

# MMBT4401L, SMMBT4401L

## Switching Transistor

### NPN Silicon

#### Features

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

#### 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         | $^\circ\text{C/W}$         |
| 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         | $^\circ\text{C/W}$         |
| Junction and Storage Temperature                                                                                     | $T_J, T_{stg}$  | -55 to +150 | $^\circ\text{C}$           |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

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

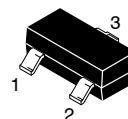
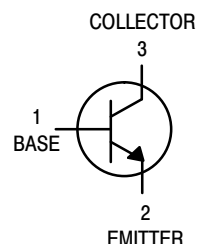
1. FR-5 =  $1.0 \times 0.75 \times 0.062$  in.

2. Alumina =  $0.4 \times 0.3 \times 0.024$  in. 99.5% alumina.



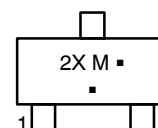
ON Semiconductor®

<http://onsemi.com>



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

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

†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.

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

| Characteristic                                                                          | Symbol        | Min | Max | Unit            |
|-----------------------------------------------------------------------------------------|---------------|-----|-----|-----------------|
| <b>OFF CHARACTERISTICS</b>                                                              |               |     |     |                 |
| Collector – Emitter Breakdown Voltage (Note 3)<br>( $I_C = 1.0\text{ mA}$ , $I_B = 0$ ) | $V_{(BR)CEO}$ | 40  | –   | Vdc             |
| Collector – Base Breakdown Voltage<br>( $I_C = 0.1\text{ mA}$ , $I_E = 0$ )             | $V_{(BR)CBO}$ | 60  | –   | Vdc             |
| Emitter – Base Breakdown Voltage<br>( $I_E = 0.1\text{ mA}$ , $I_C = 0$ )               | $V_{(BR)EBO}$ | 6.0 | –   | Vdc             |
| Base Cutoff Current<br>( $V_{CE} = 35\text{ Vdc}$ , $V_{EB} = 0.4\text{ Vdc}$ )         | $I_{BEV}$     | –   | 0.1 | $\mu\text{Adc}$ |
| Collector Cutoff Current<br>( $V_{CE} = 35\text{ Vdc}$ , $V_{EB} = 0.4\text{ Vdc}$ )    | $I_{CEX}$     | –   | 0.1 | $\mu\text{Adc}$ |

## ON CHARACTERISTICS (Note 3)

|                                                                                                                                                                                                                                                                                                             |               |                             |                         |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----------------------------|-------------------------|-----|
| DC Current Gain<br>( $I_C = 0.1\text{ mA}$ , $V_{CE} = 1.0\text{ Vdc}$ )<br>( $I_C = 1.0\text{ mA}$ , $V_{CE} = 1.0\text{ Vdc}$ )<br>( $I_C = 10\text{ mA}$ , $V_{CE} = 1.0\text{ Vdc}$ )<br>( $I_C = 150\text{ mA}$ , $V_{CE} = 1.0\text{ Vdc}$ )<br>( $I_C = 500\text{ mA}$ , $V_{CE} = 2.0\text{ Vdc}$ ) | $h_{FE}$      | 20<br>40<br>80<br>100<br>40 | –<br>–<br>–<br>300<br>– | –   |
| Collector – Emitter Saturation Voltage<br>( $I_C = 150\text{ mA}$ , $I_B = 15\text{ mA}$ )<br>( $I_C = 500\text{ mA}$ , $I_B = 50\text{ mA}$ )                                                                                                                                                              | $V_{CE(sat)}$ | –<br>–                      | 0.4<br>0.75             | Vdc |
| Base – Emitter Saturation Voltage<br>( $I_C = 150\text{ mA}$ , $I_B = 15\text{ mA}$ )<br>( $I_C = 500\text{ mA}$ , $I_B = 50\text{ mA}$ )                                                                                                                                                                   | $V_{BE(sat)}$ | 0.75<br>–                   | 0.95<br>1.2             | Vdc |

