# MMBT4401L, SMMBT4401L

# Switching Transistor

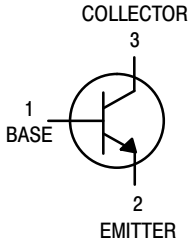
## NPN Silicon

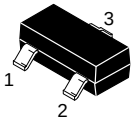
**ON Semiconductor®**

www.onsemi.com

### 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

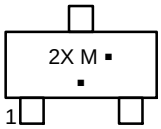
| Characteristic | Symbol | Max | Unit |
|---|---|---|---|
| Total Device Dissipation FR−5 Board (Note 1) @$T_A$ = 25°C<br>Derate above 25°C | $P_D$ | 225<br>1.8 | mW<br>mW/°C |
| Thermal Resistance, Junction−to−Ambient | $R_{\theta JA}$ | 556 | °C/W |
| Total Device Dissipation Alumina Substrate (Note 2) @$T_A$ = 25°C<br>Derate above 25°C | $P_D$ | 300<br>2.4 | mW<br>mW/°C |
| Thermal Resistance, Junction−to−Ambient | $R_{\theta JA}$ | 417 | °C/W |
| Junction and Storage Temperature | $T_J$, $T_{stg}$ | −55 to +150 | °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 × 0.75 × 0.062 in.
2. Alumina = 0.4 × 0.3 × 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† |
|---|---|---|
| MMBT4401LT1G<br>SMMBT4401LT1G | SOT−23<br>(Pb−Free) | 3000 / Tape & Reel |
| MMBT4401LT3G | SOT−23<br>(Pb−Free) | 10,000 / Tape & 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.

© Semiconductor Components Industries, LLC, 1994

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

| Characteristic | | Symbol | Min | Max | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| Collector−Emitter Breakdown Voltage (Note 3) | ($I_C$ = 1.0 mAdc, $I_B$ = 0) | $V_{(BR)CEO}$ | 40 | − | Vdc |
| Collector−Base Breakdown Voltage | ($I_C$ = 0.1 mAdc, $I_E$ = 0) | $V_{(BR)CBO}$ | 60 | − | Vdc |
| Emitter−Base Breakdown Voltage | ($I_E$ = 0.1 mAdc, $I_C$ = 0) | $V_{(BR)EBO}$ | 6.0 | − | Vdc |
| Base Cutoff Current | ($V_{CE}$ = 35 Vdc, $V_{EB}$ = 0.4 Vdc) | $I_{BEV}$ | − | 0.1 | μAdc |
| Collector Cutoff Current | ($V_{CE}$ = 35 Vdc, $V_{EB}$ = 0.4 Vdc) | $I_{CEX}$ | − | 0.1 | μAdc |
| **ON CHARACTERISTICS** (Note 3) | | | | | |
| DC Current Gain | | $h_{FE}$ | | | − |
| | ($I_C$ = 0.1 mAdc, $V_{CE}$ = 1.0 Vdc) | | 20 | − | |
| | ($I_C$ = 1.0 mAdc, $V_{CE}$ = 1.0 Vdc) | | 40 | − | |
| | ($I_C$ = 10 mAdc, $V_{CE}$ = 1.0 Vdc) | | 80 | − | |
| | ($I_C$ = 150 mAdc, $V_{CE}$ = 1.0 Vdc) | | 100 | 300 | |
| | ($I_C$ = 500 mAdc, $V_{CE}$ = 2.0 Vdc) | | 40 | − | |
| Collector−Emitter Saturation Voltage | | $V_{CE(sat)}$ | | | 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 | | $V_{BE(sat)}$ | | | 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 | ($I_C$ = 20 mAdc, $V_{CE}$ = 10 Vdc, f = 100 MHz) | $f_T$ | 250 | − | MHz |
| Collector−Base Capacitance | ($V_{CB}$ = 5.0 Vdc, $I_E$ = 0, f = 1.0 MHz) | $C_{cb}$ | − | 6.5 | pF |
| Emitter−Base Capacitance | ($V_{EB}$ = 0.5 Vdc, $I_C$ = 0, f = 1.0 MHz) | $C_{eb}$ | − | 30 | pF |
| Input Impedance | ($I_C$ = 1.0 mAdc, $V_{CE}$ = 10 Vdc, f = 1.0 kHz) | $h_{ie}$ | 1.0 | 15 | kΩ |
| Voltage Feedback Ratio | ($I_C$ = 1.0 mAdc, $V_{CE}$ = 10 Vdc, f = 1.0 kHz) | $h_{re}$ | 0.1 | 8.0 | X $10^{-4}$ |
| Small−Signal Current Gain | ($I_C$ = 1.0 mAdc, $V_{CE}$ = 10 Vdc, f = 1.0 kHz) | $h_{fe}$ | 40 | 500 | − |
| Output Admittance | ($I_C$ = 1.0 mAdc, $V_{CE}$ = 10 Vdc, f = 1.0 kHz) | $h_{oe}$ | 1.0 | 30 | μmhos |
| **SWITCHING CHARACTERISTICS** | | | | | |
| Delay Time | ($V_{CC}$ = 30 Vdc, $V_{EB}$ = 2.0 Vdc, $I_C$ = 150 mAdc, $I_{B1}$ = 15 mAdc) | $t_d$ | − | 15 | ns |
| Rise Time | | $t_r$ | − | 20 | |
| Storage Time | ($V_{CC}$ = 30 Vdc, $I_C$ = 150 mAdc, $I_{B1}$ = $I_{B2}$ = 15 mAdc) | $t_s$ | − | 225 | ns |
| Fall Time | | $t_f$ | − | 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

