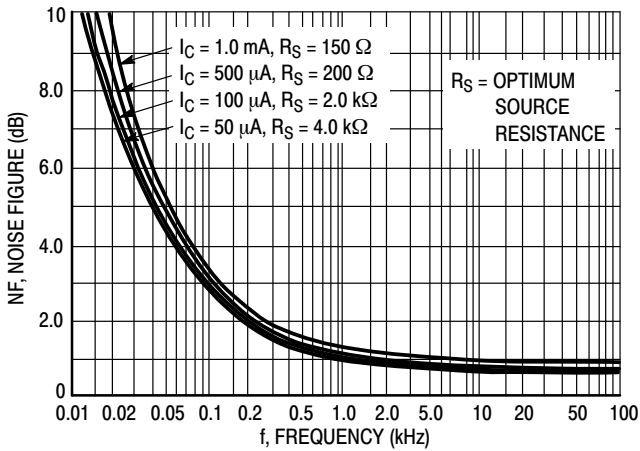


Figure 8. Frequency Effects

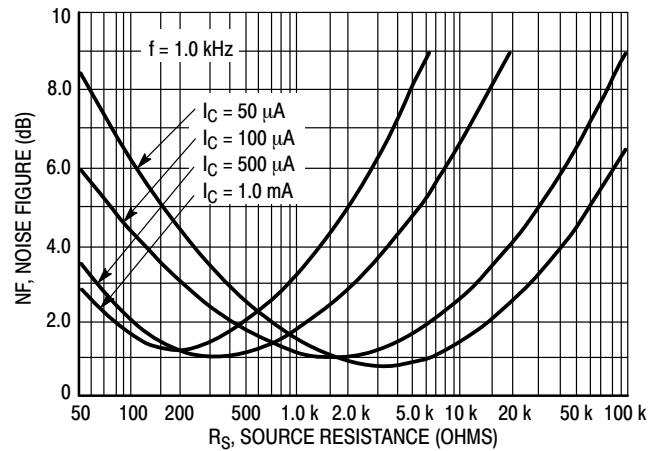


Figure 9. Source Resistance Effects

## 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.

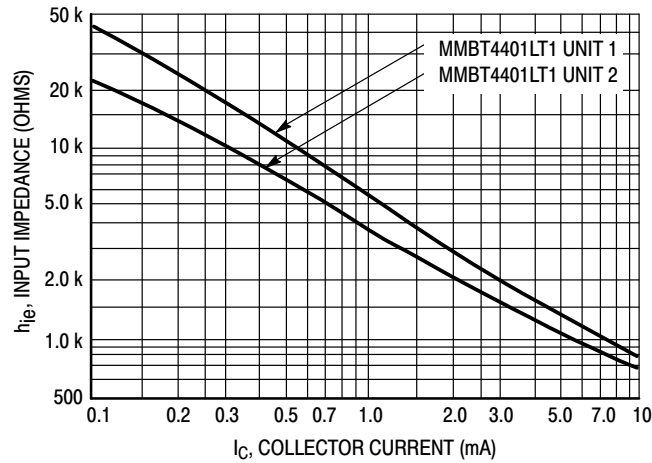


Figure 10. Input Impedance