## SMALL-SIGNAL CHARACTERISTICS

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

## SWITCHING CHARACTERISTICS

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

3. Pulse Test: Pulse Width  $\leq 300\text{ }\mu\text{s}$ , Duty Cycle  $\leq 2.0\%$ .

## SWITCHING TIME EQUIVALENT TEST CIRCUITS

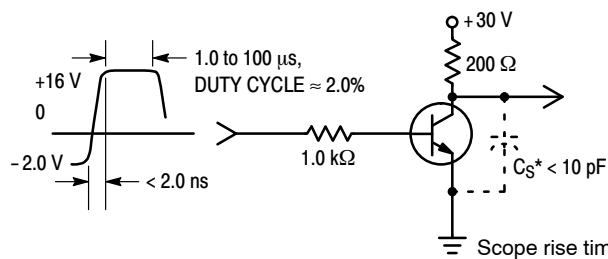


Figure 1. Turn-On Time

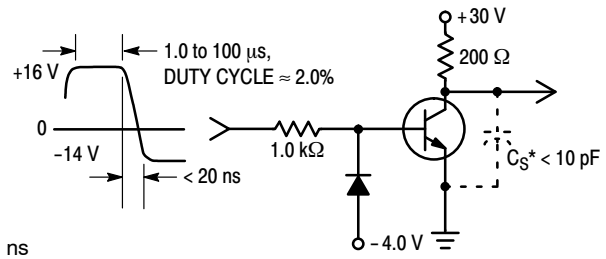


Figure 2. Turn-Off Time

# MMBT4401L, SMMBT4401L

## TRANSIENT CHARACTERISTICS

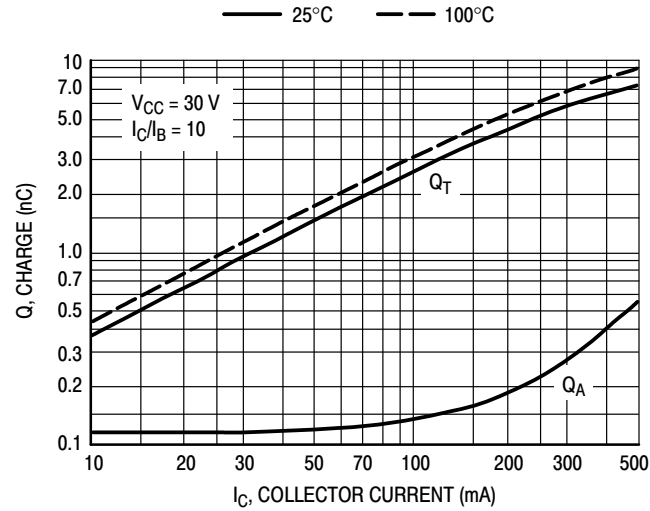


Figure 3. Charge Data

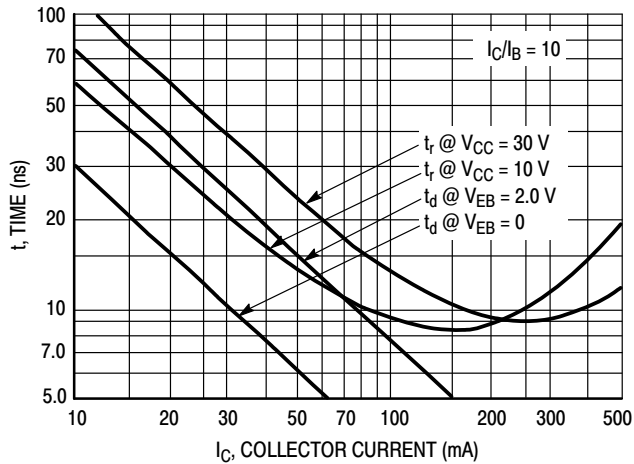


Figure 4. Turn-On Time

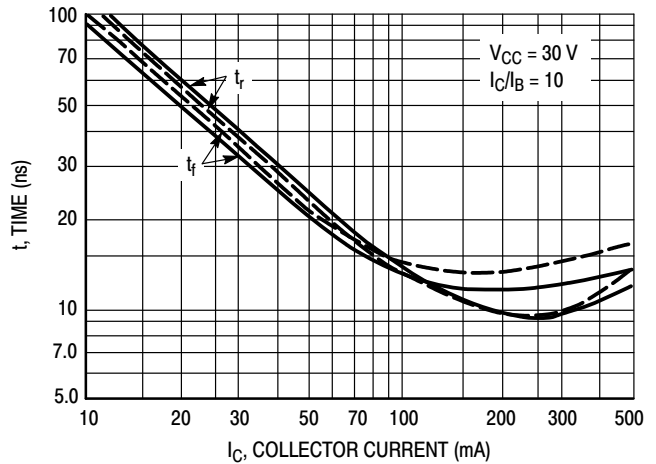


Figure 5. Rise and Fall Times

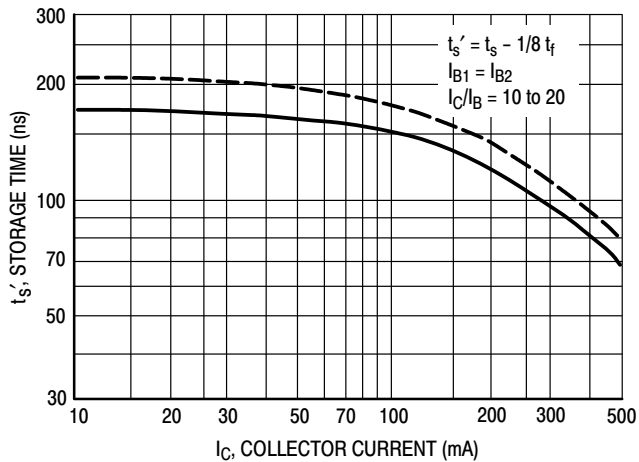