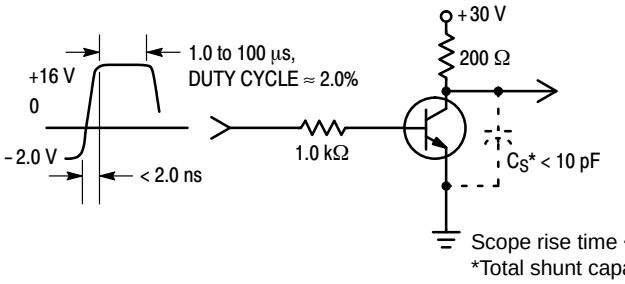



**Figure 1. Turn−On Time**

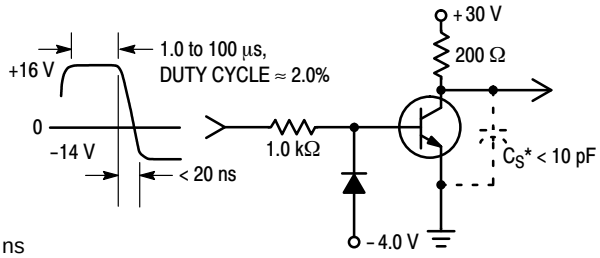



**Figure 2. Turn−Off Time**

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

## TRANSIENT CHARACTERISTICS

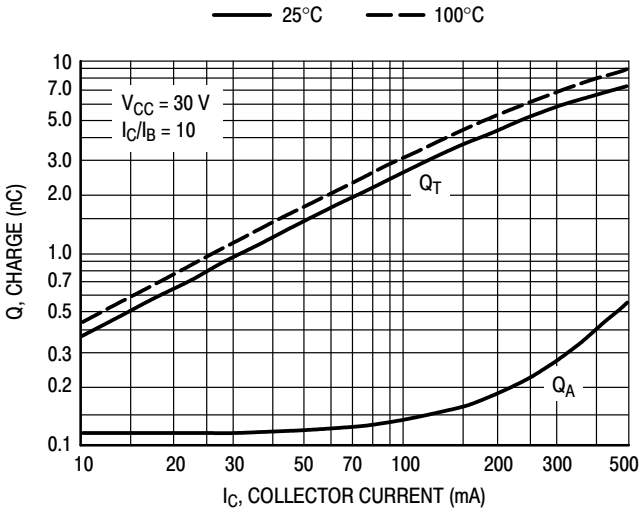



**Figure 3. Charge Data**

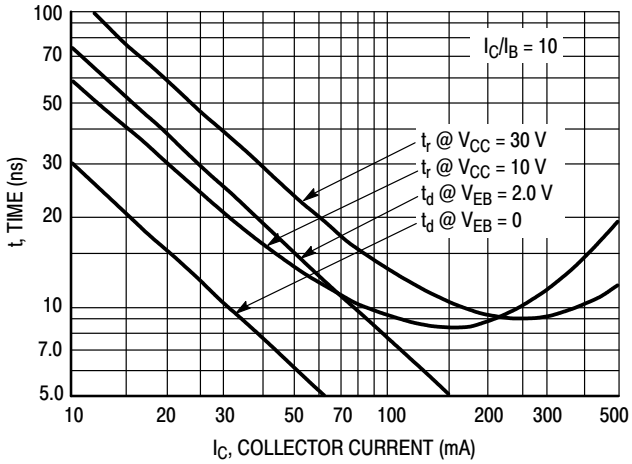



**Figure 4. Turn−On Time**

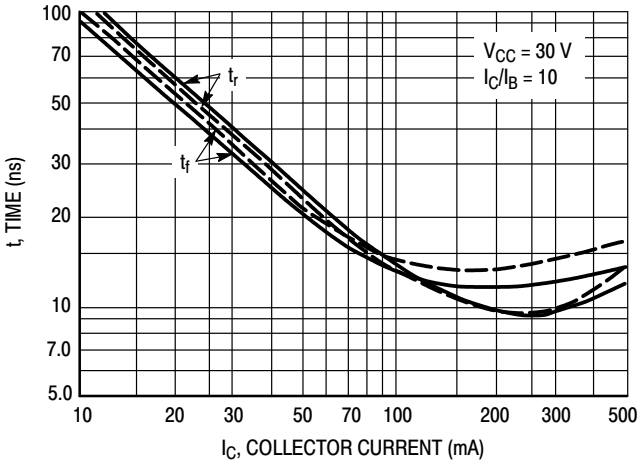