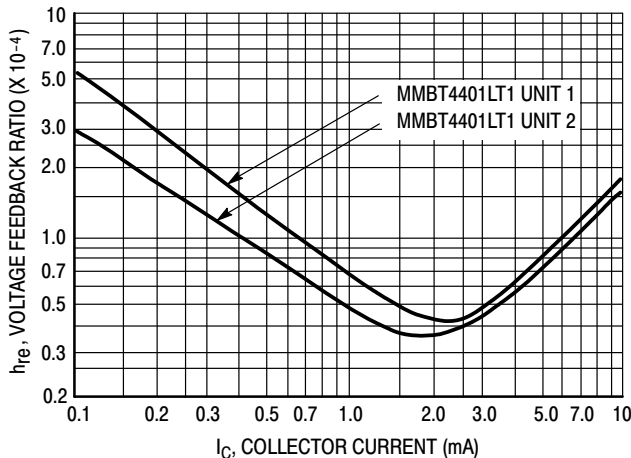


Figure 11. Voltage Feedback Ratio

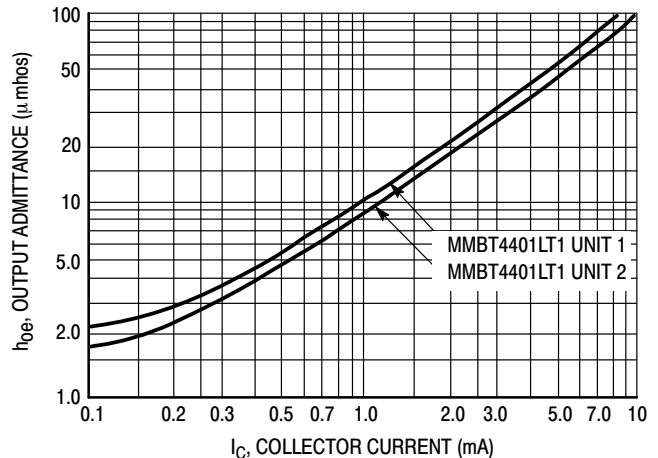


Figure 12. Output Admittance

# MMBT4401L, SMMBT4401L

## STATIC CHARACTERISTICS

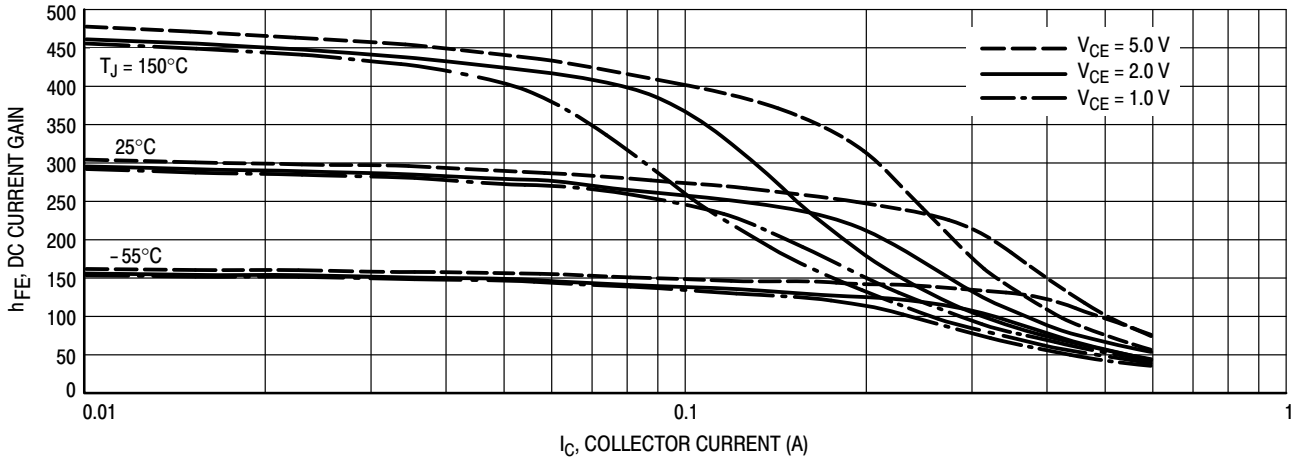


Figure 13. DC Current Gain