Figure 6. Storage Time

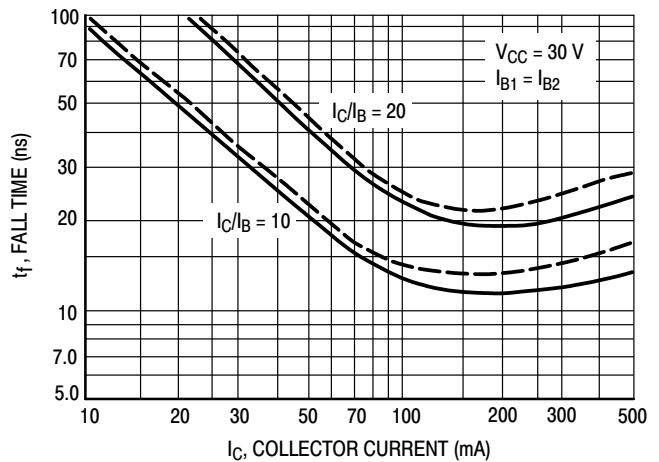


Figure 7. Fall Time

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## SMALL-SIGNAL CHARACTERISTICS NOISE FIGURE

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

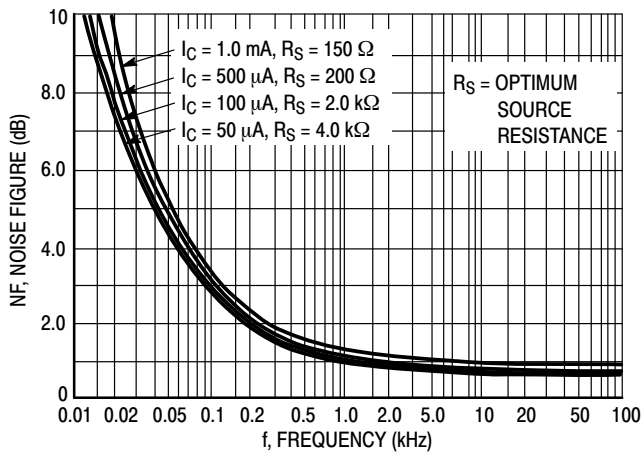


Figure 8. Frequency Effects

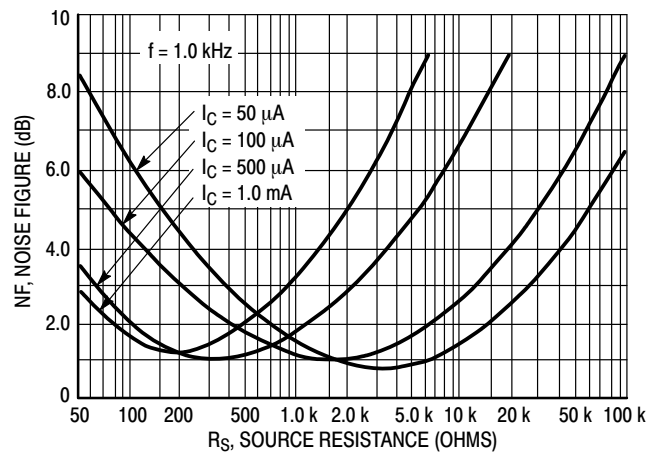