**Figure 5. Rise and Fall Times**

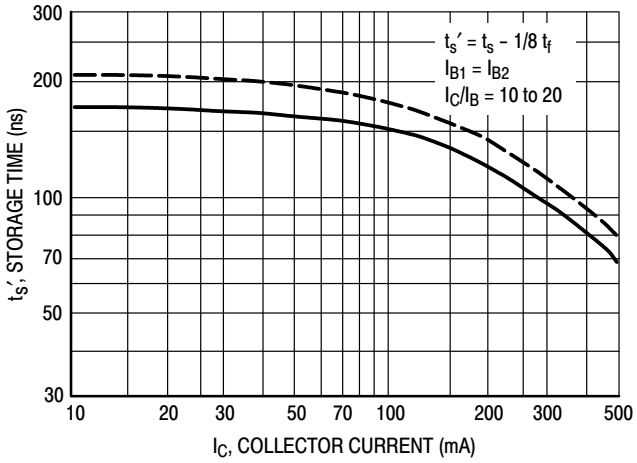



**Figure 6. Storage Time**

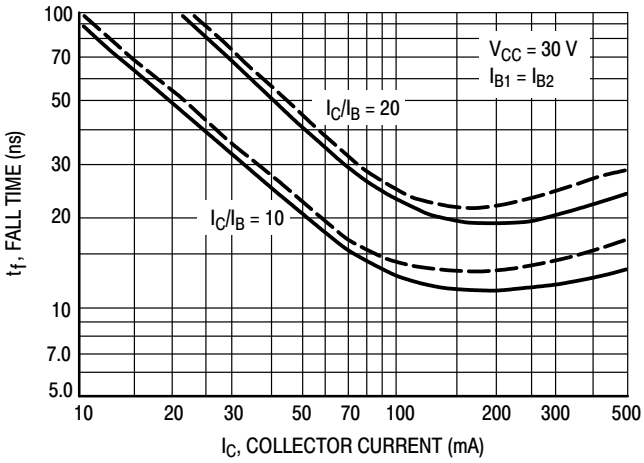



**Figure 7. Fall Time**

## SMALL−SIGNAL CHARACTERISTICS NOISE FIGURE

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

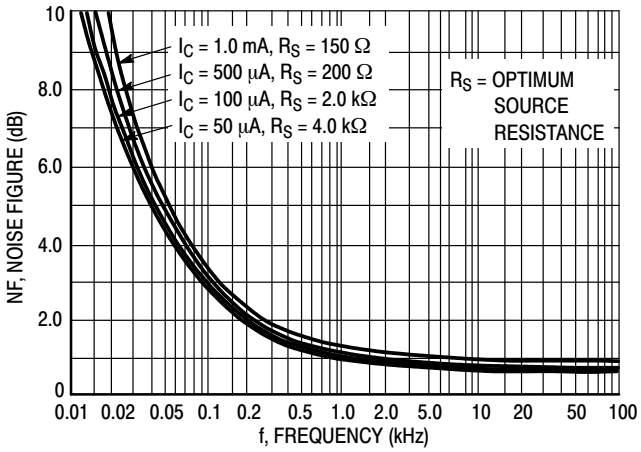