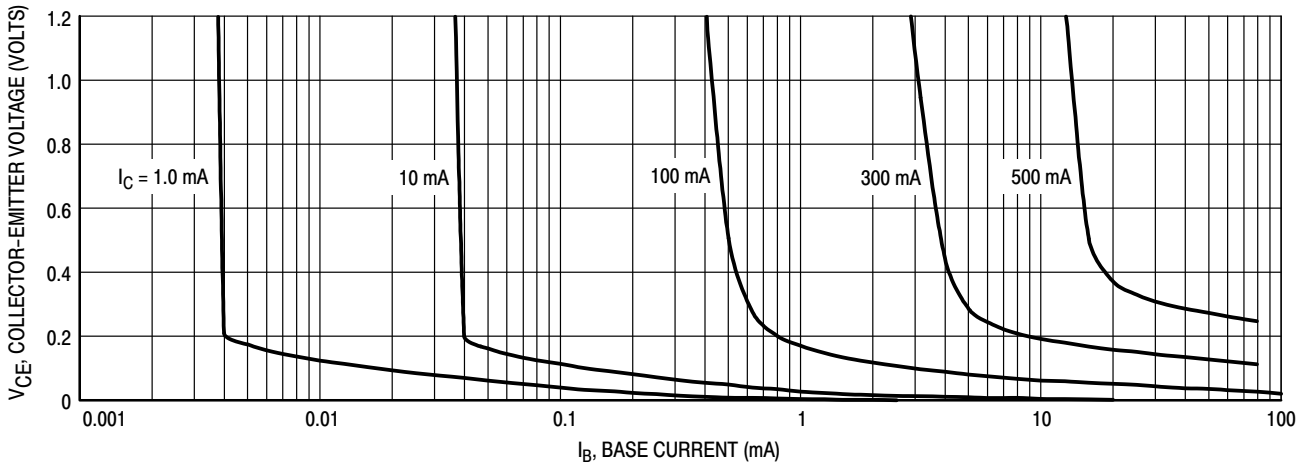


Figure 14. Collector Saturation Region

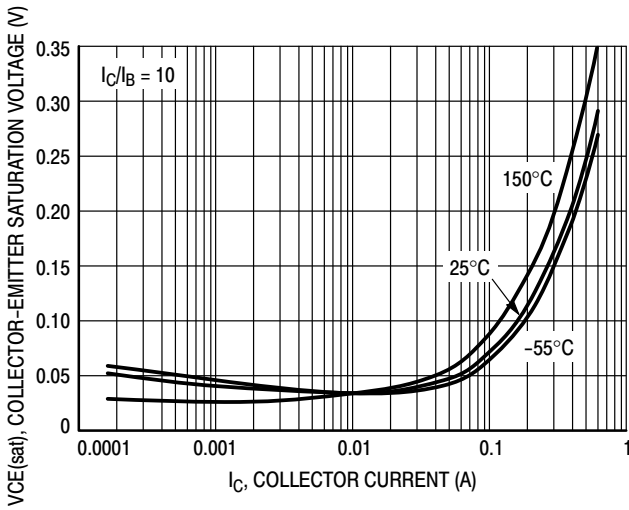


Figure 15. Collector-Emitter Saturation Voltage vs. Collector Current

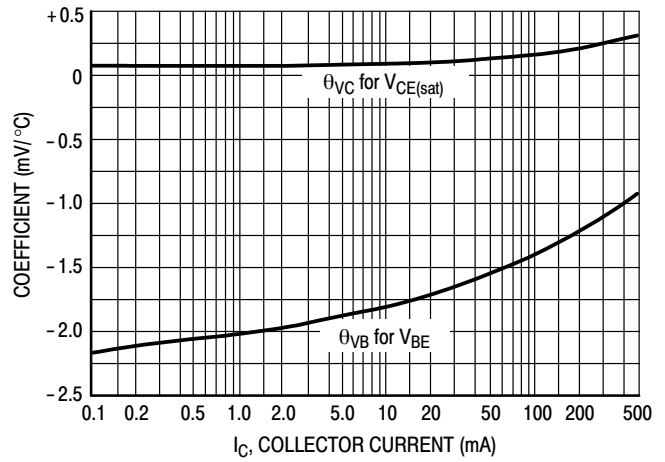
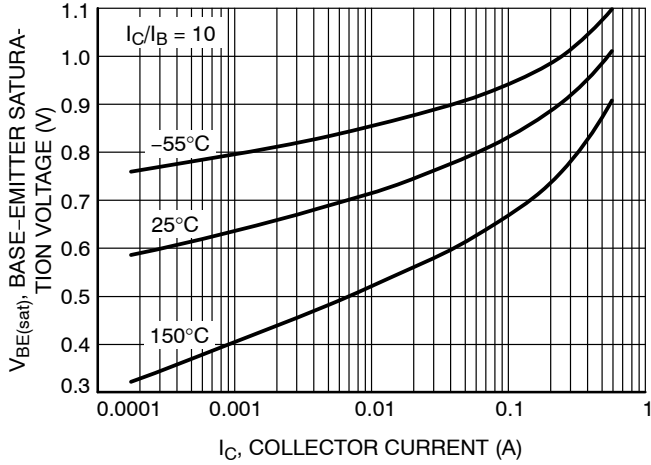