Figure 9. Source Resistance Effects

## 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.

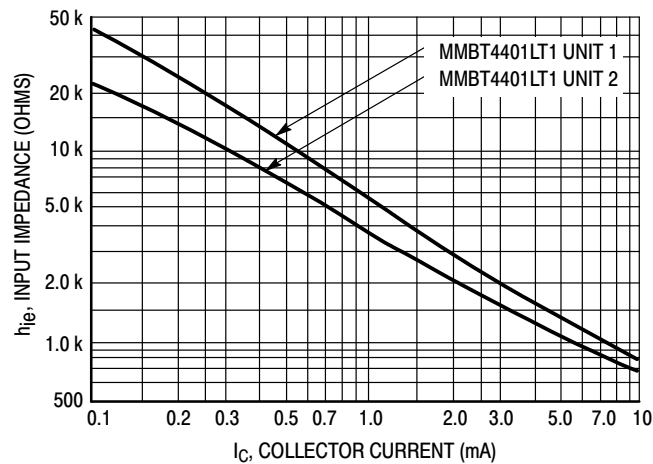


Figure 10. Input Impedance

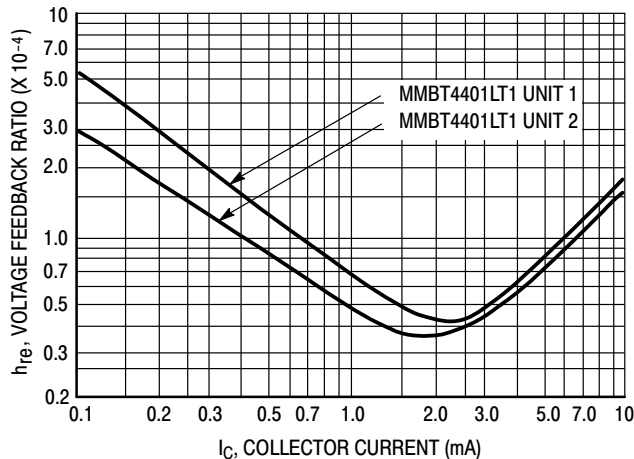


Figure 11. Voltage Feedback Ratio

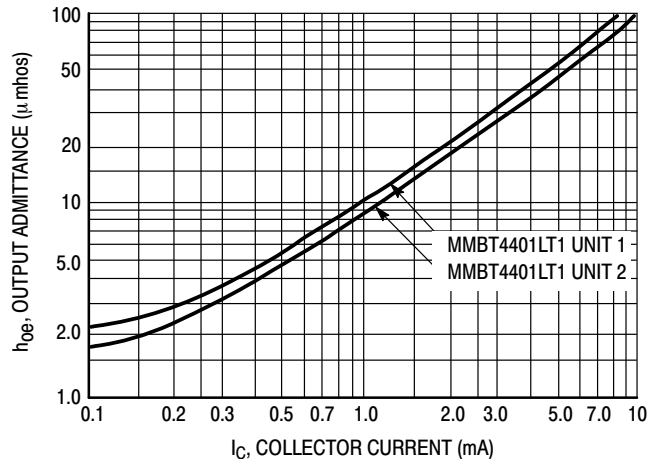


Figure 12. Output Admittance