**Figure 8. Frequency Effects**

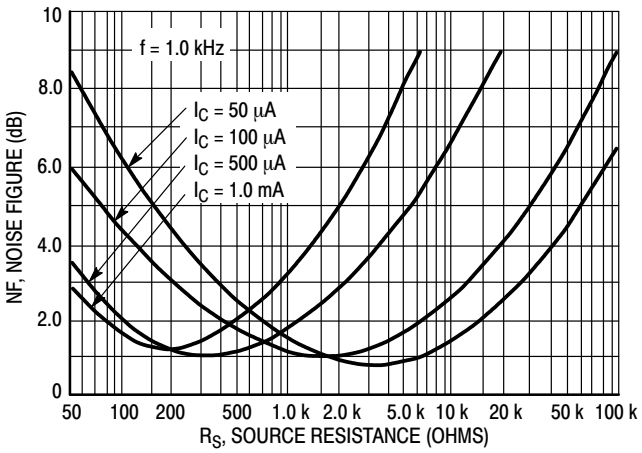



**Figure 9. Source Resistance Effects**

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

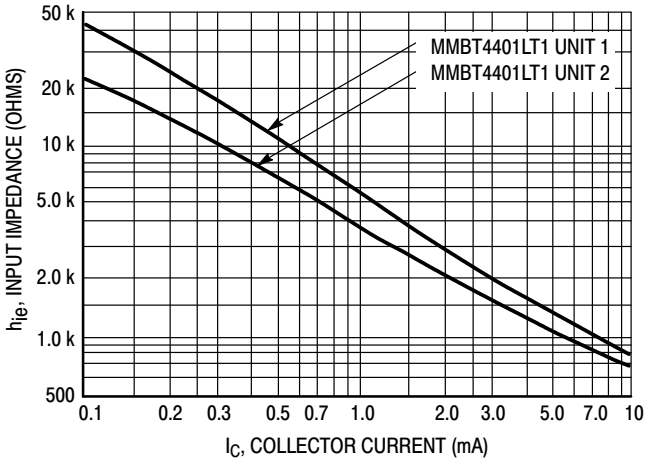



**Figure 10. Input Impedance**

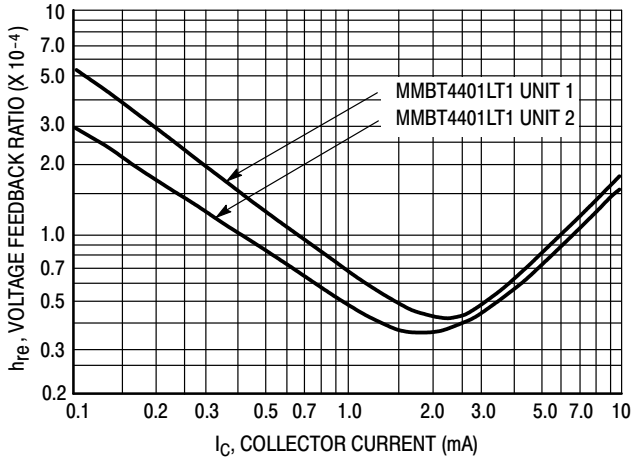



**Figure 11. Voltage Feedback Ratio**

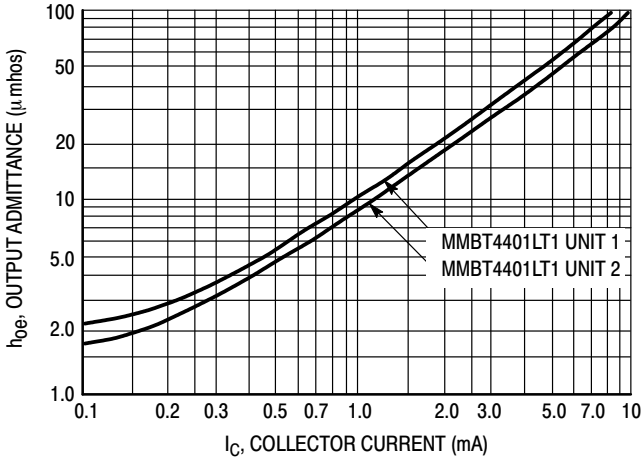