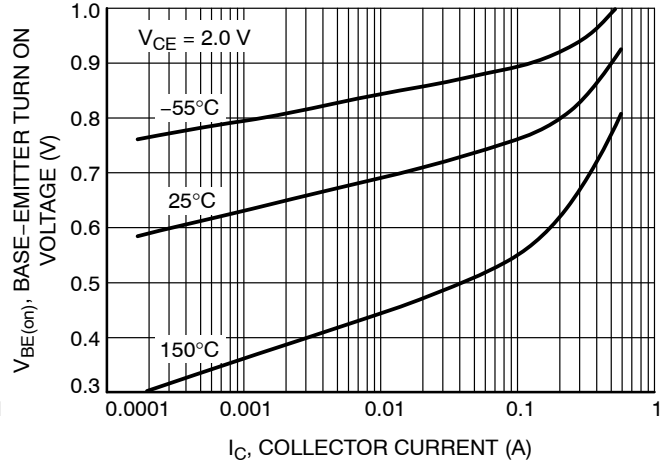
Figure 16. Temperature Coefficients

# MMBT4401L, SMMBT4401L

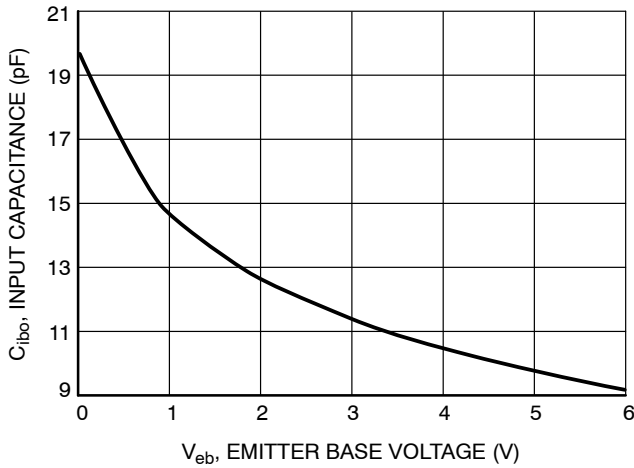
## STATIC CHARACTERISTICS



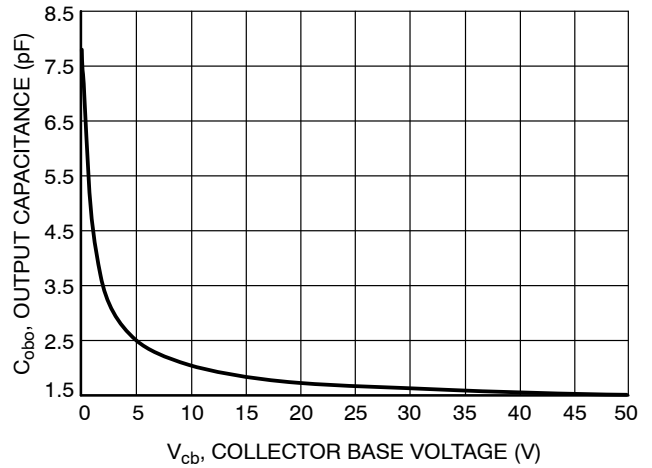
**Figure 17. Base-Emitter Saturation Voltage vs. Collector Current**