# MMBT4401L, SMMBT4401L

## STATIC CHARACTERISTICS

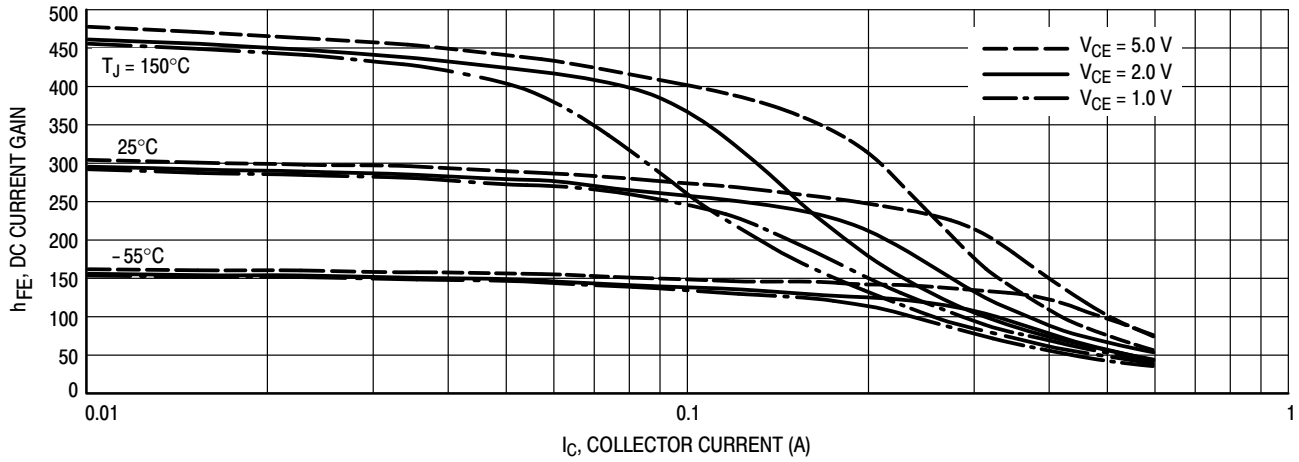


Figure 13. DC Current Gain

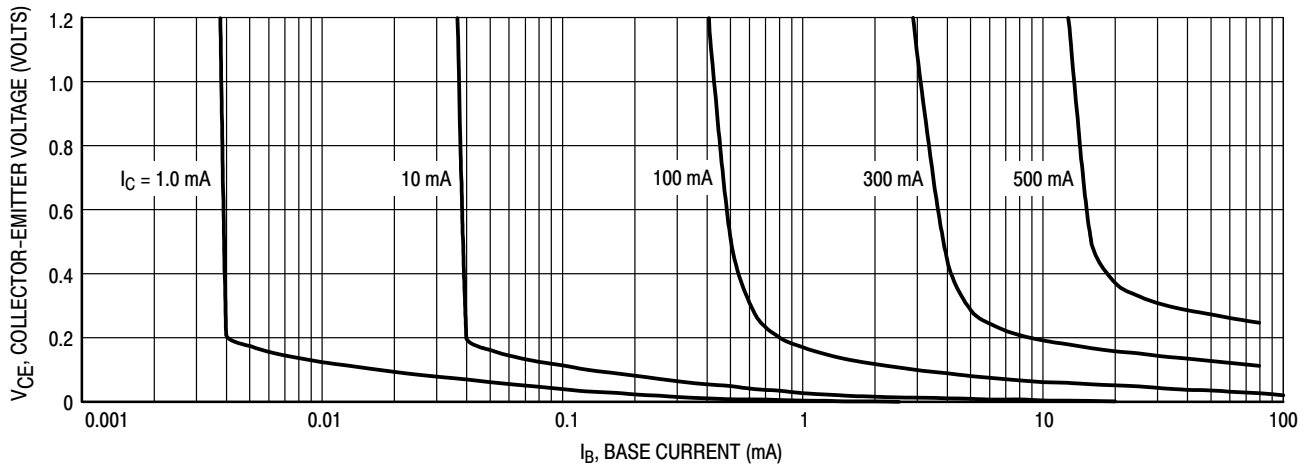


Figure 14. Collector Saturation Region

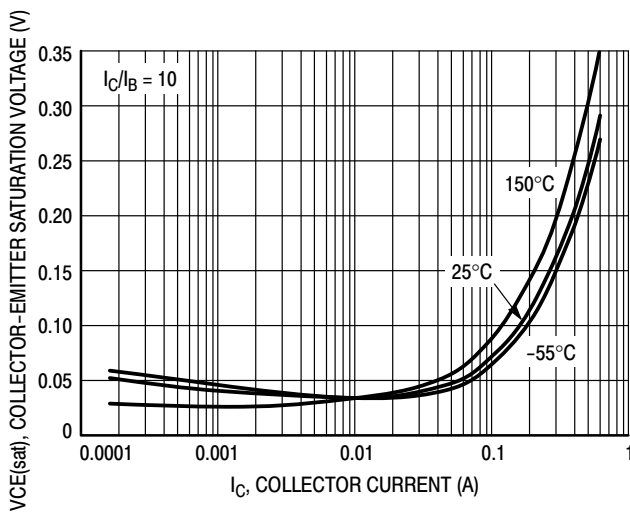


Figure 15. Collector-Emitter Saturation Voltage vs. Collector Current

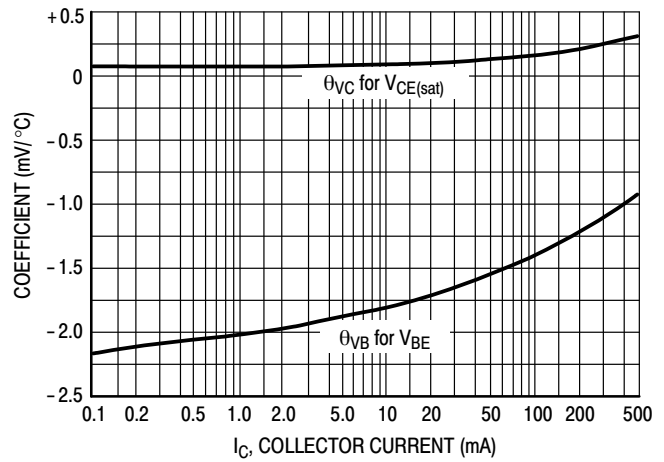
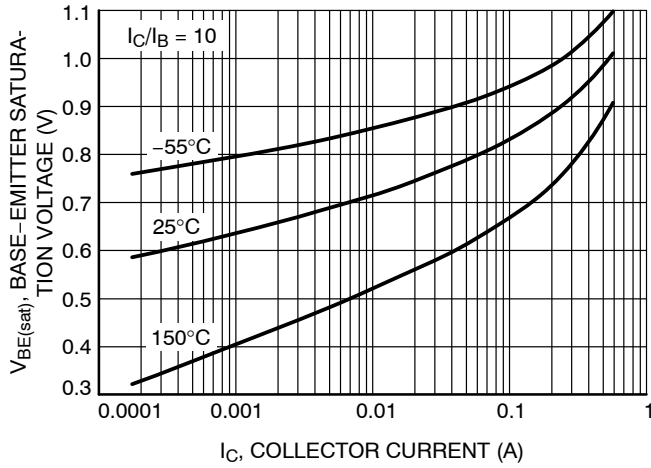