**Figure 12. Output Admittance**

## STATIC CHARACTERISTICS

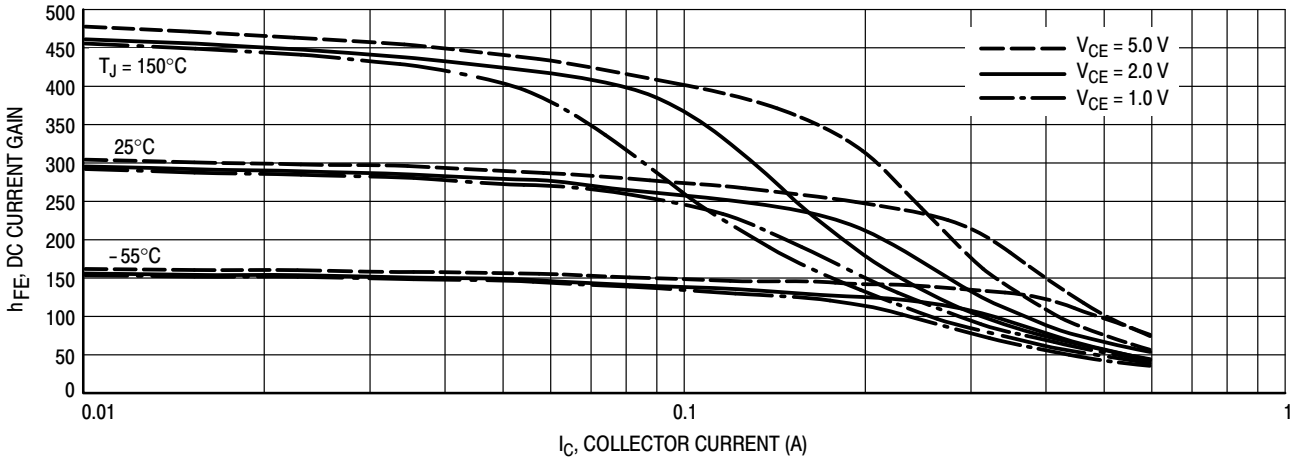



**Figure 13. DC Current Gain**

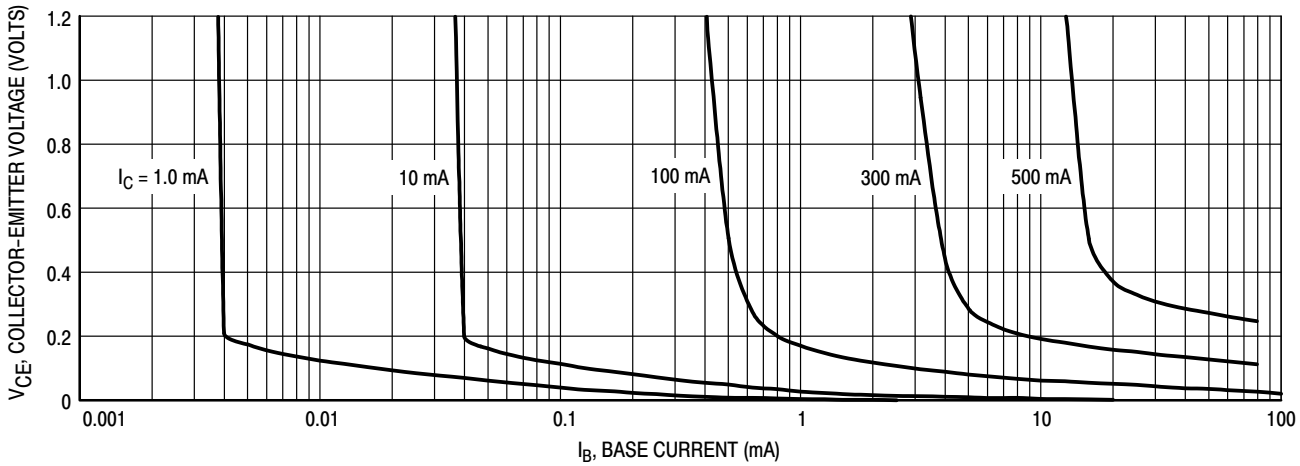



**Figure 14. Collector Saturation Region**

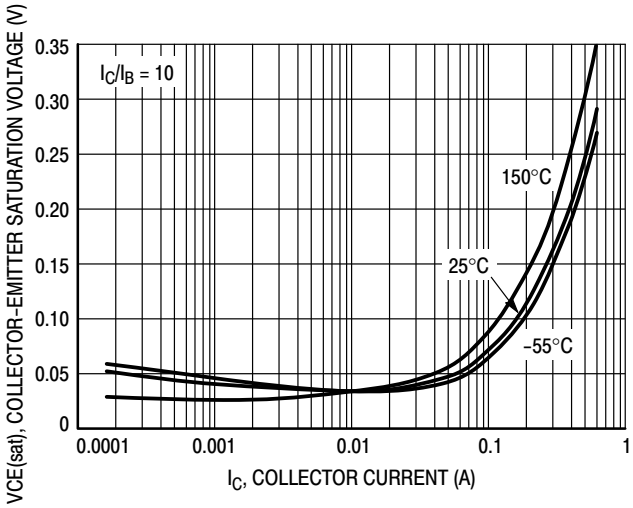



**Figure 15. Collector−Emitter Saturation Voltage vs. Collector Current**

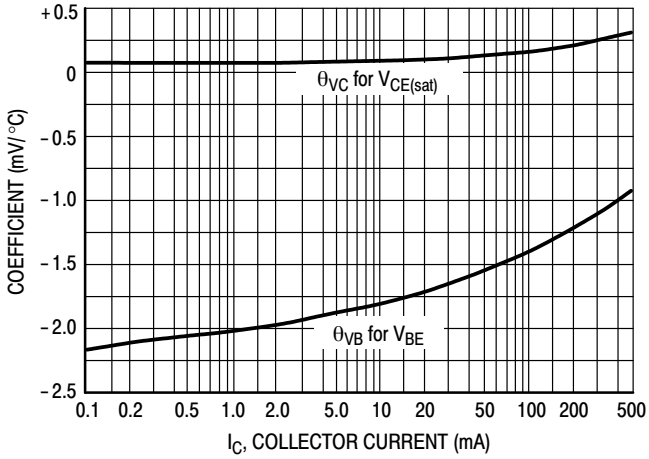