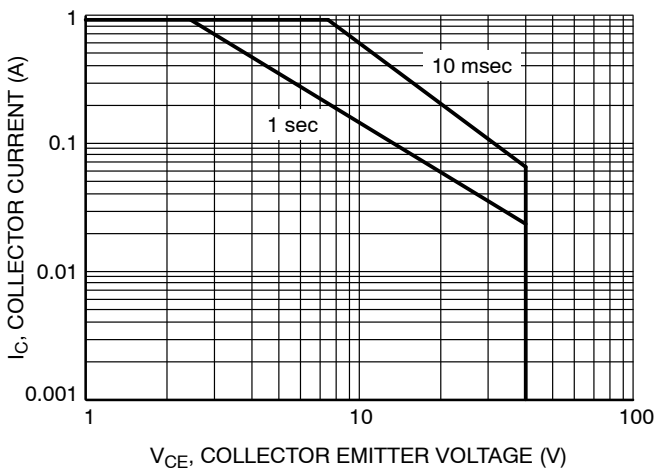
**Figure 18. Base-Emitter Turn On Voltage vs. Collector Current**



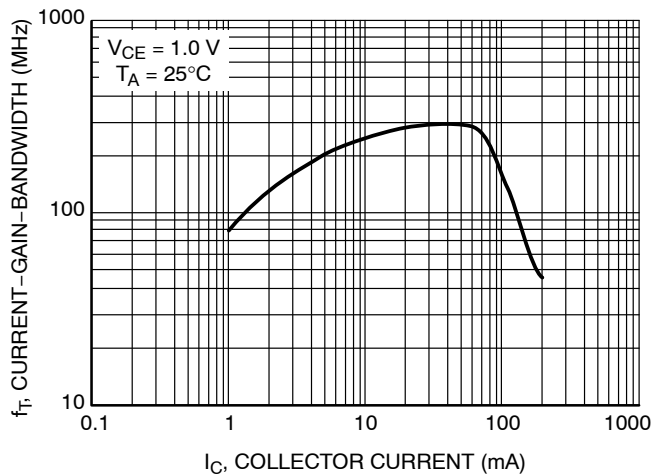
**Figure 19. Input Capacitance vs. Emitter Base Voltage**



**Figure 20. Output Capacitance vs. Collector Base Voltage**



**Figure 21. Safe Operating Area**



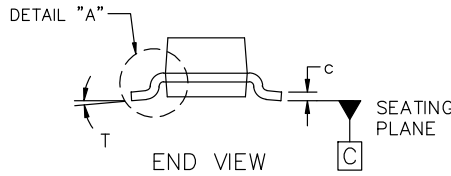
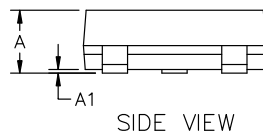
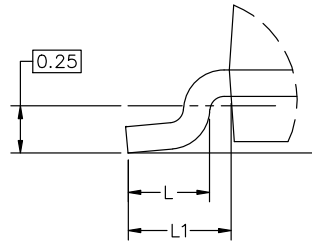
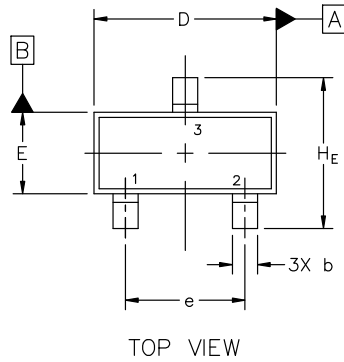
**Figure 22. Current-Gain-Bandwidth Product**



SCALE 4:1

**SOT-23 (TO-236) 2.90x1.30x1.00 1.90P**  
CASE 318  
ISSUE AU

DATE 14 AUG 2024

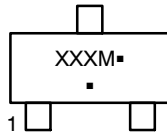


| MILLIMETERS |      |      |      |
|-------------|------|------|------|
| DIM         | MIN  | NOM  | MAX  |
| A           | 0.89 | 1.00 | 1.11 |
| A1          | 0.01 | 0.06 | 0.10 |
| b           | 0.37 | 0.44 | 0.50 |
| c           | 0.08 | 0.14 | 0.20 |
| D           | 2.80 | 2.90 | 3.04 |
| E           | 1.20 | 1.30 | 1.40 |
| e           | 1.78 | 1.90 | 2.04 |
| L           | 0.30 | 0.43 | 0.55 |
| L1          | 0.35 | 0.54 | 0.69 |
| HE          | 2.10 | 2.40 | 2.64 |
| T           | 0°   | ---  | 10°  |