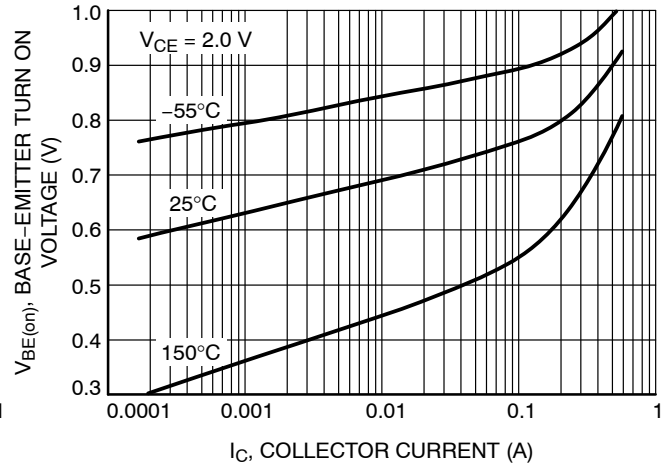
Figure 16. Temperature Coefficients

# MMBT4401L, SMMBT4401L

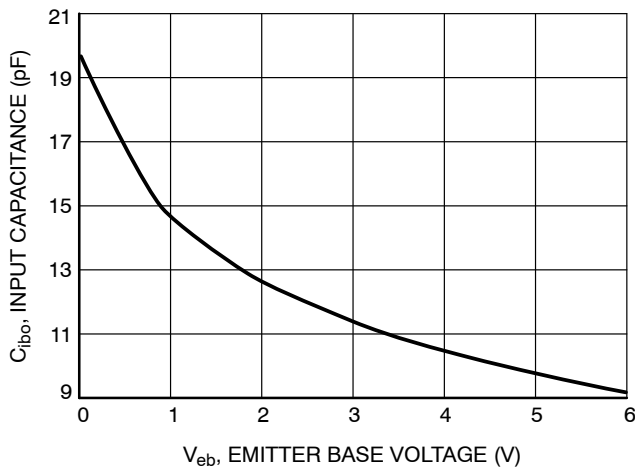
## STATIC CHARACTERISTICS



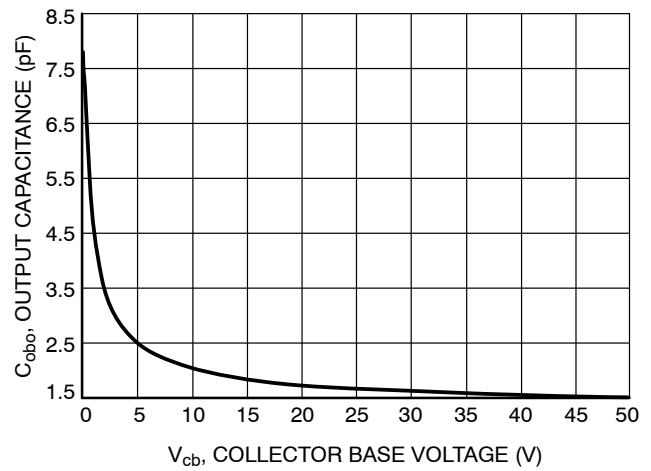
**Figure 17. Base-Emitter Saturation Voltage vs. Collector Current**



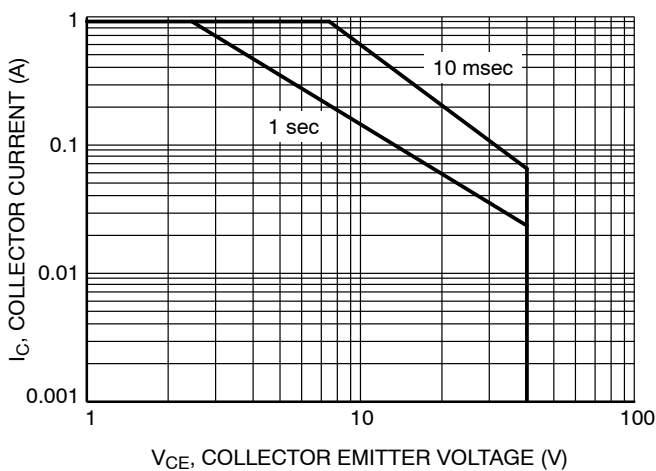
**Figure 18. Base-Emitter Turn On Voltage vs. Collector Current**



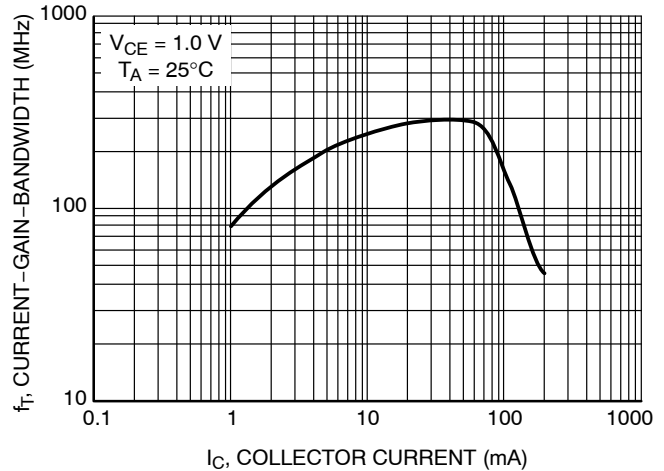
**Figure 19. Input Capacitance vs. Emitter Base Voltage**