**Figure 16. Temperature Coefficients**

## STATIC CHARACTERISTICS

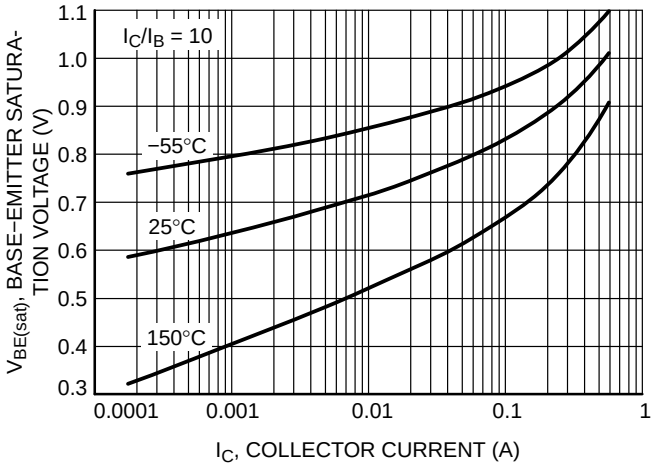



**Figure 17. Base−Emitter Saturation Voltage vs. Collector Current**

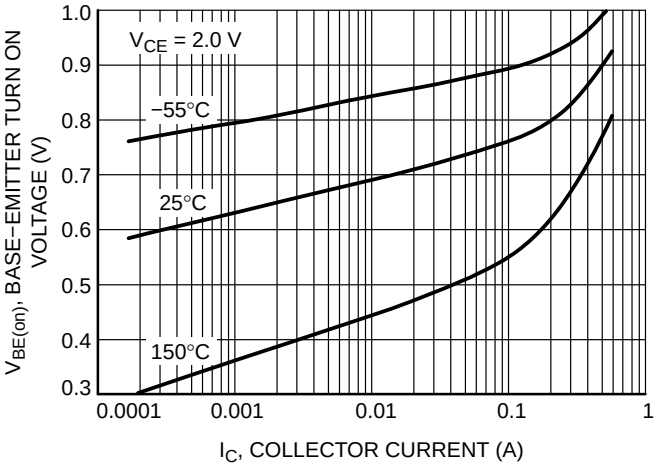



**Figure 18. Base−Emitter Turn On Voltage vs. Collector Current**

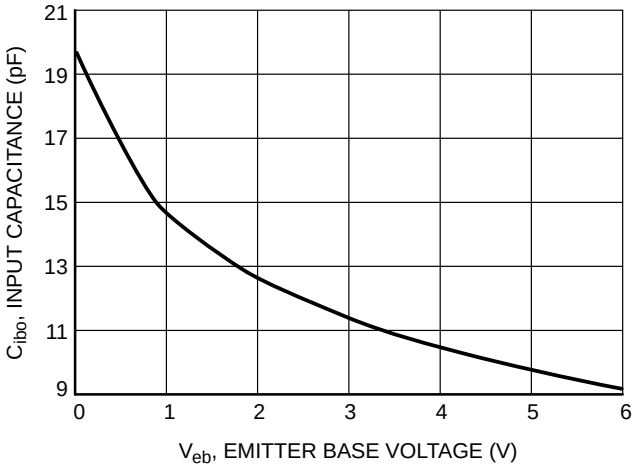



**Figure 19. Input Capacitance vs. Emitter Base Voltage**

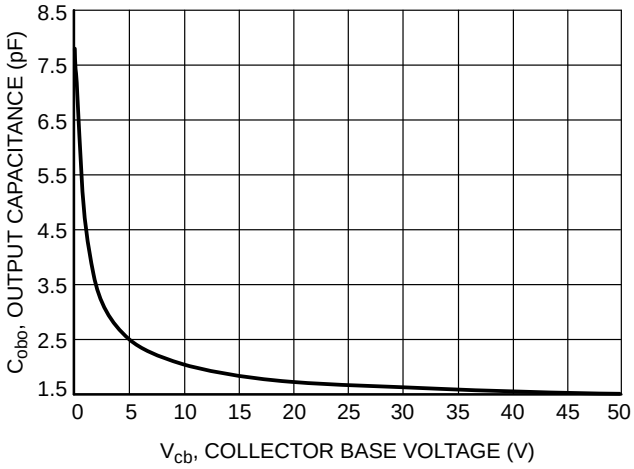