NOTES:

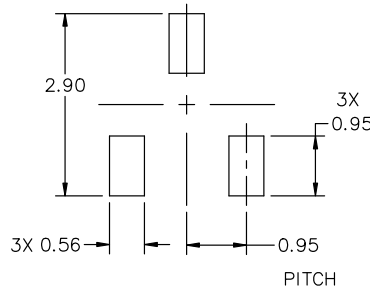
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2018.
2. CONTROLLING DIMENSIONS: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

**GENERIC MARKING DIAGRAM\***



XXX = Specific Device Code  
M = Date Code  
▪ = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.



\* For additional information on our Pb-Free strategy and soldering details, please download the onsemi Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

**STYLES ON PAGE 2**

|                         |   |  |
|-------------------------|---|--|
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| <b>DESCRIPTION:</b>     | <b>SOT-23 (TO-236) 2.90x1.30x1.00 1.90P</b> | <b>PAGE 1 OF 2</b>   |

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**SOT-23 (TO-236) 2.90x1.30x1.00 1.90P**  
**CASE 318**  
**ISSUE AU**

DATE 14 AUG 2024

STYLE 1 THRU 5:  
CANCELLED

STYLE 6:  
PIN 1. BASE  
2. EMITTER  
3. COLLECTOR

STYLE 7:  
PIN 1. EMITTER  
2. BASE  
3. COLLECTOR

STYLE 8:  
PIN 1. ANODE  
2. NO CONNECTION  
3. CATHODE

STYLE 9:  
PIN 1. ANODE  
2. ANODE  
3. CATHODE

STYLE 10:  
PIN 1. DRAIN  
2. SOURCE  
3. GATE

STYLE 11:  
PIN 1. ANODE  
2. CATHODE  
3. CATHODE-ANODE

STYLE 12:  
PIN 1. CATHODE  
2. CATHODE  
3. ANODE

STYLE 13:  
PIN 1. SOURCE  
2. DRAIN  
3. GATE

STYLE 14:  
PIN 1. CATHODE  
2. GATE  
3. ANODE

STYLE 15:  
PIN 1. GATE  
2. CATHODE  
3. ANODE

STYLE 16:  
PIN 1. ANODE  
2. CATHODE  
3. CATHODE

STYLE 17:  
PIN 1. NO CONNECTION  
2. ANODE  
3. CATHODE

STYLE 18:  
PIN 1. NO CONNECTION  
2. CATHODE  
3. ANODE

STYLE 19:  
PIN 1. CATHODE  
2. ANODE  
3. CATHODE-ANODE

STYLE 20:  
PIN 1. CATHODE  
2. ANODE  
3. GATE

STYLE 21:  
PIN 1. GATE  
2. SOURCE  
3. DRAIN

STYLE 22:  
PIN 1. RETURN  
2. OUTPUT  
3. INPUT

STYLE 23:  
PIN 1. ANODE  
2. ANODE  
3. CATHODE

STYLE 24:  
PIN 1. GATE  
2. DRAIN  
3. SOURCE

STYLE 25:  
PIN 1. ANODE  
2. CATHODE  
3. GATE

STYLE 26:  
PIN 1. CATHODE  
2. ANODE  
3. NO CONNECTION

STYLE 27:  
PIN 1. CATHODE  
2. CATHODE  
3. CATHODE

STYLE 28:  
PIN 1. ANODE  
2. ANODE  
3. ANODE

|                         |   |   |
|-------------------------|---|---|
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| <b>DESCRIPTION:</b>     | <b>SOT-23 (TO-236) 2.90x1.30x1.00 1.90P</b> | <b>PAGE 2 OF 2</b>  |

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