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



**Figure 21. Safe Operating Area**

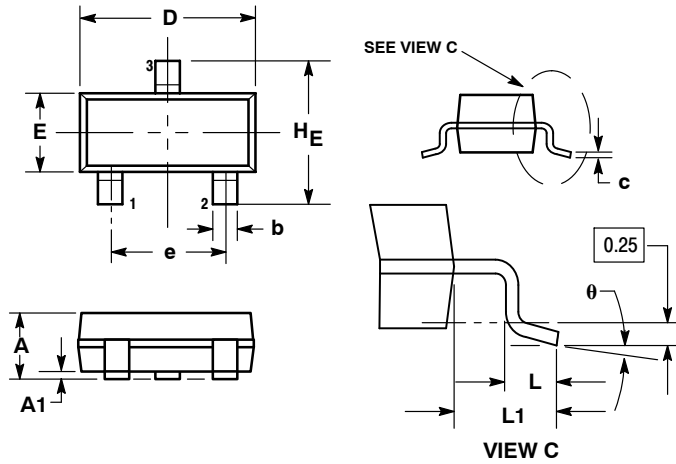


**Figure 22. Current-Gain-Bandwidth Product**

# MMBT4401L, SMMBT4401L

## PACKAGE DIMENSIONS

SOT-23 (TO-236)  
CASE 318-08  
ISSUE AP



### NOTES:

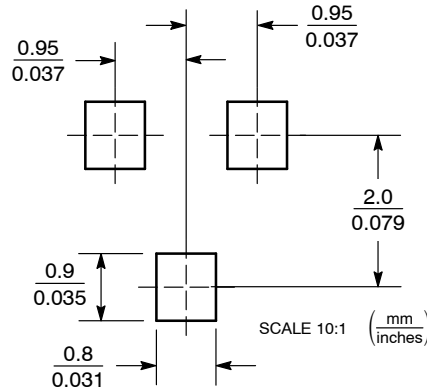
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.

| DIM   | MILLIMETERS |      |      | INCHES |       |       |
|-------|-------------|------|------|--------|-------|-------|
|       | MIN         | NOM  | MAX  | MIN    | NOM   | MAX   |
| A     | 0.89        | 1.00 | 1.11 | 0.035  | 0.040 | 0.044 |
| A1    | 0.01        | 0.06 | 0.10 | 0.001  | 0.002 | 0.004 |
| b     | 0.37        | 0.44 | 0.50 | 0.015  | 0.018 | 0.020 |
| c     | 0.09        | 0.13 | 0.18 | 0.003  | 0.005 | 0.007 |
| D     | 2.80        | 2.90 | 3.04 | 0.110  | 0.114 | 0.120 |
| E     | 1.20        | 1.30 | 1.40 | 0.047  | 0.051 | 0.055 |
| e     | 1.78        | 1.90 | 2.04 | 0.070  | 0.075 | 0.081 |
| L     | 0.10        | 0.20 | 0.30 | 0.004  | 0.008 | 0.012 |
| L1    | 0.35        | 0.54 | 0.69 | 0.014  | 0.021 | 0.029 |
| HE    | 2.10        | 2.40 | 2.64 | 0.083  | 0.094 | 0.104 |
| theta | 0°          | ---  | 10°  | 0°     | ---   | 10°   |

### STYLE 6:

- PIN 1. BASE
- EMITTER
- COLLECTOR

## SOLDERING FOOTPRINT\*



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

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MMBT4401LT1/D



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- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



#### Как с нами связаться

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**Факс:** 8 (812) 320-02-42

**Электронная почта:** [org@eplast1.ru](mailto:org@eplast1.ru)

**Адрес:** 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.