**Figure 20. Output Capacitance vs. Collector Base Voltage**

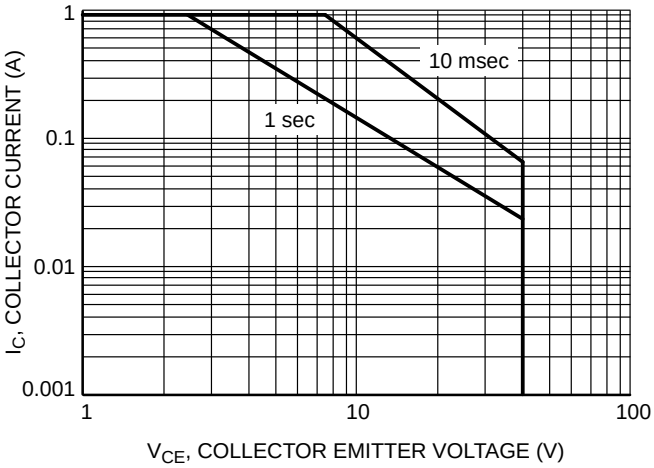



**Figure 21. Safe Operating Area**

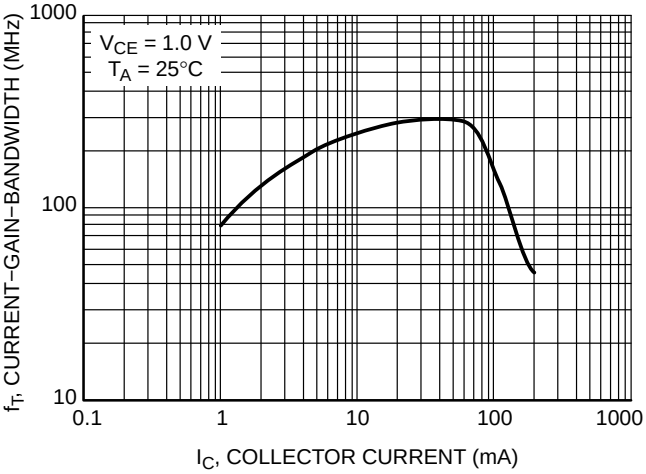



**Figure 22. Current−Gain−Bandwidth Product**

**onsemi**, onsemi, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent−Marking.pdf. **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as−is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## ADDITIONAL INFORMATION

**TECHNICAL PUBLICATIONS**:
**Technical Library:** www.onsemi.com/design/resources/technical−documentation
**onsemi Website:** www.onsemi.com

**ONLINE SUPPORT**: www.onsemi.com/support
**For additional information, please contact your local Sales Representative at**
www.onsemi.com/support/sales